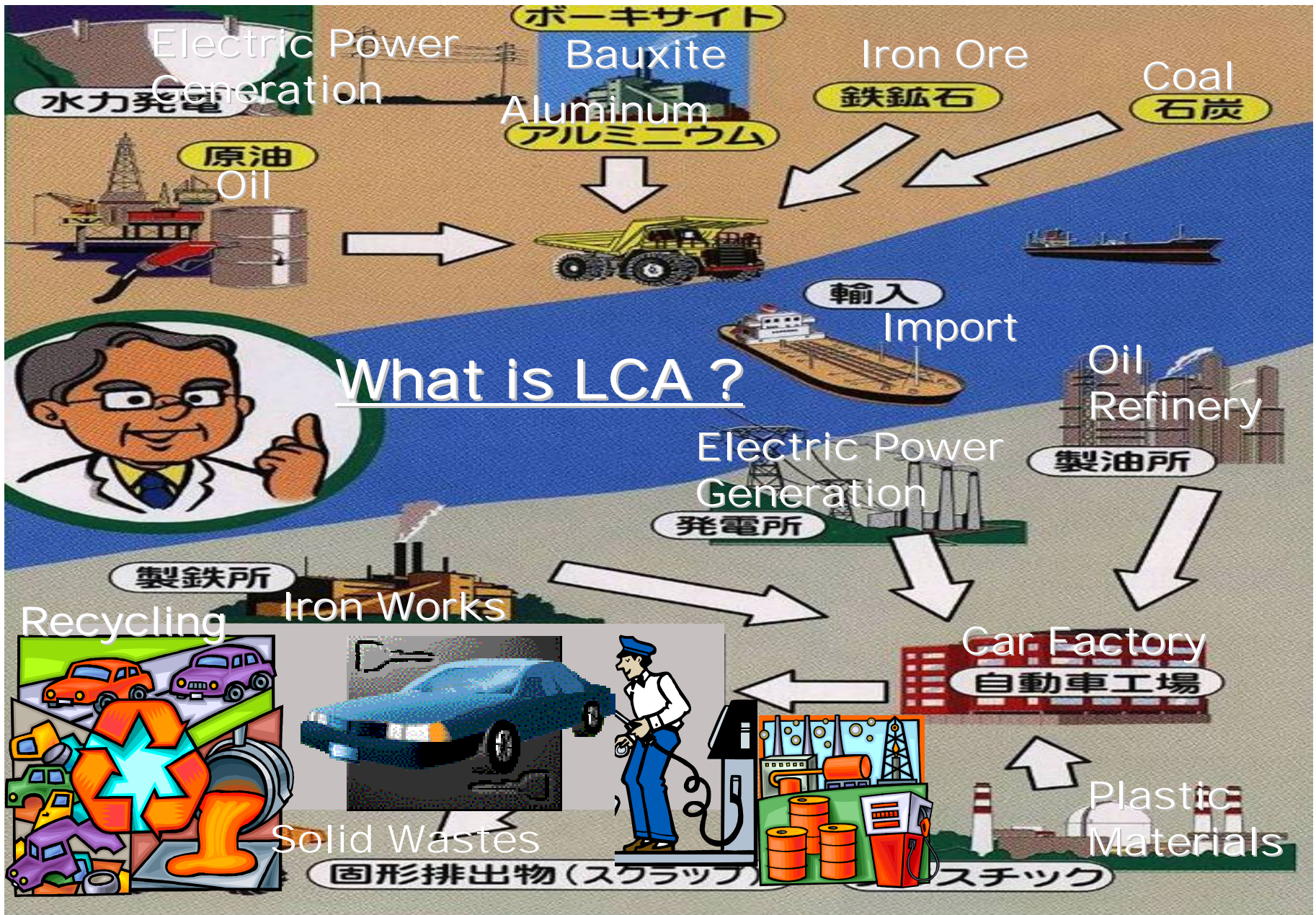


Lifecycle Environmental Evaluation of Exploitation & CO₂ Sequestration of Coal

by SAGISAKA M.

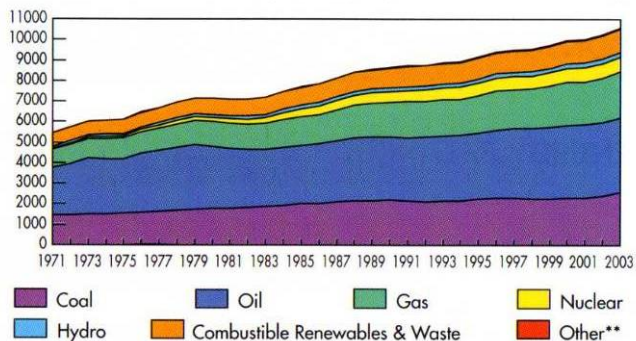
**Life Cycle Assessment Research Centre,
National Institute of Advanced Industrial
Science & Technology (AIST), JAPAN**



