OIL USAGE AND AIR POLLUTION

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Introduction

We are all only too well aware of the impact on each of our lives of the so-called "energy crisis" thrust upon the Western World in the last quarter of 1973 resulting in higher costs, threats of perpetual shortage and possibly even non-availability, of Oil - a fossil fuel originating from the bowels of the earth hitherto considered to have been of endless availability and both cheap and very convenient to use, as its growth rate world-wide only too amply illustrated.

Of all the oil produced world-wide, almost 85% is used as a source of energy, i.e. it is burnt as a fuel and the products of combustion dispersed into the atmosphere. Despite the ease and efficiency with which it is burnt and used, and the relative cleanliness of its combustion, the rapid growth of its use, particularly in densely populated areas, has inevitably given rise to air pollution problems - for example, vehicle emissions from the use of petrol, sulphur dioxide emissions from the use of heavy fuel oils, to name but two of popular concern.

Vast technological efforts were, and still are, being directed to reducing pollution from the combustion of oil in its various forms, and with marked, even if not complete nor necessarily cheap, success. But, until the "crisis", little acceptance was given to reducing the consumption of oil and reducing pollution by this means - for example, people still wanted their large 3,4 or 5 litre engined cars for single occupant urban commuting - adding to traffic, roadway and parking problems as well as intensifying the pollution one. Our desire for ever-improving standards of living demanded an ever-increasing energy supply and ever-increasing consumption of fossil fuels to provide it - often to wasteful proportions. In the U.S.A., for example, - the world's largest per capita energy consumer - 25% of its total energy consumption was, in 1970,[1] being used for domestic and commercial purposes - principally to provide the "shirt sleeve" environment winter and summer alike - as much as the percentage total energy used for transportation. Moreover, almost as much (49%) of the total energy consumed was being wasted in the form of energy losses - electricity generation and transmission 70% of sector energy use; domestic and commercial 25%; industrial 25% and transportation 75% - and only 51% used in the form of useful work and heat. Projections of energy flow in the U.S. for the year 2000[2] show a wastage of 55,5% of total energy consumed, and we would think this a more realistic figure even for present day manners of use!

Despite the banning of Arab oil during a period of peak demand (last winter), the U.S. was well able to ease up on its demands and conserve available supplies with little real distress.

Even for the wealthier nations of the world, the higher cost of oil can only help to foster conservation of its use and reduce the growing rate of air pollution to which it contributes. At the same time, with the growing awareness of its eventual drying-up, a spur must be given to the intensive development of alternative, hopefully non-polluting, sources of energy - to take full advantage of the lead time we still have to do this.

In the meantime, a resurgence of interest in coal has taken place. Up to this time last year, coal was a dirty word: now its place in our vocabulary has been taken, even if ineptly, by oil. The pique of higher cost, even though hurtful both to the individual and (more so) to the nation, is not however justified, and oil, intelligently used, will continue to be used necessarily and economically for many years to come - bridging the energy gap - with, in South Africa's case, little change in its present pattern of use.

Changing Values

Of Crude Oil to Importing Nations

The Crude Oil requirements of importing nations have of course to be paid for with, often hard-earned, foreign exchange and the virtual fourfold increase in costs imposed in October and January last by member countries of OPEC (Organisation of Petroleum Exporting Countries) have caused balance of payments problems to varying drastic degrees according to the dependence of the importing country on imported oil as a source of energy. The national economies of all main industrialised countries have been seriously affected, with even threats of massive unemployment looming on the horizon. Even with ultimate user economies in use of petroleum fuels resulting from the greatly increased costs, growing balance of payment problems may necessitate governments adding mandatory restrictions on oil usage.

Countries in Western Europe and Japan, which are very dependent on imported oil supplies, are all suffering badly, and it is only by dint of judicious management of overall economic affairs that they can hope for economic survival.

