UNITED NATIONS

CENTRE AGAINST *APARTHEID*

NOTES AND DOCUMENTS*

9/85

October 1985

SOUTH AFRICA'S ATTEMPTS TO REDUCE DEPENDENCE ON IMPORTED OIL

by

Paul Conlon

/Note: This paper, which is published at the request of the Special Committee against Apartheid, is a summary of two studies prepared by Dr. Conlon and entitled "South Africa's offshore oil exploration" and the "Sasol coal liquefaction plants: economic implications and impact on South Africa's ability to withstand an oil cut-off".

Dr. Conlon is a research consultant on energy and oil.

The views expressed in this paper are those of the author./

SOUTH AFRICA'S ATTEMPTS TO REDUCE DEPENDENCE ON IMPORTED OIL

Introduction

1. The following paper is a synopsis of two longer reports, "South Africa's offshore oil exploration" and "The Sasol coal liquefaction plants: economic implications and impact on South Africa's ability to withstand an oil cut-off", which are currently being prepared for publication by the United Nations Centre against Apartheid. Because these reports were technical in nature, it was felt that a shorter synopsis of their findings should be made available to a lay public less concerned with some of the more technical aspects of these questions. Readers wishing to go into more detail on this subject are therefore referred to the two aforementioned reports where they will also find a bibliography and information on source material.

Responses to the oil embargo

2. Faced with an interntional oil embargo, the white minority Government of South Africa has evolved several different responses with varying degrees of success. Its most successful response has been to build up a network for the clandestine purchase and transportation of crude oil from international spot markets, as well as the strategic stockpiling of oil as a buffer against abrupt supply disruptions. Additional measures have been introduced also seeking to decrease consumption of motor fuels or stretch those available through blending. Taken together, these measures have thus far provided the South African economy with access to as much petroleum-based fuels as it basically needs, albeit at a marginally higher cost. The production of motor fuels from coal at the two new Sasol coal liquefaction plants has provided additional, though marginal alleviation of the problem, but at considerably higher cost. Finally, attempts to discover oil through exploration in off-shore areas have proved totally futile and will presumably continue to be futile in the future despite high costs.

Racism and the energy sector

3. The South Africa's energy sector has always been peculiar because of the country's history of racism. Originally, coal provided about 80 per cent of the energy needs of the national economy and oil provided only 20 per cent, a ratio which is internationally unique. One basis of this peculiar energy system was cheap black labour in the collieries, but the availability of underpaid black labour at other points in the economy also contributed. Much of the coal is converted into electricity at power plants near the collieries and transmitted to industrial and private consumers. This is possible because mining, which is one of the South Africa's major industries, can easily use energy in the form of electricity. Another main economic sector, agriculture, is undermechanized because of an abundance of underpaid black labour and it can therefore do without petroleum-based motor fuels.

Low labour costs - a cornerstone of energy sector

4. Originally, energy was artificially underpriced in South Africa and the energy sector was consequently subsidizing the other areas of economic activity. Because of the threat of an oil embargo, this sector must now be subsidized by other sectors. While the energy sector had originally developed on the basis of labour-intensive technologies using underpaid black labour, it must now increasingly resort to capital-intensive and technology-intensive defence strategies. Because its consumption of petroleum was always artificially low, its possibilities of replacing petroleum are limited. Low-paid mine labour also made coal viable as a chemical feedstock and in South Africa not only petrol but even methanol and acetylene are produced from coal. As black mine workers are now organizing and becoming militant, the entire system is threatened at its base, as well as being threatened externally by the oil embargo. The countermeasures by the minority Government are partially contradictory, partially inadvisable because they go counter to the longe-range trends of the economy. Thus when the inevitable adjustment comes, its effects will be even more traumatic.