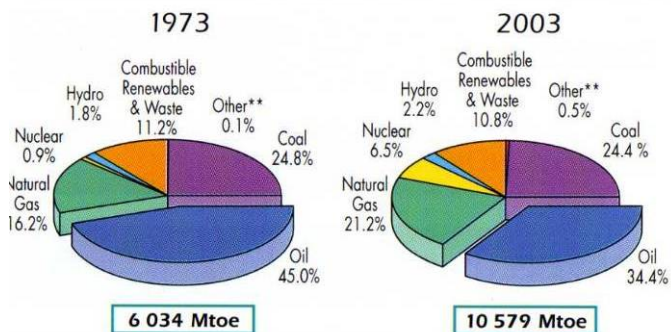
TOTAL PRIMARY ENERGY SUPPLY

The World

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



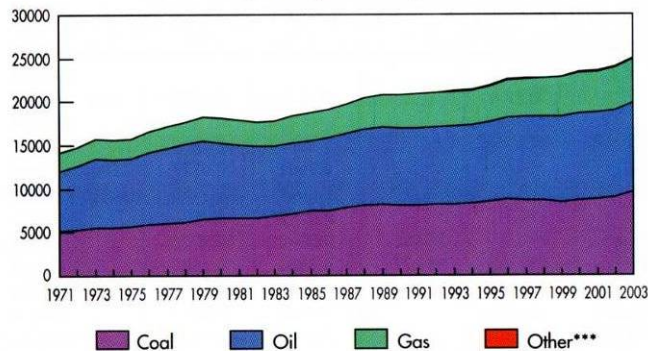
1973 and 2003 Fuel Shares of TPES*



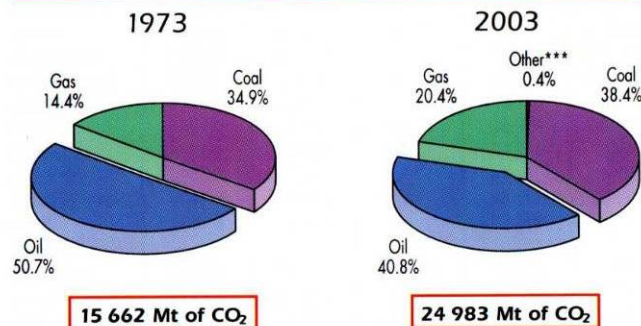
*Excludes international marine bunkers and electricity trade.
**Other includes geothermal, solar, wind, heat, etc.

CO₂ Emissions by Fuel

Evolution from 1971 to 2003 of World* CO₂ Emissions** by Fuel (Mt of CO₂)



1973 and 2003 Fuel Shares of CO₂ Emissions**

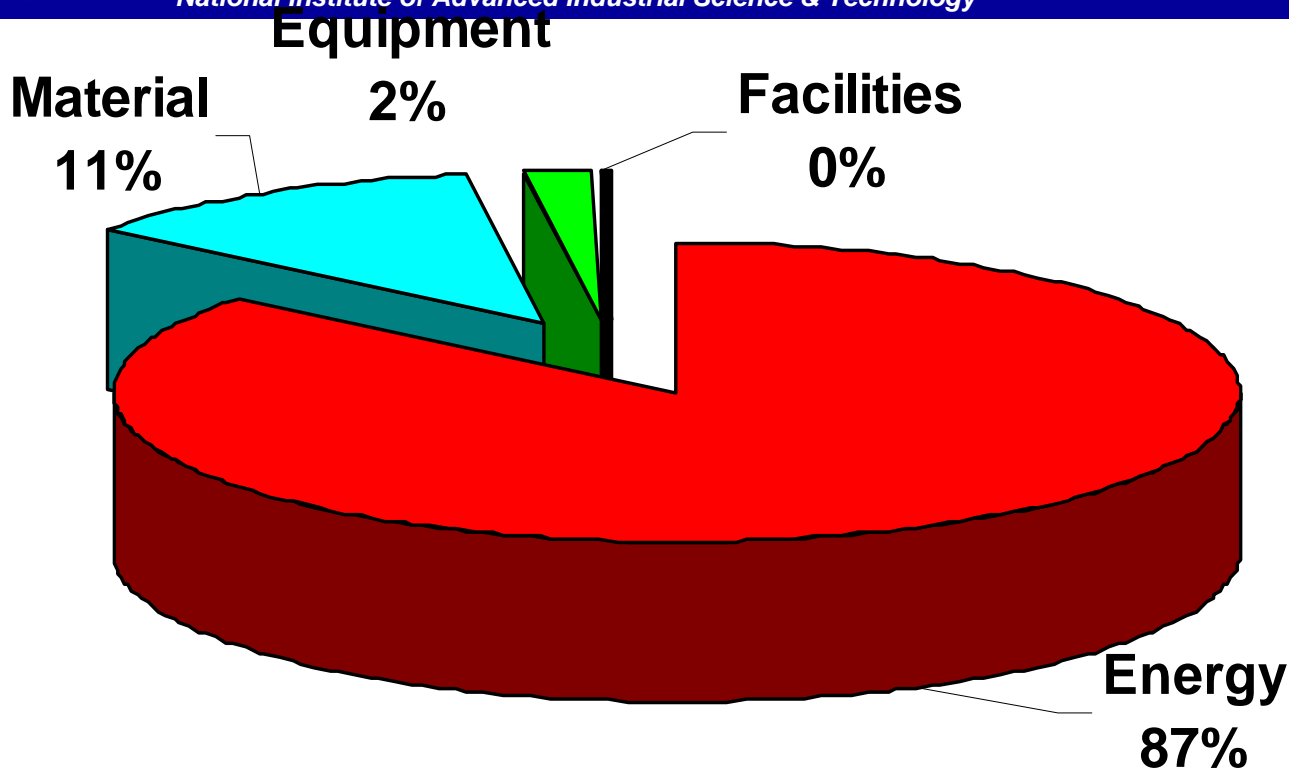


* World includes international aviation and international marine bunkers.
** Calculated using IEA's Energy Balance Tables and the Revised 1996 IPCC Guidelines. CO₂ emissions are from fuel combustion only. *** Other includes industrial waste and non-renewable municipal waste.

Source: Key World Energy Statistics 2005

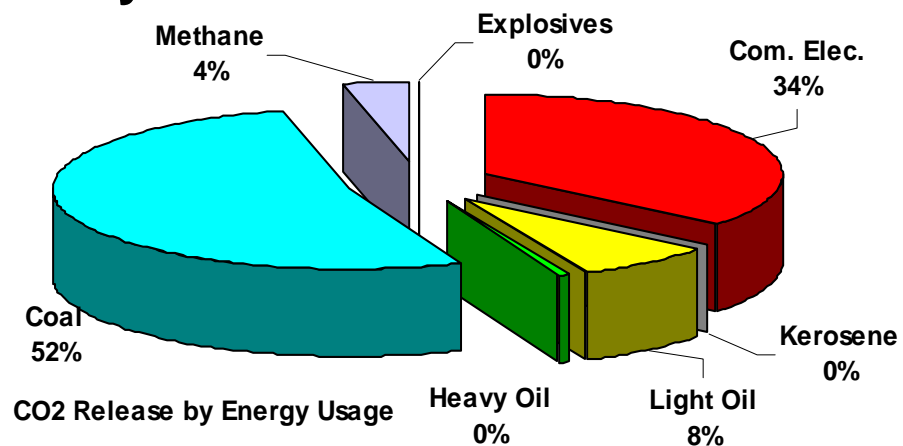
Scope of the Investigation COALExploration | **Extraction** | Transportation

