GASEOUS POLLUTANTS FROM COMBUSTION OF FUELS IN THAILAND

Prida Wibulswas

School of Energy and Materials
King Mongkut's Institute of Technology Thonburi
Bangkok 10140, Thailand

ABSTRACT

Combustion of imported and indigenous fuels in Thailand is now causing serious air pollution problems. Without a compulsory emission standard, a rapid growth in lignite utilization in the country will increase sulphur dioxide emission from about 0.27 M tons in 1987 to 1.52 M tons in the year 2000. High percentages of sulphur in Thai fuel oil and diesel oil contributed about 0.24 M tons of the sulphur dioxide emission in 1987 and 0.39 M tons in 1990.

The content of tetra ethyl lead in Thai gasoline is about 0.40 g/litre which is quite high in comparison to 0.15 g/litre in Singapore and Malaysia. According to measurement taken in 1988-89, lead contents in the air at several locations in Bangkok reached alarming levels close to 7 µg/cu.m of air.

Combustion of petroleum products and natural gas in Thailand produced 43.8 M tons of carbon dioxide in 1987 and will generate about 201 M tons in the year 2000. Contribution from lignite combustion will increase the amount of carbon dioxide emission from 7.5 M tons in 1987 to about 42 M tons in the year 2000. The amount of carbon dioxide emission from the combustion of biomass which accounted for 35% of the total energy consumption in 1987 was approximated at about 35.6 M tons and increased to 38.4 M tons in 1989. Combustion of non-commercial biomass has not been included.

To abate the geseous pollutants, the Thai government has issued improved fuel standards in which the lead content in gasoline will be limited to 0.15 g/litre and the maximum allowable content of sulphur in diesel oil is 0.15 g/litre. New lignite-fired power stations have to be fitted with flue gas desulphurization units.

KEYWORDS

Carbon dioxide, combustion, emission, fuels, sulphur dioxide, tetra ethyl lead.

SULPHUR DIOXIDE EMISSION

Sulphur dioxide is one of the most serious problems caused by combustion of fuels. In 1985, China emitted 12.5 M tons of sulphur dioxide and appeared at the top of the list of the Asian offenders [1]. During the same year, Thailand emitted about 0.43 M tons of sulphur dioxide from combustion of lignite, diesel oil and fuel oil, see Tables 1 and 2, and ranked as the fifth offender in Asia.

Combustion of indigenous lignite is the main contributor of sulphur dioxide emission in Thailand. The consumption of lignite for electricity generation and industries in the country has increased from 5.1 M tons in 1985 to 12.4 M tons in 1990 [2]. It is estimated that at an average growth rate of about 30% per annum, the consumption of lignite in Thailand will reach 38.1 M tons in the year 2000 [3].

Assuming an average sulphur content in the Thai lignite of 2%, the amount of sulphur dioxide emission will increase from 0.50 to 1.5 M tons between 1990 and the year 2000. Lignite fired power station will be responsible for about 90% of the emission [4]. Distributions of lignite consumption and sulphur dioxide emission in electricity generation and industries are shown in Table 1.

Fuel oil which is locally refined and has a high sulphur content also significantly contributes to sulphur dioxide emission. The consumption of fuel oil has grown from 2.15 M tons in 1985 to 2.99 M tons in 1990 [2]. With an average sulphur content of 3%, the amount of sulphur dioxide emission has increased from 0.13 to 0.25 M tons between 1985 and 1990.

The last contributor to sulphur dioxide emission in Thailand is diesel oil. Its consumption has grown from 4.47 M tons in 1985 to 7.42 M tons in 1990. The maximum allowable sulphur content in the Thai diesel oil is quite high at 1 % in comparison to 0.34 and 0.38 % in Hong Kong and Japan respectively. Assuming an average sulphur content in the Thai diesel oil of 0.9 %, the amount of sulphur dioxide emission has increased from 0.086 to 0.134 M tons between 1985 and 1990. Table 2 summarizes the distributions of consumptions and sulphur dioxide emissions from the fuel oil and diesel oil.

