Energy and Emission in Ammonia Sector

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Background

- **Basic chemical product**
  - Important input and raw material:
    - For fertilizer use: 70%
    - For industry use: 30%
  - Largest in yield and energy consumption in chemical industry

- **Enjoy policy support and develop very fast**

  Increase from 1000 ton to 38,000,000 ton in about 50 years, and rank 1st in yield in the world

- **Decentralized location but main capacities are in agricultural provinces or resource-rich provinces**

Background

- **Different technologies coexist:**
  - Introduced and domestically developed
  - Very advanced and backwards
  - Feedstock: coal, coke, gas, oil
  - Coal-based technology accounts for main production

- **Different plant scales coexist**
  - Large, medium and small scale
  - Small-scale enterprises take leading role in number and yield (56%)
  - Trend of expansion of equipment size

Current problems

- Small scale, low technology level, high energy consumption
- Domestic factors: energy price fluctuation, natural gas supply, environment pollution, backward management
- International factors: Low international competition over foreign enterprises (especially after WTO)

Technology categories and levels

- Feedstock type: coal-, oil- & gas-based
- Introduced and domestic developed
- Size: large, medium and small
- Traditional and advanced
  - Pressure gasification of Coal-water slurry
  - Pulverized (fine) coal gasification

Energy consumption

- Different with other countries, coal plays a leading role for ammonia production, accounting for 62% of total in yield

Feedstock	Share in total ammonia output
Coal	56%
Coke	5.8%
Oil (heavy, lignite, light)	17.8%
Gas (NG, refinery gas, coke gas)	21.4%

- Energy consumption rate varies between different plants and processes and far behind the international advanced level.

Tech.	Energy consumption rate (kgce/ton NH_3)		Energy use efficiency
	1990	*2003*	
Introduced	1376	1346	56%[1)]
Medium-size	2176	1946	37.8%
Small-size	2263	1782	39%
Average		1700	42%
Target (11th five-year period)			46% [2)]

1): International advanced level: 70%

2): In year 2010

Sectoral planning

- Central task:
  - Improvement of quality and economy benefit
  - Increase of market competition
- Program:
  - Technology innovation (clean coal technology) and energy-saving reformation
  - Modification of product and feedstock structure
  - Enhancement of environmental treatment

Sectoral planning

- Main countermeasures:
  - For large-size: adopting energy-saving technologies, increasing conversion rate, enhancing the heat recovery
  - For small- and medium-size: adopting energy-saving equipment, enhancing energy saving
  - For gas-based: new heat recovery tech., modification of steam system
  - For oil-based: change to gas or clean coal
  - For coal-based: new clean-coal technologies to substitute the traditional ones

Pollutant emission

- Waste water: large amount and difficult to treat, still main problems for sector
- Solid waste and waste catalysts: still problems to be resolved
- SO_2 emission: has been improved and major plants have reached the national standard
- CO_2 emission: mainly from traditional coal-based processes

Develop trend

- The fertilizer demand and ammonia production will increase gradually but energy consumption will reduce

Prediction for ammonia output and energy consumption:

	2005	2010	2020
Ammonia output (10,000 ton)	3800	3900	4000
Energy consumption (10,000 tce)	6194	6123	5820

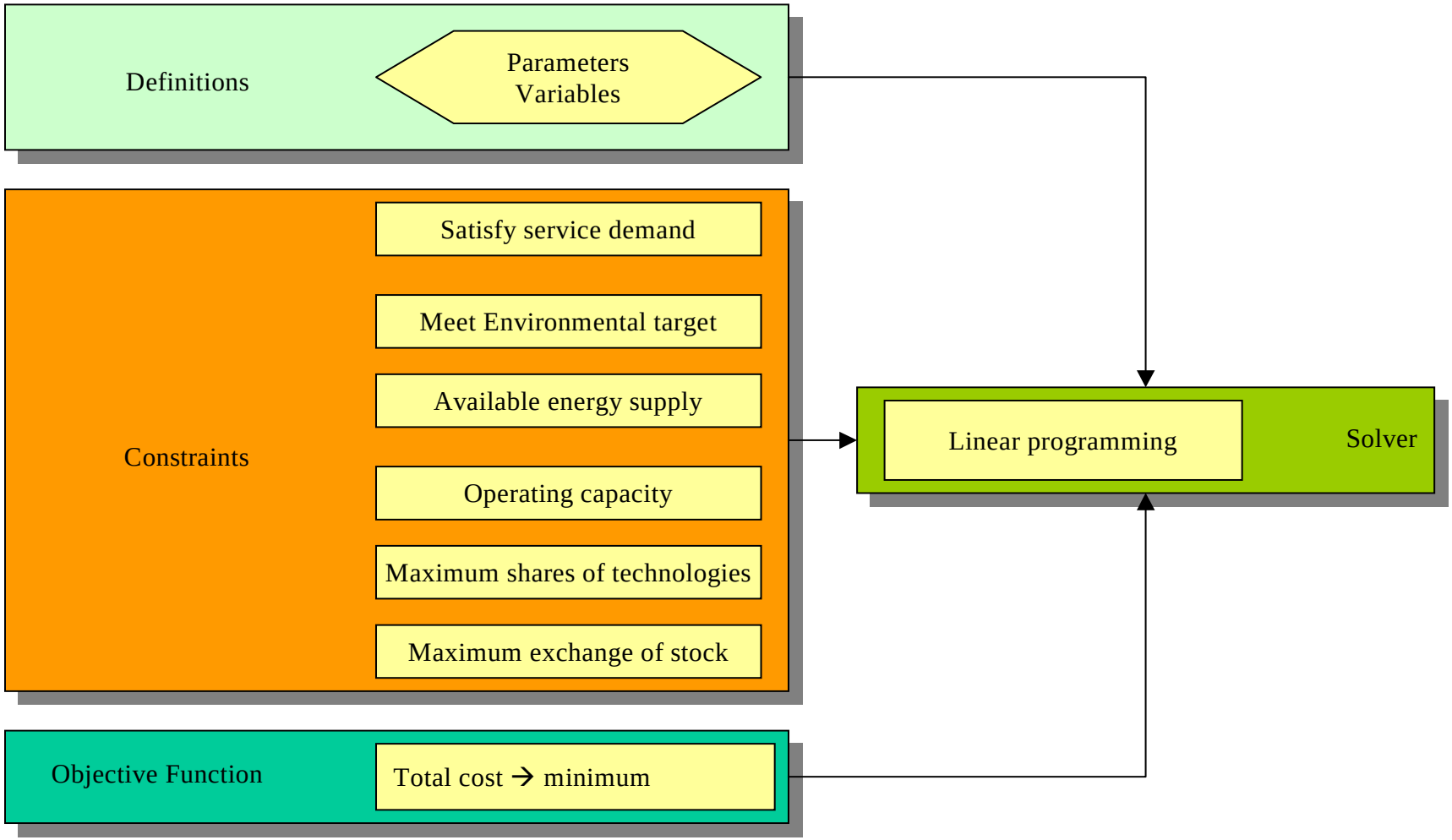
Develop trend

- The feedstock mixture: gas share will increase while oil share will drop sharply and coal share will drop gradually

Prediction for feedstock structure:

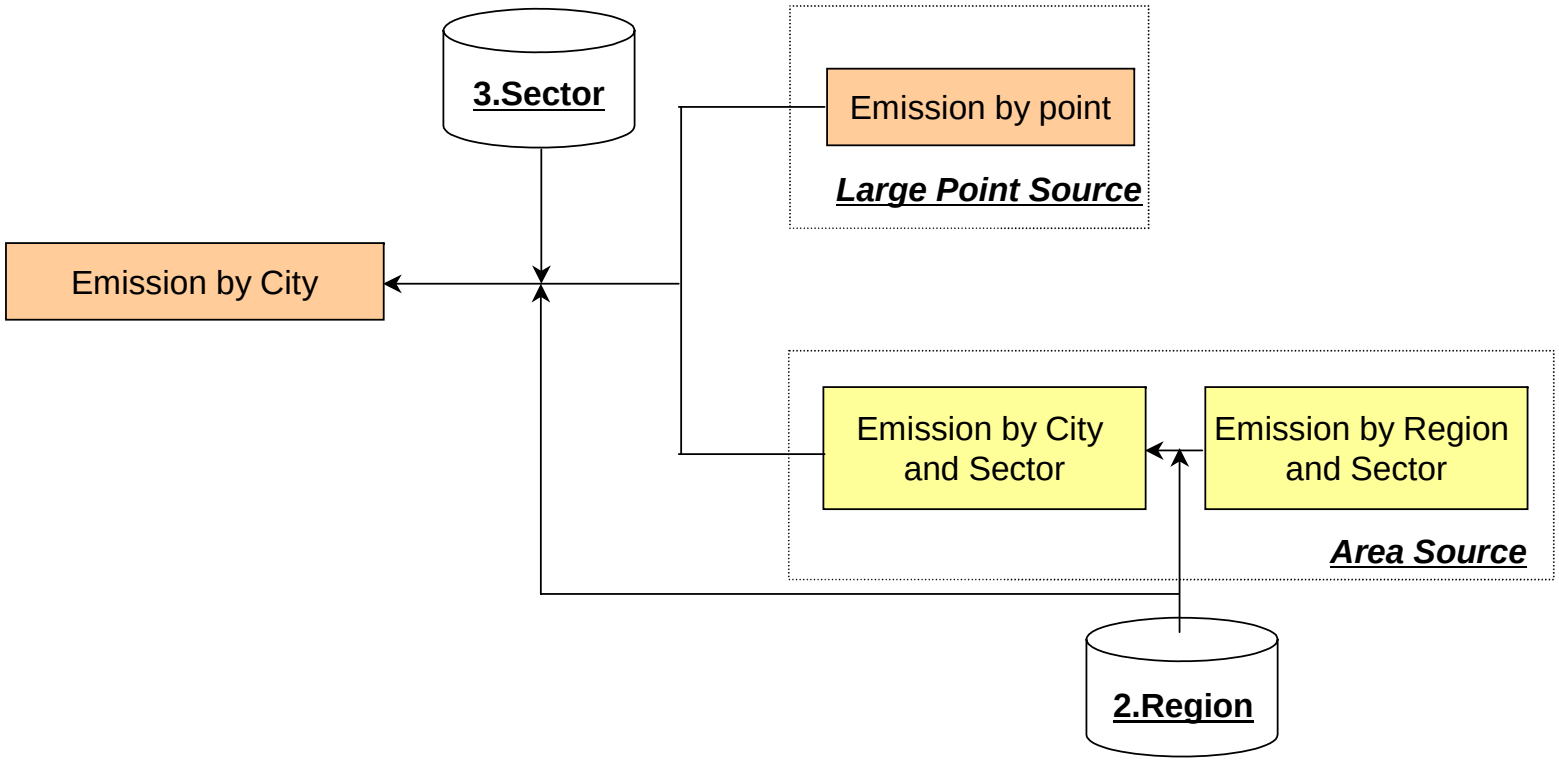
Stock	2005	2010	2020
Natural gas	25.53	28.21	36.50
Oil	6.58	5.13	3.50
Coal	67.90	66.66	60.00

Model description: AIM-LOCAL

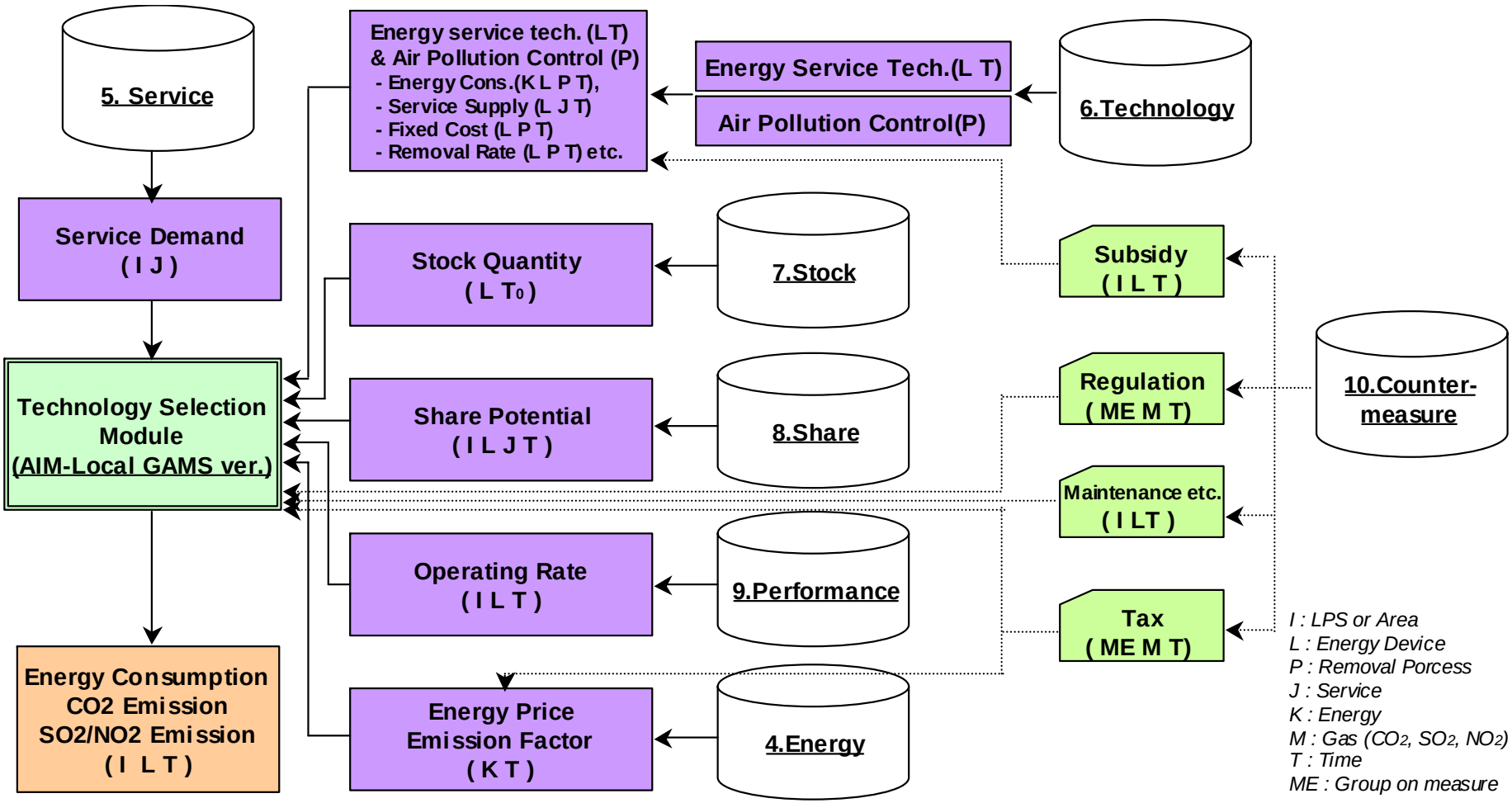


Schematic flowchart of the program

Model description: AIM-LOCAL



Large point source and area source of AIM-Local database system



Structure of AIM-Local database system

Input to the model

- Energy:
  - fuel type
  - fuel price
  - emission factors by fuel and technology
  - energy resource constraints
- Technology:
  - initial cost
  - management cost
  - unit energy consumption by fuels
  - life span
  - capacity share
  - pollutant removal technologies
- Service demand by regions and sectors:
  - historical service data
  - economic development plants from the local government
  - development plant from the local industries
- Air pollution constraints:
  - current air pollutant emissions
  - local environmental protection policies

Output of the model

- Aggregated results:
  - Total energy consumption by years
  - Total costs by years
  - Total CO_2 emissions by years
  - Total air pollutant emissions by years
- Technology options :
  - CO_2 emissions by technologies and years
  - Air pollutant emissions by technologies and years
  - Energy consumption by technologies and years
- Service output :
  - Service output by regions, sectors, technologies and years
- Energy balance table :
  - Energy balance table for the local region by years (with energy information for sectors, technologies and fuel types)

Input data

- Total Service demand of ammonia
  - 2010: 38.71 Mton
  - 2020: 40.00 Mton
  - 2030: 40.91 Mton
- 25 Large Point sources (LPS): large-sized introduced ammonia facilities with unit capacity larger than 300,000 ton
- 31 area sources (AS): divided in province

Input data for this analysis

- Technology data:
  - 8 categories (including potential ones)
  - No removal technology considered
  - Technology parameter maintain unchanged