- Energy : Electricity, Coal, Oils, CH₄, ...
- Materials : Steel (supports, tracks, pipes, ...)
Cement, Timber, Plastics,
- Equipment : Machines for Mining, Driving,
Transportation, Separation,
- Buildings : Offices, Houses, Rooms,



Relative Contribution of CO₂ Release by Coal Extraction

82 kg-CO₂/t-coal in 1999
(3.4 g-CO₂/MJ-coal)



Consumed energies for COAL production in Japan FY1999

Item	Consumed quantity		Per ton of shipped clean coal produced	
	Quantity	Unit	Value	Unit
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
Domestic elec.*	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	kt	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

Input materials

Acrylonitrile 0.22 kg
styrene 0.60 kg
butadiene 0.17 kg

Acrylonitrile-Butadiene-Styrene copolymer resin

ABS 1kg

Input

Electricity 0.71 kWh
steam 1.7 kg
cooling water 330 kg
heavy oil 1.046 MJ
catalyst 0.0013 kg
chemicals 0.0285 kg
additives 0.030 kg

Output

BOD 0.00098 kg
COD 0.014 kg
SS(Suspended Solid) 0.000035 kg
prod. Waste unspecified 0.0077 kg

Input materials

Propylene 1.19 kg
CH3CH=CH2
Ammonia 0.47kg
NH3

acrylonitrile 1kg
CH2=CHCN

Input

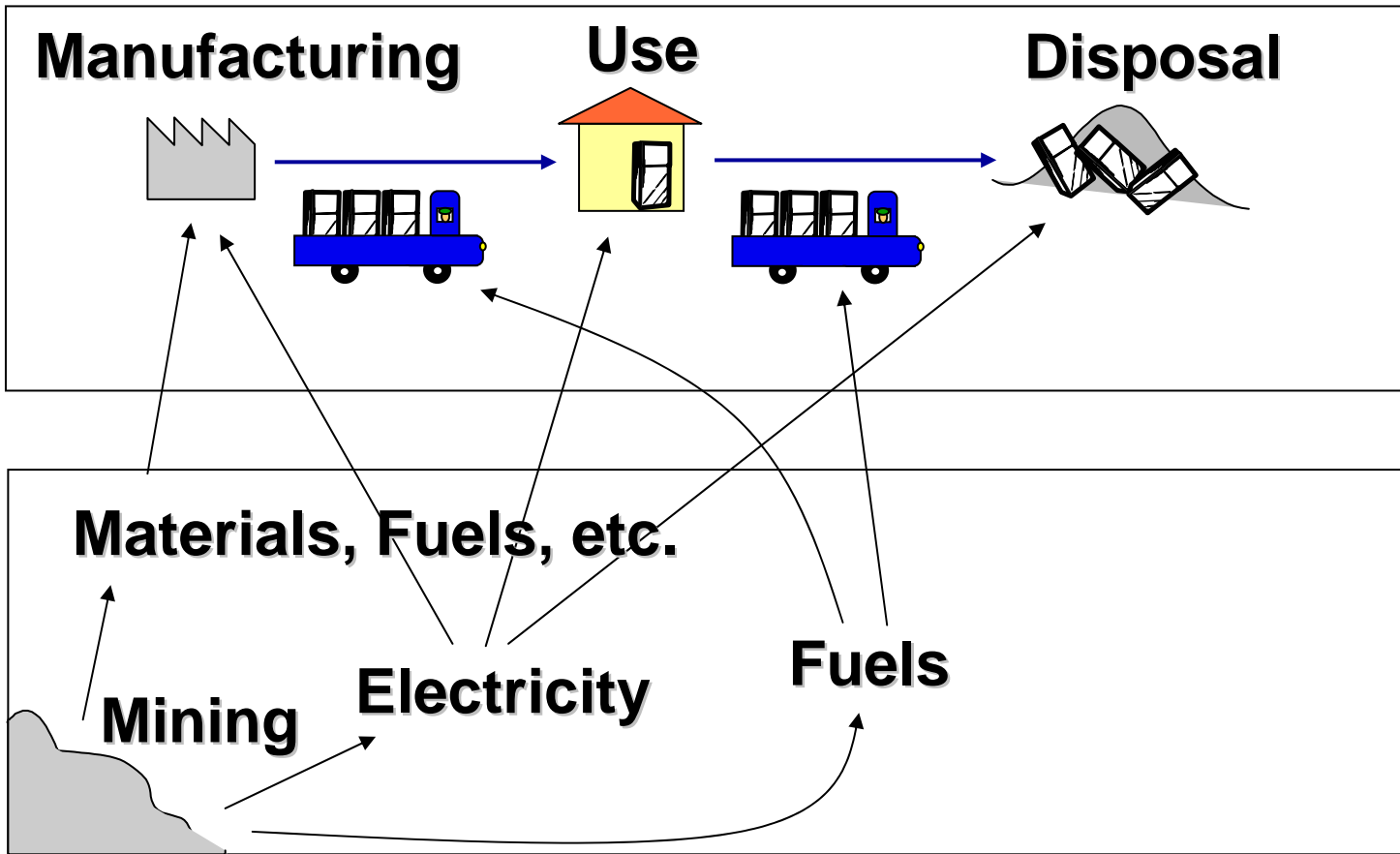
Electricity 0.2 kWh
cooling water 0.3 kg
process water 2.3 kg

Output

waste water 2.6 kg

Inventory Analysis (Example)

Foreground Data



Back ground Data

Transparency, Impartiality, Consistency,
International Data Sharing

The Life Cycle Initiative Life Cycle Inventory Programme - Microsoft Internet Explorer

http://ip1.estis.net/communities/lci/

Life Cycle Inventory Programme

Aims of the LCI Programme

Based upon the last three aims of the Life Cycle Initiative, discussed in chapter 1, the aims of the LCI programme have been formulated in the Terms of Reference for the LCI Definition Study:

- To facilitate life cycle inventory analysis and improve the reliability of its results, by promoting the development of and access to reviewed, publicly accessible LCI databases and/or information systems;
- To harmonise existing bodies of LCA knowledge, and develop consistency in recommended practice;
- To stimulate multidisciplinary scientific work in the fields of LCI and LCIA and possibly other LCA areas, under the leadership of UNEP and SETAC;
- To ensure continuity of the presently ongoing scientific work, in the fields of LCI and LCIA and possibly other LCA areas;
- To ensure that LCA is applicable on a global level (including developing countries); and
- To present demonstration studies showing the successful application of the developed recommended practice.

