ENVIRONMENTAL IMPACTS OF COMMERCIAL ENERGY UTILIZATION IN SRI LANKA

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1. OVERVIEW

Petroleum products, coal and electricity are the commonly known commercial energy sources. World commercial energy consumption has increased more than three-fold over the past three decades. Oil is the main commercial fuel in North America, Western Europe, Japan and in developing countries. Consumption of the world's commercial energy resources is heavily concentrated in the developed regions - the industrial market economies and centrally planned economies. Though, these regions account only for 30 percent of the global population, they consume 85 percent of the total world production of commercial energy. The other 70 percent of the population comprising the developing countries consume about 15 percent. (1)

In Sri Lanka, 6.6 million tonnes of oil equivalent of total energy was supplied in 1989, the share of commercial energy (electricity, petroleum and gas) was 1.9 million tonnes of oil equivalent or 29 percent. The balance 71 pent was from fuelwood, charcoal and bagasse. Of the gross commercial energy supplied, petroleum contributed 61 percent, electricity 35 percent, LPG 3 percent and coal 0.06 percent. Sectoral consumption of commercial energy in 1989 divides into transport - 55 percent, household - 20 percent, industry - 18 percent, agriculture - 2 percent, and commercial and others - 4 percent. (2)

Hydro remains the major source of electricity, supplying 2800 GWh in 1989. Thermal generation accounted for 56 GWh. Impacts associated with the generation of hydro-power, is linked to the construction of dams and reservoirs. No major impacts can be expected from thermal sources at present, in view of its limited use. But environmental safeguards will be required when thermal plants are continuously operated or when new plants are planned. From the preceding paragraph it is evident, that the transportation sector is the largest consumer of commercial energy. The principal environmental impact associated with transportation is air pollution. The major focus of this paper will be the impact of commercial energy sources on air quality.

National Environmental (Amendment) Act of 1988 gives the Central Environmental Authority (CEA), among other powers, the functions: to control the discharge, emission or disposal of wastes into the environment; and to subject development activities (prescribed projects) to Environmental Impact Assessment (EIA) at the project planning stage. The former has been given operational effect through the National Environmental (Protection and Quality) Regulations No 1 of 1990. Regulations making EIA mandatory have been drafted

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and is expected to become law in late 1991. Both these legal instruments govern existing and proposed power-plants for ensurance of environmental protection. However, with respect to mobile sources know such regulations have been drafted to-date.

2. ESTIMATED EMISSIONS FROM COMBUSTION SOURCES

Petroleum and coal that exist in nature contain carbon, hydrogen and several other impurities. Complete combustion of carbon with air will produce carbon dioxide, while incomplete combustion results in carbon monoxide and sometimes unburnt hydrocarbons. Carbon monoxide in high concentration causes death. Burning of fossil fuels release carbon dioxide in large quantities, and the accumulation of this in the atmosphere, warms the earth. This phenomenon is known as the *green house effect*. Oxides of Nitrogen (NO_x)are also combustion products. Sulphur compounds in fossil fuels also release sulphur-dioxide and -trioxide (SO_2 and SO_3) during combustion. NO_x and SO_2 cause acid rain.

Of all the fossil fuels, petroleum is the one most commonly used in Sri Lanka. Crude petroleum is imported and refined to lighter fractions for further use. Transport sector accounts for 60 percent of the petroleum consumption. There are over 700,000 registered vehicles plying on Sri Lankan roads. Nearly two-thirds of these vehicles are concentrated in the urban areas of Colombo district. The number of vehicles registered annually island-wide between 1970 and 1990 increased 14-fold. The Ceylon Electricity Board has two diesel generating units with a total capacity of 260 MW, mainly used for standby operations. The industrial sector uses oil in boiler operations. Kerosene is used mainly for lighting in the domestic sector. There hardly exists any emission control measures in the industrial, transportation and power generation sectors to minimize air pollution.

