Lifecycle Environmental Evaluation of Exploitation & CO_2 Sequestration of Coal

by SAGISAKA M.

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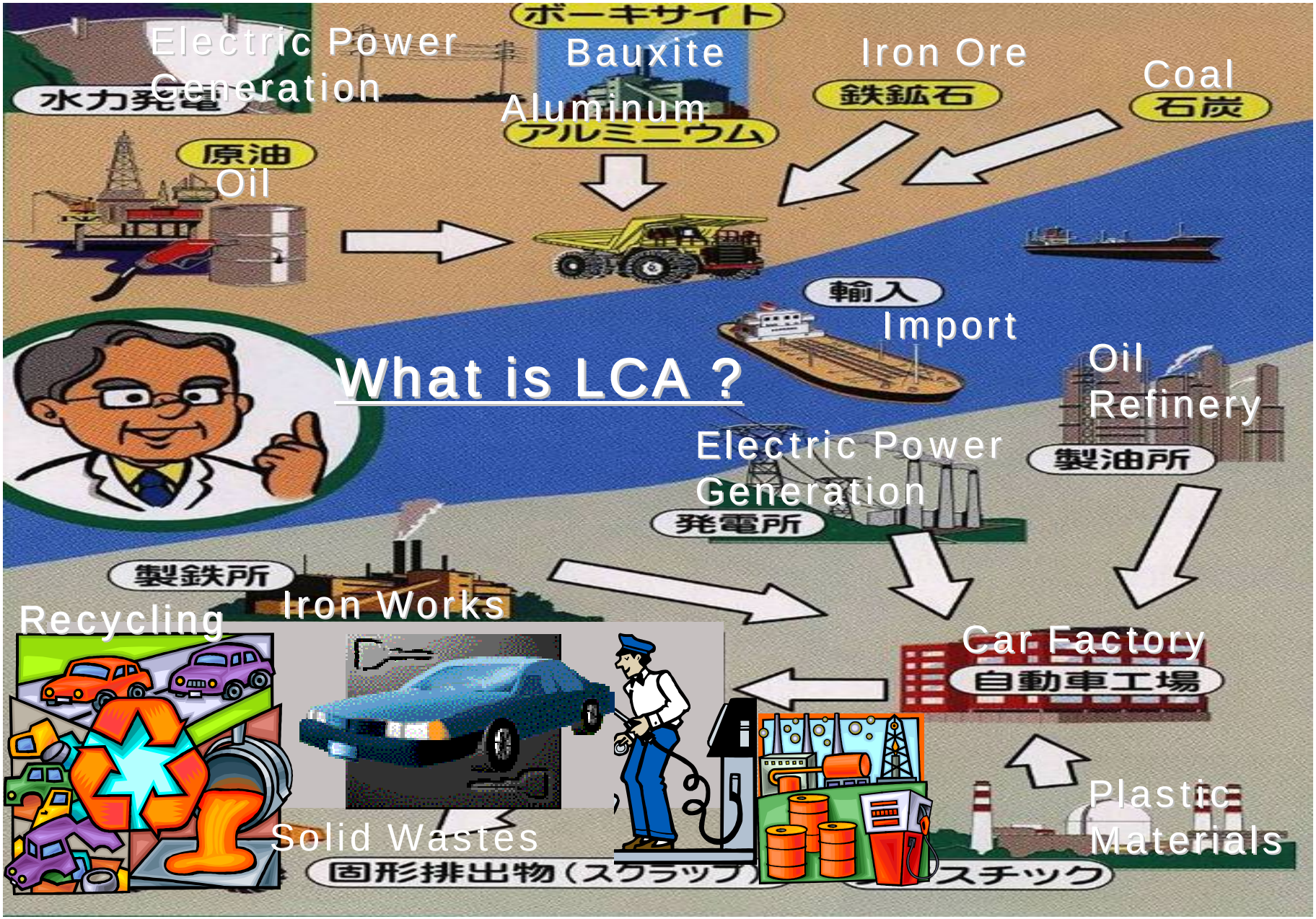
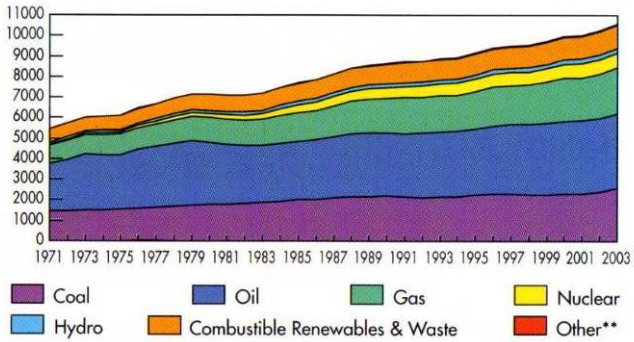

Electric Power Generation
水力発電
ボーキサイト
Bauxite
Aluminum
アルミニウム
Iron Ore
鉄鉱石
Coal
石炭
原油
Oil
輸入
Import
What is LCA ?
Oil Refinery
製油所
Electric Power Generation
発電所
製鉄所
Iron Works
Recycling
Car Factory
自動車工場
Solid Wastes
固形排出物（スクラップ）
プラスチック
Plastic Materials

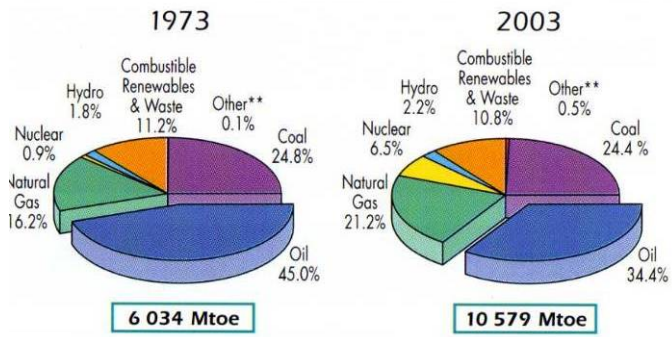
TOTAL PRIMARY ENERGY SUPPLY

The World

Evolution from 1971 to 2003 of World Total Primary Energy Supply* by Fuel (Mtoe)



