Externality Analysis of the Flue Gas Desulphurization System at Mae Moh Lignite-fired Power Plant in Thailand from LCA-*NETS* Point of View

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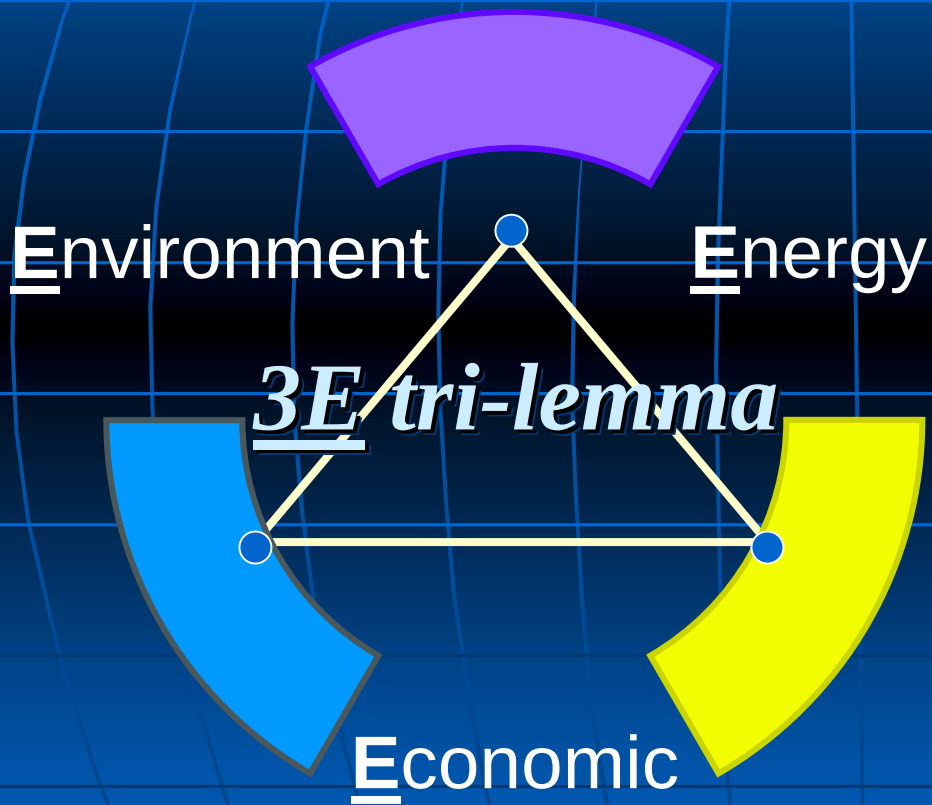
Underlying Causes *Energy, Environment and Economic*