At present, the emission standard for sulphur dioxide in Thailand is hardly effective since it is a voluntary standard. Measurements of sulphur dioxide emission from a lignite-fired fluidized -bed boiler on the outskirt of Bangkok exhibited an average value of 700 mg/cu.m [4]. Sulphur dioxide emission from the largest lignite-fired power complex in Thailand was sometimes detected at 3000 mg/cu.m [3]. By the year 2000, the unabated sulphur dioxide emission from the same power complex will be over 1 M tons [4] which are about the same as the total amount emitted in West Germany.

Without a compulsory emission standard, it is estimated that sulphur dioxide emission from the combustion of the three fuels will rapidly increase to 2.2 M tons in the year 2000 in comparison to 0.43 M tons emitted by the combustion of the three fuels in 1985.

CARBON DIOXIDE EMISSION

According to a report by the US-based World Resources Institute, developing nations now emit 45 % of the world's greenhouse gases, though USA and USSR are at the top of the list of the greenhouse offenders contributing 17.6 and 12.0 % of the word total emission respectively [6]. Thailand ranks eighteenth on the list with a contribution of 1.2 %.

One of the main greenhouse gases is carbon dioxide emitted mainly from combustion of fuels containing carbon atoms. In Thailand, petroleum-based fuels including natural gas contribute to the carbon dioxide emission more than biomass fuels.

The consumption of petroleum-based fuels has grown from 10.3 M tons in 1985 to 19.4 M tons in 1990 [2]. As a result, the amount of carbon dioxide emission has increased form 30.2 to 46.9 M tons between 1985 and 1990, assuming an average corbon content in the petroleum products of 80%. By the year 2000, the amount of carbon dioxide emission form petroleum products is estimated at 115 M tons.

With the rapid growth of lignite consumption in the country, if it is assumed that the average carbon content in Thai lignite is about 30%, carbon dioxide from lignite combustion will increase from 13.65 M ton in 1990 to 41.9 M tons in the year 2000.

Biomass fuels in Thailand comprise mainly firewood, charcoal, bagasse and rice husk. Accurate determinations of their consumptions are rather difficult, especially the amounts of non-commercial utilization. However, their consumptions in 1987 [7] were approximated at 19.8 M tons from which 35.8 M tons of carbon dioxide were produced by combustion. The total carbon dioxide emission from both petroleum-based and biomass fuels and lignite in 1987 amounted to about 70.4 M tons and increased to 93.5 M tons in 1989, also see Tables 1, 2 & 4.

It should be noted that about 40 M tons of agricultural residues such as rice straw, stalks of maize, cassava, mungbean, sorghum, soybean and cotton, etc. are generated annually [8]. They are normally burned in the fields to fertilize the soils or to destroy as waste materials. Amounts of carbon dioxide produced from these agricultural residues are being estimated.

EMISSION OF LEAD COMPOUNDS

Tetra ethyl lead is widely used as an additive to increase the octane number of gasoline as it is much cheaper than alternative additives. Upon combustion in gasoline engines, lead oxide and lead sulphate are produced and over 70 % are emitted into the air.

The maximum allowable amount of lead in Thai gasoline is relatively high at 0.40 g/litre [9] in comparison to 0.21 and 0.15 g/litre in Japan and 0.15 g/litre in both Malaysia and Singapore respectively. The consumption of gasoline in Thailand increased from 1.56 M tons in 1985 to 2.58 M tons in 1990 [2] and as a result, lead emission grew from about 780 tons to 1330 tons respectively.

Table 1 Lignite Consumption [3] and Emissions, M tons

	1985	1987	1990	1995	2000
Consumptions					
Electricity	4.60	5.73	9.65	20.8	34.0
Industry	0.53	1.09	2.77	3.3	4.1
Total	5.13	6.82	12.42	24.1	38.1
Emission, M tons					
Sulphur dioxide	0.21	0.27	0.50	0.96	1.52
Carbon dioxide	5.64	7.50	13.65	26.5	41.9

Table 2 Petroleum Products' Consumption [2] and Emissions, M tons.