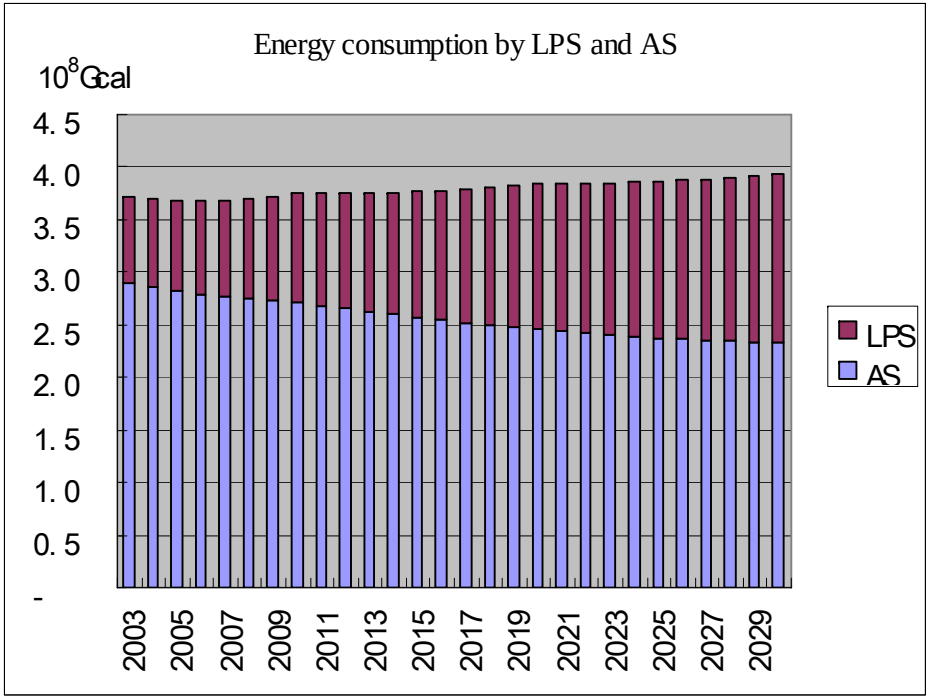
No.	Code	Description
1	LG	Large-size natural gas fueled technology
2	LO	Large-size oil fueled technology
3	LC	Large-size coal fueled technology
4	MG	Medium-size gas fueled technology
5	MO	Medium-size oil fueled technology
6	FLC	Technology of Pressure gasification of Coal-water slurry
7	FGC	Pulverized (fine) coal gasification technology
8	FBC	Fixed-bed coal gasification technology

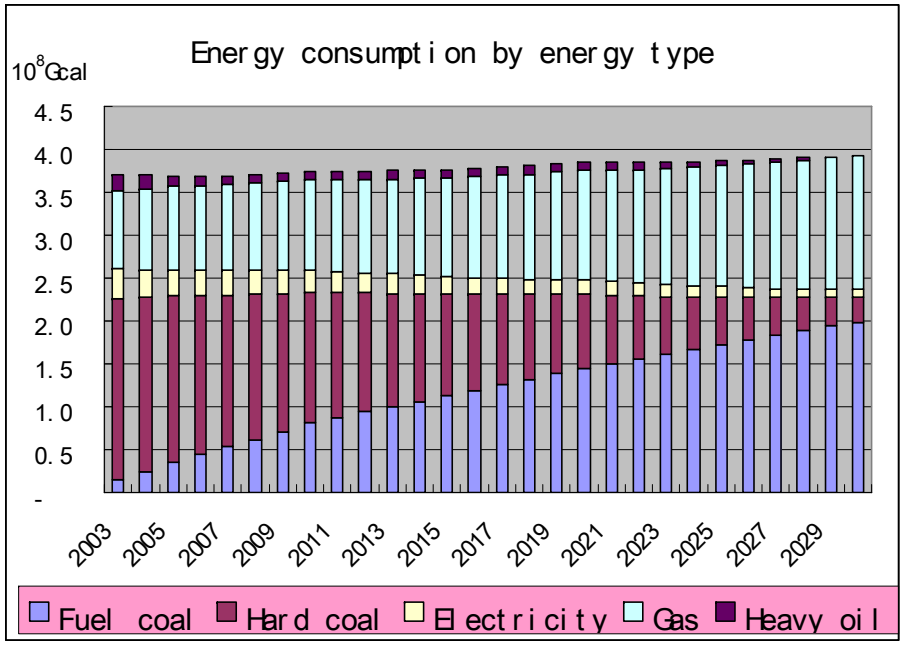
Input data for this analysis

- Energy data:
  - Four type: Hard coal, fuel coal, fuel oil, natural gas
  - Based on 2003 energy price
  - Emission factors are given through expert estimation and sectoral surveys
  - Some part of energy is used as material (feedstock) and emit no pollutants
- Scenarios:
  - BAU: no tax and subsidy
  - C2: carbon tax: 2 Yuan/kg CO_2

Modeling result - BAU scenario

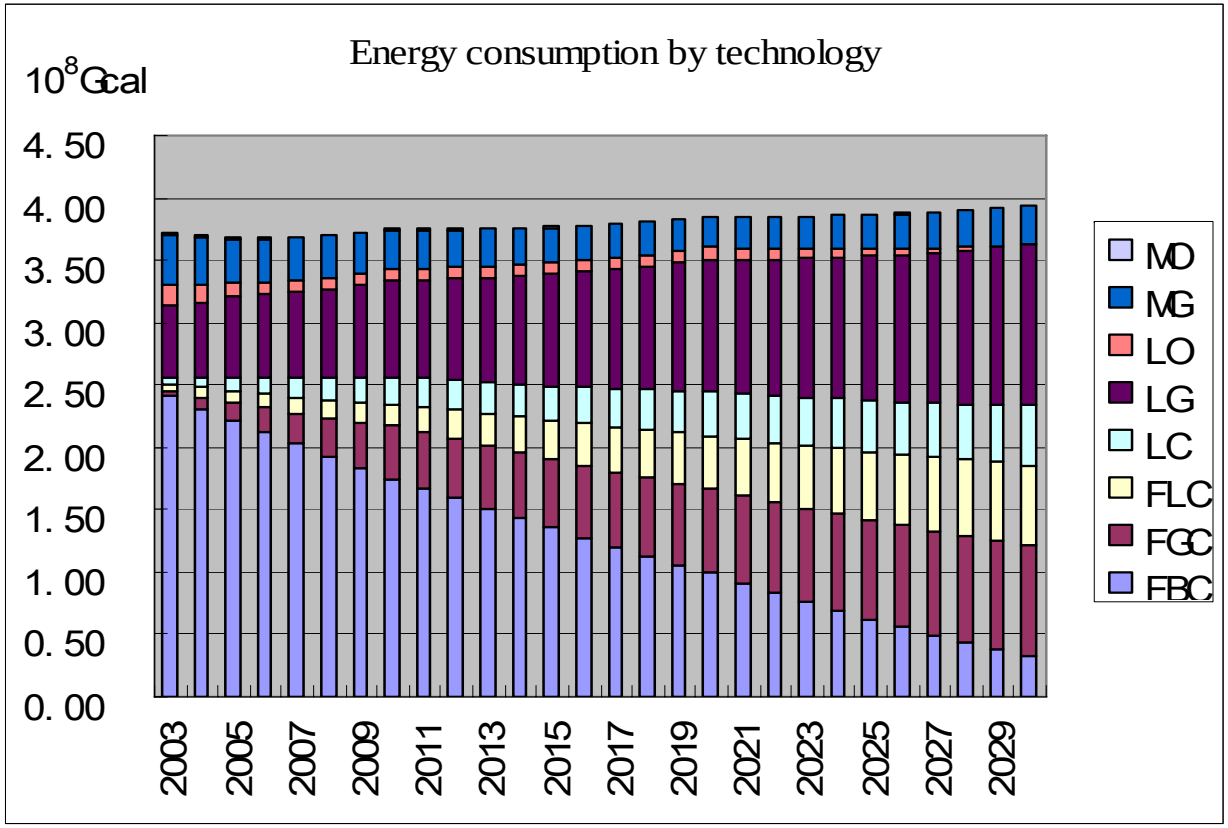
- Energy consumption
  - By LPS and AS (upper right)
  - By energy (lower left)