Solution

"Top-runner" approach

Green procurement policy

Eco labeling and green taxation

LCA and LCC

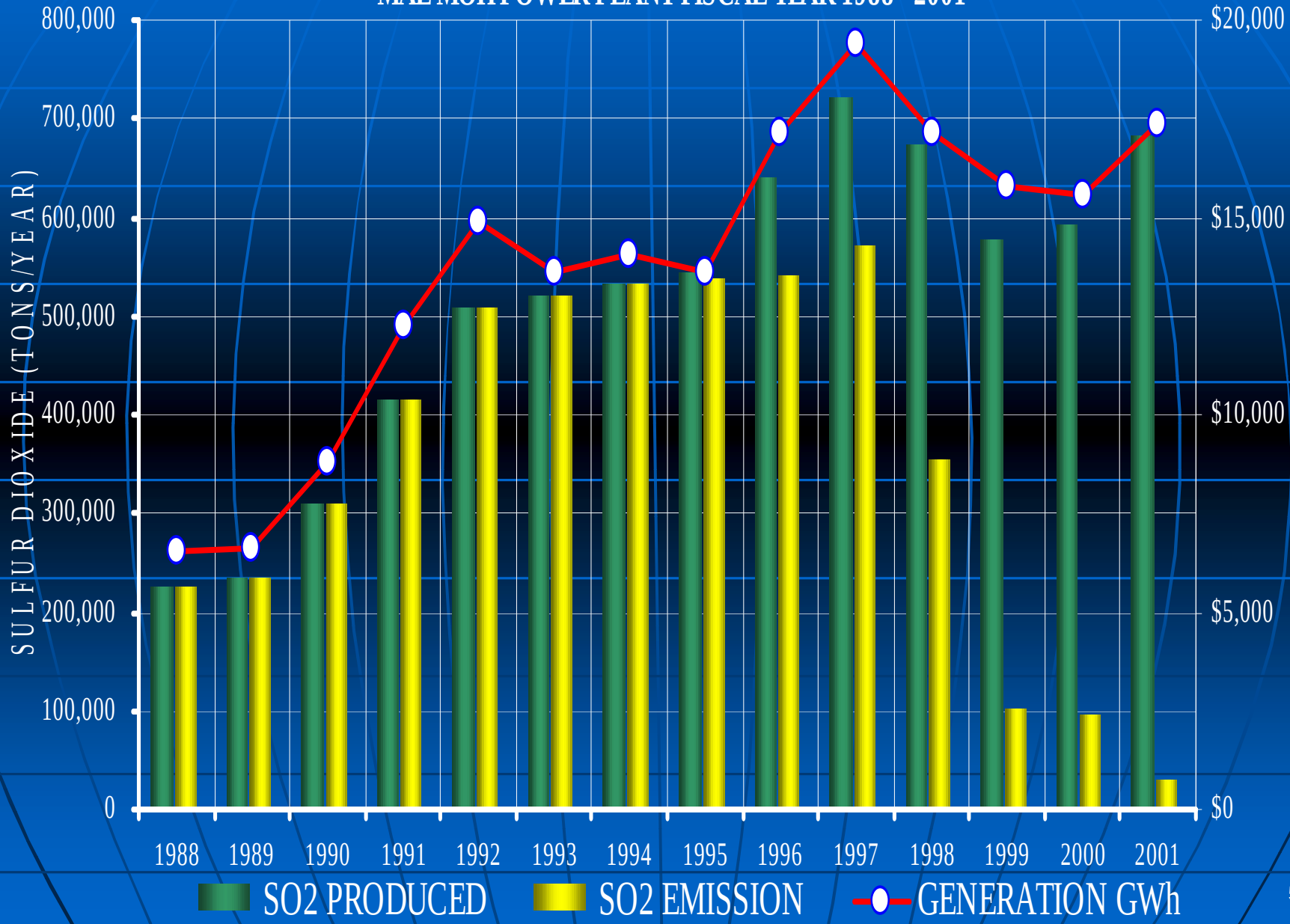
Overview of Mae Moh Power Plant

- Overall capacity 2,625 MW of 13 units
- Largest open mining of Lignite site nearby the power plant
- Lignite proved reserve approximately about 1,332 [Million-ton] could be use more 118 years
- High sulphur content of lignite 2-3% and low calorific heating value 2,750 kcal/kgCoal
- There were serious impacts to the villagers due to SO_2 over emission in 1992 and more than 1,000 people were suffered from the respiratory symptom
- FGD systems have been installed to solve the problem since 1993

FGD: Flue Gas Desulphurization System

- Limestone wet scrubbing systems have been installed for the power generating stations unit 4 to unit 13
- The efficiency of SO_2 demolition are approximately 92 – 97%
- SO2 produced = 0.68 [Mton/year]
- Limestone consumption = 1.20 [Mton/year]
- SO2 Emission = 0.03 [Mton/year]
- Byproduct Gypsum = 1.92 [Mton/year]

SULFUR DIOXIDE FROM MAE-MOH POWER PLANT FISCAL YEAR 1988 - 2001



NETS (Numerical Eco-load Total Standardization)

L-R Tolerance Balance Theory

Loader: Giving allowable environmental load

P_i [kg, kWh,m^3, …, etc.]