Structure of the LCI Programme

The LCI Definition Study and proposed Task Forces (TFs) have emerged from a year-long process which included a global survey and an international process of drafting, peer review, and discussions at multiple international workshops. The proposed:

- LCI Database Registry (Guidance TF)
- LCI Database Characteristics and Quality (Guidance TF)
- LCI Methodological Consistency (Guidance TF)
- LCA Case Study Library for Meta-Analyses (Practice TF)
- LCI Databases and Capacity Building (Practice TF)
- Distance learning courses and materials.

UNEP's Life Cycle Initiative Home - Microsoft Internet Explorer

http://www.unepie.org/pc/sustain/lcinitiative/

UNEP Production and Consumption Branch
Sustainable Consumption [SC]

10 Year Framework Life Cycle Initiative Government Policies Products & Services Advertising Youth SC-Net

Life Cycle Initiative
UNEP SETAC

More information:
Go to the new Life Cycle Initiative website

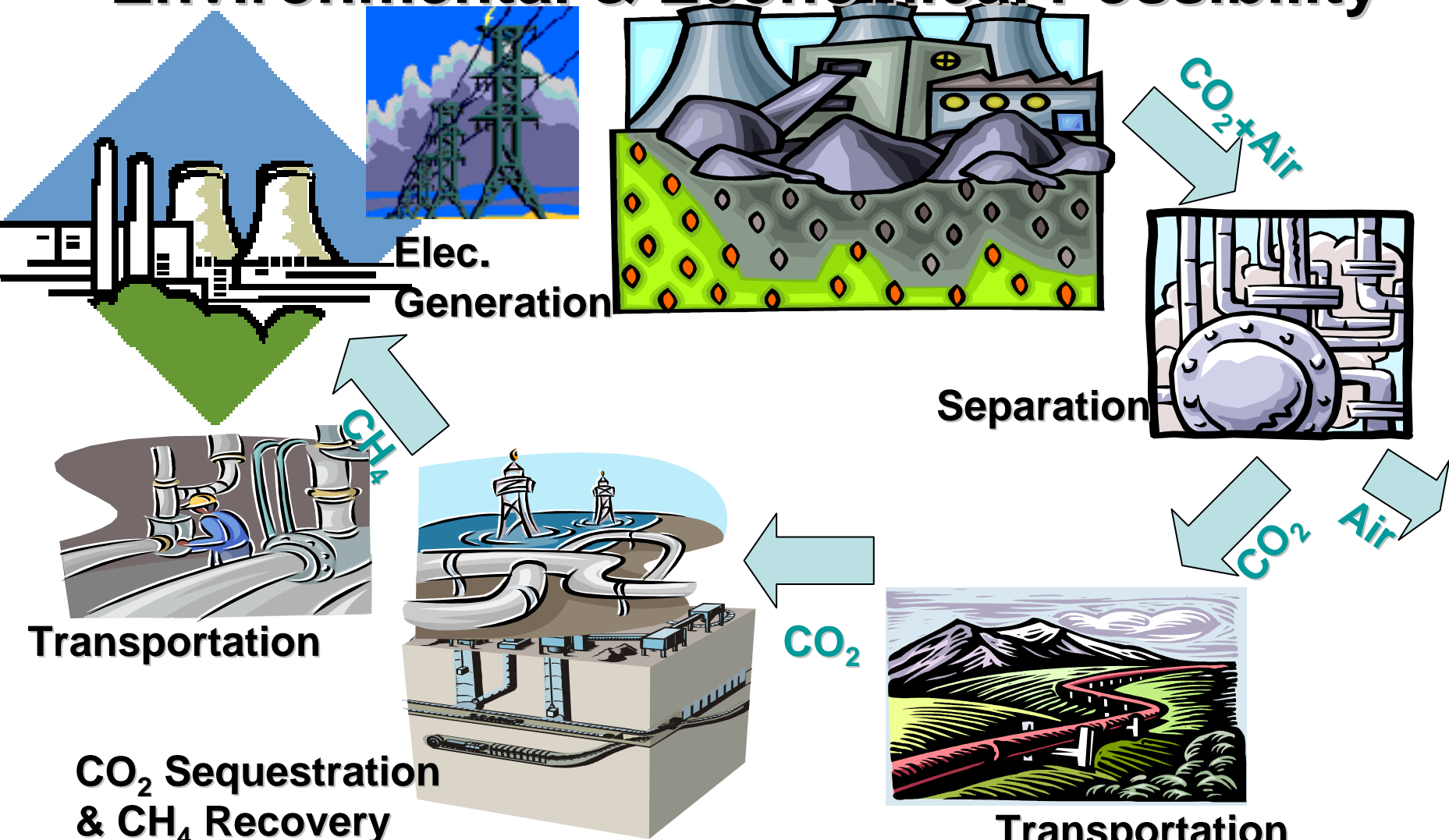
Our Mission International Life Cycle Partnership