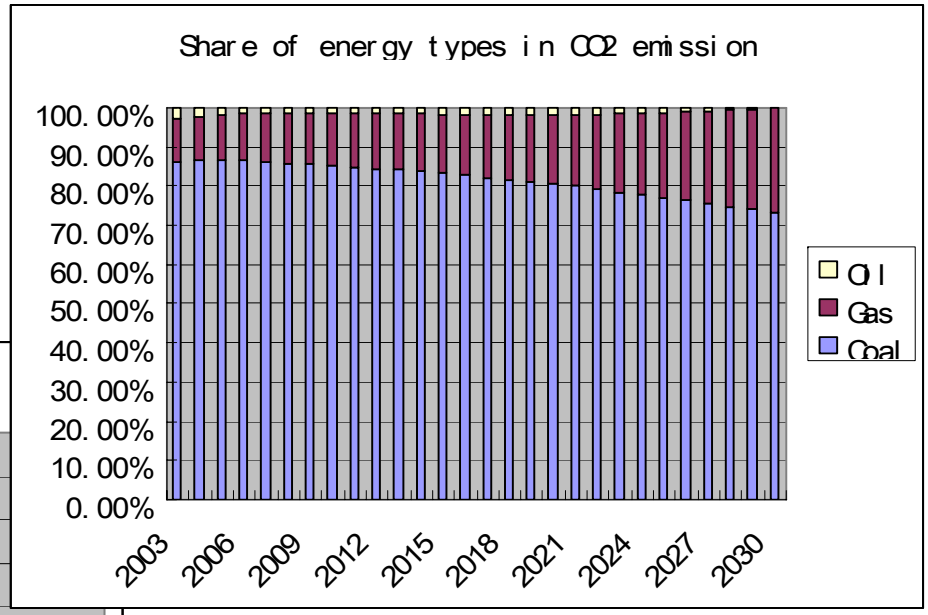
Modeling result - BAU scenario

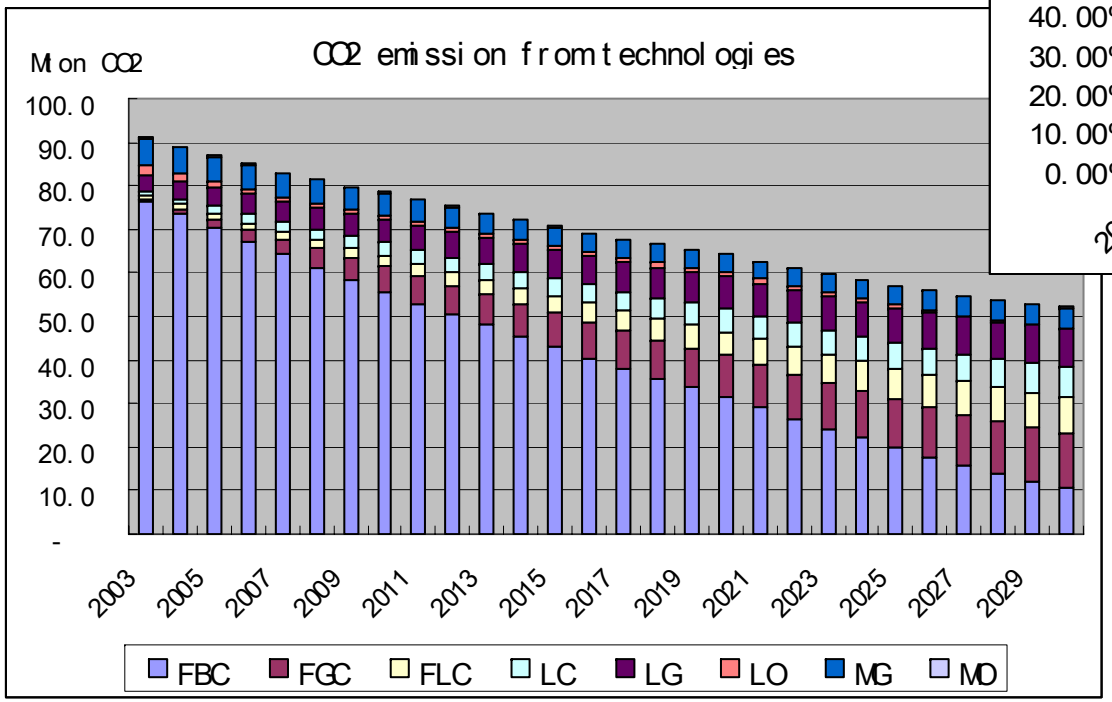
- Energy consumption by technology



Modeling result - BAU scenario

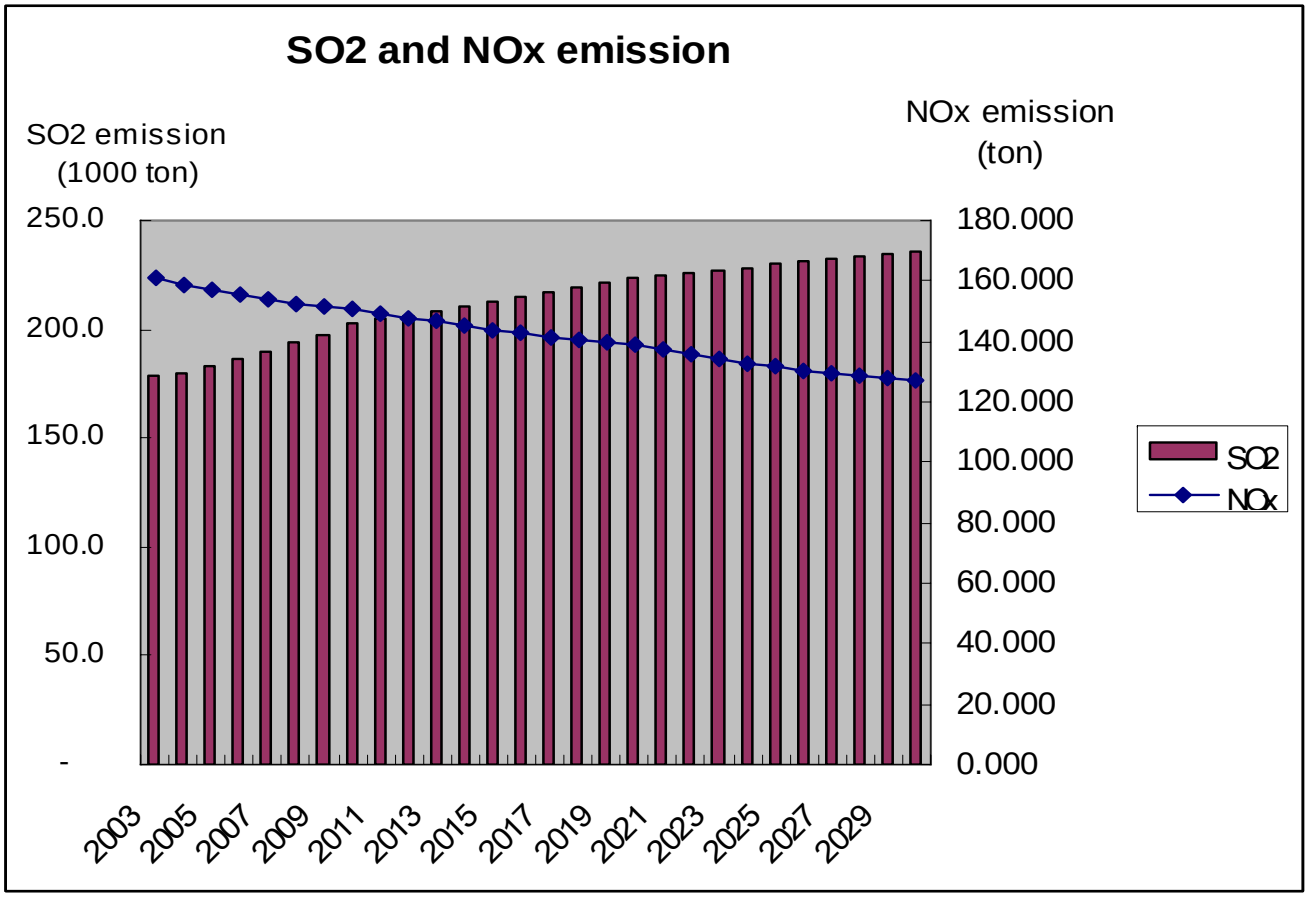
- CO_2 Emissions
  - By energy (upper right)
  - By technology (lower left)