Receiver: Received allowable environmental load

MEV_i [NETS]

$$P_i\,[\text{kg, kWh,...}] \times ELM_i \left[\frac{\text{NETS}}{\text{kg, kWh,...}}\right] = MEV_i\,[\text{NETS}]$$

	Environmental load factors	No.	Consolidated standardization values
Global Scale	Depletion of fossil fuel	4	Proven Reserve
	Global warming	43	GHG emissions, GWP
	Ozone layer depletion	24	Emission of CFCs, ODP
	Air and Water pollution	Many	WHO regulation values
District Scale	Acid rain	7	[H+] Concentration in rain
	Waste problem	2	Amount of residuals in disposal

Maximum sufferable load of the biological capacity; e.g., for one person

100 [NETS]

100[NETS/person] x (6.0×10^{9}) persons

= 6.0×10^{11} [*NETS*]

MEV_G

(World population in 1999 = 6.0×10^{9} persons)

Example: Fossil fuel depletion (Oil)

$MEV_G = 6.0\times10^{11}$ [*NETS*]

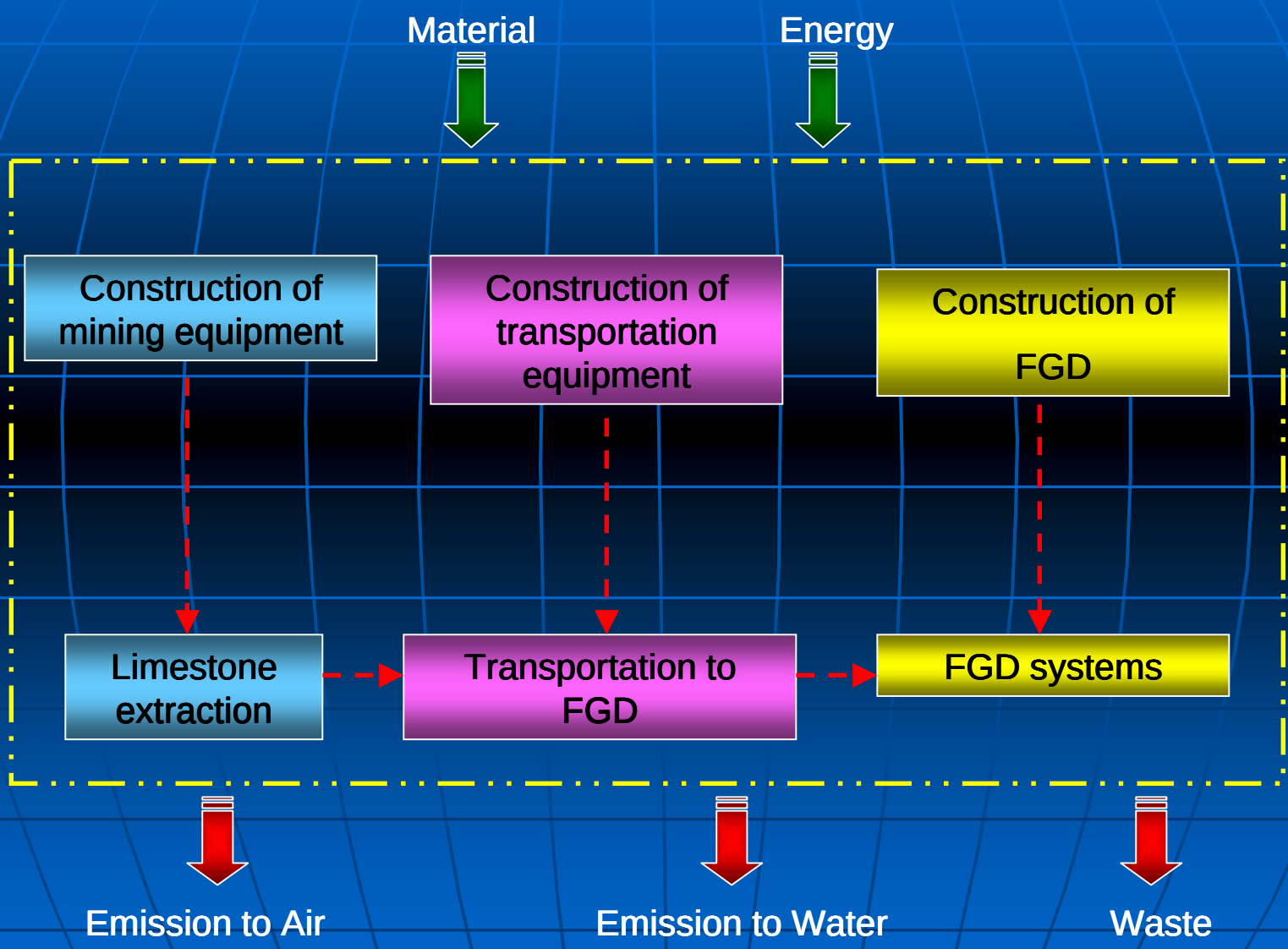
$P_{oil} = 1.46 \times 10^{11}$ton

$$ELM_{Oil} = \frac{(\text{the earth's carrying capacity})}{(\text{Proved reserves})}$$