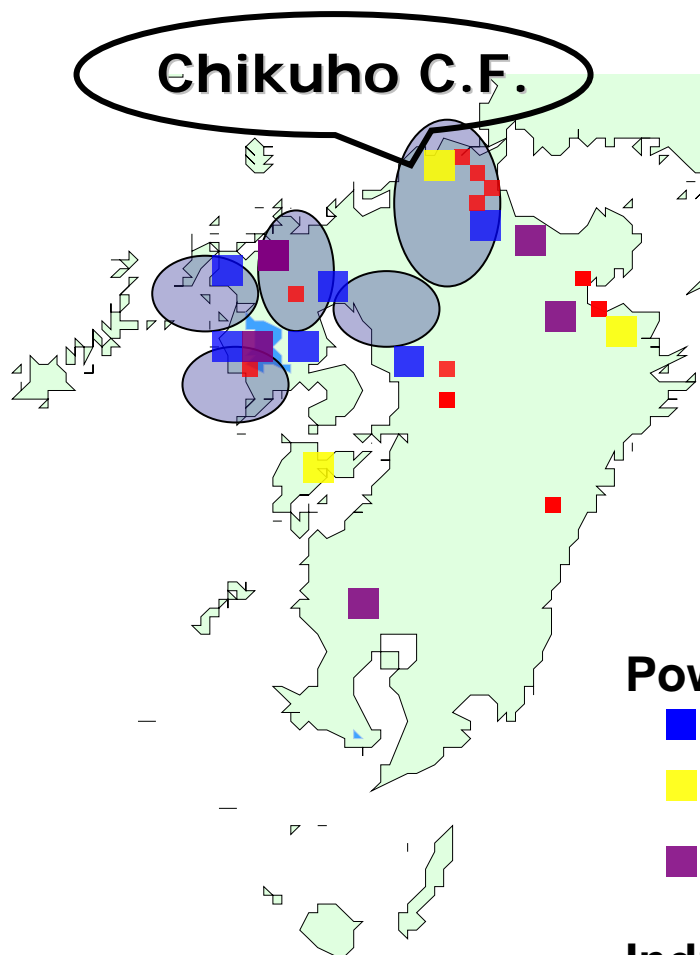
International LCA Network

ex. Data Sharing

ECBMR

- Environmental & Economical Possibility -





Power Plants

■ ; Coal

■ ; LNG

■ ; Oil

Industrial

■ Boilers

Chikuhō Coal Field CO₂ Supply & CBM (CH₄) Demand

ECBMR

- Environmental & Economical Possibility -

- CBM Production

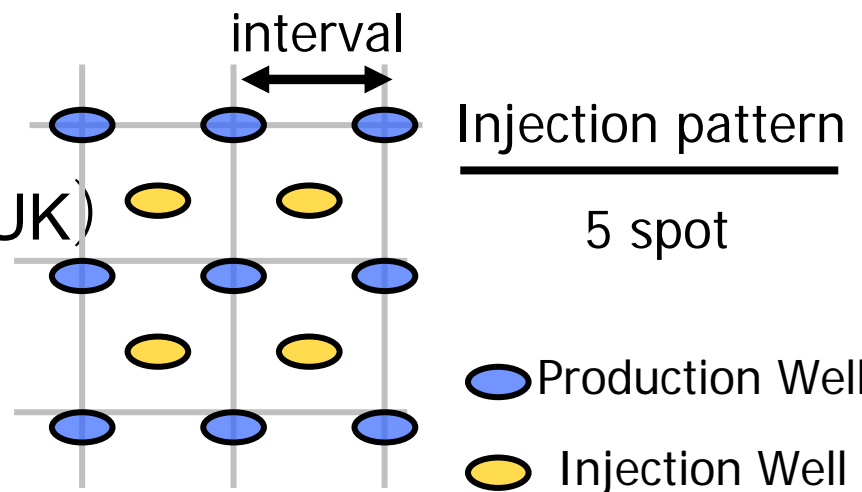
METSIM2 (by Imperial College, UK)

- Field

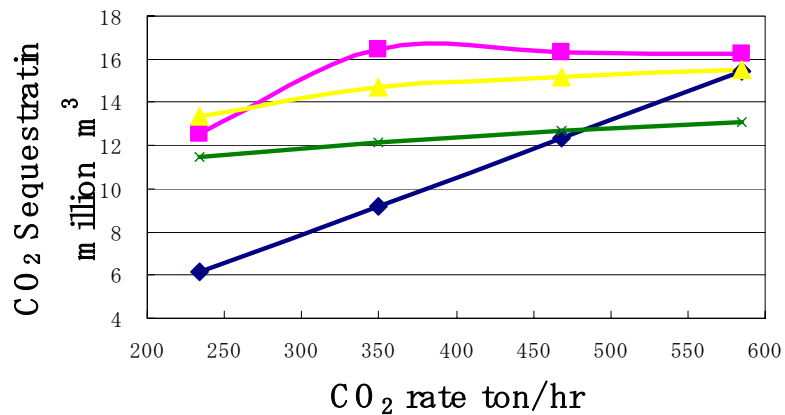
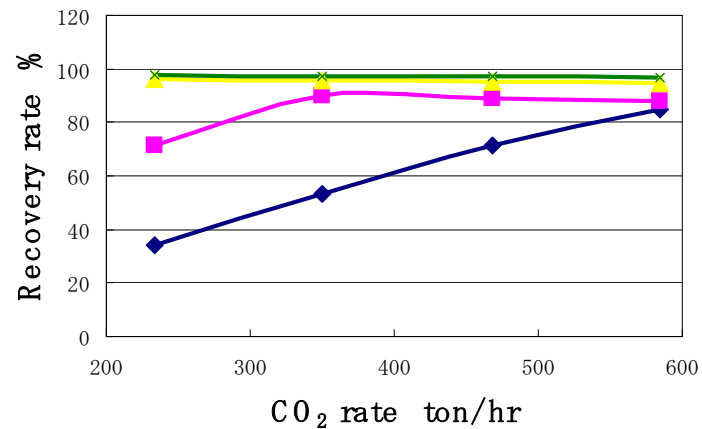
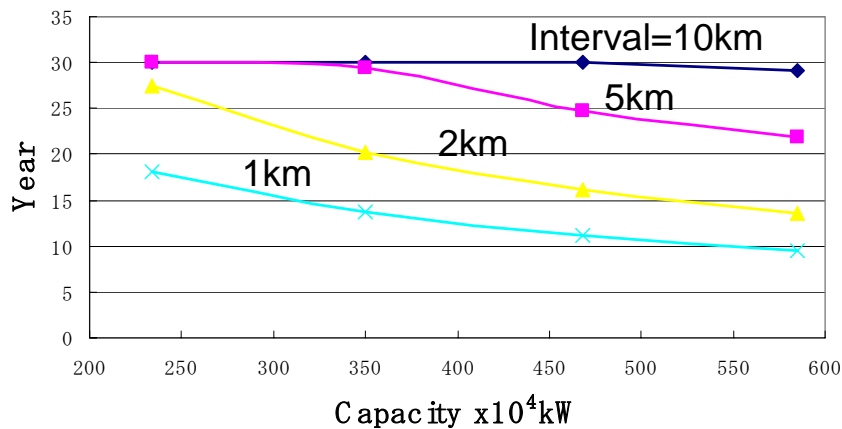
Chikuho Coal Field