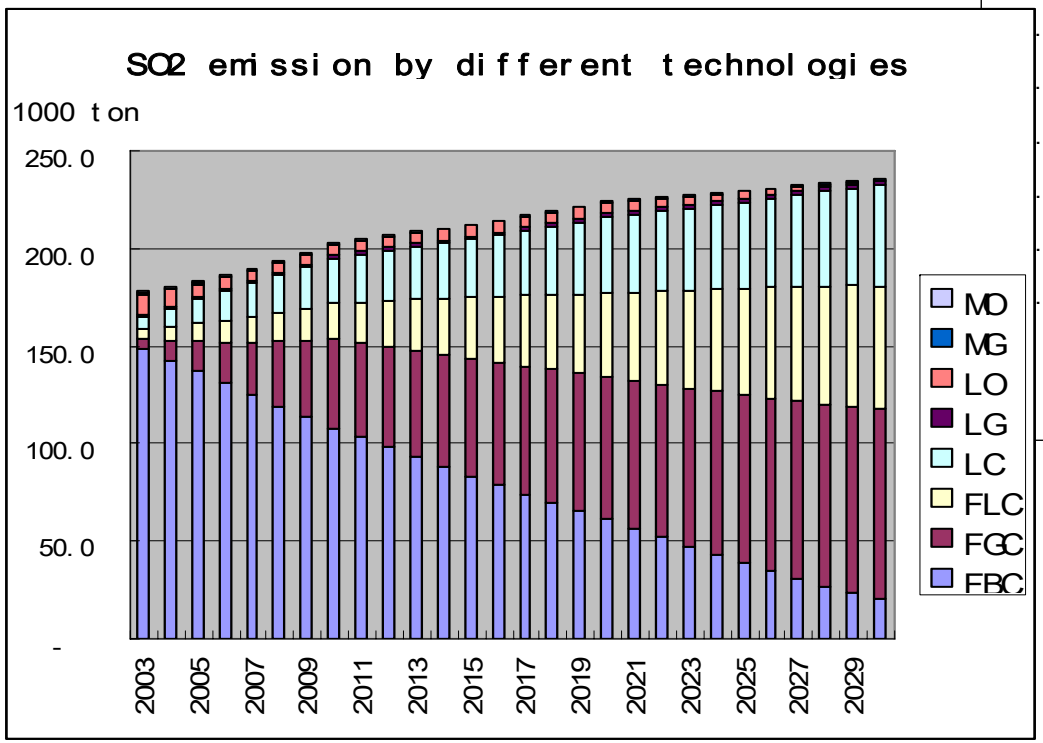
Modeling result - BAU scenario

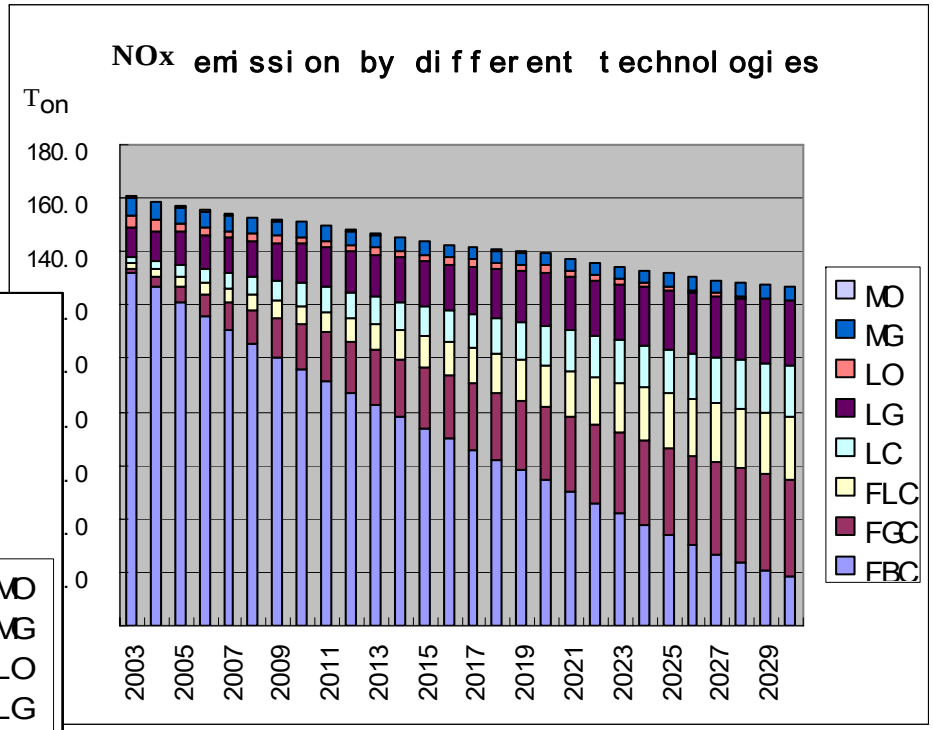
- SO_2 and NO_x emission



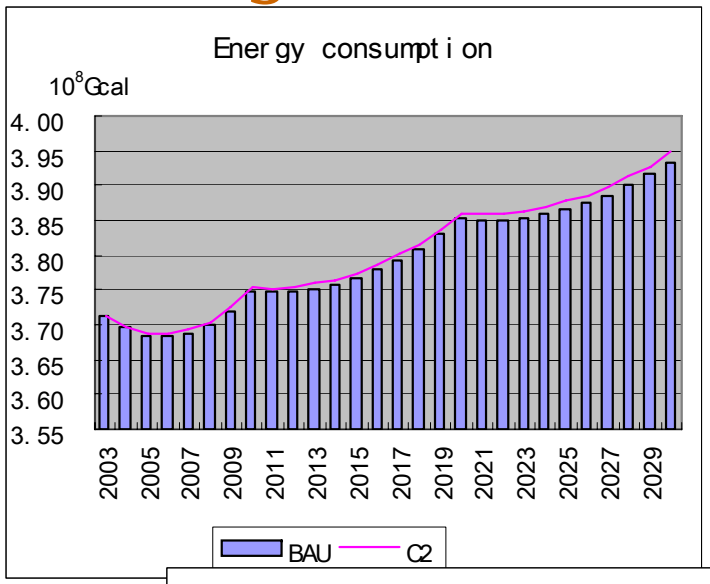
Modeling result - BAU scenario

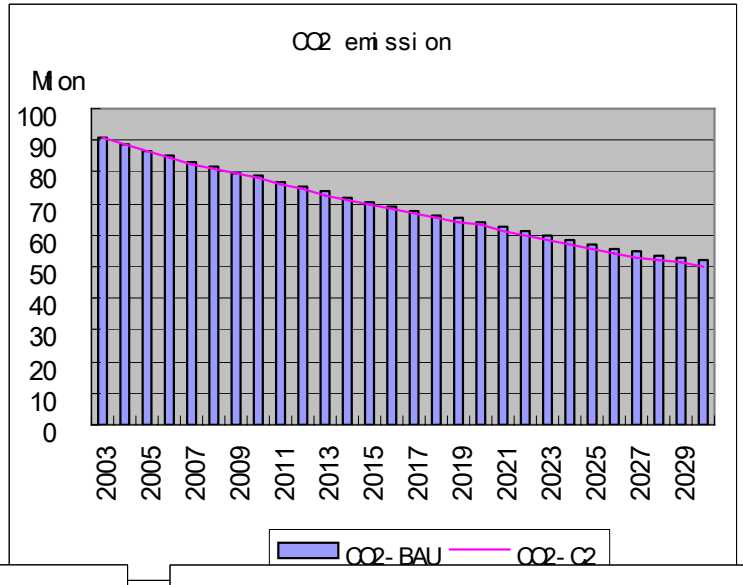
- SO_2 and NO_x emission by technology

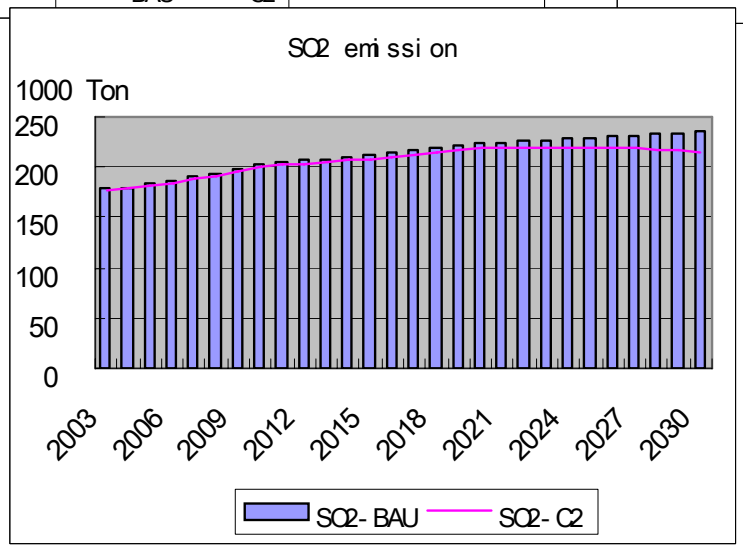


