Non-Power Opportunities for CCS in China

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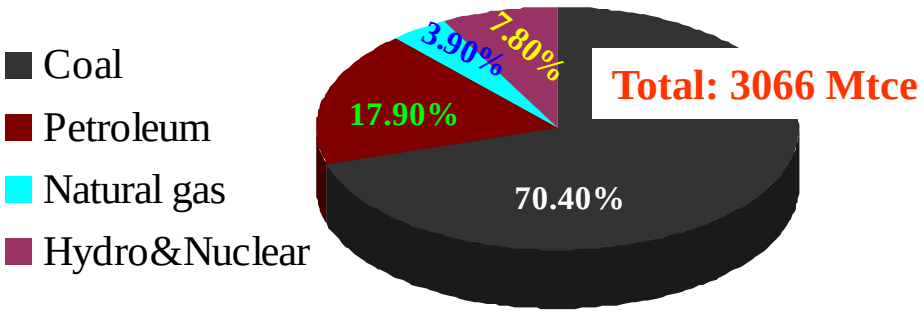
Outline

- **Industry CO_2 emission in China**
- **Non-power industry CCS opportunities**
  - **Iron & steel industry**
  - **Coal chemical industry**
  - **Cement industry**
- **CAS carbon budget project**
- **Conclusion**

Energy consumption & CO_2 emission in China

- **Coal provides the mainly power in China**

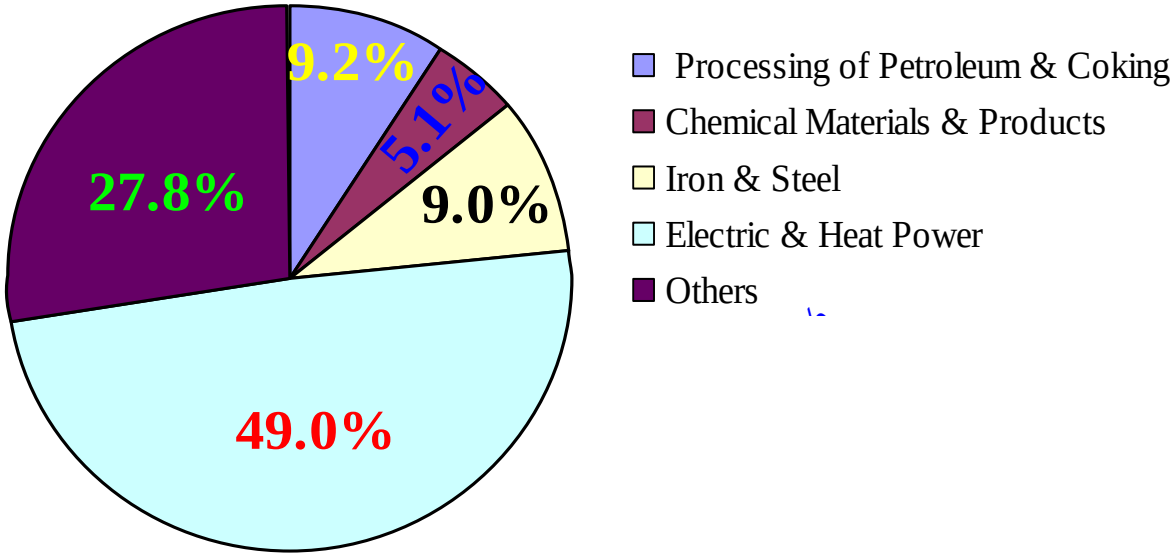
中国能源消费中煤炭占70%左右，工业过程CO_2排放量巨大



Energy consumption (China,2009)