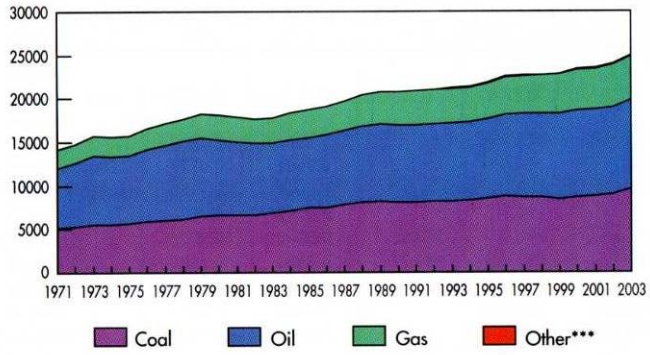
1973 and 2003 Fuel Shares of TPES*



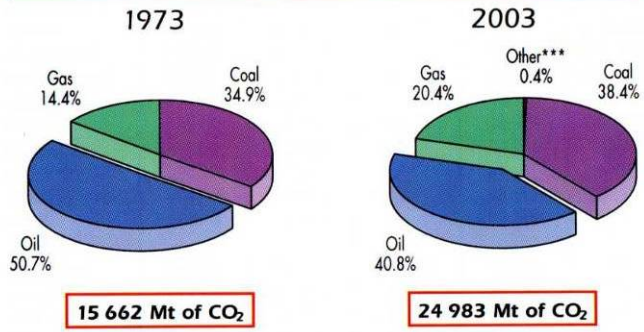
*Excludes international marine bunkers and electricity trade.
**Other includes geothermal, solar, wind, heat, etc.

CO_2 Emissions by Fuel

Evolution from 1971 to 2003 of World* CO_2 Emissions** by Fuel (Mt of CO_2)



1973 and 2003 Fuel Shares of CO_2 Emissions**



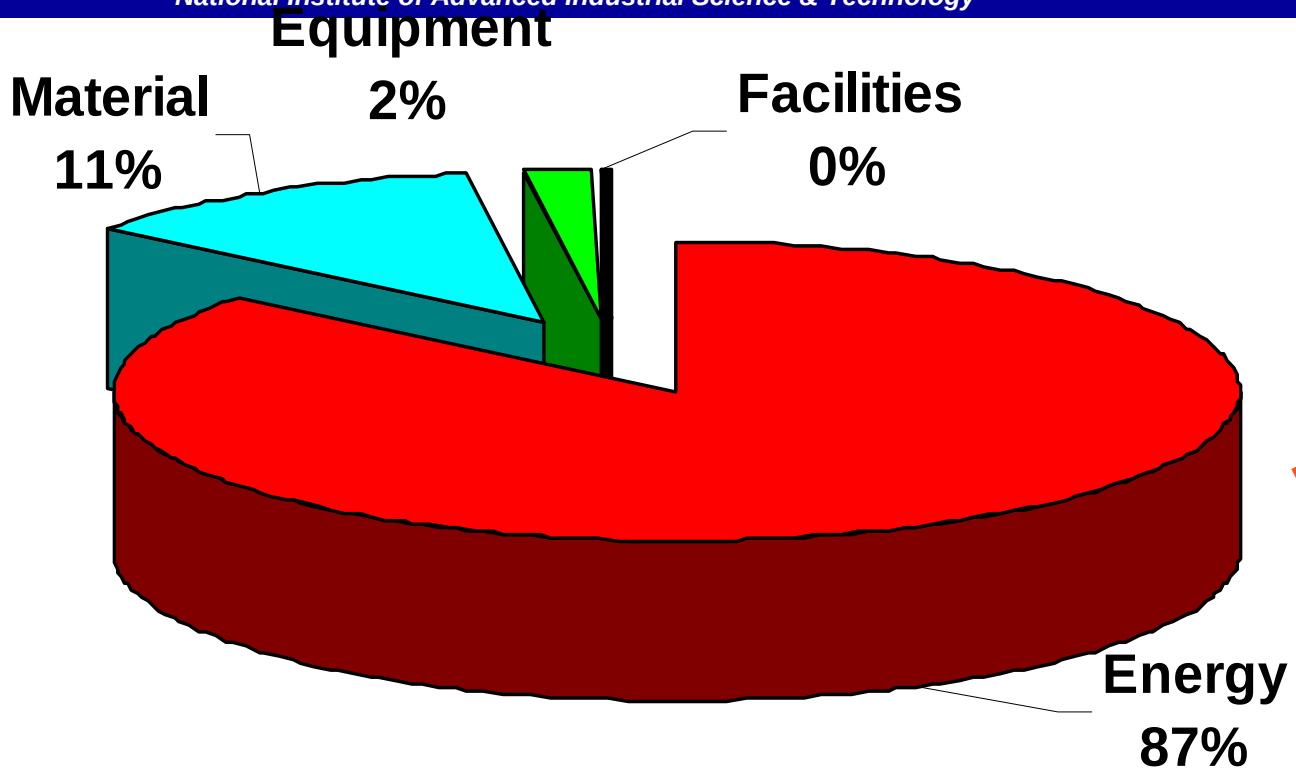
* World includes international aviation and international marine bunkers.
** Calculated using IEA's Energy Balance Tables and the Revised 1996 IPCC Guidelines. CO_2 emissions are from fuel combustion only. *** Other includes industrial waste and non-renewable municipal waste.