- Area

10km(E-W) × 30km(N-S)



Extraction up to $\text{CO}_2 < 10\%$



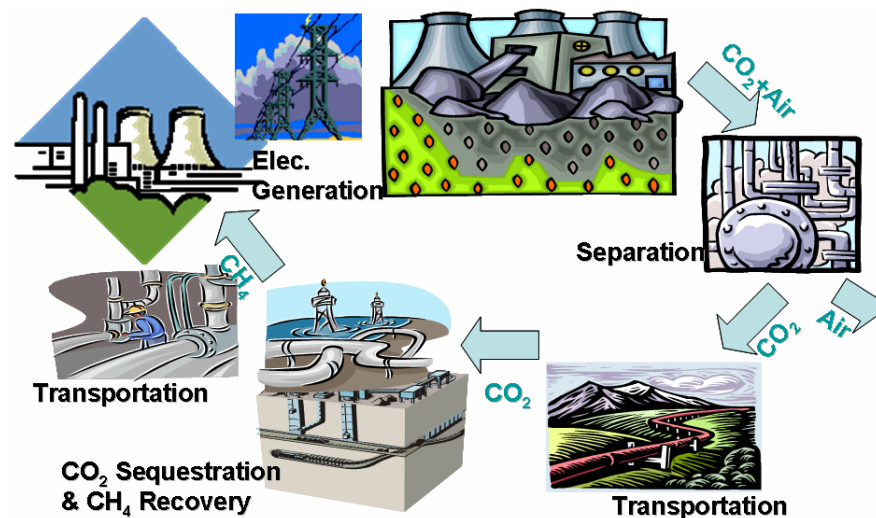
CO₂ Sequestration & CBM production

- Injection rate **585 t - CO₂/h**
- Well interval **2km**

Lifecycle CO₂ 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-CO₂/MJ (imported LNG)



Balance: -100 g-CO₂/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

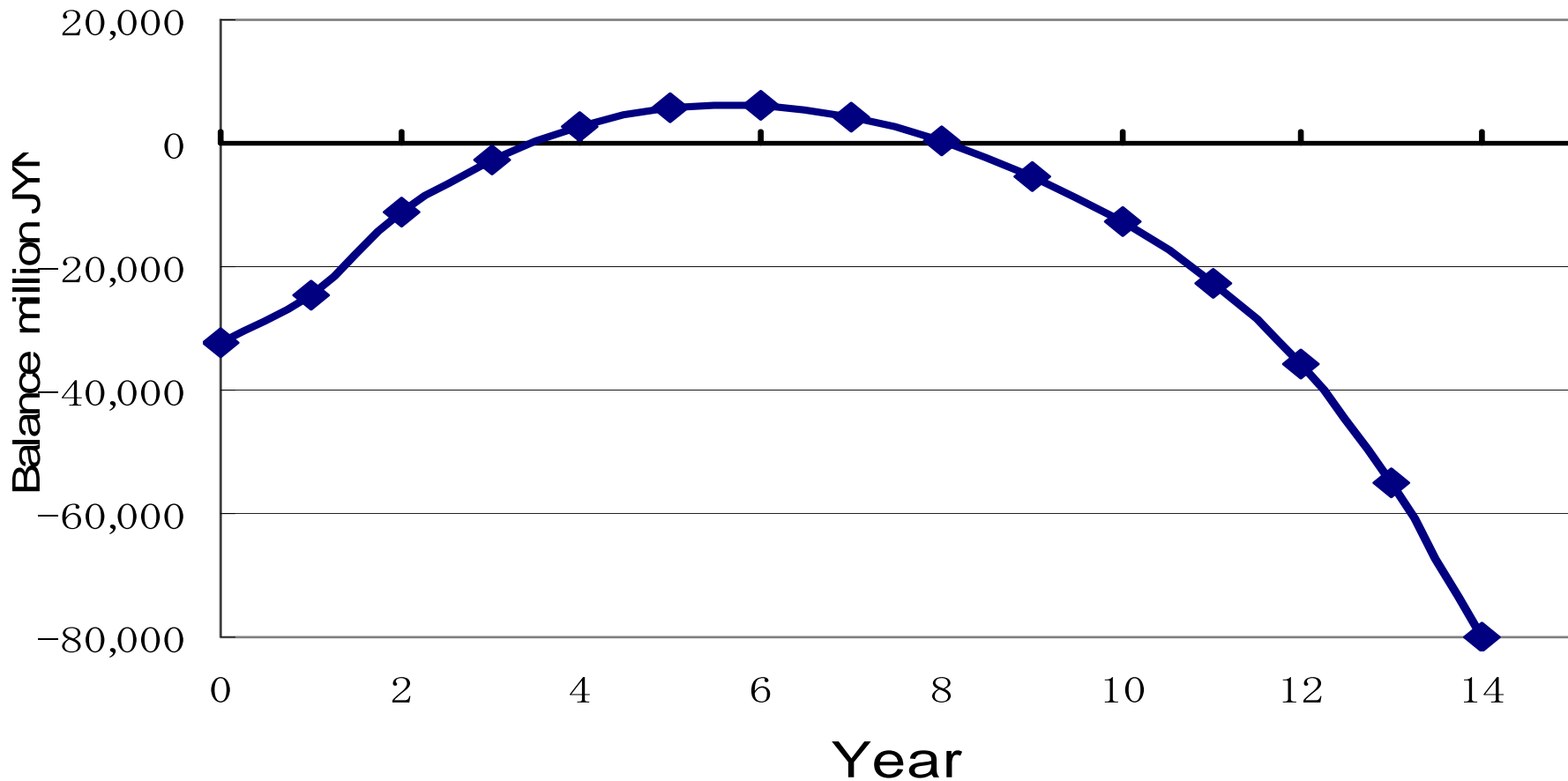
+ Costs for Labour, Management, Tax

Revenue:

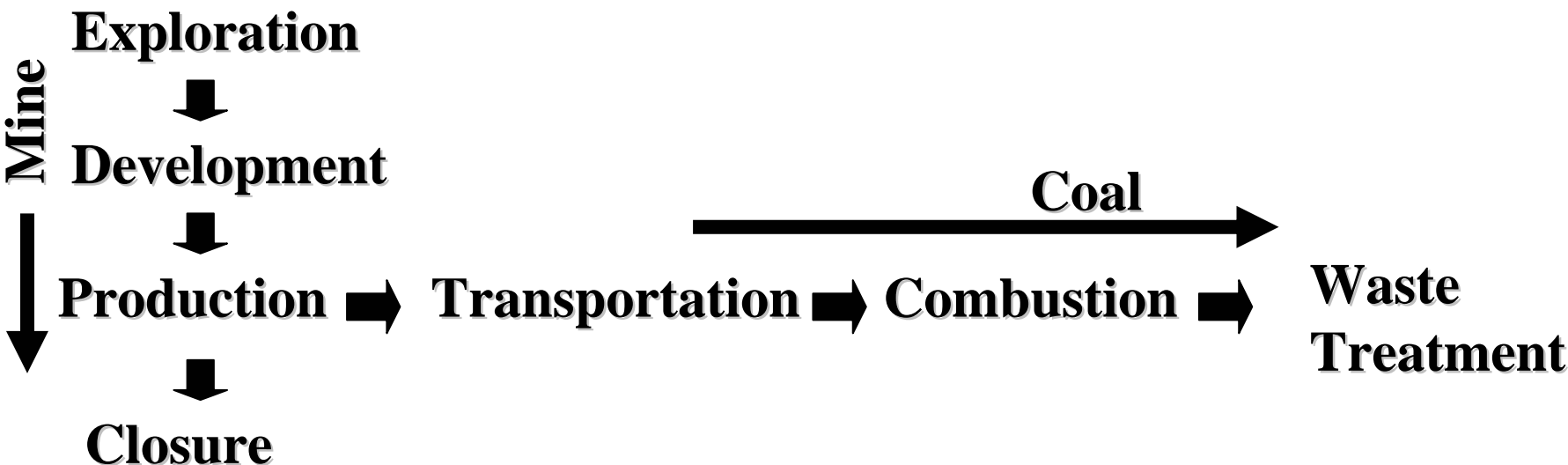
CBM Price = imported LNG (average '91-'00)