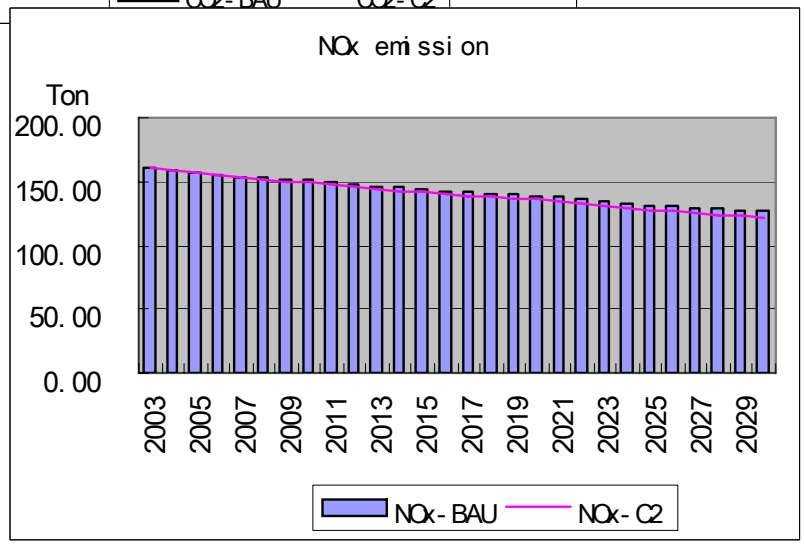


Modeling Result – C2 scenario



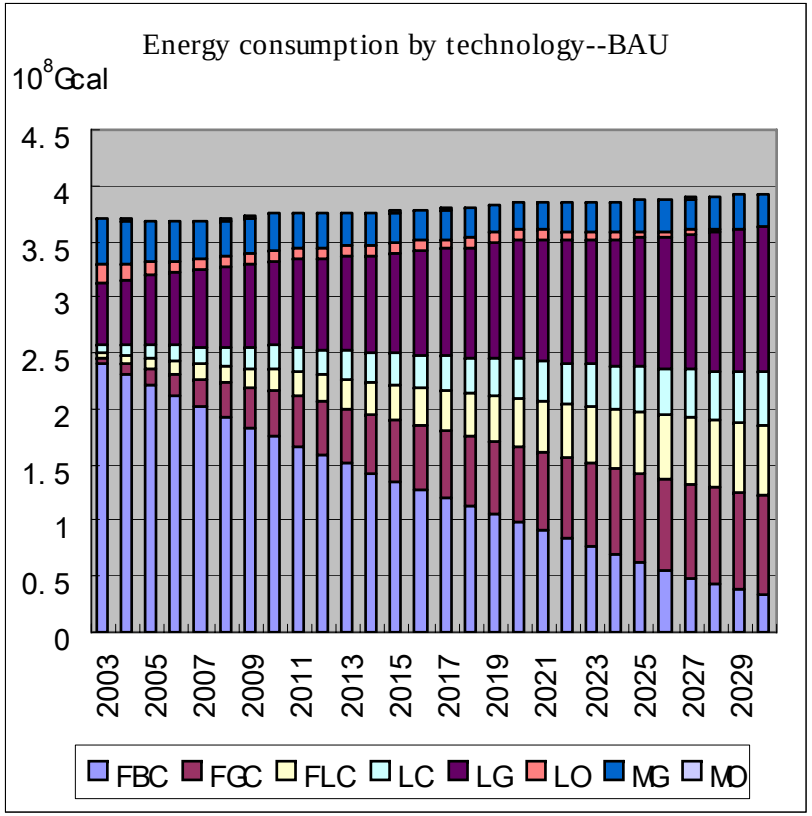


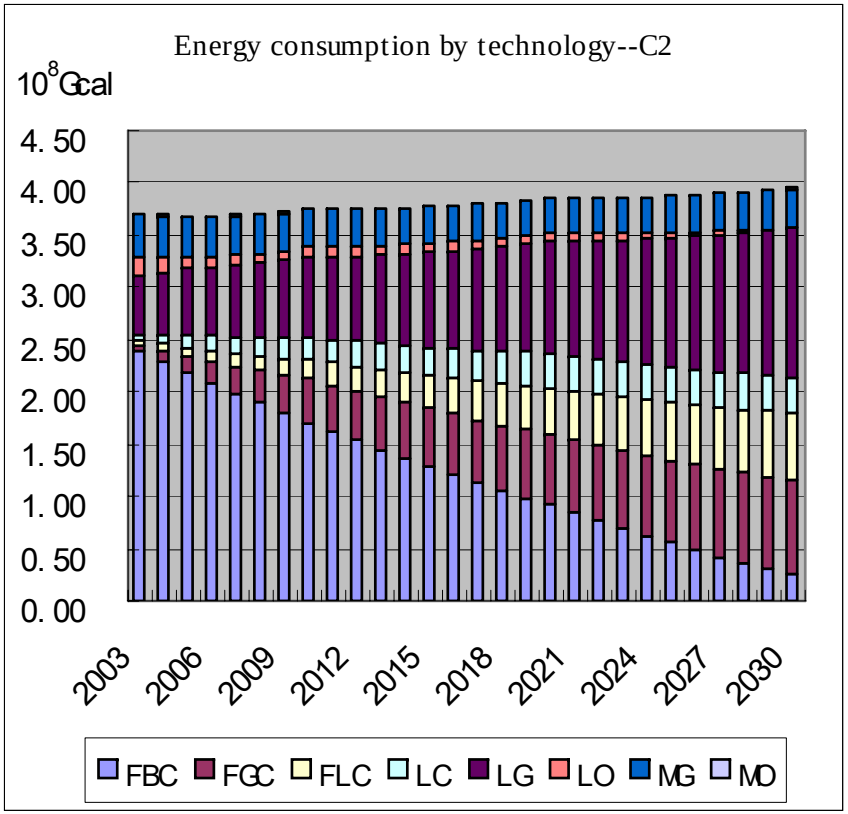




Modeling result – C2 scenario

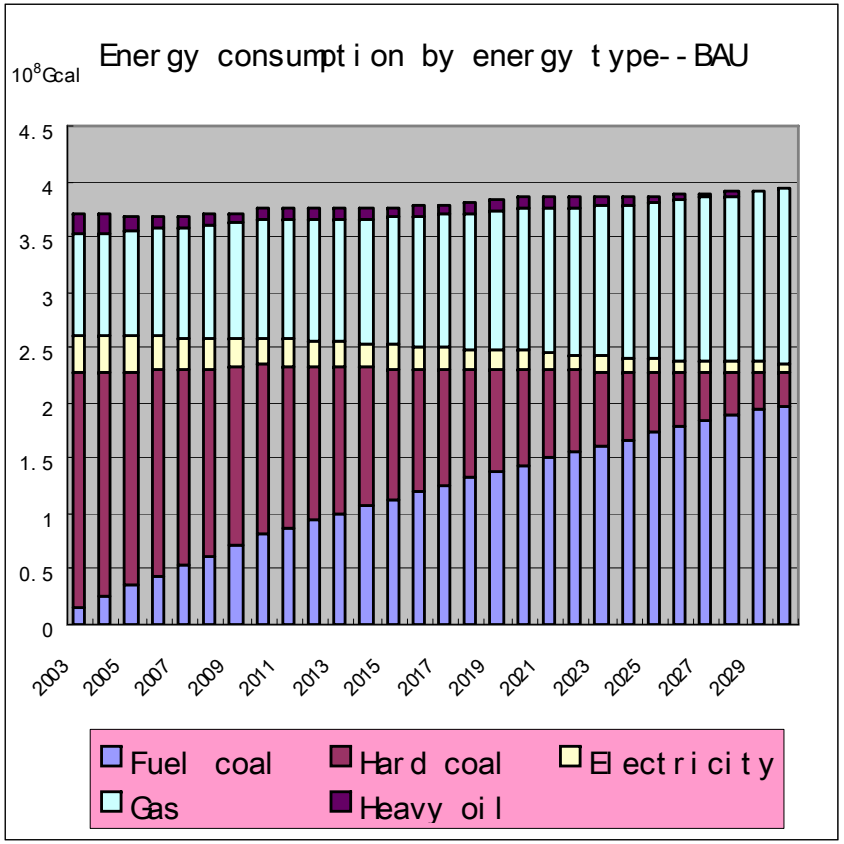
- Energy consumption by technology (BAU result for reference)