- **Fossil fuel consumption in China's main industries**

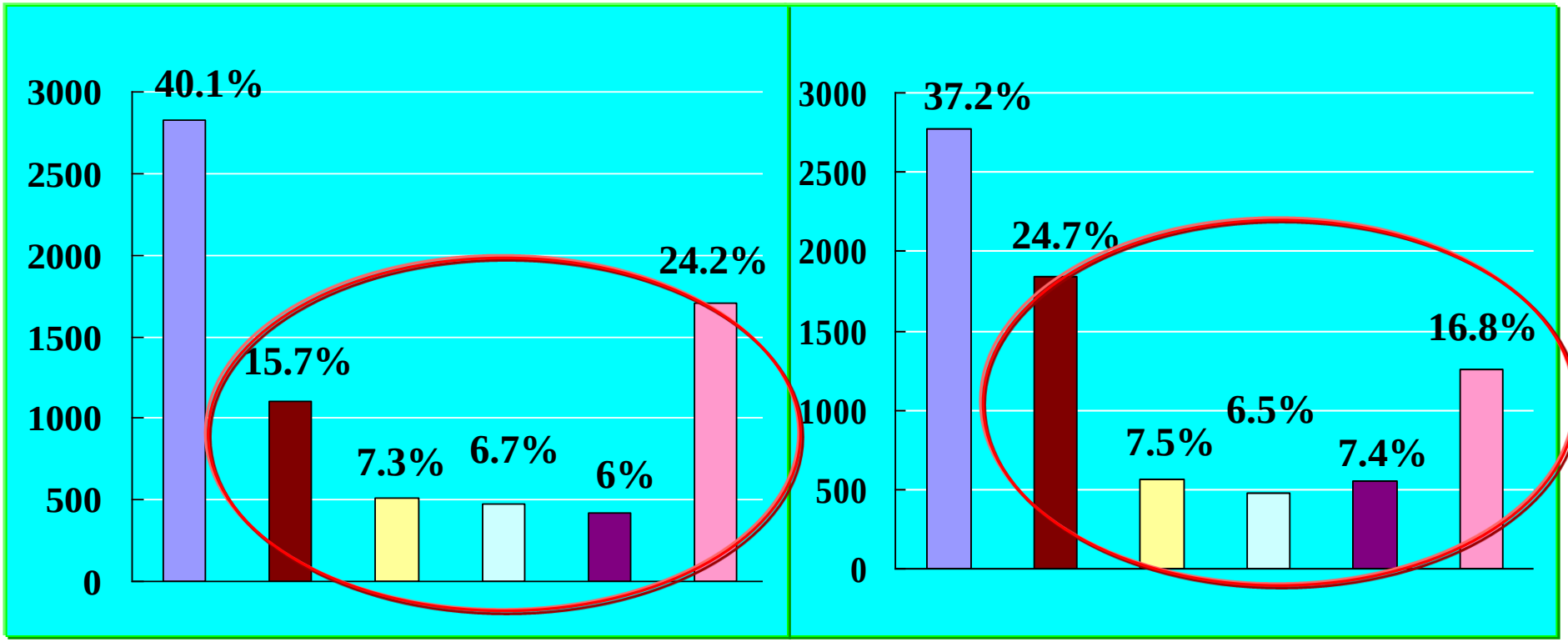
石化、水泥、冶金等过程煤炭消耗量占40%以上，是CO_2的主要排放源之一



Source: China energy statistical yearbook 2010

CO_2 emission in China's main industry

冶金、石化、水泥等非能源工业过程CO_2排放量占到工业过程总排放量的40%以上，并在逐渐增加。

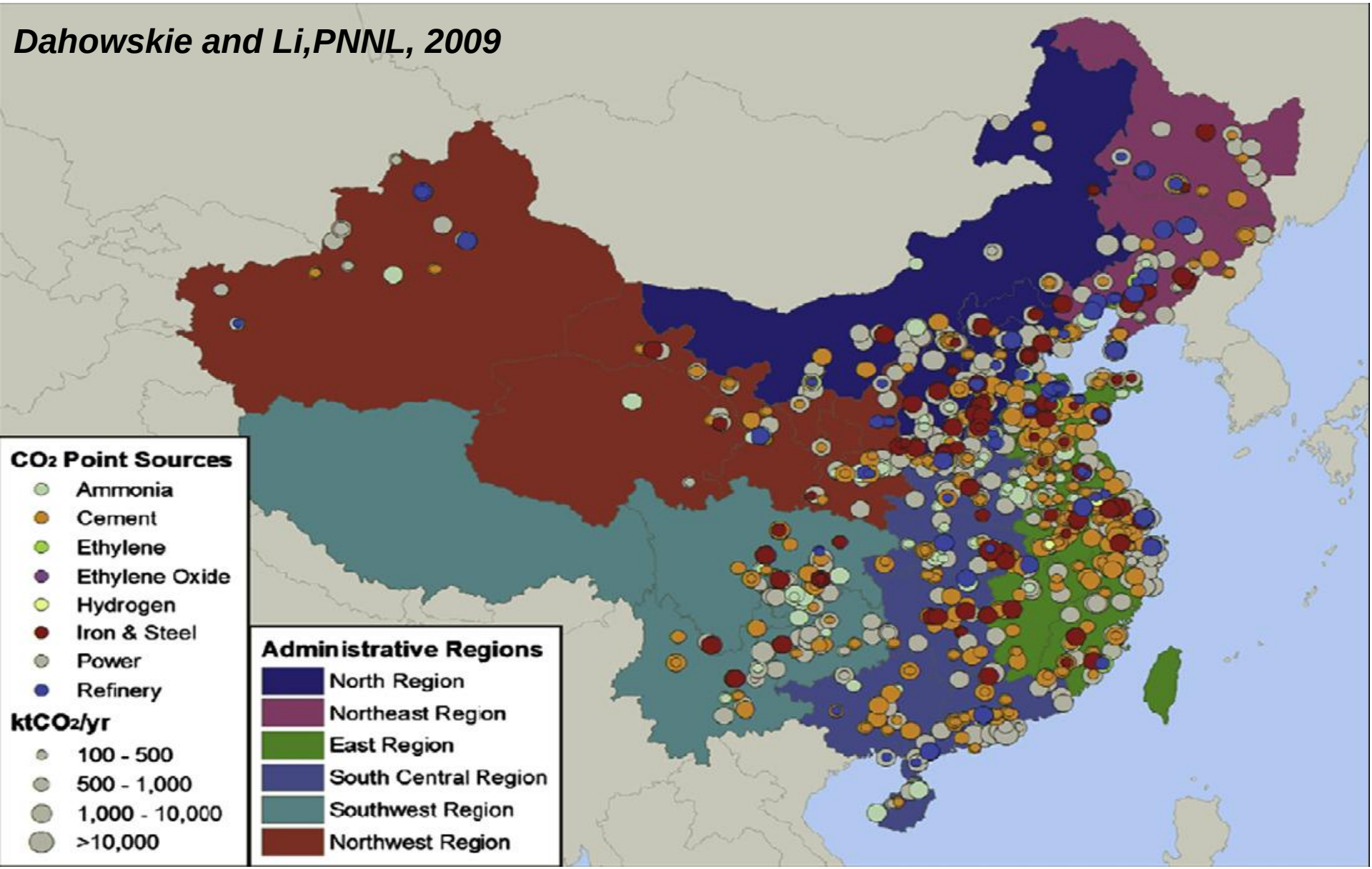


CO_2 emission (2010)　　CO_2 emission (prediction,2011)

Electric & Heat Power　Processing of Petroleum & Coking　Iron & Steel　Others

Manufacture of Non-metallic Mineral Products　Chemical Materials & Products

CO_2 emission sources across China

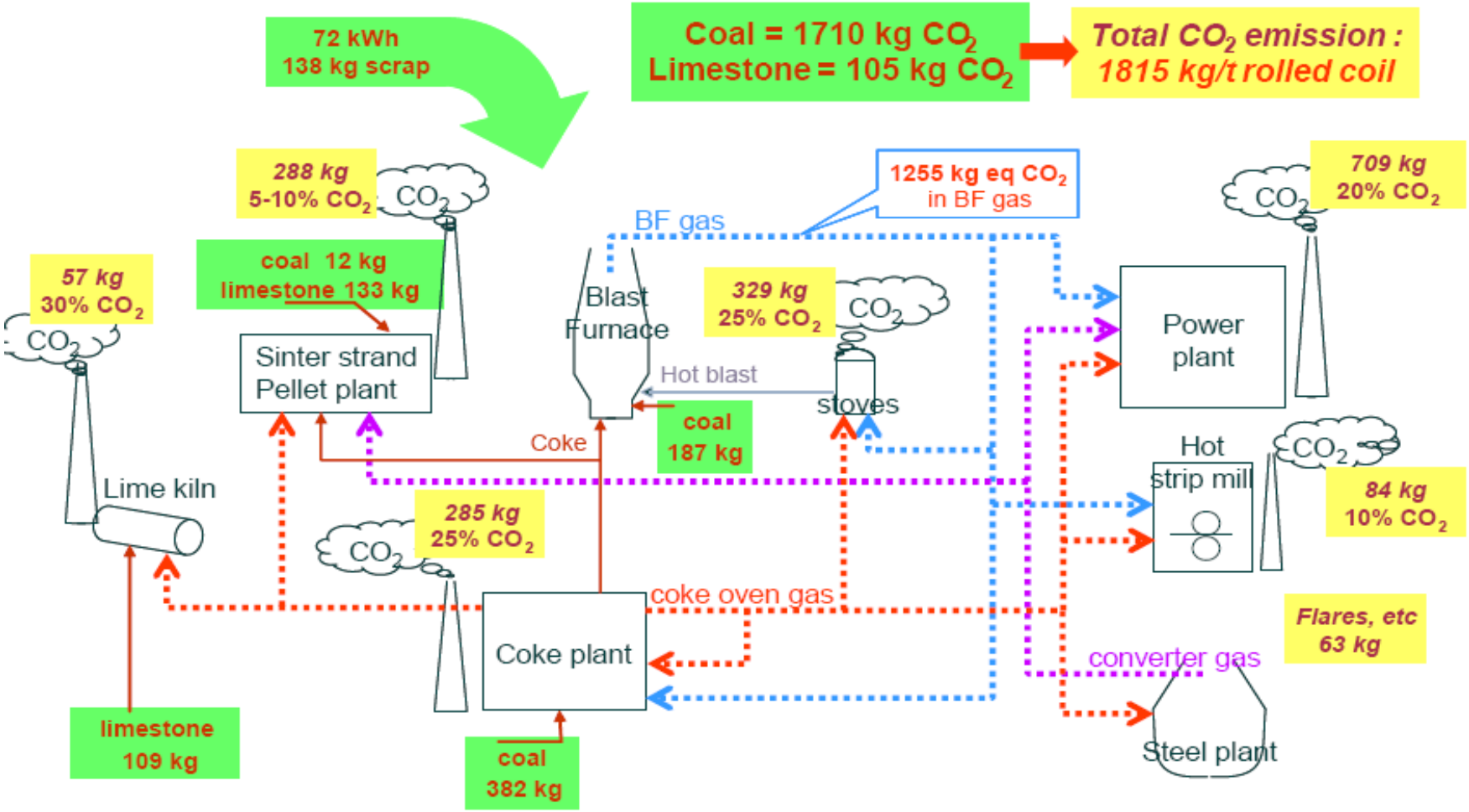


Characteristics of CO_2 emission in non-power industry

- **Mainly refers to Iron & steel, petroleum & chemical, cement.**
- **The amount of CO_2 emission accounts for about 40% of the total China's CO_2 emission, which nearly to that of from power industry.**
- **Discharged gases from non-power industry usually have higher CO_2 concentration (20~100%), and more complicated compositions.**
- **CO_2 production does not restrict to fuel combustion like in power generation, the conversion of C to CO_2 are flexible , such as gasification, reduction reaction.**
- **Lower energy penalty and cost can be achieved in some processes with higher CO_2 concentration, which regarded as early opportunity for CCS.**