The counter-strategies of the minority Government

5. Strategic contingency planning of the minority Government appears to be three-tiered. In the short-term petrol rationing, stock run-downs and conservation measures were sufficient. The medium-term strategy is to lessen part of the oil needs by the liquefaction of domestic coal, as is now being done in the Sasol plants. For the long run, however, some domestic oil supply would be necessary. But on the latter point the minority Government is no nearer to any solution than before. The authorities are quite aware that most of the present makeshifts are unreliable in the long run and, while they continue to demonstrate considerable resourcefulness with purely technical solutions to problems of detail, there is no evidence that they possess any long-range strategy to meet the ultimate threat. Even if South Africa were to evolve a coherent counter-strategy, it would require resources or options which the régime clearly does not have at present and stands even less chance of having in the future.

Secrecy, disinformation and wishful thinking

6. The minority Government has suppressed much information and statistics relating to oil and the energy sector, something which makes the present task more difficult but not impossible. This suppression of information is done for strategic reasons in the narrow sense of the word, but there are strategic considerations of a more commercial nature involved as well. The production of fuel from coal is disastrously unprofitable and the present predicament weakens the national economy. Moreover, the racist authorities are interested in preventing the international financial community, on which they depend for loans, from gaining too much insight into their embarrassing condition. There is the additional problem of morale-boosting propaganda and deliberate disinformation tactics. As the white minority meets with success or adversity in its attempts to defend apartheid, its morale rises or falls accordingly; the morale of the black majority does so too, invariably in the opposite direction. There is probably also a certain degree of sincere self-delusion

on the part of many individuals in the Government. Disinformation has occasionally backfired. Thus the absurd claims of the minority Government regarding the capacity of the Sasol plants led to too much critical analysis on the part of interested outsiders. The régime eventually found it prudent to retreat into silence on the subject; outbursts of euphoria over oil "discoveries" in the past have also dulled the senses of Western businessmen who do not take South African claims on this subject seriously.

Diesel shortage - the real Achilles' heel

7. A critical problem has always been that the South Africa's production and refining plants do not produce enough diesel fuel. This was a problem before 1978, when refineries were producing 1.06 units of petrol for every unit of diesel. However, the Synthol technology used in the two new Sasol plants turns out 21.3 times as much petrol as diesel. Thus, assuming that they cover one fourth of all motor fuel production, the country is now producing 1.32 units of petrol for every unit of diesel. One problem is that demand for petrol is more elastic than demand for diesel because it is largely used in private motoring and, hence, rationing measures have less effect on diesel consumers in manufacturing and agriculture. Furthermore, the gradual mechanization of agriculture, long overdue in any case, promoted by the minority Government as a means of eliminating black labour from agriculture, remains blocked as long as the country suffers from a chronic shortage of diesel fuel. This shortage is indeed the real Achilles' heel of South Africa's energy sector.

Fuel substitution measures

8. There have been further attempts to alleviate the situation with measures aiming either to substitute one fuel for another, save fuel in general, or to decrease dependence on foreign suppliers of fuels. One strategy has been to stretch petroleum by blending other things into motor fuels. Another has been to substitute petrol for diesel in certain types of vehicles. A third has been to use renewable biological source-stocks for fuel. At times, such exotic things as woodchips, sunflower oil and maize cobs have been considered for this purpose. There is also ongoing research into fuel economies and the development of new fuels, but the total amounts spent in South Africa in both public and private sectors are pitifully inadequate for the purpose. In addition, most of these measures, even if they were possible, run into other contradictions. For example, the marginal shift back from diesel to petrol only increases total petroleum consumption. Some strategies are inadvisable because of sabotage. The minority Government is practically in a state of war with its own population and much sabotage, organized or spontaneous, is directed at the energy and transportation sectors. Certain fuel substitution or saving schemes, such as the use of trolley-buses in municipal transportation, are out of the question because they are too vulnerable to sabotage. Counter-measures against sabotage in the energy sector are also becoming economically burdensome.

Contradictory nature of most counter-strategies

9. There is an additional contradiction in goals because a high standard of living requires motor fuels, which is precisely what the white minority is trying to defend. Then, too, the development of a black middle class, with middle class lifestyles and political attitudes, would be counteracted if the private automobile sector has to shrink or if it cannot grow. In fact, from here on, the greatest source of growth of demand for fuel will come precisely from private black motorists buying cars. In general, all these strategies may have greater success in industry or space-heating, but in the transportation sector there is little room for substitution or savings. Most such strategies are contradictory and create the appearance, rather than the reality, of substitution or independence.