Emissions from petroleum combustion sources, have been estimated from petroleum consumption data and emission factors. No emission control was assumed. Petroleum consumption data was obtained from *The Sri Lanka Energy Balance and Energy Data 1989 (CEB)*. The emission factors were based on *Rapid Assessment of Sources of Air, Water and Land Pollution (WHO, 1982)* along with *US EPA's Air Pollutant Emission Factors (EPA, AP-42, 1976)*. Petroleum consumption data and emission factors are given in tables 1 and 2.

TABLE 1
PETROLEUM CONSUMPTION BY SECTORS
('000 MT)

SECTOR	DIESEL	HEAVY DIESEL	PETROL	FUEL OIL	RESIDUAL OIL	KEROSENE	LP GAS
TRANSPORT							
* CTB Buses	72.541						
* Private Buses	105.24						
* Lorries, Vans, Jeeps	280.33						
* Cars			158.437				
* Railway	17.078						
INDUSTRY		19.49	3.5	143.465			
HOUSEHOLD						167.086	24.348
AGRICULTURE	24.38					20.4	
POWER GENERATION		1.404		1.380	10.630		
COMMERCIAL	9.366						4.427

Source: Sri Lanka Energy Balance and Energy Data, CEB, 1989

TABLE 2

EMISSION FACTORS FOR COMBUSTION SOURCES (Kg/Ton of Fuel)

SOURCES	TYPE OF FUEL	SPM	SO_2	NO_x	HC	CO
POWER PLANTS	Fuel oil residue	1.04	69.6	13.2	0.13	0.66
	Natural gas	0.29	0.056	11.5	0.019	0.32
	Lignite	56	30	8	0.5	0.5
	Coal	1.2	13.3	9	0.15	0.5
INDUSTRIAL	Diesel	2.13	20.1	7.5	0.41	0.59
AND	LPG	0.38	0.0008	2.6	0.05	0.35
COMMERCIAL	Fuel oil distillate	2.13	60.3	7.5	0.41	0.59
FURNACES	Kerosene	3	3.4	2.3	0.4	0.25
	Natural gas	0.34	0.056	3.6	0.058	0.32
	Coal/lignite	56	30	3	0.5	1
DOMESTIC	LPG	0.42	0.0008	1.8	0.17	0.44
FURNACES	Fuel oil distillate	1.42	60.3	1.8	0.41	0.71
	Bagasse	?	-	0.6	-	-
	Fuel wood	13.7	0.5	5	1	1
VEHICLES	Gasoline	2.0	0.54	10.3	14.5	377
	Diesel	2.4	19	11	2.6	43.5
	LPG	0.03	-	0.52	0.28	1.7
BOATS	Diesel	-	2.7	27	5.1	11

Sources: WHO, 1982 and USEPA 1976

Only the major air pollutants like suspended particulate matter, SO_2, NO_x, CO and hydrocarbons have been included in this inventorization. The computation of the inventory is shown in table 3. The transportation sector is the biggest contributor of pollutants to the environment. The emissions from other sectors are fairly low, excepting in the case of sulphur dioxide, where the industrial sector accounts for nearly half of the total emissions. By and large carbon monoxide is the largest pollutant being emitted and followed by sulphur dioxide.

TABLE 3

ESTIMATED EMISSION FROM PETROLEUM COMBUSTION SOURCES
(TONS/YEAR AND PERCENT)

SOURCES	SPM	SO_2	NO_x	HC	CO
TRANSPORT	1,460	9,115	6,870	3,548	80,779
%	59	45	76	93	98
INDUSTRY	348	9,043	1,222	67	96
%	14	44	13	2	<1
POWER GENERATION	17	851	161	3	9
%	<1	4	2	<1	<1
COMMERCIAL	22	188	82	7	8
%	1	1	1	<1	<1
AGRICULTURE	120	532	315	71	1,066
%	5	3	3	2	1
HOUSEHOLD	511	508	428	71	53
%	21	3	5	2	<1
TOTAL	2,478	20,297	9,078	3,767	82,011

Table 4 gives category-wise emission of pollutants in the transport sector. Of all petroleum combustion emissions, vehicles produce 98 per cent of the carbon monoxide, 93 per cent of the hydro-carbons, 76 per cent of the oxides nitrogen, 59 per cent of particulates and 45 per cent of sulphur dioxide. Buses and trucks are the major offenders responsible for two/thirds or more of all the vehicle emissions other than carbon monoxide. The amount of lead emitted has not been estimated. Lead in the form of tetra ethyl lead is added at the rate of 0.34 - 0.55 grams per litre to petrol to improve the octane rating.