CCS in Iron & steel industry

CO_2 emissions from a typical steel mill

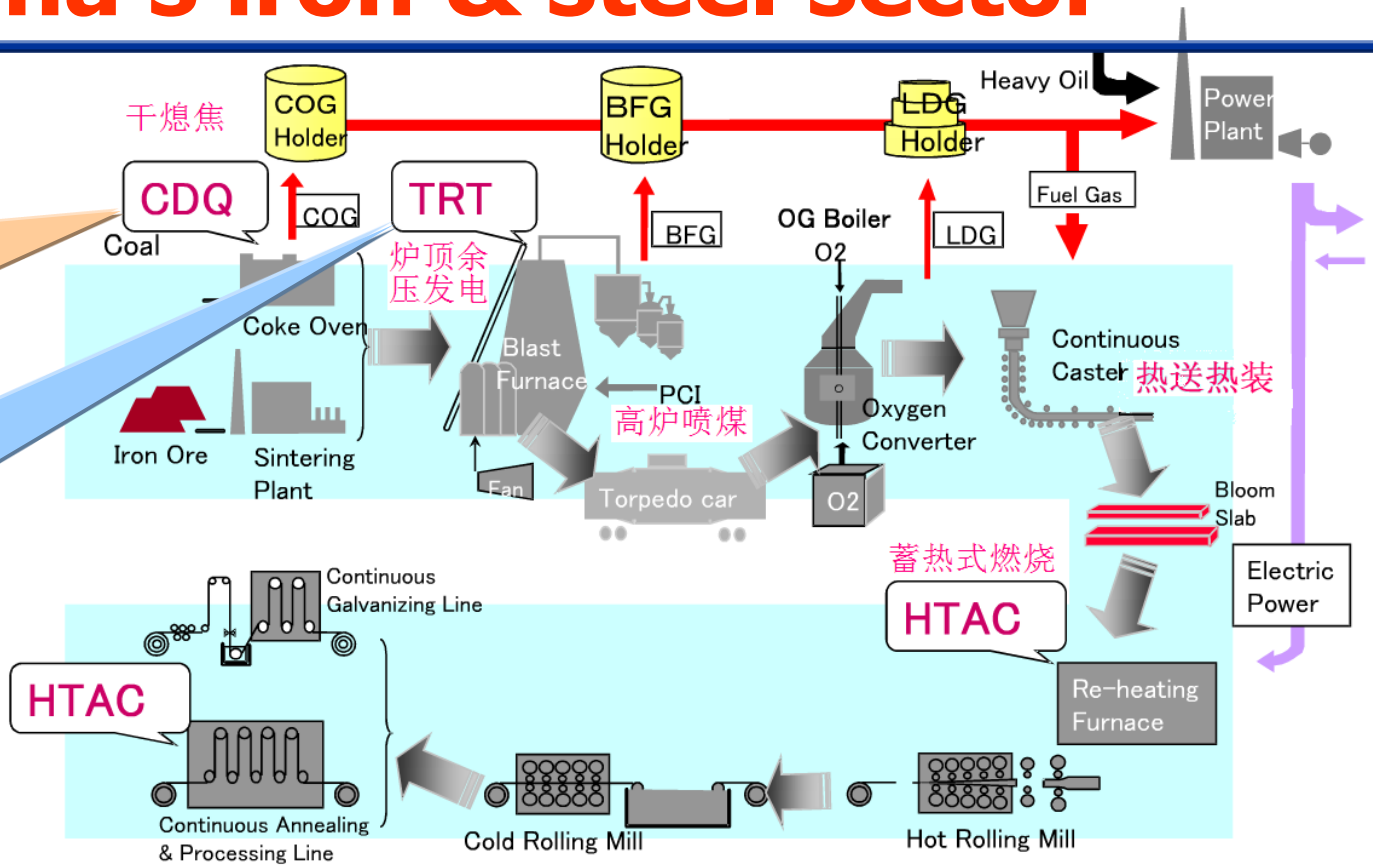


- CO_2 emission: 1800~2200kg/ t crude steel

Energy saving technologies in China's iron & steel sector

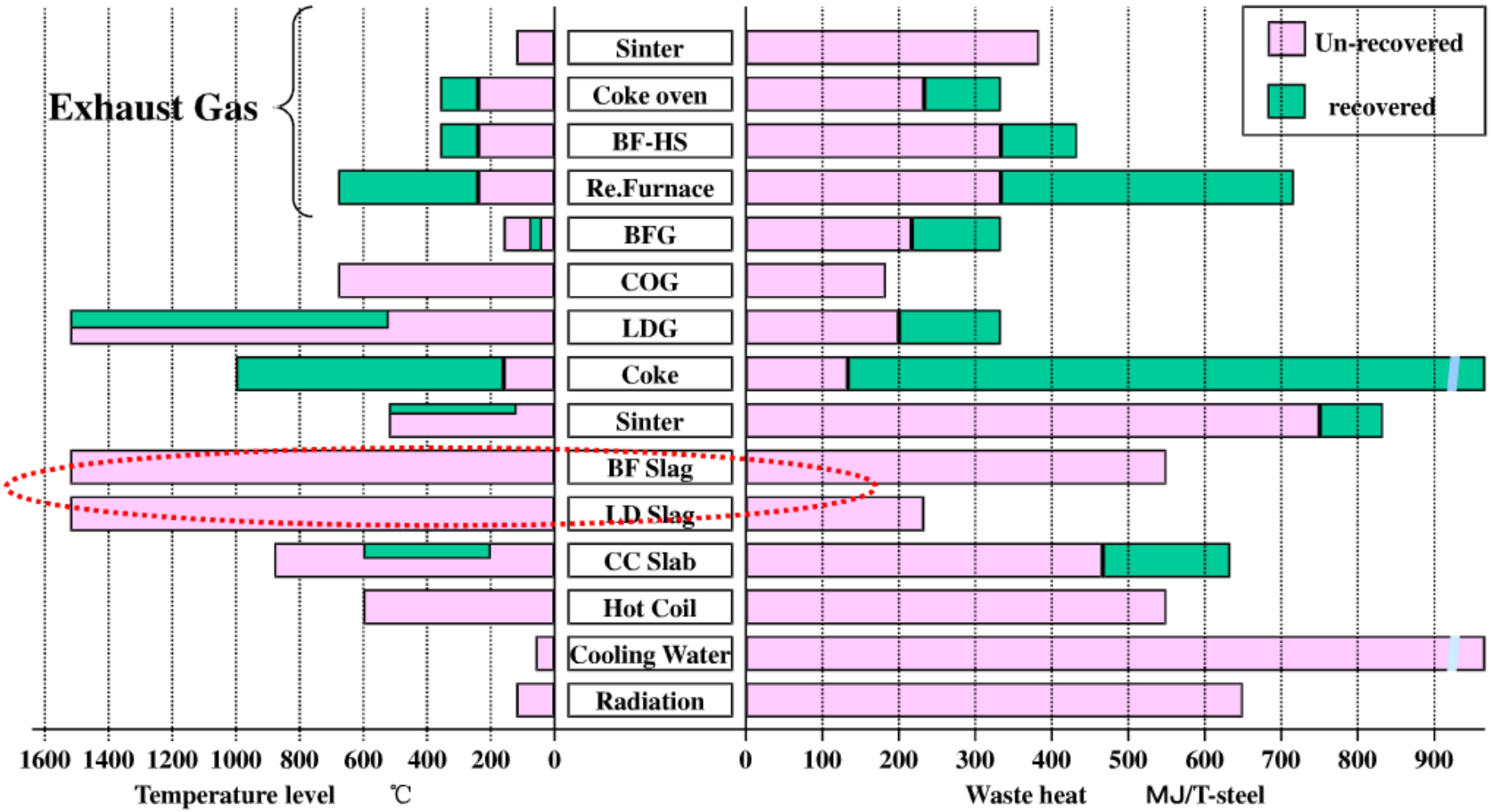
10~14kg Coal /t crude steel
30~40kg CO_2/t crude steel

40~60kWh /t crude steel
20~30kg CO_2/t crude steel



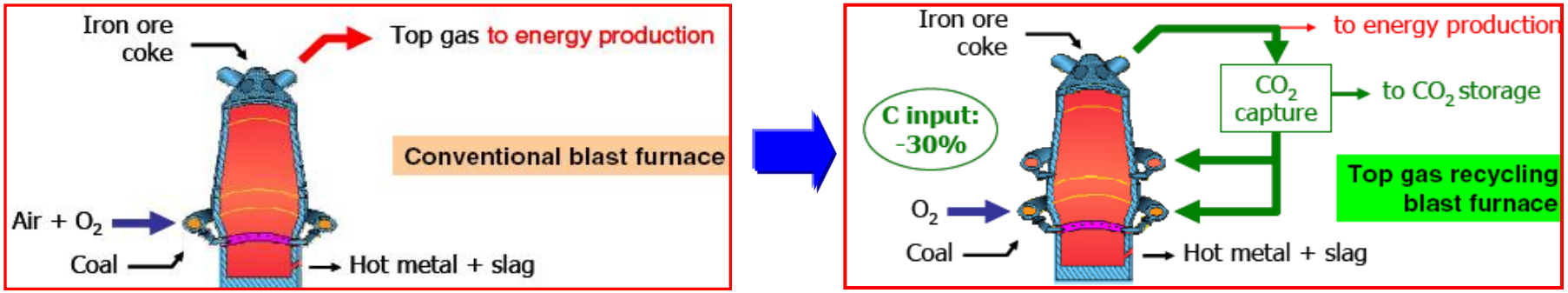
- **Energy saving technologies： the potential for minimizing CO_2 emission 20%~30%.**
- **End-of-pipe CCS on main emitter (BF) brings only 25 to 30% reduction in CO_2 emissions, at high abatement costs.**