One form of dependency exchanged for another

10. In most cases, dependence on one thing is traded off against dependence on another and the ultimate advisability is open to question. For example, the coal liquefaction plants require little labour, and then mostly skilled labour, and hence would seem to be strategically sound because they can do without black labour. But they gorge themselves on enormous amounts of coal which, of necessity, must be produced by black labour in the collieries. Similarly, the resourceful idea of producing tractor fuel from sunflower oil on the farm would, if it should ever come about, shift a certain amount of fuel production into the black labour sector. There are similar contradictions in most of the strategies of self-sufficiency of the white minority Government. They may decrease dependence on foreign suppliers, but they increase the need for capital and technology which, ultimately, must also come from abroad. There are 25 to 30 countries in the world from which South Africa could potentially obtain oil; there are only three from which it can obtain coal liquefaction technology. The minority Government has learned to live without the Organization of Petroleum Exporting Countries (OPEC), but it is even more dependent on Silicon Valley and the City. This may be an advisable option, but it is not independence.

"Pariah penalties" and other consequences of South Africa's lack of options

11. Thus far, the minority Government has been able to purchase most of the crude needed on the international spot market. But there have been serious supply disruptions at times, and to do so the régime has been obliged to build up a network of institutions and arrangements. In addition, it has been obliged to pay a higher price and this has cynically come to be known as the "pariah penalty". Rumours about its exact magnitude are hard to evaluate, but this expert has conservatively estimated the "pariah penalty" at about $5 per barrel under average operating conditions. Rumours have occasionally put it at double that price, and one claim is that in the crisis of 1978-1979 the minority Government had to pay $40 per barrel at a time when the benchmark price was $18 per barrel. The racists' lack of options has made them vulnerable to the manipulations and fluctuations of the spot market and they have several times been victimized by unscrupulous intermediaries, of whom there is no dearth in the oil industry. These intermediaries have perpetrated outright frauds on them. Lack of options necessitates using crudes which are less suitable for their needs or their refining equipment. South Africa's

refineries are basically geared for heavier crudes; running lighter crudes through these refineries wastes a portion of the oil. This is presumably one of the reasons why the régime has recently signed a contract with the Fluor Corporation to revamp the refinery at Sasolburg. This will presumably make it possible to use a wider spectrum of crudes in general, lighter ones in particular.

The unreliability of oil supplies

12. The ability of the minority Government to obtain oil externally is dependent on many transient factors, but also on a critical distinction between oil production and oil distribution. The success by the régime is due to the fact that it has much better relations with those countries and companies which trade, transport and distribute oil than it does with those that produce it. In fact, South Africa's only producer sources of oil are autocratic régimes which could be swept out of power at any time. Its main source of oil, the Islamic Republic of Iran, came to an abrupt end in 1979 for precisely this reason. Most of the oil is obtained from traders and intermediaries over the expressed opposition of the producers. Furthermore, production and trans-shipment are located at considerable distance ranging from 5,000 to 15,000 kilometres from South Africa and the régime would have no means of bringing in oil from these sources under escort. The only producer or exporter of oil which is close enough to South Africa to be within striking distance is Angola. For this reason, there is always a danger that, in the very long run, the minority Government will try to get hold of Angolan oil. Though the régime prudently stays off the subject in public, the long-range temptation is enormous, not because it would be easy or advisable, but simply because it is the only source that is not excluded *a priori* on the criterion of distance. However, this could bring the minority Government into conflict with the oil companies operating in Angola, many of which are the national oil companies of countries not friendly to the racist régime anyway. These companies need that oil to supply their own domestic markets and have no incentive to sell it to outsiders at any price. The other oil companies operating there have, until now, not been particularly involved in the South African market, though this may change due to recent mergers in the oil industry. There is also the national oil company of Angola which can always dispose of 51 per cent of all oil produced.