	1985	1987	1990	1995	2000
Diesel Oil:					
Consumption	4.76	5.54	7.42	12.3	18.0
Sulphur dioxide	0.09	0.10	0.134	0.22	0.32
Fuel Oil:					
Consumption	2.15	2.21	2.99	5.85	7.35
Sulphur dioxide	0.13	0.14	0.25	0.35	0.44
Gasoline:					
Consumption	1.56	1.994	2.58	4.35	6.06
Lead, k tons	0.69	1.16	1.33	2.60	3.61
Petroleum products:					
Consumption	10.3	11.8	19.4	29.2	39.3
Carbon dioxide	30.2	34.6	56.9	85.7	115.2

Table 3 Natural Gas Consumption and Carbon Dioxide Emission.

Comsumpton	
Carbon Dioxide	

Table 4 Biomass Consumption [7] and Carbon Dioxide Emission, M tons.

	Consumption		Av. Carbon	Carbon Dioxide	
	1987	1989	Content, %	1987	1989
Firewood	7.5	7.4	50	13.8	13.6
Charcoal	3.1	2.9	98	11.1	10.5
Rice husk	2.3	2.6	60	5.1	5.7
Bagasse	6.9	10.6	22	5.6	8.6
Total	19.8	23.5		35.6	38.4

Table 5 Tentative Thai Emission Standard [11]

Pollutant	Source	Limiting Value
Sulphur dioxide	Bangkok	400 ppm
	Others	700 ppm
Nitrogen oxides	Combustion	1000 mg/m^3
Carbon monoxide	All sources	1000 mg/m^3

Sulphur Dioxide Estimation:

Combustion Equation, $S + O_2 \longrightarrow SO_2$
Mass, 32 64

If s = mass fraction of sulphur in a fuel,
M = mass of the fuel,

Amount of sulphur dioxide emission = 64 sM/32
= 2 sM.

Carbon Dioxide Estimation:

Combustion Equation, $C + O_2 \longrightarrow CO_2$
Mass, 12 44

If c = mass fraction of carbon in a fuel,
M = mass of the fuel,

Amount of carbon dioxide emission = 44 cM/12
= 3.67 cM

Measurement of lead contents in the air in Bangkok during 1988-89 indicated that at several locations, alarming levels of the lead contents were reached, for examples, 6.9 and 6.3 µg/cu.m of air at the Great Circle and Din Daeng Toll Gate. It should be mentioned that the air quality standard in Thailand limits the lead content at 10 µg/cu.m of air.

Realizing the danger of lead emission, the Thai government has stated a policy to reduce the maximum allowable lead content in Thai gasoline down to 0.15 g/litre within 1993. As the first step, local production of methyl tertiary butyl ether as a cleaner additive will be granted investment privileges. At the same time, feasibility of production on ethyl alcohol as an alternative additive is being studied as Thailand produces several types of raw materials suitable for ethanol production such as cassava, sugar cane, corn, etc. and their exports now become more difficult.

A research institute in Thailand has recommended that though non-leaded gasoline is now available in Bangkok, it should be available in the whole country by 1993 so that calalytic converters can be installed in all new cars then [12]. However, the environmental impacts of mitrogen oxide and carbon monoxide in the country should be clearly determined in order to justify the cost of imported catalytic converters at about 250 M USD per annum.

CONCLUSIONS AND RECOMMENDATIONS

The recommended Thai emission standard on sulphur dioxide emission is quite mild in comparison to the compulsory standards in West European countries [10]. The standard should be made mandatary as soon as possible. Otherwise, by the year 2000, the total amount of sulphur dioxide emitted in Thailand will exceed those in Korea, Japan, Italy, etc. Neigh/bouring countries may be affected by acid rain then.

As a result of combustion of commercial fuels, Thailand position is not low on the list of greenhouse offenders [6], and biomass fuels account for more than 50 % of the carbon dioxide emission in the country. As the biomass will remain one of the main sources of energy in Thailand for at least two decades, accelerated reforestation programme can help reduce the amount of carbon dioxide emission in the country.

Though the Thai government's policy is to reduce the lead content in gasoline down to 0.15 g/litre by 1993, non-leaded gasoline has already been available in Thailand. Comparative merits between methyl tertiary butyl ether and ethyl alcohol as additives should also be thoroughly studied.

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