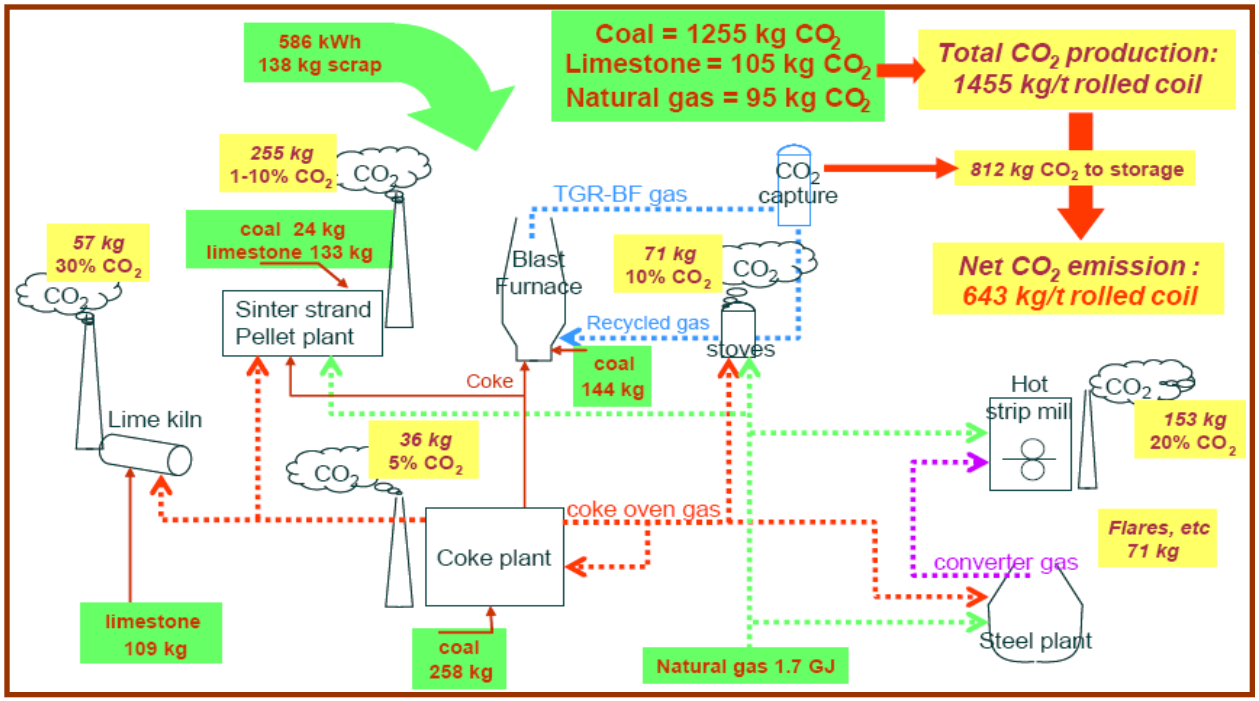
Opportunity of Integration of waste solid & heat with CO_2 capture in steel industry



- Slag: CO_2 carbonation
- Low temperature heat： heat source for CO_2 absorption process

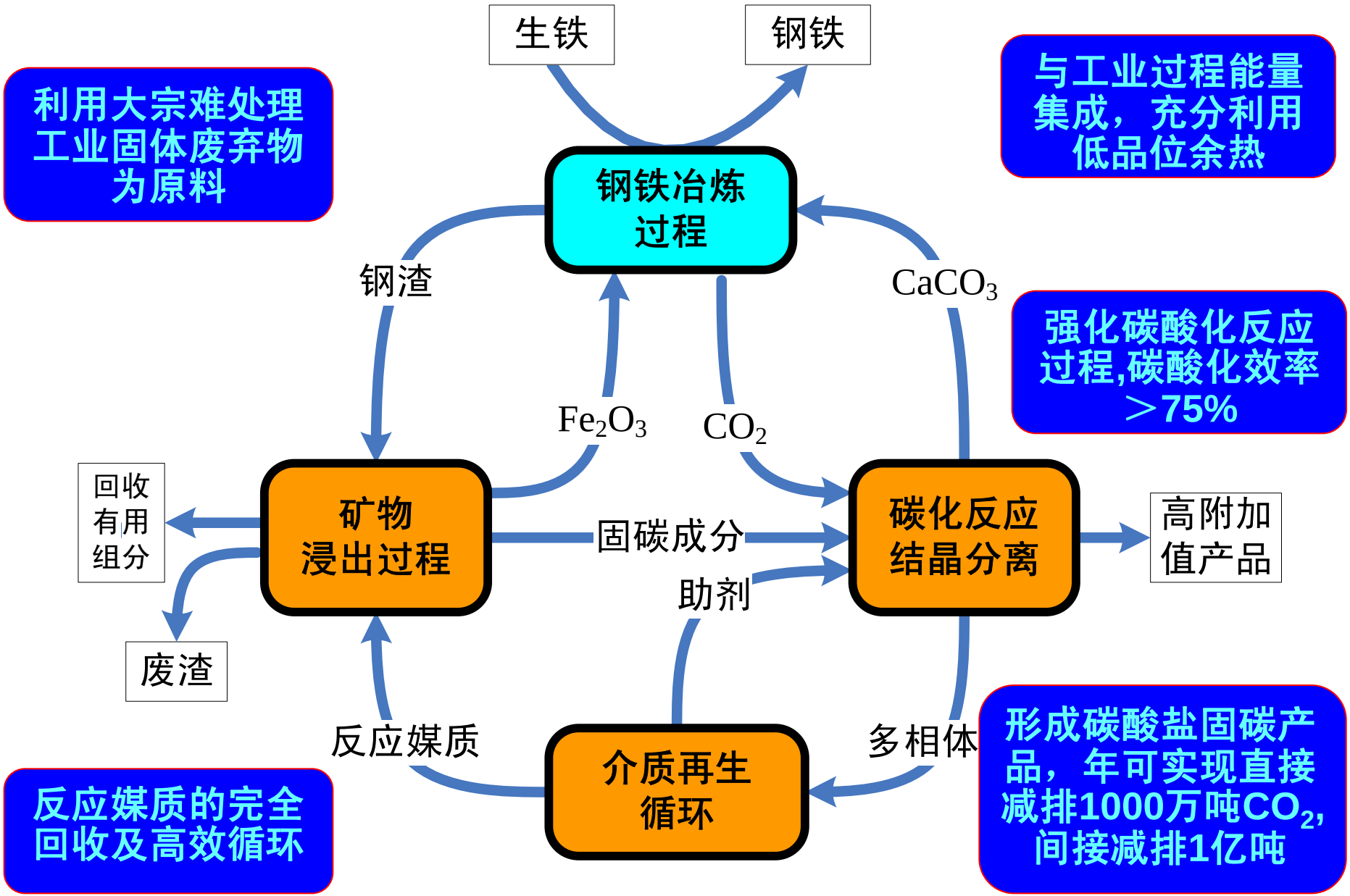
Top Gas Recycling Blast Furnace with CCS





Overall CO_2 emission reduction:
TGRBF+CCS 50%~60%
TGRBF alone 5%~10%

IPE-利用钢铁过程废渣固定捕获的CO_2



CCS in coal chemical industry

China needs new coal chemical industry

Direct liquefaction:

Indirect liquefaction::