Source: Key World Energy Statistics 2005

Scope of the Investigation **COAL**

Exploration | **Extraction** | Transportation

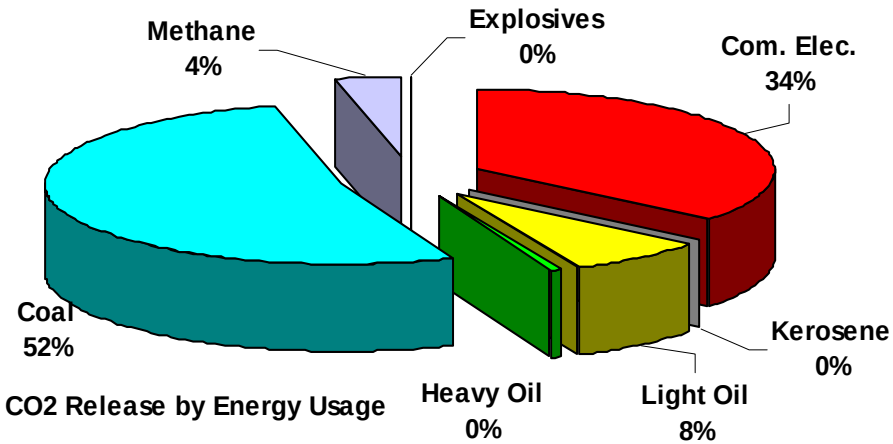
- **Energy** : **Electricity, Coal, Oils, CH_4 , ・・・**
- **Materials** : **Steel (supports, tracks, pipes, ・・・)**
  Cement, Timber, Plastics, ・・・・・
- **Equipment** : **Machines for Mining, Driving,**
  Transportation, Separation, ・・・・・
- **Buildings** : **Offices, Houses, Rooms, ・・・・・**



Relative Contribution of CO_2 Release by Coal Extraction

82 kg-CO_2/t-coal in 1999

(3.4 g-CO_2/MJ-coal)



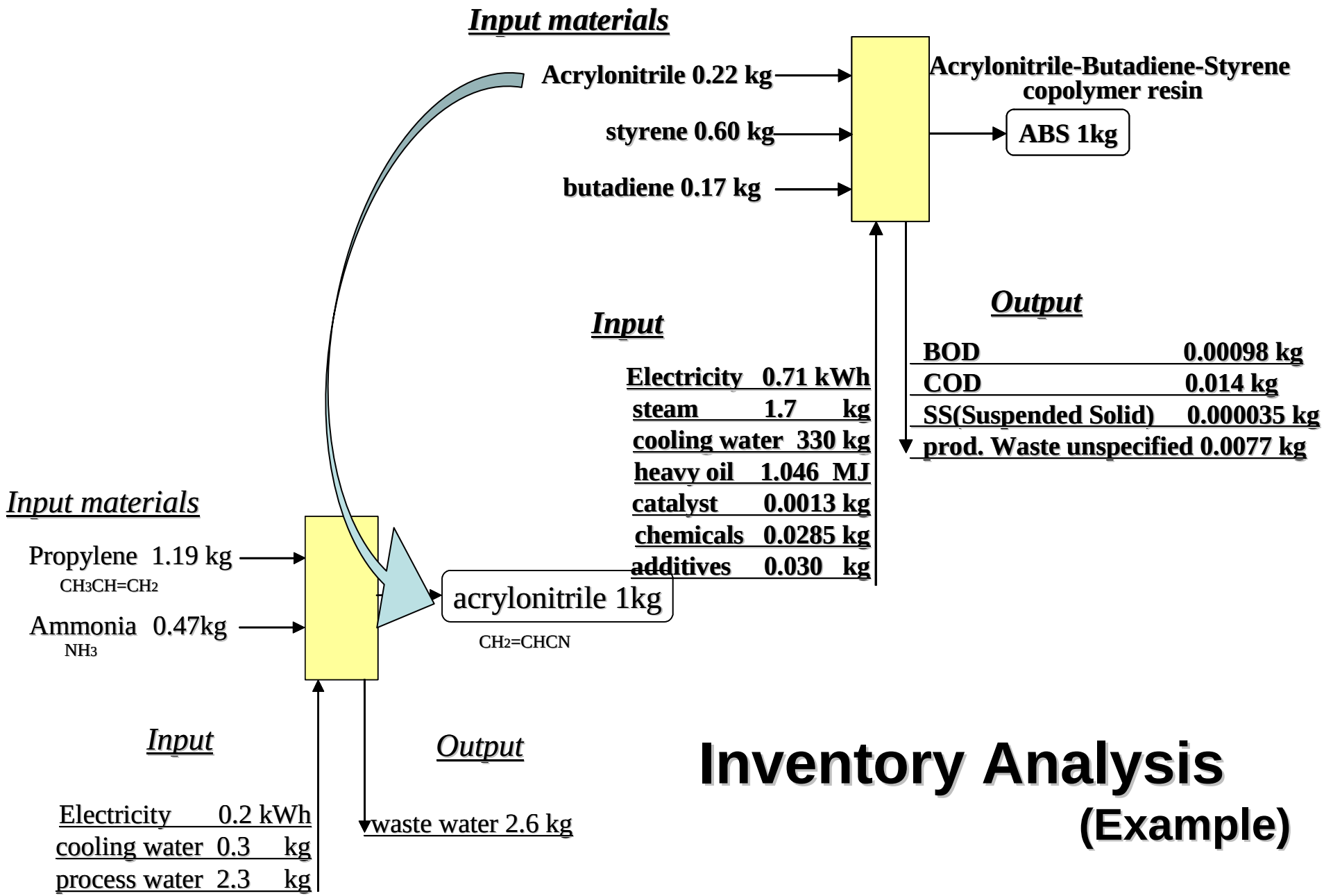
Consumed energies for COAL production in Japan FY1999

Item	Consumed quantity		Per ton of shipped clean coal produced	
Commercial elec.	252	GWh	42.0	kWh/t
Kerosene	29	kl	0.00483	l / t
Light oil	10363	kl	1.73	l / t
Heavy oil	1160	kl	0.193	l / t
Coal	160	k t	26.6	kg/t
Powder coal	68.2	k t	11.4	kg/t
Methane	5.4	Mm^3	0.899	m^3/t
Explosives	476	t	79.3	g/t
Domesticelec.*	273	GWh	45.5	kWh/t

*Used energies(coal, powder coal and heavy oil) for domestic energy production are included in each item.