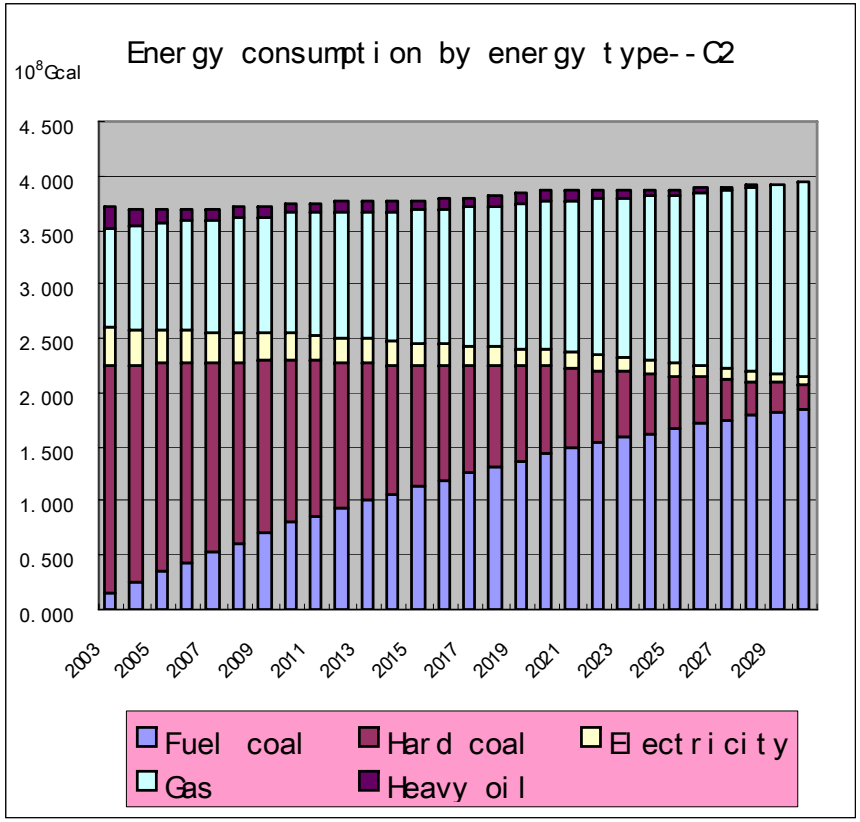




Modeling result – C2 scenario

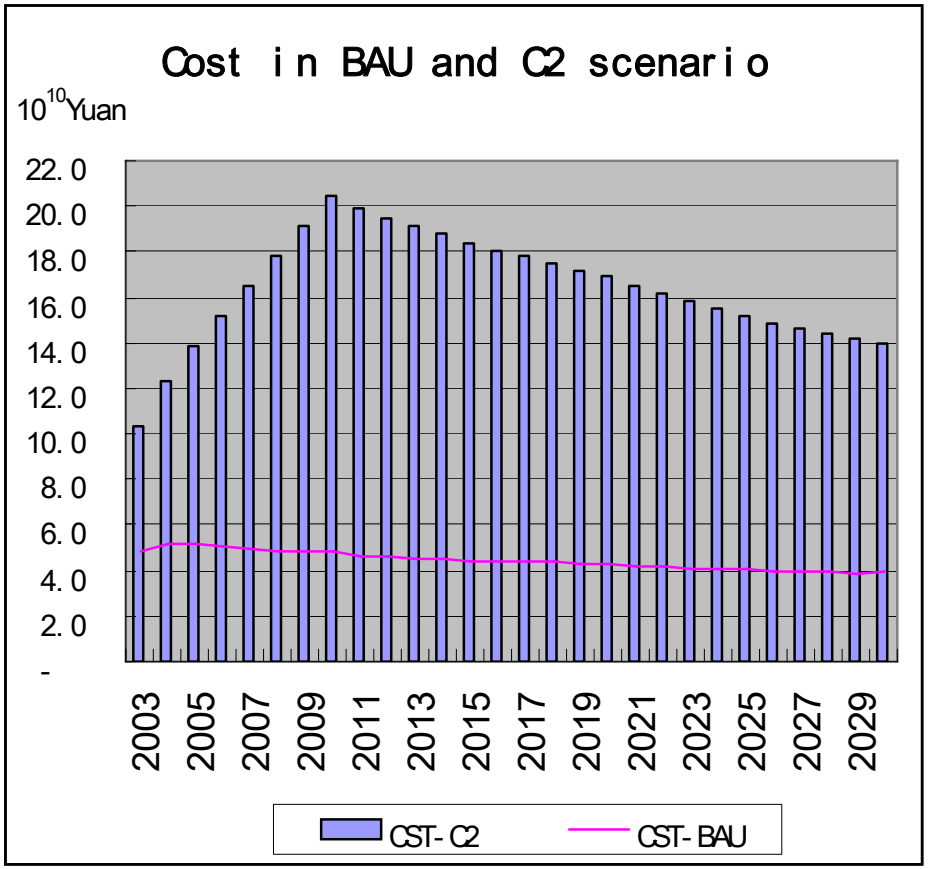
- Energy consumption by type (BAU result for reference)





Modeling result – C2 scenario

- Total cost in C2 scenario (BAU result for reference)



Primary conclusion and discussion

- The total energy consumption in ammonia industry will grow slowly, with coal accounting for main part, gas gaining a large increase in share, and oil being gradually excluded from the sector.

- Even in BAU scenario, the technology structure of ammonia industry will be optimized, which can be reflected in two aspects:
  - most of traditional coal fired technologies will be removed and replaced by clean coal technologies and gas-fueled technologies.
  - More plants with larger device scale will be selected

Primary conclusion and discussion

- CO_2 emission will decrease apparently during the whole prediction period, and coal will be a main contributor for it.
- SO_2 emission will increase slightly, owing to the increase use of fuel coal by clean coal technologies
- NO_x emission amount will be relatively small and decrease gradually.

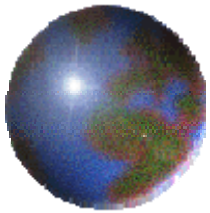
Primary conclusion and discussion

- When carbon tax of 2 Yuan/kg CO_2 is levied on system, little change will occur on energy consumption and pollutant emission. Only the share of gas in energy use will increase compared with that in BAU scenario.

- The ammonia industry has established the industry planning to promote the adoption of gas technology and clean coal technology and eliminate the oil technology. In this case, the levy of carbon tax will have very limited impact on optimizing the technology structure and promoting the energy efficiency further, but only induce large extra cost to industry.

Further work

- Energy price change
- Technology improvement
- Including remove technologies
- Different discounting rate
- Effect of subsidy
- More scenario



Thank you!