煤制烯烃 2020:8Mt/a

Olefins

11 projects in the construction & plan

MeOH/ DME

煤制甲醇/二甲醚

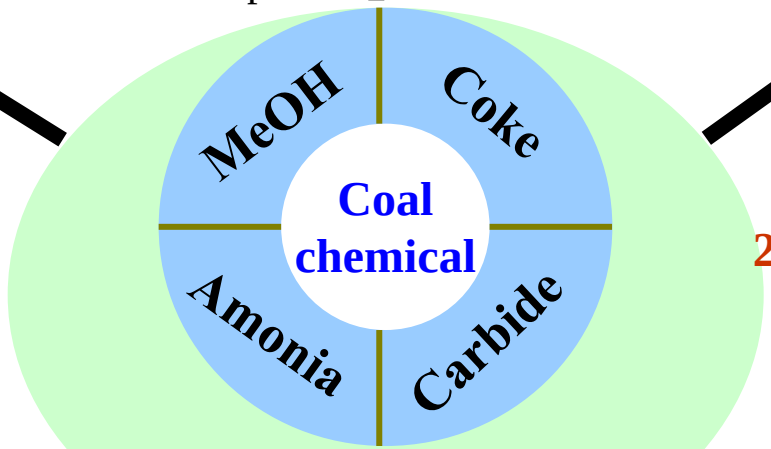
2020:60Mt/a

CTL

煤制油

2020:30Mt/a

Scale:16~40×10^{12} m^3



New coal chemical

(ethylene) glycol

煤制乙二醇

NG/ SNG

6 projects in the construction & plan

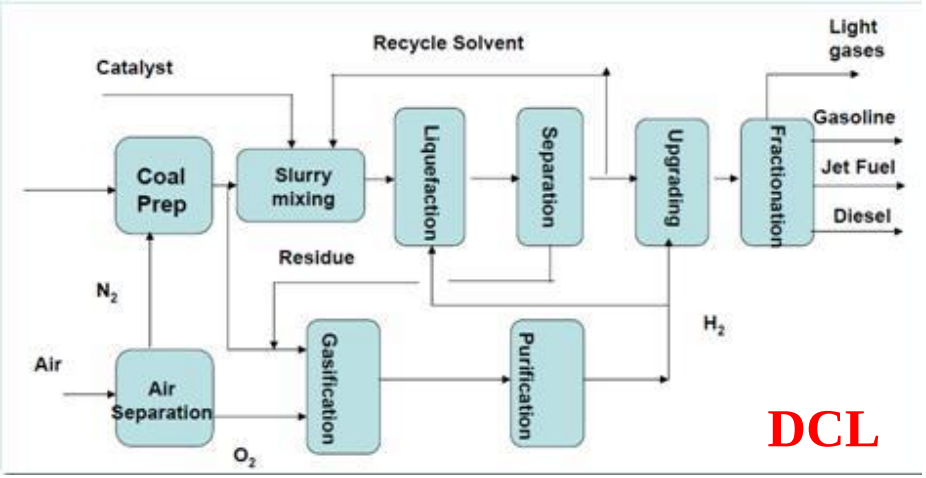
煤制天然气

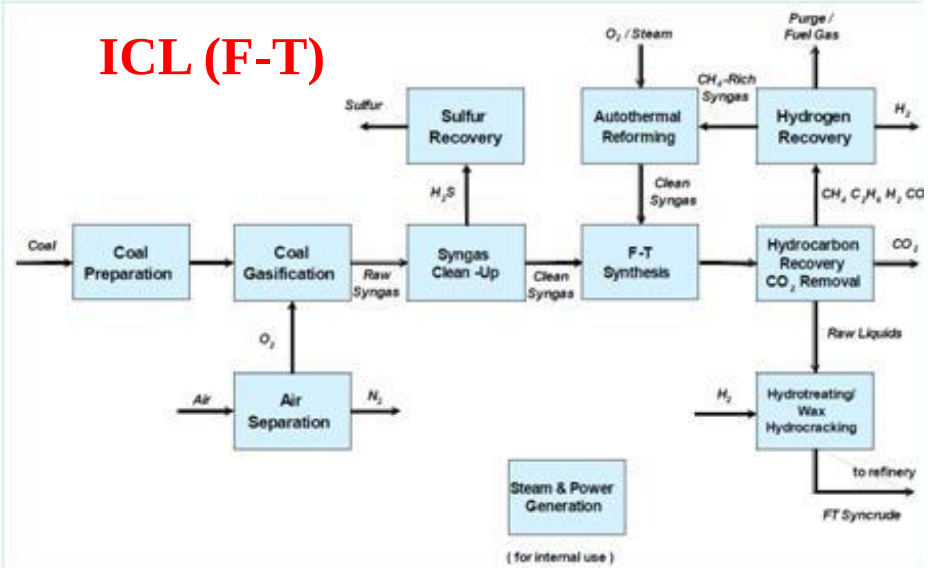
2020: Huge emission of CO_2(>2Gt)

Large CO_2 emission of coal chemical industry

- 新型煤化工行业：
  - ✓ 年产100万吨直接煤制油项目将年排放二氧化碳210万吨；
  - ✓ 年产60万吨聚烯烃装置将年排放360多万吨二氧化碳；
  - ✓ 年产20亿立方米的煤制天然气项目将年排放二氧化碳近600万吨；

Direct coal liquefaction (DCL) vs Indirect coal liquefaction (ICL)



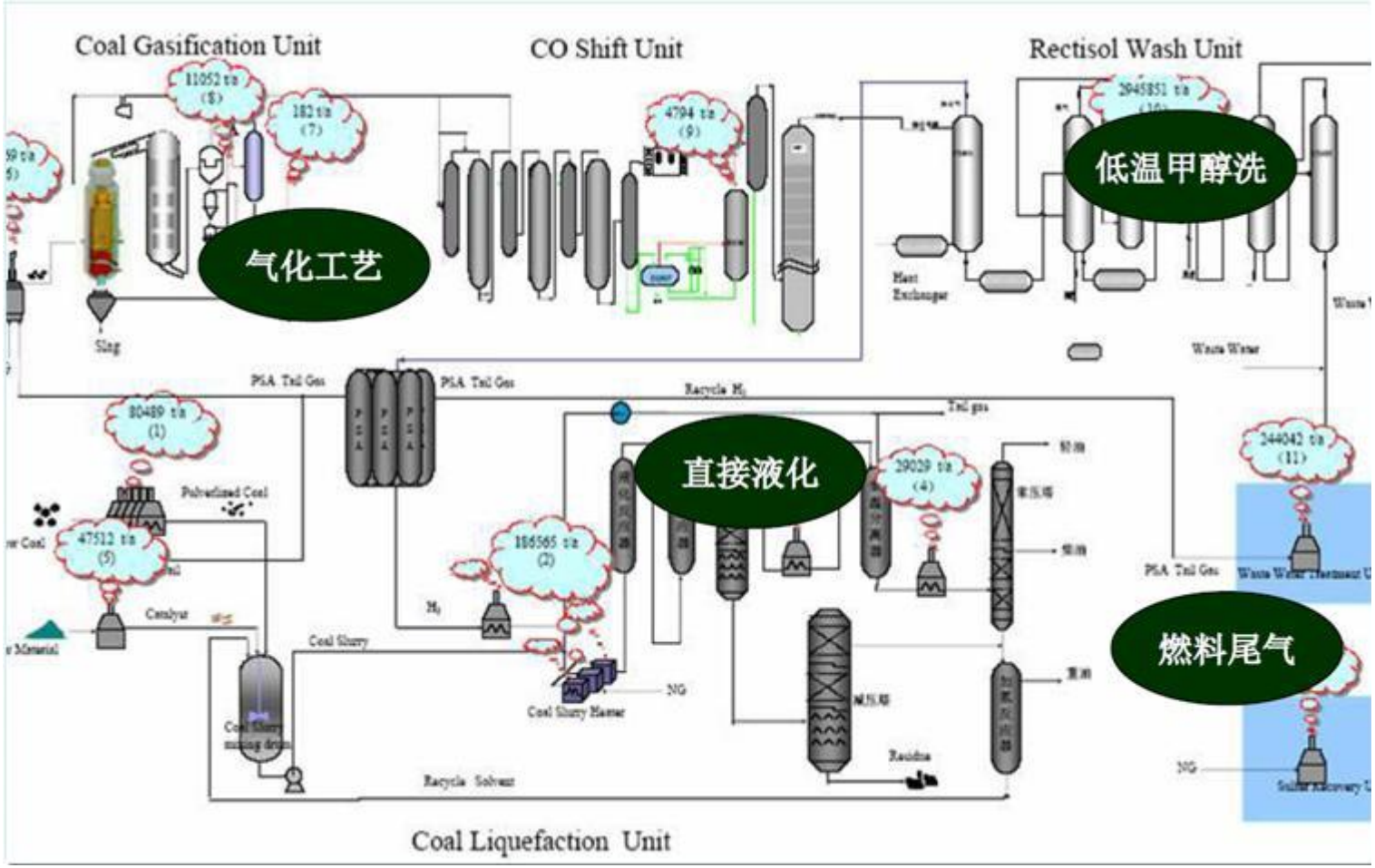


Comparison of various CTL configurations

	DCL	ICL Recycle	ICL Once Through	Hybrid DCL/ICL
Coal consumption (tonnes per day, dry basis)	23,027	29,307	34,450	23,146
Product Mix				
Diesel (bpd)	45,812	47,687	47,687	46,750
Naphtha (bpd)	18,863	22,313	22,313	20,591
LPG (bpd)	5,325	0	0	2,660
Total (bpd)	70,000	70,000	70,000	70,000
Net Export Power (MW)	0	399	1139	45
Thermal efficiency (%)	60.1	48.4	47.4	58.7
Product yield (bbl/t dry coal)	3.04	2.39	2.03	3.02
Plant CO_2 generation (kg CO_2 /bbl product)*	434	706	894	458