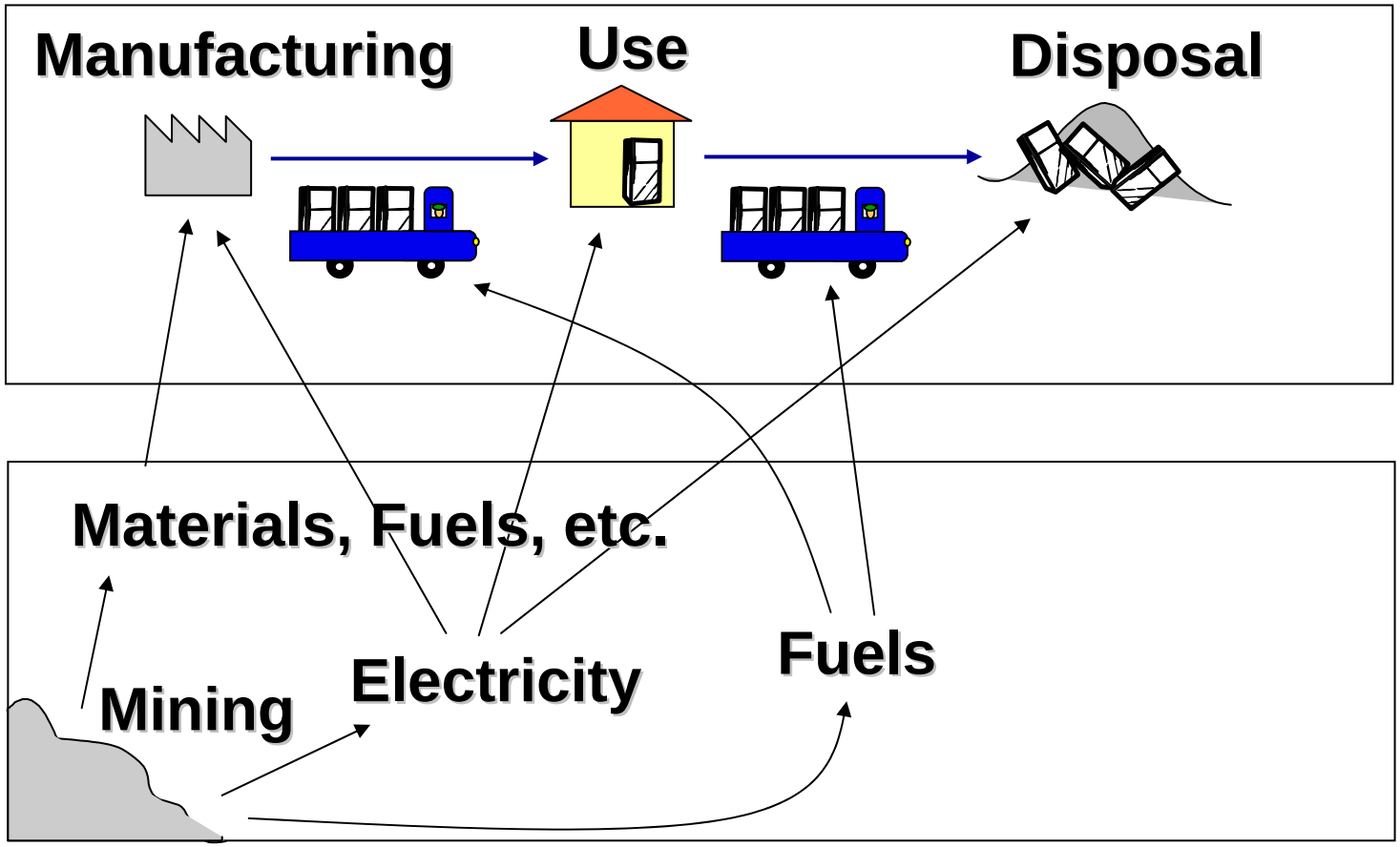
Consumed materials for coal production in Japan FY1999

Item	Consumed quantity		Per ton of shipped clean coal produced	
Steel	23.2	k t	3.8628	kg/t
Timber	33900	m^3	0.00564	m^3/t
Cement	11688.9	t	2.18	kg/t
Sand	39570.8	t	7.38	kg/t
Fly ash	16782.7	t	3.13	kg/t
Kerosene	75.1	kl	0.014	l/t
Plastics (ABS)	16.1	kg	0.003	g/t



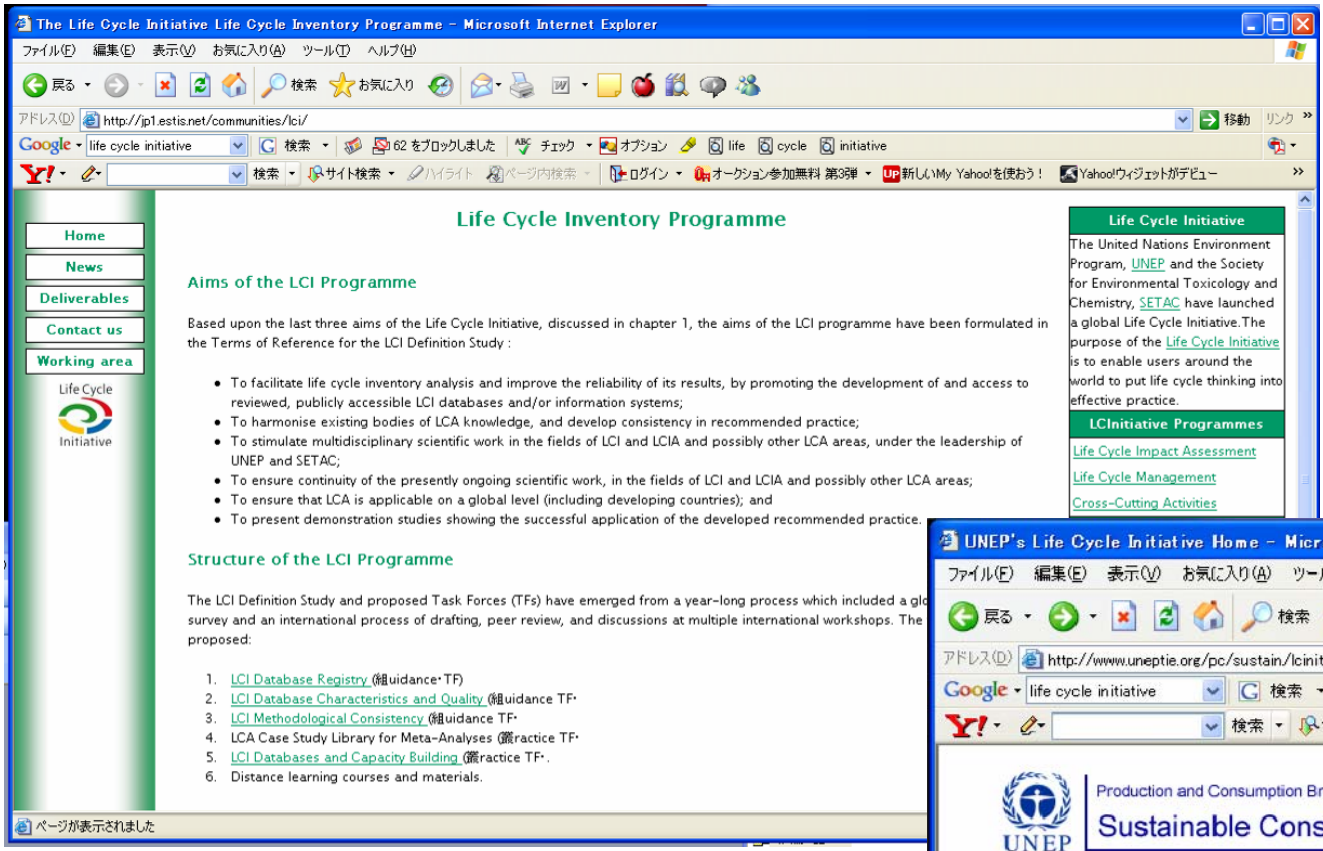
Inventory Analysis (Example)