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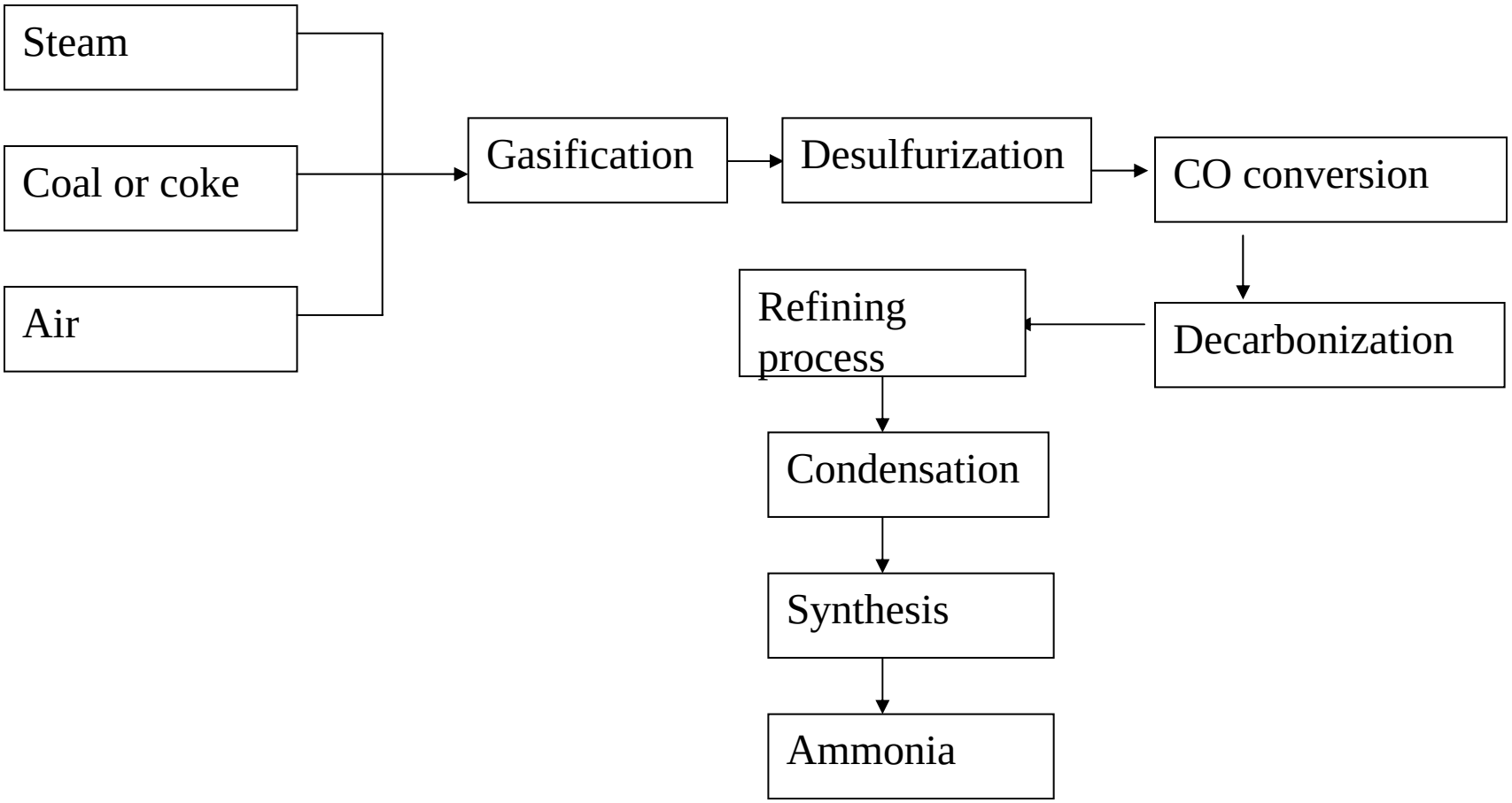
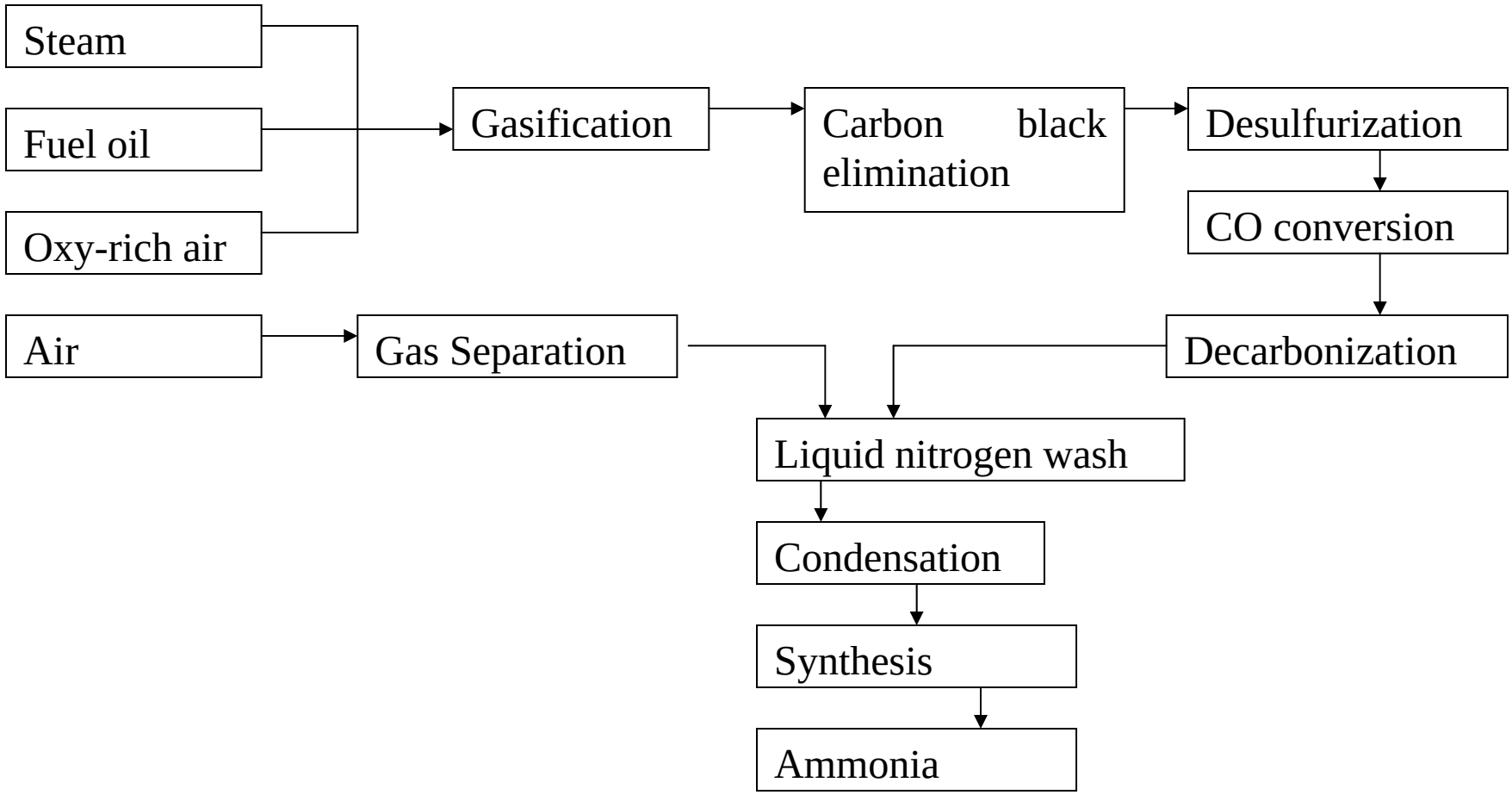
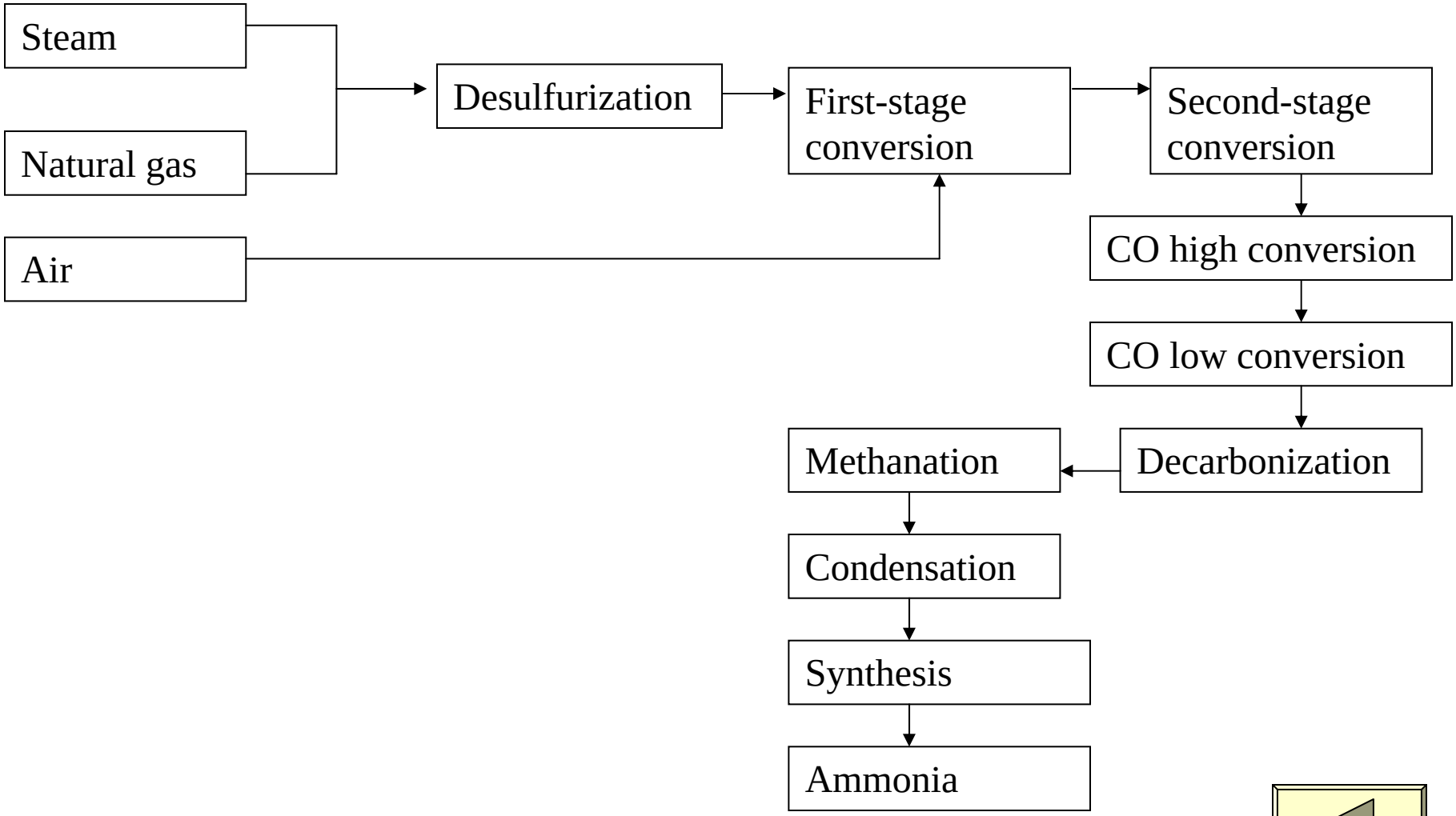
Annex



Coal based ammonia process



Oil based ammonia process



Gas based ammonia process

- Introduced large-size:
  - Mainly gas-based but still lower technology level than foreign ones
  - Kellogg, Kellogg-TEC, Topsoe, AMW, Braun, KBR, Texaco traditional, etc.
- Medium-size:
  - All domestically developed and mainly constructed in 1980s
  - Relatively high energy consumption rate, low load factor and high environmental pollution
- Small-size:
  - All domestically developed and use coal as feedstock
  - With very low capacity and high energy consumption

- Pressure gasification of coal-water slurry
  - 4 facilities installed in China
  - Technology has been localized in large part except key equipment components
- Pulverized (fine) coal gasification
  - No facilities installed in China
- Advantages:
  - A broad range of coal can be used as feedstock
  - High unit capacity and operation temperature
  - High heat efficiency and carbon conversion rate
  - Low emission of wastes