Moreover, apart from the unilateral action of OPEC countries in raising the so-called "Posted Tax Reference Prices" (responsible for the October and January increases), there is the growing task of producing country (host) governments in so-called "participation oil" - that share of production that they themselves have negotiated (opted?) a right to and can sell either back to the participant producing Oil Companies - "buy back" oil - or direct to anyone else - "direct deal" oil - as the participation agreement may decree. The position is such that last year producing Oil Companies controlled 78% of OPEC production but next year ('75) are expected to control as little as 26%. Thus, with the reducing amounts of "equity oil" (Co.-owned Oil) available to Oil Companies, their total demands to meet their own commitments can only be met with an increasing proportion of more costly "buy-back" oil and yet more costly "direct deal" oil (the latter at virtually the Posted Tax Reference Price) - the total cost of which must of course be met by the importing nation. It is to be hoped that we are spared any further drastic increases in Crude Oil costs, but increases there certainly will be as time passes by - even if only in sympathy with world inflation rates. This prospect naturally strengthens the determination of individuals and governments to reduce their dependence on OPEC oil, by more rapid exploitation of oil resources in other parts of the world and by the active development of all alternative forms of energy.

In South Africa, we are indeed fortunate that oil provides only approximately 20% of our energy requirements - that portion used mainly in an indispensible "convenience" form, as fuel for engines in road, rail, air and (local) marine transportation, in civil engineering work, mining operations, agriculture, etc. where mobility is required. Even so, from a cost of approximately 4% of our total foreign exchange expenditure before the "crisis", an increase to 18% or so as of now can be only of great concern to any Minister of Economic Affairs, especially with escalations in cost of other goods and services we must import, and with little compensating increase in earnings from exports. Oil is by no means a luxury for us, and it is a matter of delicate management of our overall economic affairs and economic growth that, barring any outside political interferences, the continued availability of imported oil to satisfy our essential convenience needs depend. (The situation would of course be considerably relieved if we were to find oil in South African waters but, whilst we can remain hopeful and must continue our efforts, we cannot rely on it).

Changing Values

Of Oil Products to the User
To offset the increased costs of crude oil effected by the "crisis", selling prices of refined oil products have been increased accordingly. Generally, the increases reflect the local currency equivalent of the increased unit cost of the crude oil.

The resulting increase in cost of the refined product to the user naturally promotes considerations of economy in use and possibilities of changing to an alternative cheaper source of energy. However, the percentage increase in product cost to the user is not reflected to anything like the same extent in the total cost of what the product is used for, as the former is only part of the total cost of the operation, process or manufacture concerned.

In the case of motoring for example, using AA figures [3], the petrol cost in August 1973 was 15% of the total motoring cost yet, despite an increase of 25 - 30% in petrol cost (not as much as the direct increase in view of speed restrictions and resultant fuel saving), one year later (August 1974) it still only amounts to 17 - 18% of the total motoring cost. Meantime, of course, other constituent costs have also changed and the total motoring cost is approximately 12% up over the year. It is significant that of this increase only approximately 1/5th is due to increased fuel cost, i.e. 2 - 3% on the total.

Petrol, Jet Fuel, Diesel Fuel and even Marine Bunker Fuel (similar to Heavy Furnace Fuel) are still indispensable sources of energy and, despite increases on total operating costs of less than 10% (though maybe up to 30% for ship's bunkers), still provide the most economic and practical fuels for transportation and mobile use purposes.

In industrial steam raising or heating, with the very large increase in the cost of Heavy Furnace Fuel, it is the larger users who have generally suffered from the larger percentage increases. Even so, the overall effect still amounts to no more than an increase of up to 10% or so on total manufacturing costs and, in some cases, can be as little as 1%.

In other end uses similar considerations apply. The cost of solvents for paints and lacquers has doubled, but the increase on total manufacturing cost due to this is only 7 - 10%. Bitumen for road surfacing has also virtually doubled in cost, but the increase on total cost of even a deep asphalt surfaced road due to this is only approximately 20%.

In the inflationary times in which we live it could therefore be easy to dismiss these "small" percentage increases on total costs as being not really significant or worth bothering about, and here lies the danger. The incentive to save on oil consumption is much less than the direct increase in cost might suggest. This is not to say that savings cannot, nor will not, be made, but the overall effect will not be great especially if, by conversion to more efficient methods of use or an alternative energy source or system, large capital expenditure may be incurred.