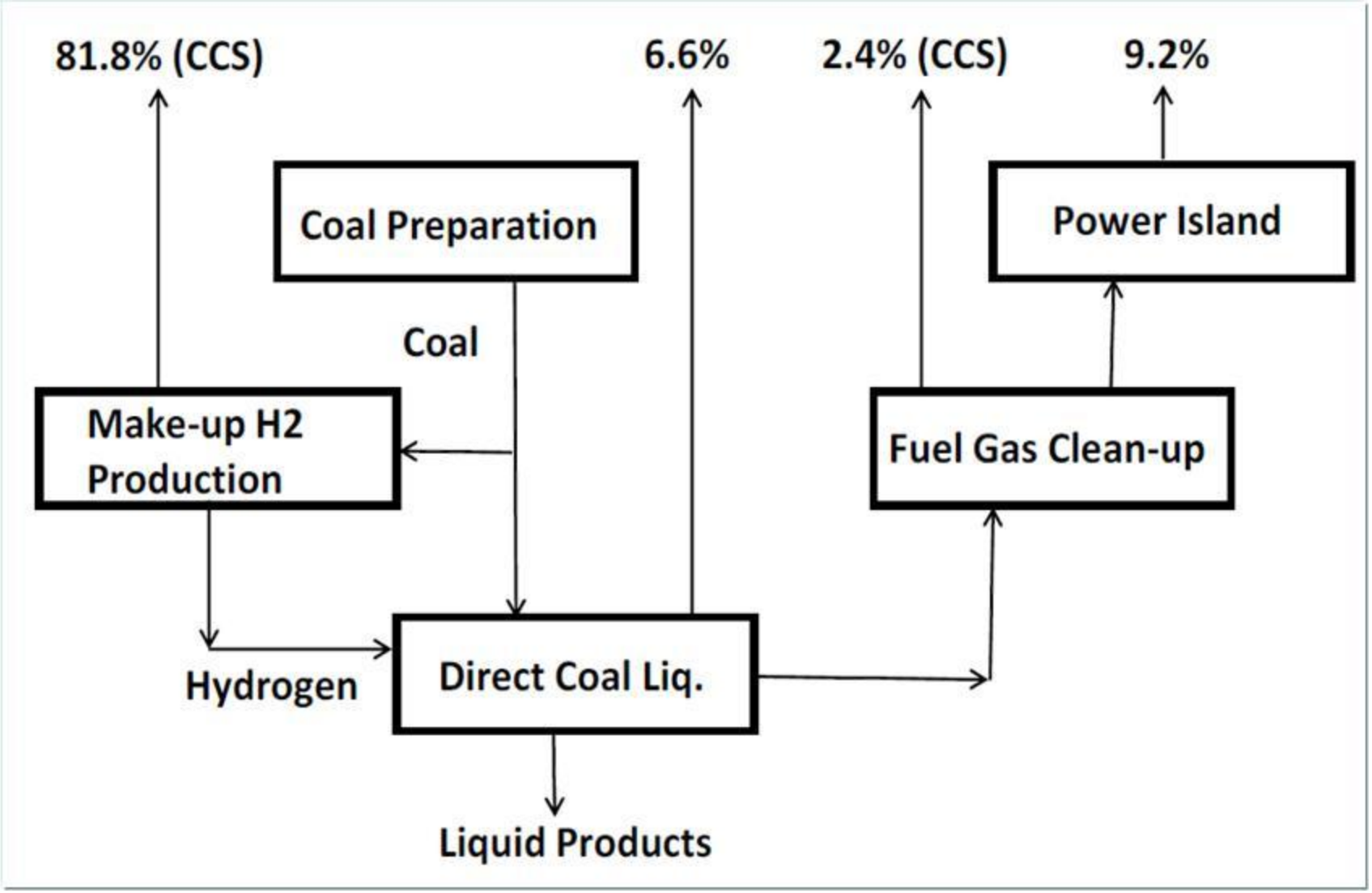
- **CO_2 emission from DCL is 50% less than ICL**
- **Over 80% of this CO_2 is in concentrated form ready for sequestration**

CO_2 Emission sketch map of DCL demenstration plant in Ordos

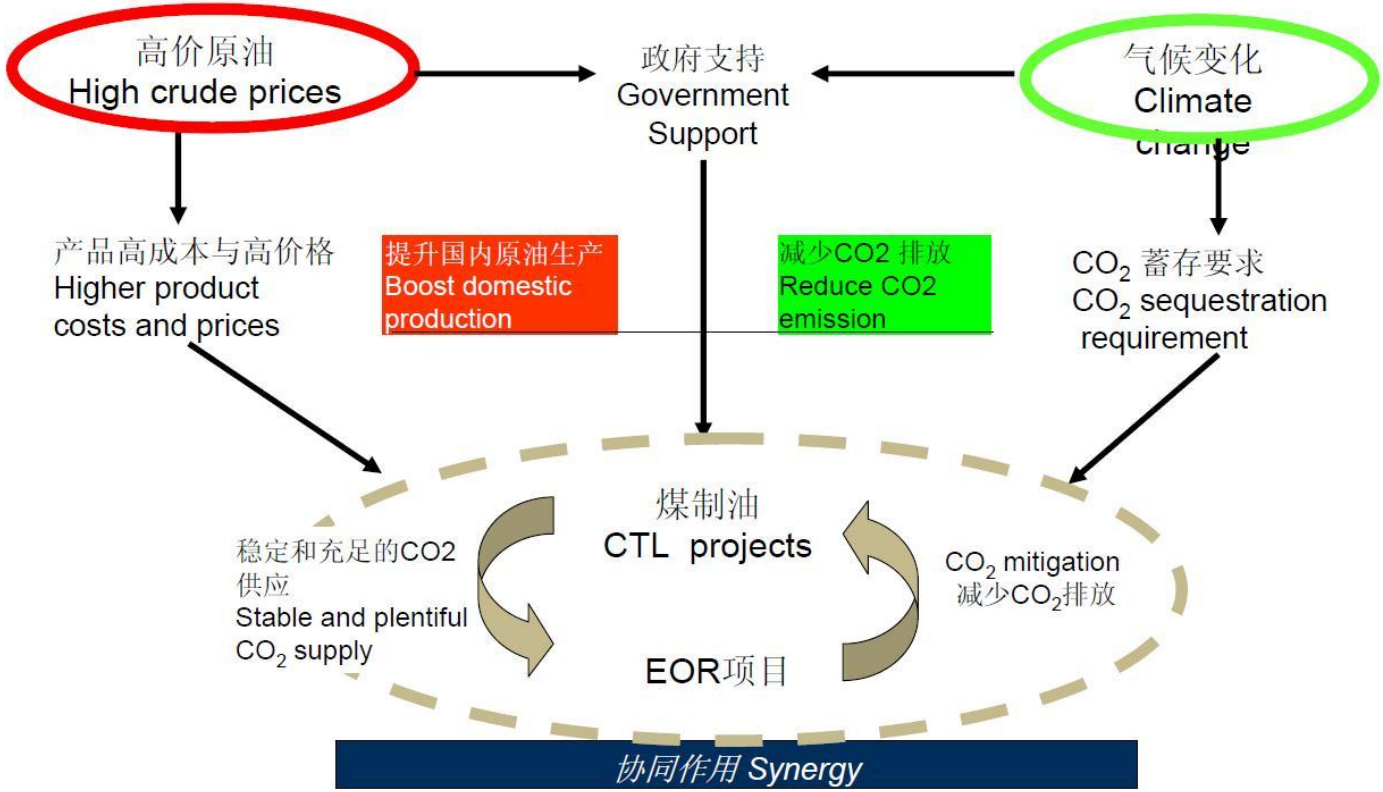


- Direct liquefaction process produces little CO_2
- CO_2 comes from: hydrogen production (2.9 t/t), fuel combustion (0.7t/t) ,total 3.6t/t