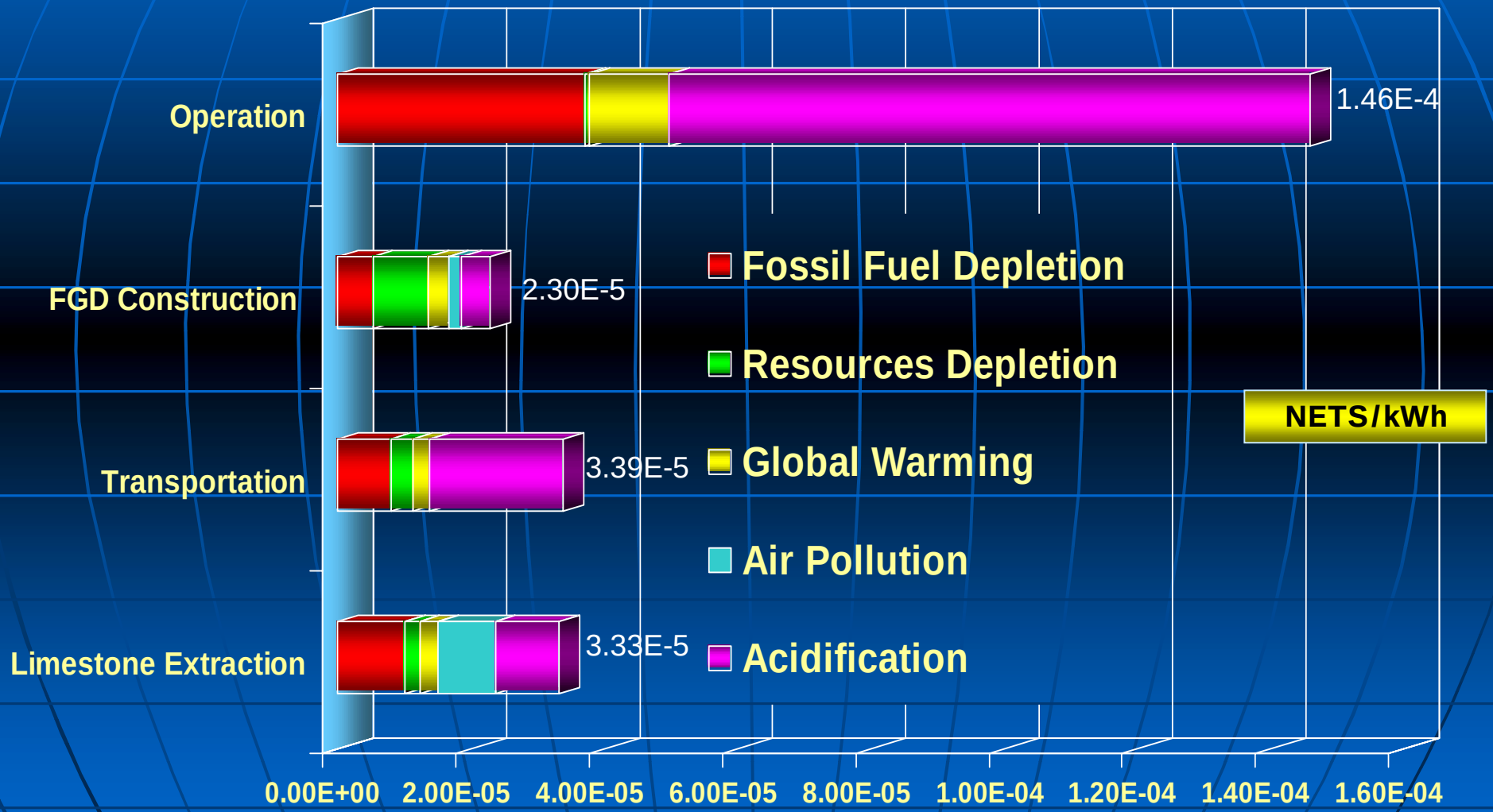
$$= 4.11\,[\text{NETS/ton}]$$

Consumption 1 [ton] → **Give impact 4.11 [*NETS*]**

Process Tree of FGD.



Eco-Load of FGD System at LCA step



LCC Analysis

Unit lifetime [Years]	Up to 30
Investment Cost (8 units)	218.42 Million dollars/year
Maintenance Cost	2.70 Million dollars/year
Operating Cost	18.13 Million dollars/year
Limestone Cost	1.86 Million dollars/year
Others Cost	22.80 Million dollars/year
Interest rate	8%
Rate of growth	5%

$$NPV\ (FGD) = LCC \times \left[\frac{(1+i)^n - 1}{i(1+i)^n} \right]$$

NPV_{FGD} (i=8%, 30 years) = 513.25 Million dollars (467.63 Million Euro)

LCA-NETS & LCC

LCA-NETS Value

LCC Value

$$\text{LCC/LCA [/NETS]} = \frac{\text{Total Cost [Euro]}}{\text{Total Emission [ton } SO_2\text{]*Impacts per unit [NETS/ton } SO_2\text{]}}$$

FGD environmental impact costing = 0.72 Euro/[NETS]

Calculating Externality Costs

- Pollution problems contribute to the externality costs because of it can ruin the society and sometime without any reflection in market system.
- Pollution has occurred since the first step of the energy exploration until the end user. The externality cost should be add up in each step.

- **Externality costs = Size of Insult x VED**
  - **Externality costs = total external cost to society [Euro, dollars, yen, baht,…]**
  - **Size of insult = [NETS]**