Foreground Data



Back ground Data

Transparency, Impartiality, Consistency, …..
International Data Sharing



International LCA Network

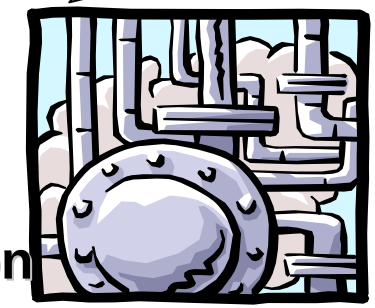
ex. Data Sharing

ECBMR

- Environmental & Economical Possibility -

Elec. Generation

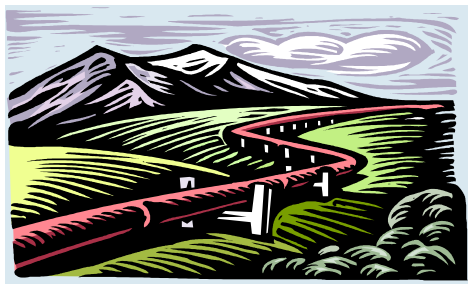
CO_2+Air



Separation

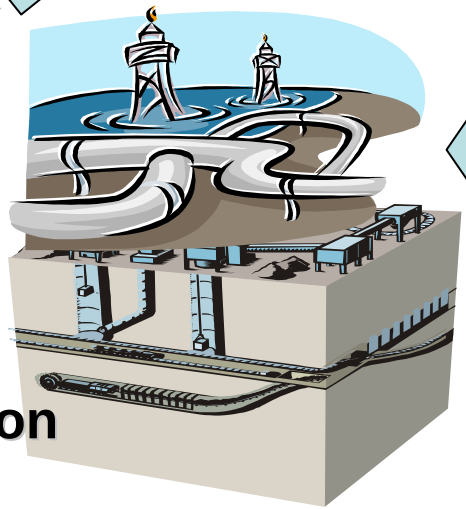
CO_2

Air



Transportation

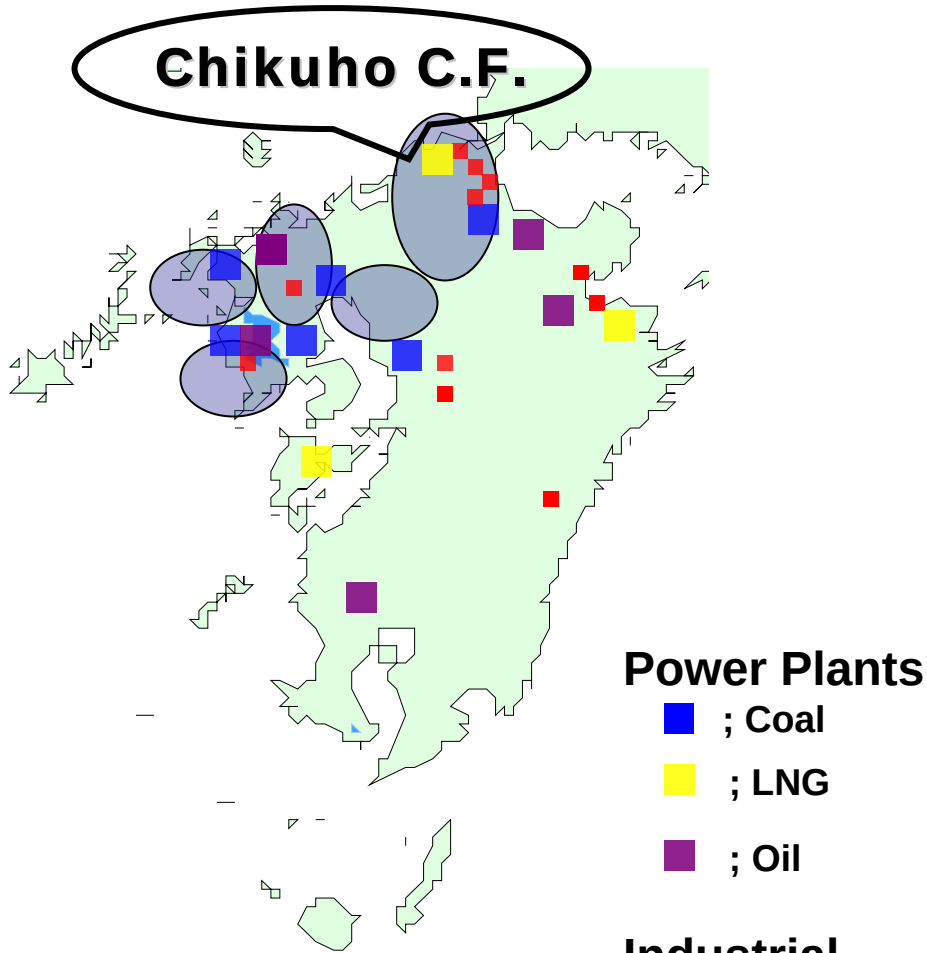
CO_2



CH_4

Transportation

CO_2 Sequestration & CH_4 Recovery



Chikuho Coal Field
CO_2 Supply & CBM (CH_4) Demand

ECBMR
- Environmental & Economical Possibility -

- CBM Production

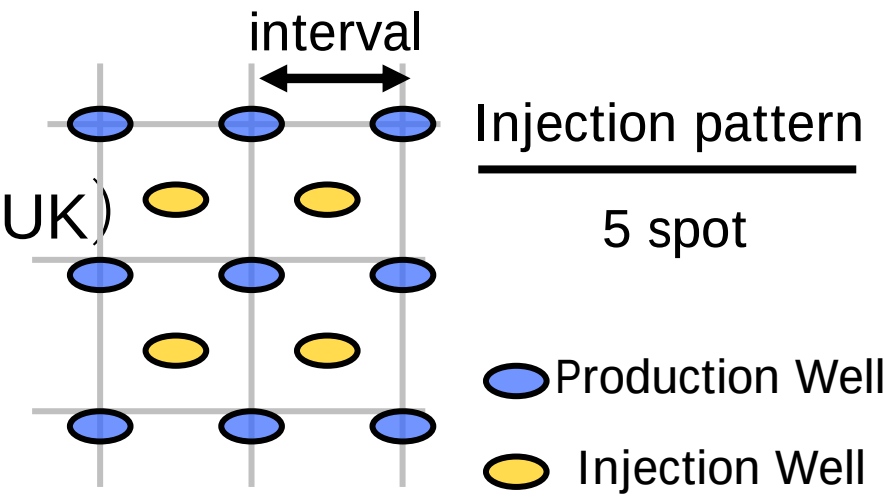