Complications with respect to Namibia

13. The potential danger of this situation is further increased because of the strategic importance which Namibia, or, more narrowly, Walvis Bay, would have if the minority Government should develop its lusts for Angolan oil. Further disturbing ramifications derive from the fact that one area with a certain small hydrocarbon potential, although probably no oil, straddles the

border between Namibia and Angola. The South Africans are themselves exploring for oil in an offshore area which lies just south of the mouth of the Orange River. Should there be any oil there--which is very unlikely--there would probably be even more on the Namibian side of the border as the underlying geological formation is concentrated northwards.

South Africa as a major coal exporter

14. In the last decades, the minority Government has been trying to mitigate its economic decline by developing new extractive export industries based on the country's time-tried traditions of racist exploitation at home and colonial dependence on export markets abroad. Most of these have been what is known as "specialized minerals", but coal has also been included in this category. At present, South Africa exports about 35 million tons of coal per year and it will probably increase this to about 45 million tons by the end of the decade. The use of underpaid black labour in the collieries permits South Africa to export at prices which are marginally, but only marginally, competitive on the international coal market. There is also a widespread feeling that South Africa has accepted an inadvisably high depletion rate. The long-range significance of this development is ambiguous and uncertain. The decision to invest in this sector speculated on increased use of coal as a substitute for oil in the OECD countries. This, in turn, was based on the belief in a continued rapid rise of the price of oil. Because this has not occurred, it is possible that the trend towards coal has now played itself out and South Africa would be the first coal exporter to suffer because of its location and because of the poor quality of its coals which contain too much ash. It is almost an article of faith in the international coal industry that only the low cost of labour makes South African coal exportable at all. On the one hand, major oil companies which co-operate with the minority Government in running the oil embargo do so largely because of their long-term interest in South African coal. If coal should fail to expand, they would lose their incentive to do so. On the other hand, an expansive coal market might bring South Africa into conflict with several Western countries which export coal too. Indeed, these countries have been instrumental in spreading the unflattering interpretation that only underpaid mine labour makes South African coal competitive at all.

Ramifications of the expansion in coal production

15. All ramifications of this expanding coal export are not clear at the moment, but there are two ramifications which are, and they are of direct relevance. First of all, the development of a coal-exporting industry must be accompanied by the development of South Africa's coal-producing and processing infrastructure. This would favour the further trend to coal liquefaction in the fuels sector. At present, moreover, the export price for coal is about three times the internal transfer price at which Sasol buys it from its own coal-mining subsidiaries. In other words, South Africa foregoes foreign currency revenues by using that coal to produce fuels. This is important to remember because the minority Government claims that it achieves

enormous savings in foreign exchange by producing petrol from domestic coal. The gross figures it cites should more properly be reduced by about two thirds because the coal used for motor fuels could otherwise be exported in exchange for that much more foreign currency. However, it has to be noted that there is a general expectation that there will be a steep rise in the cost of South African coal in the next few years. Such a development would threaten the viability of both coal exports and coal liquefaction.

Sasol's two new coal liquefaction plants

16. Two new coal liquefaction plants built by Sasol Ltd. are both located near the town of Secunda in the Transvaal which, indeed, owes its existence to them. Sasol 2 has been producing at operational capacity since 1982, Sasol 3 since 1983. Sasol 2 cost R2,503 million and Sasol 3 cost R3,276 million. The total would be R5,779 million which is the price of the plants themselves, excluding housing development costs, interest during construction and working capital. The dollar figure normally given is $5.8 billion or $5.9 billion. A certain saving was achieved by the massive use of underpaid black construction labour. But the enormous cost of the plants lies in their massive use of technology and South Africa's tradition of underpaid black labour could only mitigate this marginally. The bulk of all of this was spent abroad and also borrowed there, so it had little ripple-effect in creating employment domestically. The original Sasol plant built in 1955 had produced methane as an inevitable by-product of the technology used. This methane could be sold to a few large industrial users. But the two new coal liquefaction plants, because of their enormous size, would have produced quantities of this by-product far in excess of what could be sold. This surplus methane is therefore run through the plants a second time and converted to motor fuels. But this requires large quantities of heat and thus necessitates more operational fuel. This specific aspect of the two new plants has reduced their profitability level below that of the original plant.