  - **VED = Value of environmental damage [Euro/NETS, dollars/NETS,…]**

Externality Cost of FGD

LCA Step	EcL [NETS]	Life Cycle Cost [Million Euro]
Limestone Extraction	4.08E+7	29.36
Transportation	1.01E+8	72.64
FGD Construction	2.03E+7	14.60
FGD Operation	4.86E+8	349.82
Total	6.48E+8	466.42

Benefit & Cost Analysis

BENEFIT	COST
Taxation of SO_2	Cost of SO_2 Reduction
3.50 [Euro/kgSO_2]	0.69 [Euro/kgSO2]
SO_2 demolition	SO_2 Production
654,929.88 [ton]	680,877.67 [ton]
Saving from tax	SO_2 Reduction Cost
2,292.25 [Million. Euro]	469.81 [Million. Euro]

B/C ratio = 4.88

B-C = 1,822.44 Million. Euro

Conclusion

1. LCA-NETS has high potential to diagnose the environmental problems and find the suitable method to improve the power plant system

2. LCA-NETS results indicated that the most serious problem of FGD has occurred when operating than others LCA step.

3. Externality analysis could support to convert the impacts value in [NETS] to be the monetary value [Euro, Dollars, Baht,…]

4. Mae Moh FGD has potential to get the benefit from taxation, this mean that the taxation should be the tool to encourage the power plant and Industries to think more about environmental improvement.

5. For further development, the high efficiency of SO_2 control equipment or new technology of FGD system should be emphasized to minimize the emission and to maximize the efficiency of FGD.

ThAnK yOu FoR yOuR aTtEnTiOn