TABLE 4
CATEGORY-WISE ESTIMATION OF POLLUTANTS IN THE TRANSPORT SECTOR (TONS/YEAR)

SOURCES	SPM	SO_2	NO_x	HC	CO
TRANSPORT					
* State Buses	174	1,378	798	189	3,156
* Private Buses	253	2,000	1,158	274	4,578
* Lorries, Vans, Jeeps	673	5,326	3,084	729	12,194
* Cars (Petrol)	319	86	1,642	2,312	60,108
* Railway	41	325	188	44	743
TOTAL	1,460	9,115	6,870	3,548	80,779

The above inventorization of combustion sources is based on the assumption that emission factors given in table 2, is applicable in the Sri Lankan context, too. These figures have to be verified with field monitoring data, which of course is not possible at present, in the absence of reliable monitoring data.

3. ENVIRONMENTAL AND HEALTH IMPACTS

The known effects of common air pollutants in excessive concentrations, are listed below (4).

Sulphur dioxide - General: corrosion of metals; deterioration of electrical contacts, paper, textiles, leather, finishes and coatings, building stone; formation of acid rain; leaf damage, reduced growth in plants; impairment of visibility.
Health: Aggravation of respiratory diseases, including asthma, chronic bronchitis, emphysema; reduced lung function; irritation or eyes, respiratoy tract; increased mortality.

Oxides of Nitrogen - General: Fading of paints, dyes; impairment of visibility; reduced growth premature leaf drops in planets; formation of acid rain.
Health: Aggravation of respiratory illnesses

Carbon monoxide - Health: Some reduced tolerance for exercise, impairment of mental function and fetal development, death at high levels.

Lead - Health: Accumulation in body organs; anemia; kidney damage; central nervous system damage.

4. MONITORING

Ad hoc studies have been done in the past to estimate the emissions from mobile and stationary sources and status of ambient air quality. The National Building Research Organization (NBRO) initiated the three-year Colombo Air Quality Monitoring Programme (CAMP) in 1989 in two phases. The phase 1 which is nearing completion, measured basic indicators like sulphation rate and dust fall in 52 locations, city-wide. Nearly 15 locations were found to have unsatisfactory air quality (high levels of sulphation rate and dust fall) and the remaining 37 varied between excellent to moderate. These 15 locations are being taken up for further detailed monitoring in the second phase to estimate SO_2, NO_x and CO. This phase should yield the required data to develop the National Ambient Air Quality Standards. Monitoring of emissions from stationary or mobile sources is usually done on a need basis presently.

5. STANDARD SETTING AND CRITERIA

Section 23J of the National Environmental (Amendment) Act of 1988, stipulates that discharge or emission of waste into the atmosphere should be in accordance with standards and criteria prescribed under the act. Further, section 23K prescribes the actions (burning of waste, gaseous emission from stationary and mobile sources, etc.,) that may be considered to contravene the provisions of the act and also spells out the penalties in the event of an offence. In view of this provision in the Act, standard setting assumes importance.

According to Lohani (3) based on McKee and Wolf, *the term standard applies to any definite rule, principle, or measure established by authority. This makes it quite rigid, official or quasi-legal. It does not necessarily mean that the standard is fair, equitable, or based on sound scientific knowledge, for it may have been established somewhat arbitrarily on the basis of inadequate technical data tempered by a cautious factor of safety.* The same authors have defined a *criterion* as a means by which anything is tried in forming a correct judgement respecting it.

There are two types of air quality standards: emission and ambient. The main criteria that are considered while developing such standards are its ability to protect public health, eco-systems, property and economic values to desired levels.