excl. sequestered CO₂

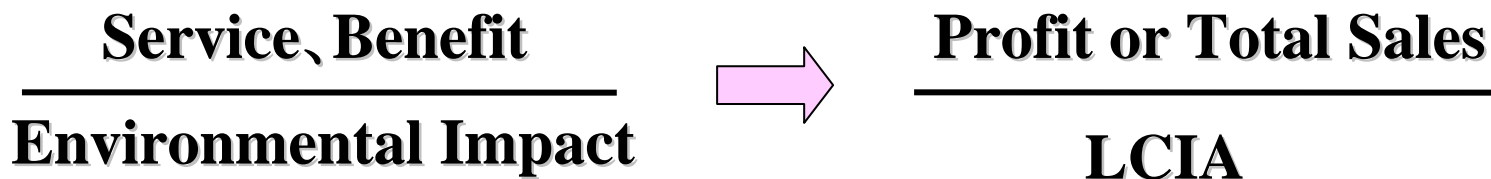
Financial Analysis



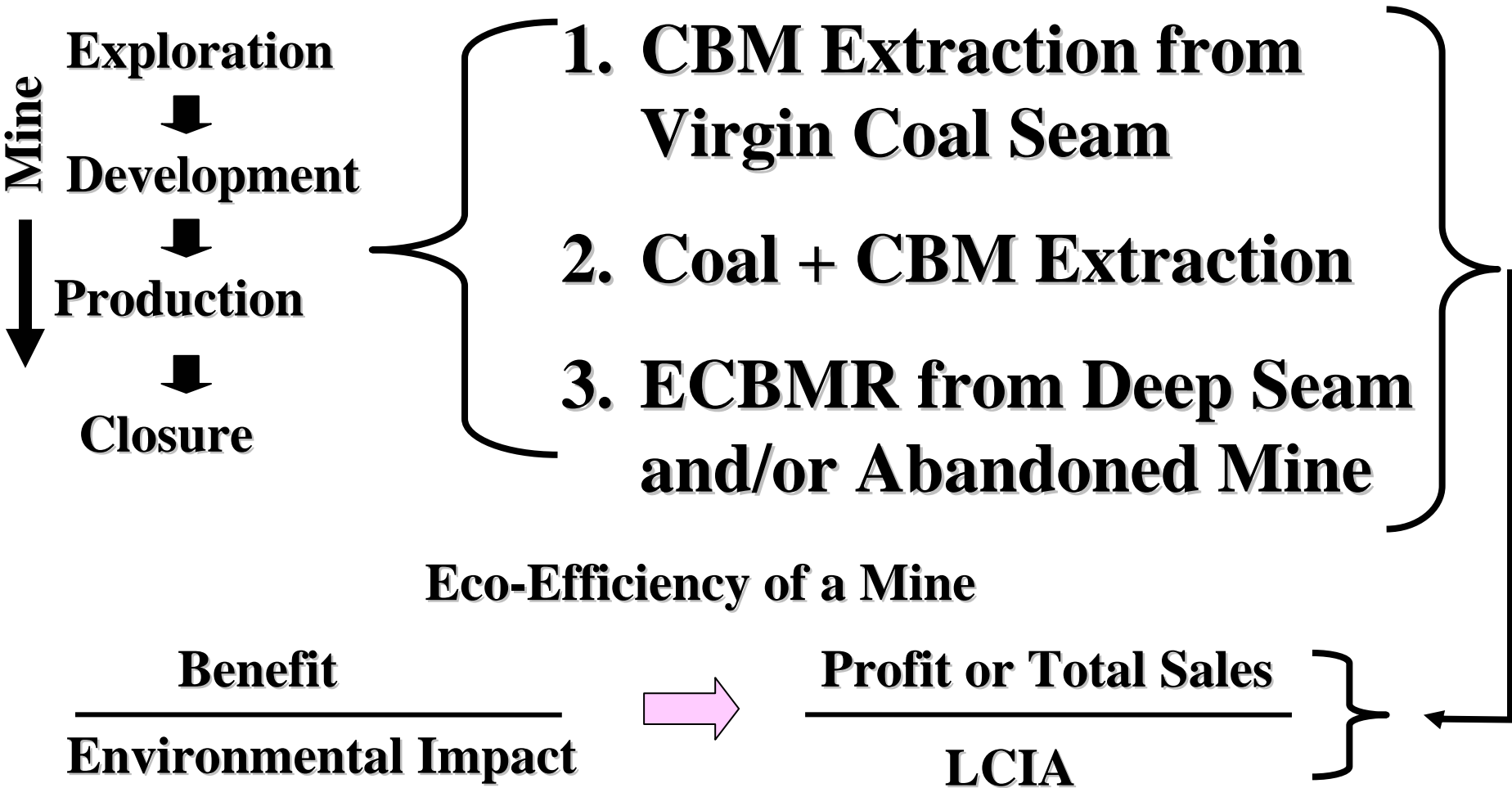
LCA for Mining ex. coal



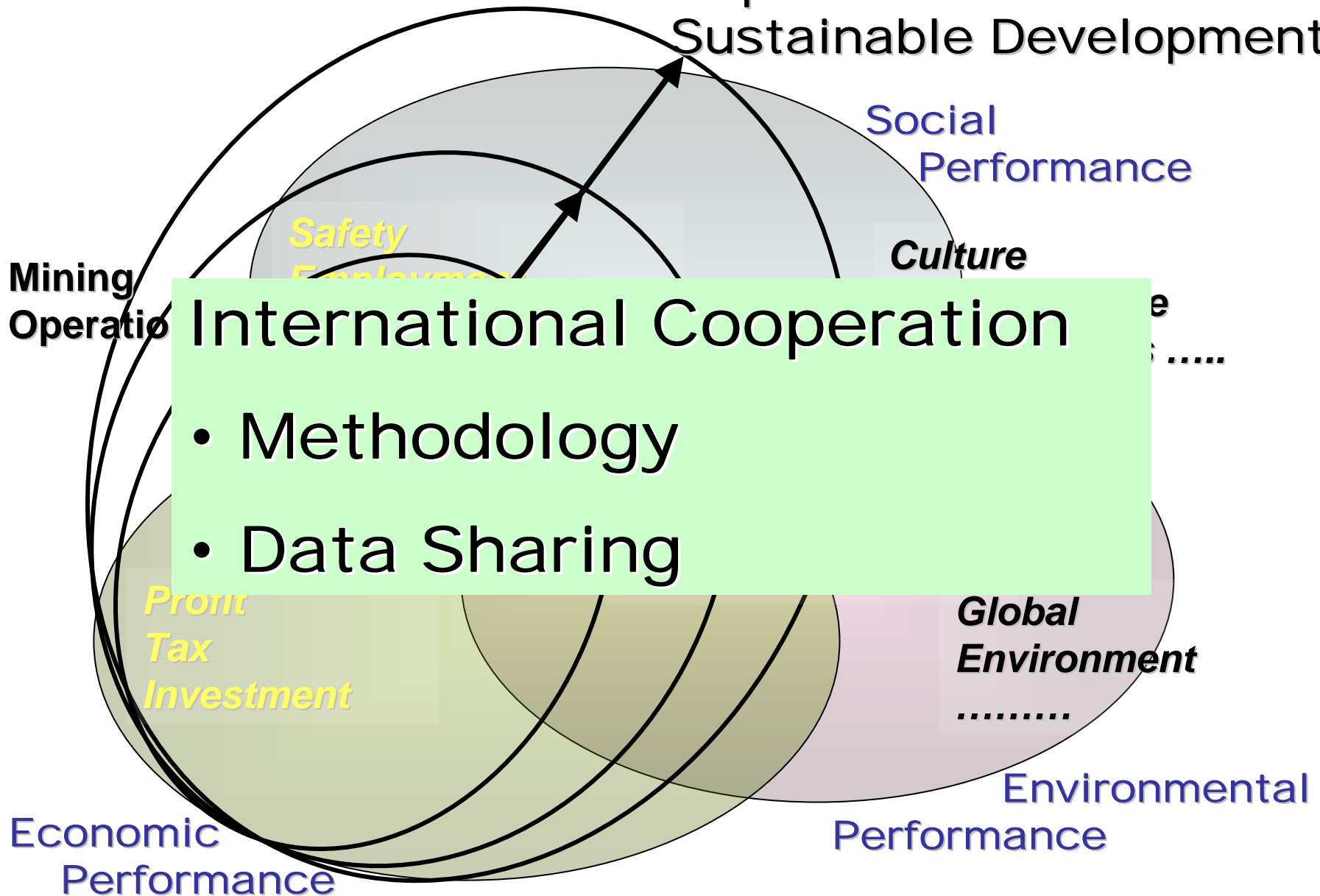
Eco-Efficiency of a Mine



LCA for Mining ex. coal



Triple Bottom Line for Sustainable Development



Lifecycle Environmental Evaluation of Exploitation & CO₂ Sequestration of Coal

by **SAGISAKA M.**

**Life Cycle Assessment Research Centre,
National Institute of Advanced Industrial
Science & Technology (AIST), JAPAN**