DCL carbon footprint



CCS opportunity for coal chemical industry



- **CTL + EOR could be an winning combination for large scale CCS implementation and commercialization**
- **Large volume, low cost， pure CO_2 supply**
- **Provides income to offset the cost, and potentially profitable**
- **Use EOR to build infrastructure that could be utilized for other CCS projects, thus lower the entry hurdle**

CCS opportunity for coal chemical industry

CO_2 工业废气

煤化工驰放气
煤层气
油田气
水泥窑气
冶金烟气
…

➢ 组份调控
➢ 提浓净化

➢ CO_2甲烷重整与转化制备合成气（70%）
➢ CO_2加氢转化低成本合成甲醇（85%）

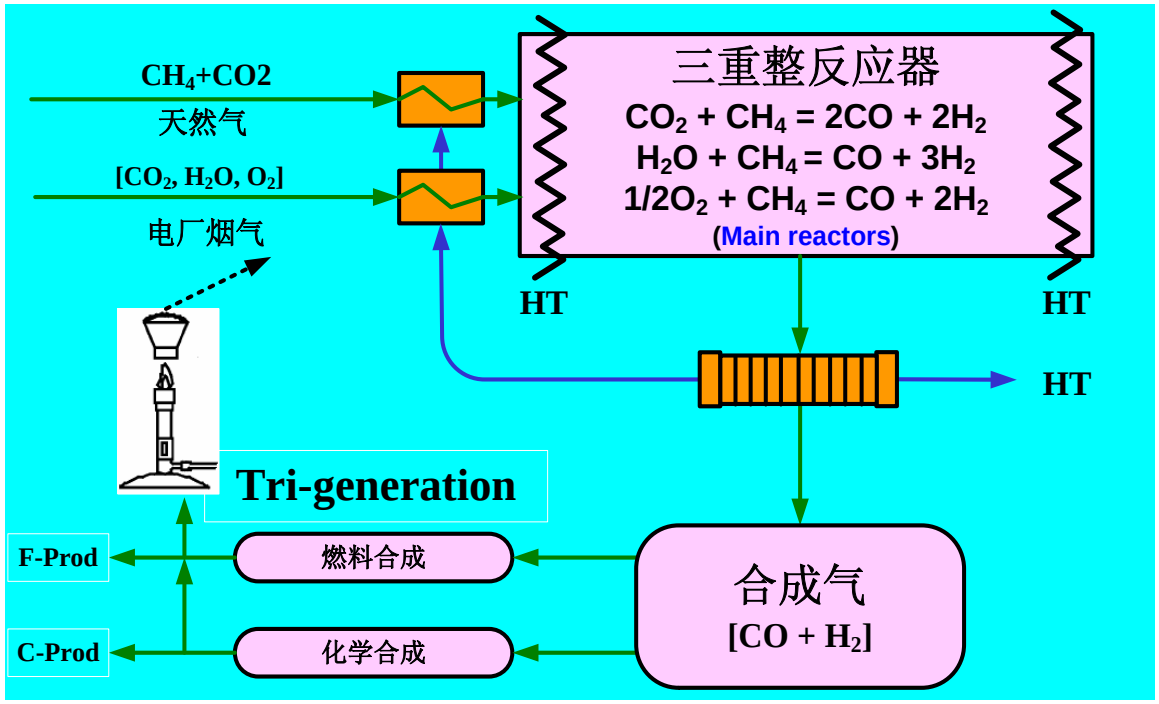
大规模制备能源燃料

➢ CO_2经碳酸酯清洁制备异氰酸酯（30%）
碳酸二甲酯 →异氰酸酯
➢ CO_2基聚氨酯的高效低成本合成（40%）
可降解聚碳酸酯多元醇→CO_2基聚氨酯
➢ CO_2经碳酸酯制备聚碳酸酯（30%）
碳酸乙烯酯 →碳酸二苯酯→聚碳酸酯

规模化制备高值化学品

- CO_2工业废气制备化学品（CTP）是煤化工过程CO_2 减排的技术重要方向
- 煤化工过程CO_2废气浓度高，现有分离提纯技术成本可以接受
- 据预测，CO_2 化工利用量可以达到年1亿吨