Disastrous improfitability of the oil-from-coal production

17. The most that Dr. Rousseau, the founder of Sasol Ltd., has ever claimed was that the original plant had been "marginally profitable...but still not attractive for private investment" for a limited period of time after 1973. In fact, the minority Government has never even claimed that the new Sasol plants could be operated at a profit. But the régime is not interested in divulging the exact extent of the loss. This is one reason why blanket embargo has been placed on all statistics about the plants. Most experts in the coal industry believe that the process technology used in the Sasol plants can never be profitable under any circumstances and point to the fact that it has only been used in extraordinary warlike situations where normal commercial considerations were set aside. One can only speculate on the price at which the Sasol plants produce fuels, but the best estimate is that they do so at about $75 per barrel of oil equivalent. In other words, this is over twice the present spot price of oil. For reasons explained in the previous paragraph, it includes a loss of about $10 to $11 per ton of coal used.

Coal liquefaction is technology-intensive

18. Lurgi GmbH, the second largest supplier of equipment and technology for the Sasol plants, has disclosed the interesting figure of 700,000 "technical man-hours", i.e. engineering hours required for its part of the Sasol project. This succinctly illustrates to what extent these plants are what is called "technology-intensive". Furthermore, the technology needed is of a very advanced and specific kind and only three countries--the United States, the Federal Republic of Germany and Japan are capable of producing it. There may be individual consultants or firms in several other countries capable of producing the technology necessary for this or that minor aspect of the process, but these three countries are the only sources for a complete technology package of this type. Thus South Africa has purchased, at best, marginal independence from the 25 to 30 countries from which it could obtain petroleum, by becoming dependent on an even more select circle of technology-exporters. There has apparently also been a significant problem of recruitment of the necessary technical staff to run the plants. Sasol now claims to have solved this problem. The number of engineers available to operate this kind of equipment is limited in the world in general; the minority Government has further problems because it can only recruit white-skinned people from abroad to perform these functions. Finally, most people so highly qualified have little incentive to move to South Africa.

The racist system is not conducive to technology

19. Attempts to defend apartheid by shifting into technology-intensive industries run up against the contradiction that the apartheid system is hostile to the production and maintenance of technology. There has been significant white graduate emigration from South Africa for over 30 years, originally because of an unwillingness to co-operate with apartheid, more recently because of unwillingness to defend it, since whites face long periods of military service. In addition, the educational system for blacks originally slowed down the rise in their educational level. Later, the "bantu education" system even succeeded in reducing it for a while. The same system that artificially depresses the value of labour, inadvertently also raises the costs of research and development. This puts the minority Government at a disadvantage. But, at any rate, the development of new synthetic fuel technologies would require research expenditures which go far beyond what the country has. It is therefore doubtful that technology in the long run can really be used to defend apartheid. But this, precisely, is the card which the present middle class technocratically orientated governmental elite is trying to play.

Coal liquefaction is also capital-intensive

20. The Sasol coal liquefaction plants, like many other counter measures taken to thwart the oil embargo, are capital-intensive. Given their size, it should also be obvious that capital of this magnitude must be borrowed abroad. Given, furthermore, the high interest rate of recent years, all these capital-intensive counter measures must be making a significant contribution to South Africa's growing external debt. Takinglower dollar figure cited in paragraph 15, which amounted to $5.8 billion and accepting the claim of the minority Government that the two plants have a capacity of 100,000 barrels

per day, this means that they require $58,000 in fixed plant equipment for every barrel of daily output. If, however, the plans' actual capacity is only 70,000 barrels, as is suspected, then the ratio of fixed plant to output capacity rises to $83,000. In any case, the extent to which capital must be tied up in fixed plant equipment is excessive; ideally it should be around $25,000 per barrel of daily output.