1) Emission standards

These prescribe levels to be maintained at the polluting source, and is often based on the features and characteristics of the polluting source and the sensitivity of the location of the source. Air pollution emission control standards are of two types:- stationary sources and mobile sources. The former specifies limits for suspended particulate matter and different gaseous pollutants, for sources like industries, power plants and incinerators. The latter is chiefly concerned with vehicle exhaust emissions. The past practice has been to base emission standards on concentration values (eg. ppm or g/m3), but this is gradually being replaced by pollution loads (eg. kg/d of pollutant), especially for stationary sources.

2) Ambient standards

Ambient standards usually specifies permissible concentrations of pollutants in a particular area at any given time. These standards are very difficult to enforce for purpose of conviction. Ambient standards are very good indicators to plan future development activities within a given location. The basis for ambient standards lie in past monitoring data which has to be reliable to make it acceptable. Also, another factors which plays an important role is the response rate and reaction time of any pollutant. USA prescribes, for example, three different time-weighted standards of 24, 8, and 3 hours - the last being an emergency response situation.

Development of standards should be approached in a careful manner. Unrealistic standards could be counterproductive for the purpose of maintaining environmental quality. Stringent standards (beyond the assimilating capacity) could make control measures very expensive. At the same time, lenient standards would lead towards serious problems of environmental and health deterioration. In view of the past difficulties encountered in enforcing standards, it is common to see countries specifying guidelines for ambient air quality which could lead to a standard after it is fully tested.

So far, no air quality standards have been developed in Sri Lanka for commercial energy generation or utilization. This task may have to be embarked upon soon in view of the provisions in the legislation. The first regulation derived from the Act prescribes only standards to control discharge of waste waters. Therefore, to make this regulation more effective, emission standards will have to be developed. Any standard setting should be done after obtaining reliable background data of common air pollutants. Such an estimate would assist in developing realistic and applicable standards.

6. STRATEGIES TO CONTROL AIR POLLUTION

In Sri Lanka, air pollution control measures are almost non-existent. The energy conservation drive of the mid-eighties resulted in improved boiler efficiency in certain large industries, which to a great extent has reduced stack emissions in such industries. The common approach adopted by many countries to reduce air pollution include;

Pre-combustion Techniques

These include the selection of low pollutant fuels for combustion, like low-sulphur fuel or the elimination of lead additives in petrol.

Combustion Modification

Advanced and costly techniques are used to control SO2 and NO_x emissions. Eg. No_x burners and fluidised bed combustion.

Post-combustion Control

The removal of pollutants from flue gases and vehicle exhausts. This is also costly. Eg. Flue gas desulphurisation in power plants, catalytic converters in vehicles.

New Processes

The development and introduction of new processes and technologies in industrial, power and transport sectors, have lead to significant reduction in pollutant emissions.

Energy Efficiency/Conservation

The adoption of conservation measures have effectively reduced the consumption of fossil fuel.

7. CONCLUSION

Transport sector accounts for most of the air pollution caused by the utilization of commercial energy. Vehicles produce 98 per cent of the carbon monoxide, 93 per cent of the hydro-carbons, 76 per cent of the oxides nitrogen, 59 per cent of particulates and 45 per cent of sulphur dioxide. Buses and trucks are the major offenders responsible for two/thirds or more of all the vehicle emissions other than carbon monoxide. Therefore, any action taken to curb environmental deterioration caused by commercial energy utilization should be directed to control emissions from vehicles. As a priority, vehicle emission control system should be developed.

The development of standards should be approached carefully. Vehicle emission standards are needed urgently to take curative steps. Standards for stationary sources have to be specified to comply with the regulations and control stack emissions from industries and power plants, and also serve as guidelines for future planning. Application of standards should be backed by a system of monitoring, surveillance and enforcement.

The present ambient monitoring programme is expected to produce the air quality trend data for the Colombo City. If possible, this should be expanded and made islandwide. Stack or tail-pipe monitoring is almost non-existent, steps should be initiated to bridge this gap. Monitoring data greatly influence standard setting or guideline formulation.

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