Economics of Control

The need, manner and pattern of any controls applied to the use of oil will of course depend on a nation's energy consumption pattern, its dependency on oil and economic position, and, where applied, will vary from country to country to suit each case. Energy consumption patterns and dependencies on oil for representative major industrial countries are shown in Table 1.

In South Africa, as we know, oil provides only 20% of our energy requirements - mainly in the form of petrol, Diesel fuel, Jet fuel etc., and apart from marginal savings by more prudent general use of oil by users, it is only with Heavy Furnace Fuel (and possibly with LPG but to an insignificant extent) that there is any real financial incentive to users to convert to or to consider the use of an alternative form of energy - yet Heavy Furnace Fuel accounts for only approximately 10% (excluding marine bunkers) of our refined product usage (and only approximately 2% of our total energy requirement).

In the manufacture of our essential "convenience" fiels from Crude Oil - i.e. petrol, Diesel fuel, Jet fuel, etc. - inevitably we must also produce Heavy Furnace Fuel, not all of which can be taken up as marine bunkers. Whilst, technically, it is possible to break down this part of the crude to increase the yield of lighter products and to finish up with a coke as the residue, this is not, in our circumstances, an economic proposition. Other measures are being taken to reduce the amounts produced, as far as economics permit, but there will still be Heavy Furnace Fuel available for industrial and commercial use where the economics or practicability of conversion do not justify.

Where else therefore can we save? Here, petrol comes into the picture. Quite apart from direct savings in conservation of use brought about by government restrictions, it is not commonly realised that, requiring more processes in its manufacture than any other fuel, a saving of approximately 17% in its demand can save approximately 10% of the total crude oil requirement without affecting the yield of any other products. Thus, as unpopular as they may be, petrol restrictions have more than a direct benefit on reduced crude oil and foreign exchange requirements.

Oil Usage and Air Pollution

The effects of changes in oil usage on air pollution brought about by the "crisis" must be looked at from three standpoints - international, local, and in respect of specific pollutants.

Internationally, with the levelling off of oil consumption world-wide due to user conservation and possible government restrictions, further growth of pollutants originating from the use of oil must, at least in the short term, cease. With the coming on stream of alternative non-restrictive sources - for example, the North Sea, Alaska, Canadian tar sands, etc. - cheaper idigenous oil may permit some increase in total oil usage in the years to come. Meantime, however, there will be some reversion to alternative sources of energy - to coal for example - and newly developed and improved alternative sources may become economically and practically viable. Furthermore, with improvements in, and more widespread application of, pollutant control systems it is possible that, even with growing oil usage, the overall pollutants originating from oil may well in fact decrease.

Locally, both nationally and in urban areas, changes will depend on local energy consumption patterns, concentrations of use and, in highly industrialised areas, the effect of pollutant drift.

In the case of South Africa, oil provides only 20% of our energy requirements - coal providing the remainder (Hydro-electric power is still an insignificant contributor). Hence changes in oil usage will - except for specific pollutants such as CO and lead from petrol, hydrocarbons from petrol evaporation and petroleum solvents - have little significant effect on overall pollutant levels. This we can amplify by examining the position with specific pollutants.

Carbon Monoxide

As a man-made pollutant this originates mainly from the petrol engine, and whilst, in 1968, was estimated[4] as being responsible for approximately 45% of the total global emission (remainder from natural sources), subsequent actions to reduce CO emissions from petrol engines must, despite the growth in global vehicle pollution, have caused a significant decrease. In the U.S. alone, 1970/71 Californian vehicle exhaust emission standards represented a 70% reduction on CO emissions from the uncontrolled vehicle, and 1973 Federal standards a 75% reduction. Elsewhere, in Europe, Japan, etc., vehicle emission controls have also been introduced, even if not to such a low level as in the U.S.A. (approx. 40% reductions).

With a general growing tendency, spurred on by the new very high petrol costs (particularly overseas) for smaller, more efficient, less fuel-consuming engines (which manufacturers themselves are now beginning to provide - more "compacts"), plus yet further improvements in emission controls, a general reduction in CO emissions must take place.