CCS opportunity for coal chemical industry

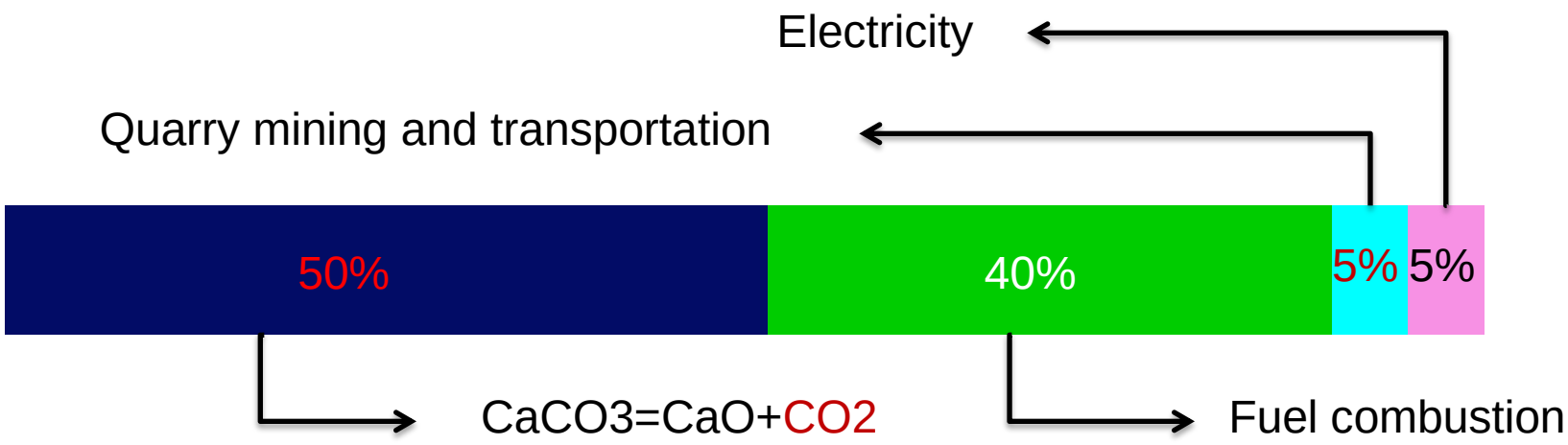


潞安集团在建重整示范平台

- CO_2与甲烷三重整（Tri-reforming）技术可以实现煤化工过程高浓CO2气体与煤层气原位制备合成气，可以实现CO_2大规模捕获利用

CCS in Cement industry

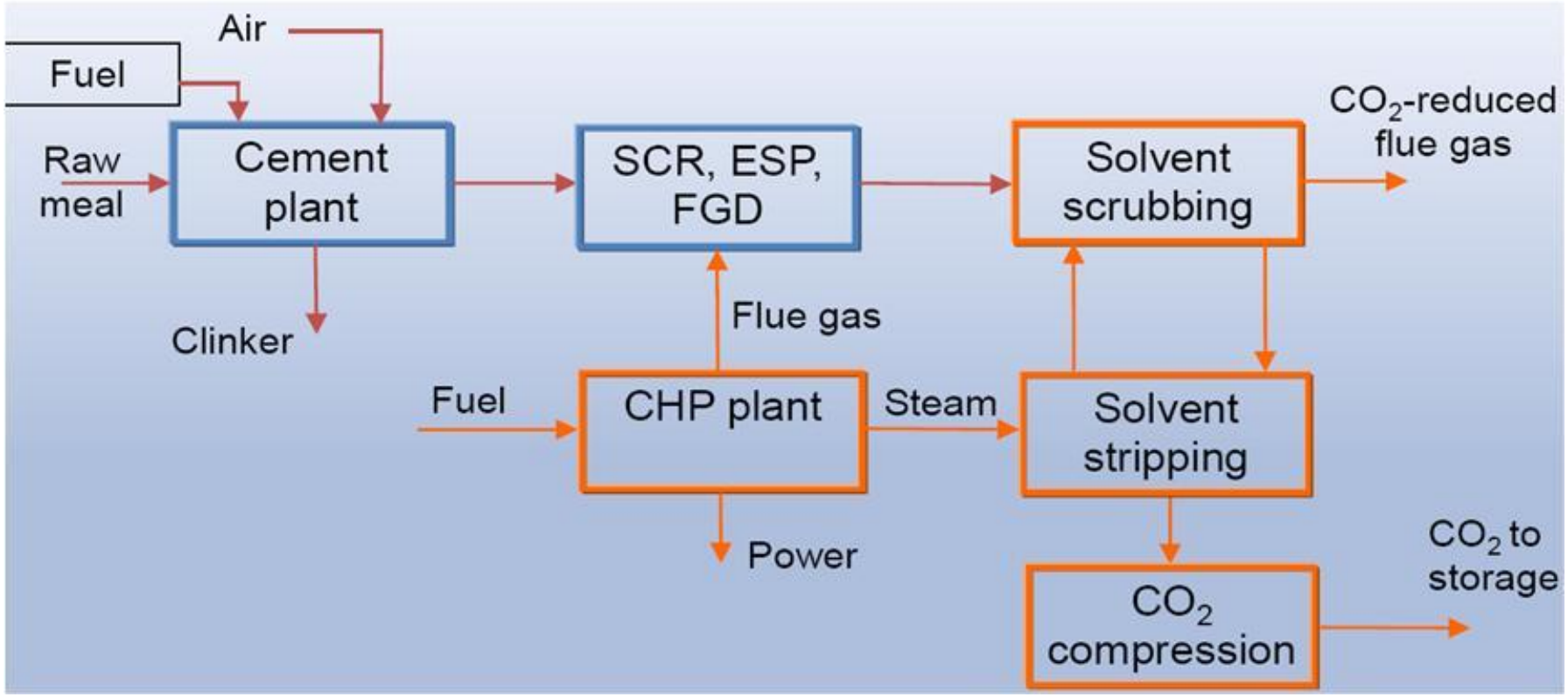
CO_2 emission in cement production process



China:0.89 t CO_2/t cement

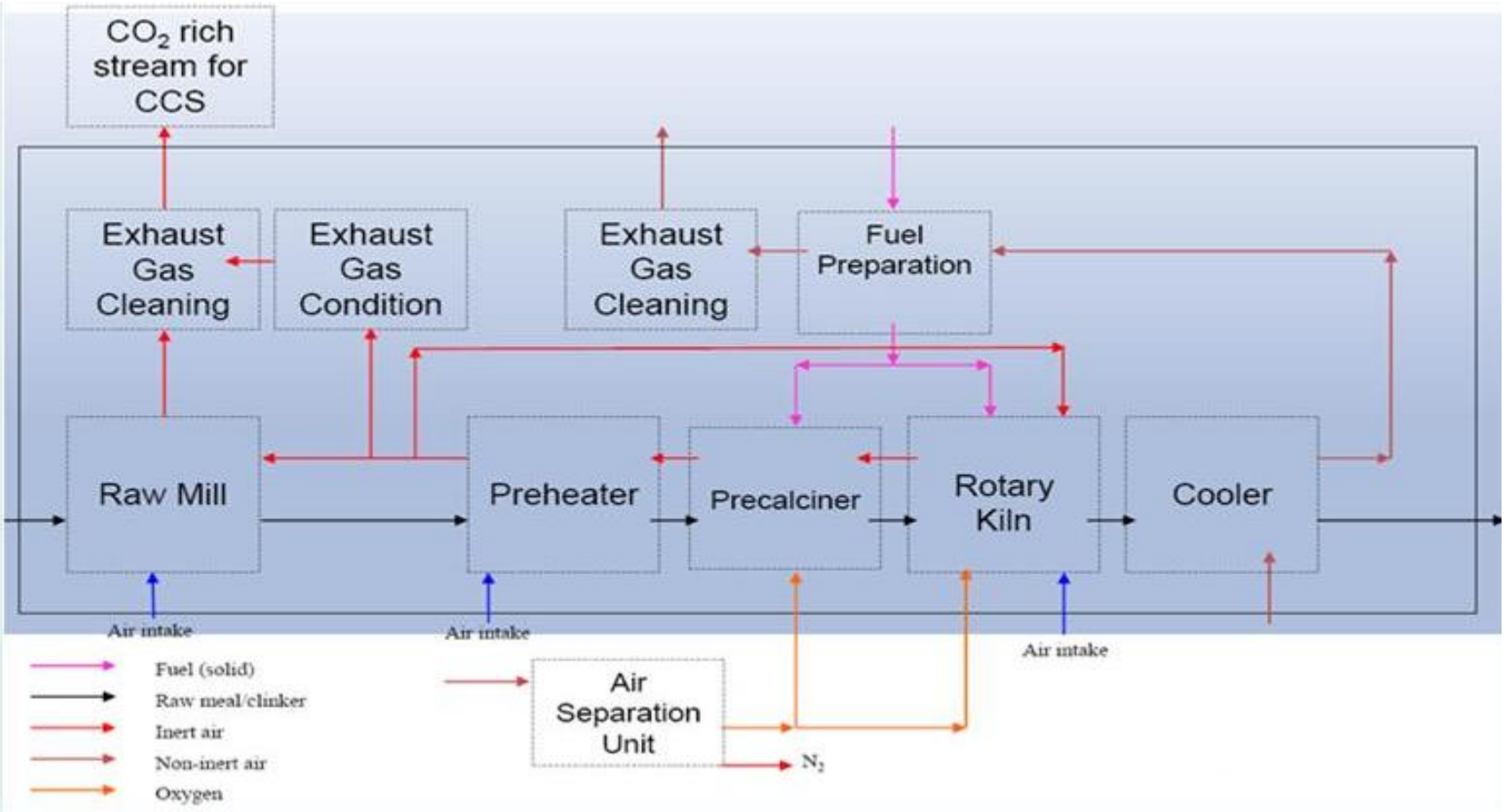
- **Half of CO_2 emission comes from $CaCO_3$ calcination, which can not be avoided.**
- **The potential for CO_2 reduction lies in fuel combustion processes, which has an upper limit to 40% as shown in the figure.**

Post-combustion cement plant



- **Cement exhausted gas CO_2 concentration: 14-33% (W/W)**

Oxyfuel cement plant (full capture)



- **Oxy-fuel combustion technology is the most promising CCS enabling technology in cement industry**

CAS carbon budget project (2011~2015)

- Construction of "carbon oxidation factor" system suitable for China
- Establishment of CO_2 emission data base across China in terms of different energy type, i.e. coal, oil and gas
- Establishment of dynamic prediction method to analysis CO_2 emission trend

Industry Classifiction

Power	Petroleum refining	Natural gas
Iron&steel	Oil terminal using	Coal seam gas
Non-Ferrous Metal industry	Bulk chemicals	Coke oven gas
Building material	Fine chemicals	LNG
Traditionlal coal chemical industry	Cement	
New coal chemical industry		
Civil coal		

Summary

- **The overall CO_2 emission from non-power industries, such as Iron & steel, coal chemical and cement, accounts for about 40% of the total CO_2 emission in China, which should be given enough concern.**
- **Implementation of CCUS in non-power industries is more complex compared to power industry.**
- **The current energy saving technologies in steel industry, such as CDQ and TRT, are limited to reduce CO_2 emission, hence, breakthrough technologies are urgent to greatly reduce CO_2 emission.**
- **New coal chemical technology provides important way of coal utilization in China, however, it also brings huge amount of CO_2 emission. On the other hand, coal chemical process provides high concentration of CO_2 and facilitate the implementation of CCS porject.**
- **It is important to develop the CCUS technology to reduce CO_2 emission in non-power industry.**

THANK YOU FOR YOUR ATTENTSION