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FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA

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TECHNICAL

GASEOUS FUELS FOR INTERNAL COMBUSTION ENGINES

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1. VEHICLES

During 1972 the registered vehicles in the Republic totalled 2,39 million, and these were classified as follows:

Motor cars	1 618 698
Buses	13 800
Mini buses	29 184
Commercial vehicles	454 203
Motor cycles	51 939
Tractors	229 756
Total	2 397 580

2. GAS CONSUMPTION

All these vehicles, with the exception of the motor cycles, could be run on gas. To obtain some idea of the gas quantities involved, the gas consumption, expressed as m_n^3/km, is listed below. The gas consumption is based on the respective petrol consumptions listed in the second column.

Vehicle	Assumed Petrol Consumption km/litre	Gas Consumption (m_n^3/km) H_2	CO	CH_4
Motor cars	10	$4,1x10^5$	$4,2x10^5$	$1,3x10^5$
Buses	5	$7x10^3$	$7,1x10^3$	$0,2x10^3$
Mini buses	7	$1x10^4$	$1,1x10^4$	$0,3x10^4$
Commercial vehicles	5	$2,3x10^5$	$2,3x10^5$	$0,7x10^5$
Tractors	5	$1,2x10^5$	$1,2x10^5$	$0,4x10^5$
Total		$7,8x10^5$	$7,9x10^5$	$2,4x10^5$

/Assuming .....

Assuming that the commercial fleet has to be maintained during an emergency, and assuming an average daily distance travelled of 100 km, this fleet would consume 23 million normal cubic metres of H_2 or CO or 7 million normal cubic metres CH_4 daily.

Gas could be made available either by means of centralised production or by means of on-line production.

3. CENTRALISED PRODUCTION

Centralised production involves the mass production of gas at a suitably located plant. The gas would have to be transported to the consumer in pressure cylinders. The advantage of this system lies in a uniform product.

3.1. Capital investment

An indication of the capital costs involved can be obtained as follows:

(a) The fleet of commercial vehicles would require 23 million normal cubic metres of CO per day or 12 000 giga joules of energy per hour. (3 300 MW).

A 60 giga joule/hour gas producer plant is estimated to cost about R400 000.

The total producer plant cost is thus estimated to be of the order of R80 million.

(b) Assuming a minimum of three cylinders per vehicle, this involves 1,36 million additional pressure cylinders and, at a cost of R60 per cylinder, amounts to a capital investment of R81 million.

/(c).....

(c) Assuming a conversion cost of R50 per commercial vehicle involves a capital investment of R22 million.

The total capital investment for running 454 000 commercial vehicles would amount to R182 million.

3.2 Cylinder capacity

H_2, CO and CH_4 cannot be liquefied at ambient temperatures. This seriously limits the energy storage capacity of normal pressure cylinders. As an illustration the petrol equivalence, expressed as litres of petrol, of normal cylinders (70 kg dead weight and 2 000 psig working pressure) is given below.

Gas	Petrol equivalence
H_2	2,76
CO	2,71
CH_4	8,56

In the case of producer gas (30% CO, 10% H_2 and 60% N_2) the petrol equivalence of a cylinder is 1,6 litres. No simple means of removing nitrogen is available. Methane obtained from organic waste is generally contaminated with CO_2, which can readily be removed by alkali washing.

3.3. Gas sources

(a) Hydrogen - produced by electrolysis, or by the steam-carbon or steam-iron reaction; these processes are expensive.

(b) Carbon monoxide - obtained by the partial combustion of carbonaceous solid fuels.

(c) The intermittent water gas plant, producing a mixture consisting mainly of H_2 and CO, could be mentioned as well. This is a fairly cheap process.

/(d) .....

(d) Methane - natural gas fields; not in abundance.
- coal fields; not abundant and generally obtained in dilute form.
- synthesis.
- biological degradation of organic wastes, e.g. sewage disposal, Quantities large enough to warrant exploitation are probably generated at a limited number of installations.

4. ON-LINE GAS PRODUCTION

On-line production involves the production of the gas at the point of consumption. Typical examples are gas generators fitted to motor vehicles, biological digesters producing methane for stationary engines, and in the broader sense, gas producers for boilers.

It stands to reason that biological digesters, due to inflexibility, are not suitable for vehicles and the discussion will be limited to portable gas producers. A portable digester has, however, been proposed (Bate).