Nevertheless, it is the local concentration that is of concern - areas surrounding busy traffic-jammed streets with many engines idling. Improvements in traffic engineering to assist traffic flow - one way streets, freeways, by-passes, no right turns (lefthand drive countries), etc. - all help to reduce not only the build-up of pollutant concentrations but also wasted fuel, man hours and bad temper. These effects are difficult to quantify and we are left to measuring actual concentrations in critical areas to check that they do not exceed acceptable levels. At present, in this country, such levels are still within acceptable standards[6] and it is to be expected that, aided by improvements such as the foregoing and the growing percentage increase in more recently emission-controlled cars on the road, the day that any government control might be necessary is gradually receding.

Carbon Dioxide

The least noxious of our pollutants and yet, despite forming 10 - 15% or so of all products of combustion, contributes only 10% of the total global emission[4]. Nevertheless the total concentration of CO_2 in the atmosphere is gradually increasing - it has by some 12% over the last 90 years - and this increase suggests that about half of the CO_2 from combustion is being retained in the atmosphere[5].

Whether or not the increase in CO_2 concentration in the atmosphere is, or is likely to be, environmentally hazardous is open to conjecture, and more research is needed on this.

Recognising, however, that efficient coal burning should produce more CO_2 in the flue gas than oil burning, the adoption of modern more efficient coal burning systems in place of current oil burning systems should result in yet a further increase in man-made CO_2 emissions, probably more than offsetting any reduction created by conservation of oil usage.

Whilst we continue to use fossil fuels in increasing amounts so must the CO_2 concentration in the atmosphere increase yet further - and we do not really know whether this is environmentally acceptable.

<u>Hydrocarbons</u>

In a man-made sense, originate mainly from:

exhausts of internal combustion engines
evaporation of petrol from tanks and carburettors
storage and distribution of petrol and petroleum solvents
drying of paints and lacquers
industrial/commercial processes using petroleum solvents

and, in 1968, were estimated[4] to contribute 14% of the total global emission. They are of concern, particularly the olefins and diolefins, because of their interaction with nitrogen oxides and ozone in strong sunlight to form photochemical smogs.

Those emanating from the motor car contributed more than from any other man-made sources but, as with CO, have been subject in recent years to vehicle emissions controls in the U.S.A. and in other countries. Positive Crankcase Ventilation to control emissions of blow by gases is now standard on all present day car engines. Tightening up of vaporisation losses from fuel tanks and carburettors has also been effected - not always to the extent of sealed/purge-controlled systems as are now used in the U.S.A., but still, with markedly reduced loss rates. Those from the vehicle exhaust have been reduced by 86% on the uncontrolled vehicle by 1973 U.S. Federal standards, and similarly, though not to such a great extent (approx. 20%) in other countries.

With such reductions, together with the growing tendency for smaller, more efficient less fuel-consuming engines, plus yet further improvements in emission controls, a general reduction of Hydrocarbon emissions from motor vehicles must take place.

Only in the U.S.A. are measures being adopted to cut down on the evaporation losses from the storage and distribution of petrol and solvents, necessitating use of special pressurised filling systems with vapour return lines to contain the displaced vapour. Hereagain, this is necessary only where local concentrations are likely to exceed acceptable levels.

Common present day paints and lacquers contain approx. 60% solvent which evaporates off into the atmosphere. Whilst legislation in the U.S. minimising such Hydrocarbon and organic solvent emissions and effluent (Los Angeles Rule 66 type limitations) is affecting solvent usage in that country, the steep rise in costs of such solvents, and of heating fuels for paint stoves, is encouraging users of paints and lacquers the world over to investigate the viability of other systems. Such systems are essentially:

water-borne coatings - require high bakes to cure (180°C), but particularly promising for automotive primers and industrial baked goods with and, more recently, without electrodeposition, and with cathodic electrodeposition, for appliances.

high solids coatings - using moderate heat (80°C) to facilitate curing - promising for metal container and appliance use, and of interest for automotive acrylic topcoats and epoxy primers. Also ambient curing solventless two-pack epoxy heavy duty maintenance coatings.

powder coatings - require high bakes (180°C), but particularly promising for thick films for exterior pipe coatings and electrical insulation - thin films for container linings and general metal surface decorative and protective coatings.

and, with their increasing adoption, hydrocarbon emissions from this source (probably 600 000 t/annum world-wide and 5 000 t/annum in South Africa) will also drop.