METSIM2 （by Imperial College, UK）

- Field

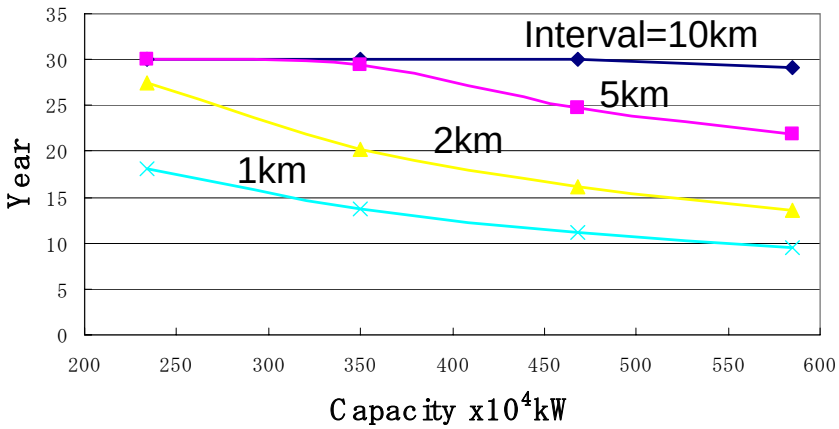
Chikuho Coal Field

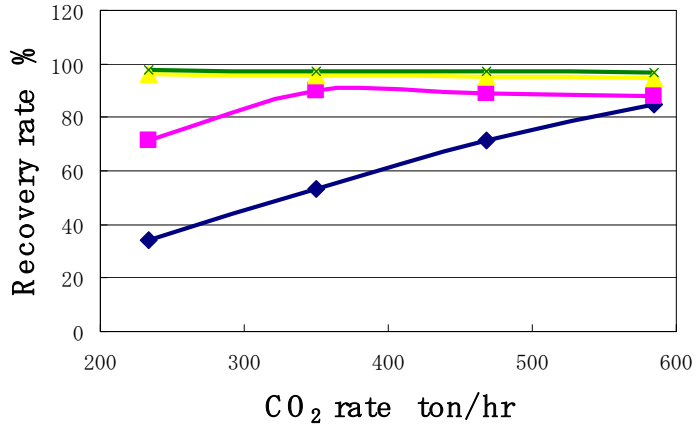
- Area

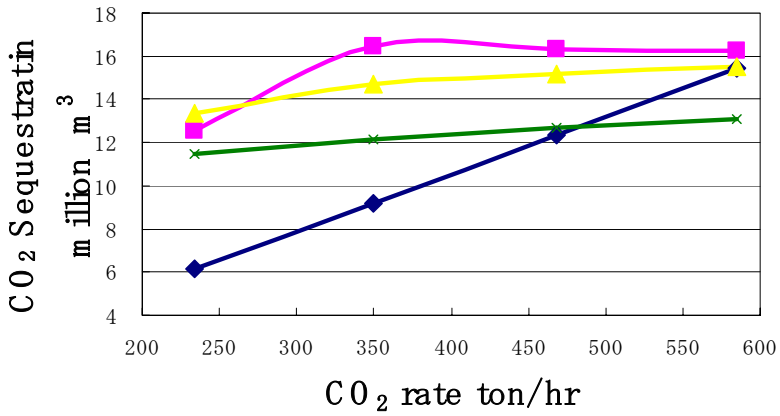
10km(E-W)×30km(N-S)



Extraction up to CO_2<10%







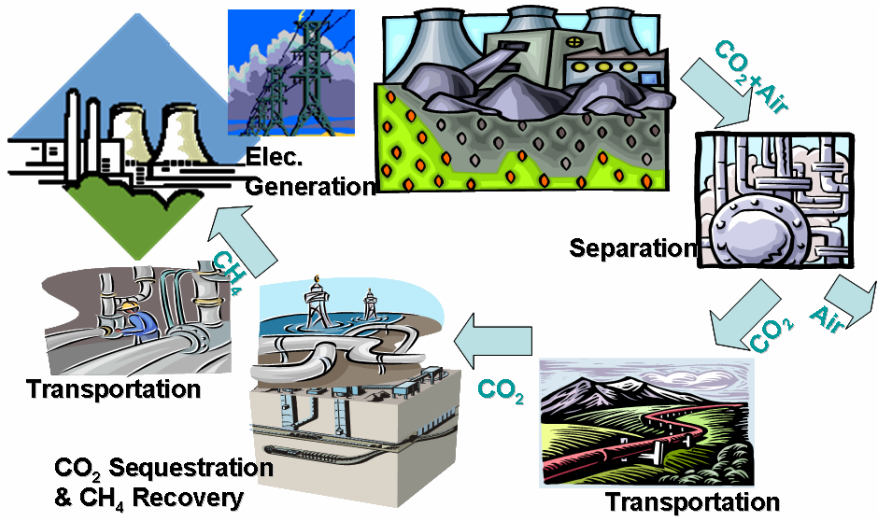
CO_2 Sequestration & CBM production

- Injection rate 585 t-CO_2/h
- Well interval 2km

Lifecycle CO_2 Emission

		CO_2 Emission (g-CO_2/MJ)
Capital	Separation	0.012
	Transportation	0.0108
	Drilling	1.244
	Recovery	0.016
	Sub total	1.3
Operation	Separation	0.557
	Transportation	3.9
	Drilling	0.073
	Recovery	0.675
	Sub total	5.2
	Total	**6.5**