4.1. Vehicle size

Producer gas consists essentially of 30% CO, 10% H_2 and 60% N_2. The effect of the inert nitrogen is to reduce the power output by about 40 to 50 per cent. Producer gas is therefore not suitable for vehicles of which the engine capacity is less than about 2 litres.

4.2. Gas quality

The calorific value of the gas produced by portable gas producers varies with time. The calorific value initially increases, reaching a maximum after approximately 15 minutes of operation, and eventually declines. This may be due to drying of the residual fuel in the producer.

/4.3. .....

4.3. Primary fuel

In order to cope with the fluctuating power demand of vehicles, it is important that the portable producer be sufficiently flexible. The flexibility is largely dependent on the reactivity of the primary fuel. A further point of importance is the ash content of the primary fuel. Clinker formation is detrimental to the operation of the producer and increases servicing stops during travel. The potential tar content of the primary fuel is also of importance as the liberation of excessive amounts of tarry matter causes problems in the gas cleaning equipment.

A South African standard specification (S.A. 19/1942) for wood charcoal for use in portable gas producers was issued in 1942.

Suitable primary fuels are: (a) charcoal (b) low ash-content anthracite (c) low ash-content chars of suitable reactivity.

Details of the availability of potential fuels for mobile gas producers are given below.

Potential Fuels for Mobile Gas Producers

	Charcoal	Anthracite	Gas Coke	Char
Present Production 000 t/a*	?	1400**	89	275
Retail Price in Pretoria. R/100 kg	11,5	2,33	0,70***	?

* These masses include relatively small proportions of fines which would have to be screened out before the fuel could be used in a gas producer.

** About 500 000 t/a used inland and 900 000 t/a exported.

*** Retail price in Johannesburg.

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It may be pointed out that the production of anthracite could probably be increased appreciably by the collieries concerned, if required, so that export could continue undisturbed.

The ash content of gas coke is rather high (varying from 15 to 22 per cent) and the fuel is therefore not attractive for mobile gas producers.

All the char produced is used by the electrometallurgical and chemical industries (production of carbide, ferrosilicon, etc.).

An Otto char production installation near Oogies was taken out of commission a few years ago due to uneconomical operation. It may be possible to re-start the plant, but the cost would be considerable. Its rated throughput of coal was about 150 t/day.

The Fuel Research Institute has a pilot-scale rotary carbonizer suitable for the manufacture of char from bituminous coal, if such a product should be required for trial purposes. The coal throughput of the plant is about 4 t/day.

4.4. Capital investment

It is estimated that the cost of a portable gas producer, complete with ancillary equipment, will be of the order of R400. The capital investment in order to maintain a fleet of 454 000 commercial vehicles thus amounts to R181 million.

It must be borne in mind that any future technological breakthrough can render this investment obsolete.

The estimated mass of the portable unit is 100 kg so that approximately 45 000 metric tons of steel would be required for the manufacture of 454 000 units. Furthermore, it is estimated that the production of a single unit would require 100 man-hours, so that a total of 45 million man-hours would be involved.

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4.5. Primary fuel consumption

An estimate of the primary fuel consumption is based on a fleet of 454 000 commercial vehicles, each covering a mean distance of 100 km/day. Assuming a primary fuel consumption of 3,2 km/kg primary fuel, the overall consumption is of the order of 14 000 metric tons per day or 5 million metric tons annually. Increased demands of this order can be met by the coal mining industry, but it is extremely doubtful whether the charcoal industry could be expanded sufficiently rapidly, especially in view of possible obsolescence.

4.6. Advantages and disadvantages

The advantage of producer gas operation lies in the fact that use can be made of indigenous fuels.

The disadvantages include:

(a) High capital investment at the risk of obsolescence.

(b) A certain amount of operating skill is required.

(c) The problem of ash disposal along highways and the risk of veld fires.

(d) Unsuitability for small vehicles.

4.7. Recommendations

Portable gas generators should only serve as a last resort. The capital investment in vehicles is enormous and an ineffective generator, especially the gas cleaning equipment can appreciably reduce the useful life of a vehicle. Continual research aimed at improving the portable gas generator is therefore of prime importance and it is imperative that it must be continued.

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(Signed) T.C. ERASMUS
CHIEF RESEARCH OFFICER