Amongst industrial/commercial processes using petroleum solvents, bitumen cutbacks for road primers and surface dressing use are likely, because of higher solvent costs, to be replaced by bitumen emulsions - using water as the "solvent".

Even though industrial uses of solvents account for the major portion of solvent usage, overall, significant reductions in Hydrocarbon emissions can be expected. Current levels in South Africa, determined as vehicle exhaust emissions, compare favourably with those obtained for cities in other countries (6).

Lead

Here we are concerned only with airborne particulate lead originating from its use as an anti-knock additive in petrol. Arguments have waxed to and fro, and continue to this day, on whether or not airborne lead at present ambient concentrations (of up to 3 - 4 $\mu g/m^3$) in urban areas (overseas) causes ill health in the general public, and whether such concentrations should be restricted to 2 $\mu g/m^3$ or even less. The main argument for further restrictions is centred on the possible effect on newborn babies contributed by natural ingestion of lead at normal tolerance levels in their mothers. Whilst not everyone agrees with a necessity for reducing present lead concentrations, all agree that it is desirable to keep them as low as possible. Lead, however, is an economic necessity, the more so now with high cost crude oil, in the manufacture of petrol. To withdraw it would mean more costly processing to achieve the equivalent Anti-Knock ratings with a reduced yield from the crude. Furthermore, a less balance fuel is obtained and refinery flexibility (on different crude oil intakes) is reduced.

To withdraw lead from our petrols would, for example, reduce our 98 octane grade to about 90, our 93 to about 87. They would be suitable only for low compression engines with a reduction in efficiency and economy of some 5 - 10%. Expensive capital investment and extended lead time would be necessary to provide the extra plant required to maintain octane ratings at their present levels on a lead-free basis, with of course a reduced yield from the crude.

Furthermore, the existing car population must be satisfied - few would run satisfactorily for long on a lead-free fuel, even of suitable octane rating, because of exhaust valve seat wear.

Non-leaded fuels of low octane ratings (91 ONR in the U.S.A.) have been introduced in the U.S. to permit the use of catalytic converters for control of exhaust emissions to their present day, and in the future, very low emission levels. (Lead in the fuel would poison the catalyst and render it inoperative). Such controls carry a fuel consumption penalty of 17%[7] against current European controls which have no such penalty. To meet U.S. proposed 76/77 emission levels, a 30% fuel consumption penalty will be incurred [7]. It is not our problem, but many people in the U.S. (and elsewhere) doubt the need for such expensive "detoxing".

In any case, should ambient lead concentrations become problematical, suitable particulate matter traps have been developed which, fitted in place of conventional silencers, can effect reductions of up to 80% of lead emissions at the tailpipe - with no fuel consumption penalty.

Ambient lead concentrations as measured in South Africa at sites in streets with high traffic densities give 1,5 - 2,1 $\mu g/m^3$ (6), and these compare favourably with those obtained for cities in other countries. Again, with the growing tendency for smaller, more efficient less fuel-consuming engines, coupled with improvements in traffic engineering, it is not expected that such lead concentrations will increase, if at all, to any significant extent.

NITROGEN OXIDES

As a composite of Nitrogen Oxide (NO) and Nitrogen Dioxide (NO_2) formed by high temperature (1650°C and above) oxidation of the Nitrogen in combustion air and emitted into the atmosphere from vehicle exhausts and industrial stacks, NO_x from combustion is estimated (4) to contribute only approx 11% of the total global emission. Total man-made emissions of all Nitrogen compounds (including Ammonia, etc) are but 1% (4) of the total global emission. NO_x are, however, not only of concern for their part in photochemical smog reactions, but also because of their toxicological effects at high local concentrations. (They are of special concern too in their likely long term effect on the atmosphere's ozone layer (25-50km up) - exhausts from supersonic aircraft and, dare we say it, continued nuclear explosions.)