7.8 g-CO_2/MJ (imported LNG)



Balance: -100 g-CO_2/MJ

CBM Production + 6.5

CO2 Sequestration - 99

LNG (avoided) - 7.8

Cost Analysis

Capital (million JYN)

Item	
Separation	4,759
Transportation	13,849
Drilling	11,257
CBM Production	2,374
Total	32,239

Operation (million JYN)

Item	
Separation	11,700
Transportation	8,670
CBM Production	292
Total	20,662

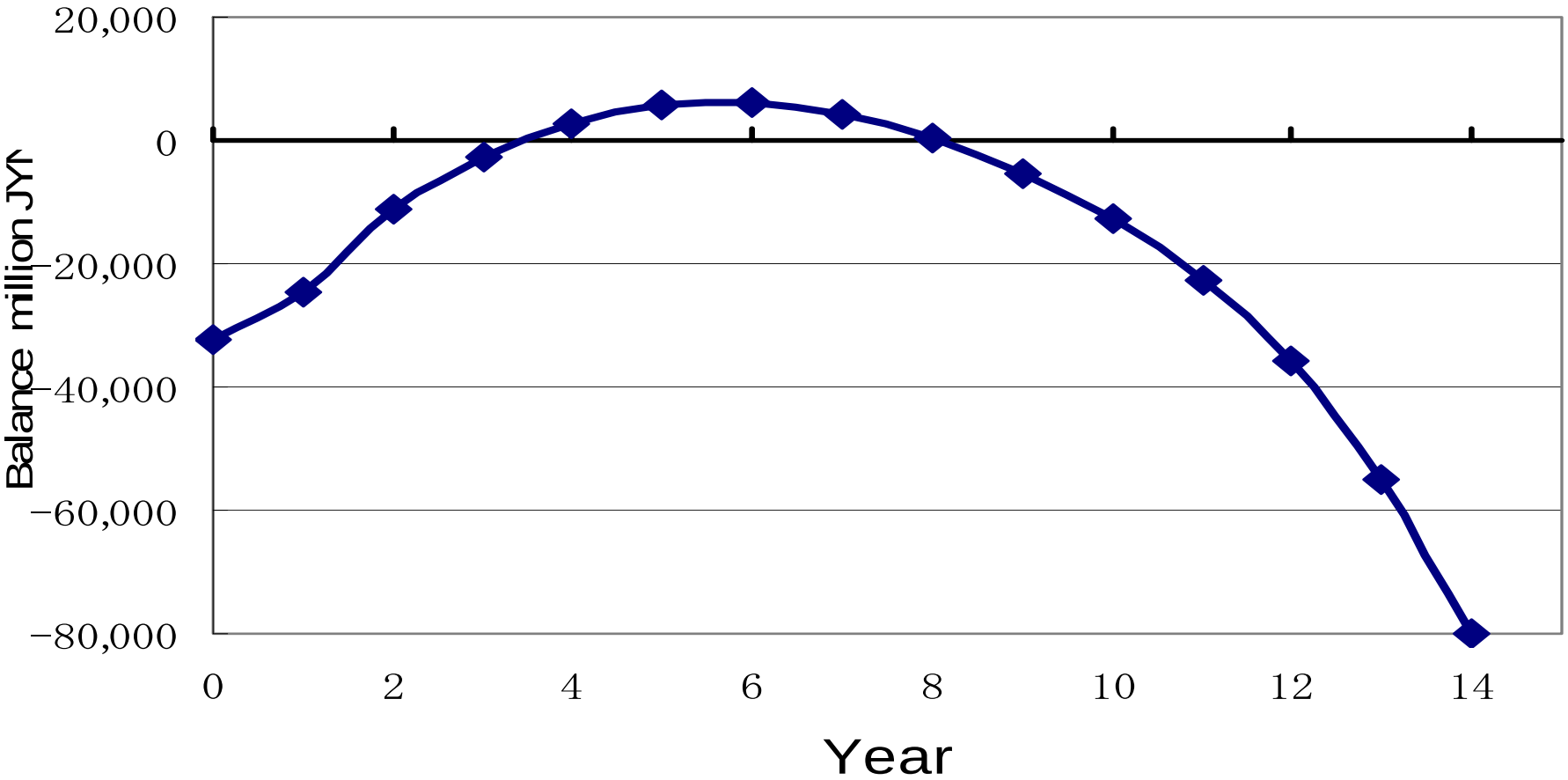
+ Costs for **Labour, Management, Tax**

Revenue:

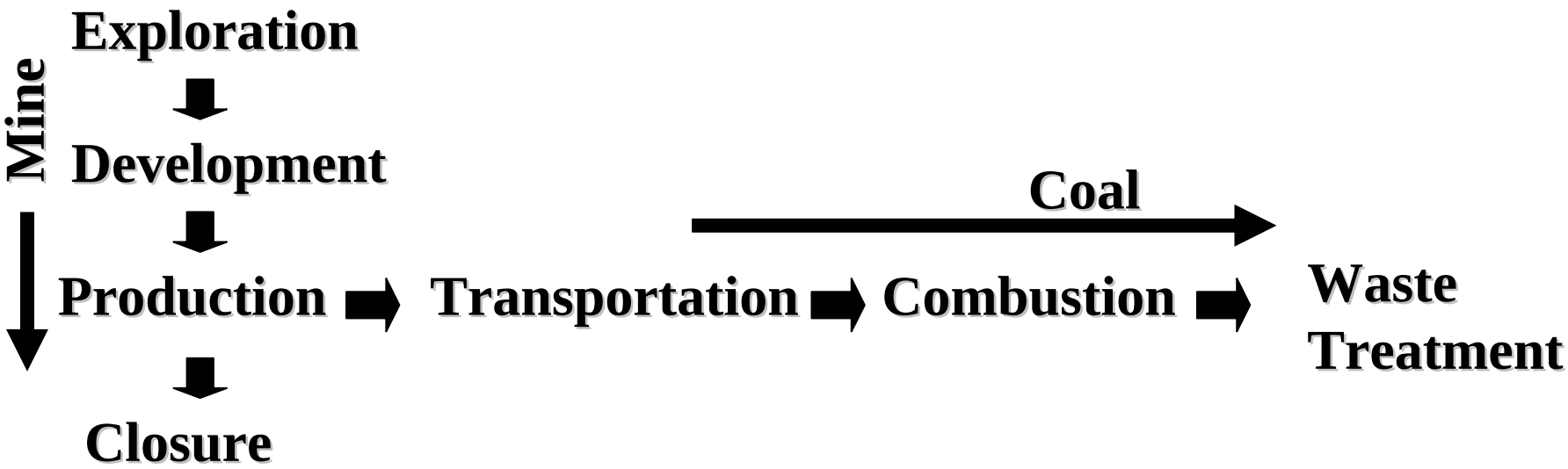
CBM Price = imported LNG (average '91-'00)

excl. sequestrated CO_2

Financial Analysis



LCA for Mining ex. coal



Eco-Efficiency of a Mine

$$\frac{\text{Service、Benefit}}{\text{Environmental Impact}} \Rightarrow \frac{\text{Profit or Total Sales}}{\text{LCIA}}$$

LCA for Mining ex. coal

Mine

Exploration

Development

Production

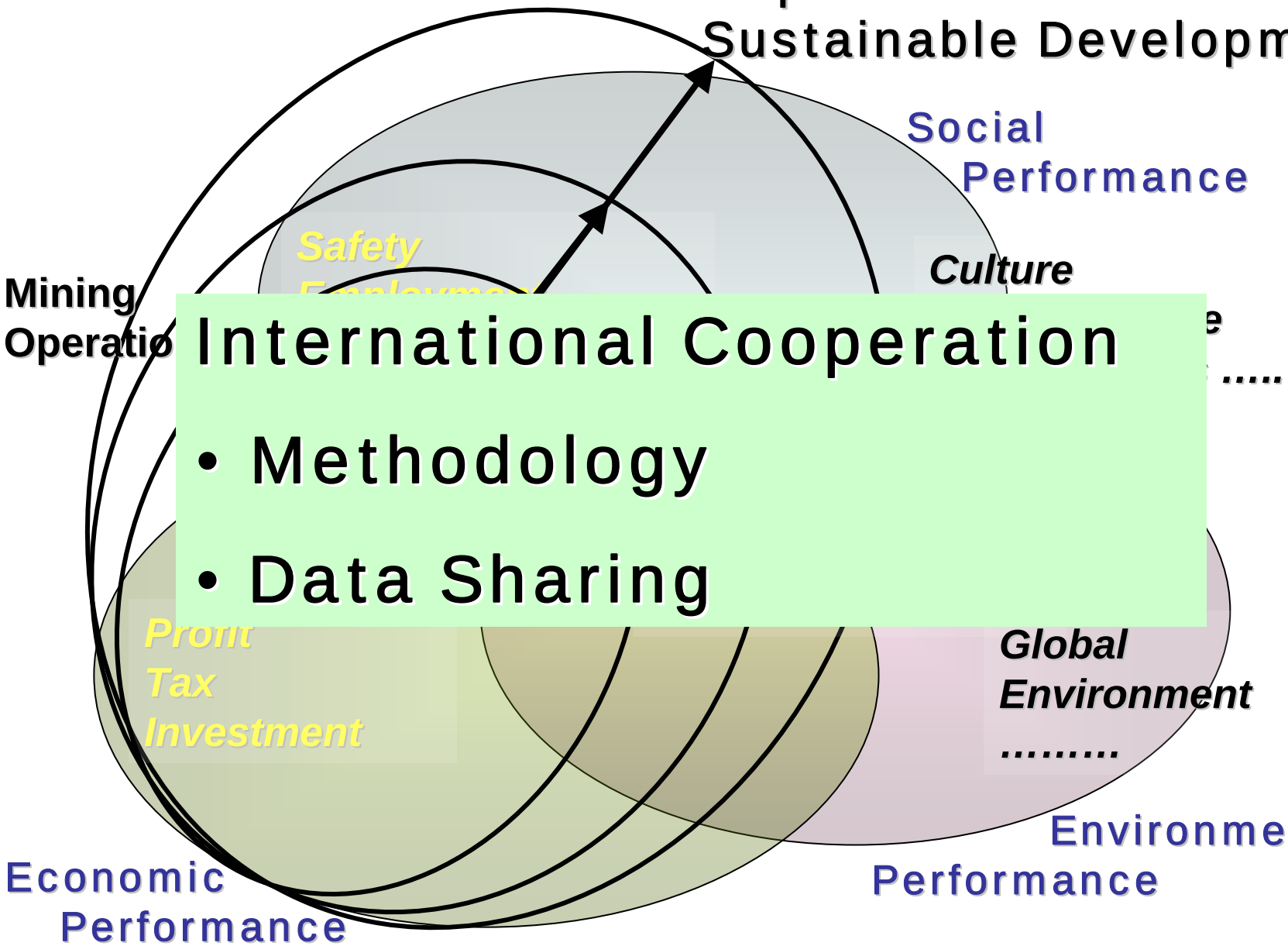
Closure

1. CBM Extraction from Virgin Coal Seam
2. Coal + CBM Extraction
3. ECBMR from Deep Seam and/or Abandoned Mine

Eco-Efficiency of a Mine

$$\frac{\text{Benefit}}{\text{Environmental Impact}} \Rightarrow \frac{\text{Profit or Total Sales}}{\text{LCIA}}$$

Triple Bottom Line for Sustainable Development



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