In the U.S.A., in 1971, it was estimated (8) that nearly 50% of the total man-made NO_x emissions were produced in that country, of which approx 50% emanated from fuel combustion in stationary equipment, 35% from petrol-engined vehicles and 3% from Diesel-engined vehicles. Related to percentages total energy in fossil fuels consumed in that country - heating fuels 69%, petrol 24% and Diesel fuel (automotive) 2,5% - it is apparent that, for unit energy consumption, the internal combustion engine produces more NO_x than stationary equipment - the petrol engine by 100% and the Diesel engine by 50%. Applying these ratios to South Africa, it would appear that petrol would produce 16% of the total man-made NO_x emission and the Diesel engine (automotive) 5% ! NO_x are heavier than air and industrial emissions from stacks would therefore tend to contribute to ground level concentrations.

The control of NO_x from combustion systems, either industrial or automotive, is extremely difficult, and with continued and growing use of any or all fossil fuels, it can but be expected that man-made emissions will gradually increase. It is necessary therefore that we monitor local concentrations to ensure that they do not become problematical.

In this country, local concentrations, determined as vehicle exhaust emissions, still remain within the "clean air" range ($<180 (\mu g/m^3)$ [6]. Despite restrictions on the use of automotive fuels, it is not considered that, especially with a continually growing vehicle population, there will be any significant reduction in these emissions in the near future, though improved traffic engineering and traffic flow may help.

Nevertheless, without resorting to catalytic reducers in the vehicle exhaust system, with all the practical problems attendant with them, there are engine design modifications coming forward, e.g. the Honda CVCC engine, that have every promise of significant reductions in NO_x emissions. It is hoped that further improved designs on these lines may become more widespread, both in the testing house and in the mass-produced car.

SULPHUR DIOXIDE

Whilst, at general ambient concentrations, SO_2 is seemingly non-toxic to animal life - though has of course a marked irritant effect causing coughing and wheezing at even low concentrations - its main damaging effect is that on vegetation and, through oxidation and hydrolysis in the atmosphere, by acid attack on structural materials, textiles, etc. Yet, at ultra low concentrations, such as that of the background global level, it plays a vital part in the nutrition of both plants and all living matter. SO_2 pollution is therefore a matter of degree, and the more important factor is the concentration in the air rather than the total quantity emitted. Thus it is in highly concentrated industrial and populous areas that ground level concentrations of SO_2 are of the greatest importance in a pollution sense.

The quantity of SO_2 generated in the combustion of fossil fuels is virtually directly proportional to the sulphur content of the fuel, and therefore arises in larger quantities from the high sulphur-containing fuels - essentially coal and Heavy Furnace Fuels. Whilst Heavy Furnace Fuels may have a higher Sulphur content than coal (in South Africa typically 3,0% versus 0,8 - 1,0% on coal), less oil is required for unit heat produced and the ratio of SO_2 emissions is reduced accordingly (in South Africa to approx. 2 : 1).

The removal of sulphur, either directly from the fuel or in the form of SO_2 from the flue gases, is very costly and it consumes energy. Dispersal of the SO_2 from high stacks with high efflux velocities is, currently, the most practical method of maintaining ground level concentrations at acceptable limits. It might be argued that such dispersal might well reduce local concentrations but that the SO_2 comes down further afield but, despite even the claims from Scandinavian countries, there is little evidence to support this [9].

Thermal power stations are, by far, the major contributors to SO_2 emissions, and the modern tendency of locating these in rural areas adjacent to coal fields (rather than bringing the coal to the city) can but be a help in reducing ground level concentrations in urban areas. In any case their flue gases are invariably emitted from very high stacks and, generally, the SO_2 emitted makes little contribution to ground level concentrations. Local industry and certain older type local thermal power stations, using coal or Heavy Furnace Fuel, are the main contributors to urban concentrations.

World-wide, the financial restraint on continued use of Heavy Fuel Oils (contributing 18% of the world energy demand) will undoubtedly inhibit the rate of growth of its use and its contribution to SO_2 emissions. The interim conversion to coal (currently contributing 20% of the world energy demand) will, however, because of varying costs and availability, not have any significant reducing effect in total man-made SO_2 emissions and, except for certain critical locations, we must await the later development of nuclear power before any halt to the overall growth rate can be expected.

In South Africa, the amount of Heavy Furnace Fuel burnt is considerably less than that of coal, not only nationally (2% versus 80%) but also in all major cities including those at the Coast. Whilst therefore the high cost of Heavy Furnace Fuel may cause some users to change back to, or to adopt, coal - particularly for steam raising - the reduction in total or local SO_2 emissions will, generally, not be of any marked significance.

Where critical locations with high ambient ground level concentrations (e.g. above $80\mu g/m^3$ annual arithmetic mean or $365\mu g/m^3$ in 24 hours) occur, - fortunately in South Africa only very rarely and then only to a very limited extent[10] - reduction is best effected by either a change in fuel type to one of lower sulphur content or to an alternative source of energy: the choice depending on availability and the economics of the case.

Conclusion

I have deliberately omitted detailed reference to Smoke and Dust Emissions. Suffice it to say that, in whatever changes are made from oil-firing to coal-firing - for steam raising and like applications - every opportunity should be taken to introduce modern, efficient plant with proper controls to minimise the pollutants from combustion to a level no worse than that obtained from automatically controlled oil-fired plant that it replaces.

In general, oil in its various forms still provides an economic form of energy for the majority of purposes for which we use it, and it will take really drastic changes in costs, or in our circumstances, before we are likely to curtail its use. There can be alternative forms of energy, but considerable research and development is needed before the use of such alternatives becomes both economically and practically viable. Current inflationary conditions mask the effect of increased costs and, by and large, reduce the incentive to conserve oil usage to any significant extent. Thus any reduction in air polluting effect attributable to their use is still dependent very largely on technological developments and innovation directed to this particular end.

Finally, and by no means least, it is not only rising costs of energy with which we must concern ourselves. Fossil fuels are not inexhaustible, and every effort should be made to conserve them and to reduce the waste of energy that we are currently perpetrating by inefficient systems and usage. There are many ways in which this can be done, but this must be the subject of a separate paper.

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TABLE 1

ENERGY CONSUMPTION PATTERNS - 1972

COUNTRY/AREA	SOLID FUELS	PETROLEUM FUELS	NATURAL GAS	HYDRO/NUCLEAR ENERGY	TOTAL CONSUMPTION
	------------ %	of	Total	------------	10^6B/DOE *
USA & CANADA	18	43	31	8	36,7
% as Gasolines		52			15,8 (Gasolines to Fuel Oil)
Kerosines		8			
Gas Oil/Diesel Fuel		22			
Fuel Oil		18			
% Total Oil consumption		85			-
% Imported	-	30	4	-	14,0
UK	37	48	11	4	4,5
% as Gasolines		30			2,14 (Gasolines to Fuel Oil)
Kerosines		8			
Gas Oil/Diesel Fuel		21			
Fuel Oil		41			
% Total Oil consumption		94			-
% Imported	-	99,9	20	-	50
WESTERN EUROPE (inc. UK)	23	58	10	9	22,4
% as Gasolines		25			13,0 (Gasolines to Fuel Oil)
Kerosines		3			
Gas Oil/Diesel Fuel		36			
Fuel Oil		36			
% Total Oil consumption		92			-
% Imported		97	10	-	59
JAPAN	16,5	76	1	6,5	5,6
% as Gasolines		24			4,1 (Gasolines to Fuel Oil)
Kerosines		8			
Gas Oil/Diesel Fuel		13			
Fuel Oil		55			
% Total Oil consumption		91			-
% Imported	67	100	100	-	87
WORLD (ex USSR, E Europe & China)	20	52	19	9	76,5
% as Gasolines		30			40,1 (Gasolines to Fuel Oil)
Kerosines		8			
Gas Oil/Diesel Fuel		27			
Fuel Oil		35			
% Total Oil consumption		84			-

* Barrels/Day Oil Equivalent (1 Barrel = 159 litres)

SOURCE - Institute of Petroleum & Petroleum Press Service Statistics (Various)