Counter-measures by the Government result in an unprofitable energy sector

21. In a country with a gross national product of about $80 billion, $5.8 billion must be tied up in plants which probably only produce about 5 to 10 per cent of the national energy supply. An investment of such capital intensity could only be justified if it could be expected, beyond any risk, to bring in a high return on investment. Yet it was accepted a priori that the plants could not run on a profit. One third of the cost of the motor fuels produced lies in covering fixed capital costs. This high proportion of capital costs makes the unit price, and hence the profitability, extremely sensitive to fluctuations in the throughput. This is assumed to be the cause of ongoing squabbling between Sasol Ltd. and the mirority Government, which breaks into the open from time to time. Strategic stockpiling of crude also drains capital resources, partially because the storage facilities have also required capital investment, but mainly because capital tied up in dormant crude, stored permanently for an emergency, is not available for productive investment or to be lent out at interest. In general, counter measures against an effective oil embargo have required so much capital investment under such unprofitable conditions that the energy sector, which once subsidized other sectors of the economy by providing cheap energy, now in turn must itself be subsidized by the others.

Oil-from coal production is unbalanced

22. Though the major product coming out of the coal liquefaction plants is petrol, these same plants also produce many other products or by-products, such as liquefied petroleum gas, diesel fuel, jet fuel, ethylene, phenols, ammonia and tar products. But as far as motor fuels are concerned, their product slate is heavily weighted towards petrol and only exacerbates the country's shortage of diesel fuel. This indeed is the real Achilles' heel of the South African energy sector. And there is little alleviation in sight under present conditions. Building further plants would only weigh the slate further towards petrol, and this explains the hesitation on the part of the minority Government in deciding when other coal liquefaction plants will be built. In addition, some of these by-products are being produced in quantities which are excessive in relation to what the local market can bear. Rumours have circulated about surpluses of ethylene and acetones which have had to be dumped on international markets.

Sasol uses the Fischer-Tropsch-Synthol technology

23. Coal liquefaction, as used here, refers to the process whereby coal, which is a solid hydrocarbon, is converted to liquid hydrocarbons, more specifically to liquid motor fuels. There have heretofore been two major methods of doing this, and the one used in the Sasol plants is called

synthesis. An alternative method is hydrogenation, while a third method, pyrolysis, is still in its infancy. Sasol process technology is more narrowly referred to as Fischer-Tropsch synthesis, after two German chemists, Franz Fisher and Heinz Tropsch, who developed it half a century ago. Even more narrowly, it uses a licensed process known as Synthol, the most advanced form of Fischer-Tropsch synthesis known. It has been developed by the M.W. Kellogg Co. Inc. with headquarters in Texas in the United States, and since 1980 a wholly owned subsidiary of another American company, Wheelabrator-Frye Inc. Synthol technology was selected because it was perfected and available, having been used in the original small Sasol plant opened in 1955. The only other fully available process technology, known as ARGE, produced less motor fuel and left enormous amounts of wax as by-product.

Fischer-Tropsch-Synthol--an antiquated, inappropriate technology

24. But Fischer-Tropsch-Synthol is already an antiquated first-generation coal liquefaction technology because a whole spate of experimental processes, all based on hydrogenation, have been developed and patented in the meantime. But they are as yet untried on a commercial scale and the authorities had no time to wait until they could be perfected. The only other argument for choosing Synthol was that this technology is capable of handling coals containing large amounts of ash and other impurities, which are present in the South African coals. In all other respects, modern hydrogenation processes are superior to Synthol. In particular, the Synthol process requires large amounts of heat and preparation and, hence, it is costly. It entails high capital costs, produces far too many undesirable or useless by-products and has a low thermal efficiency, as stated below, in paragraphs 25 and 26. In fact, the general interpretation of the international coal and petrochemical industries is that this process is only usable in South Africa because of its artificially cheap coals, and because of its lack of options for political reasons. A representative of the Kellogg Company which produced it even admitted to a subcommittee of the United States House of Representatives in 1975 that the technology would never be profitable in the United States. Likewise, in 1970, the Ministry of Research and Technology of the Federal Republic of Germany published a report by Professor Helmut Pichler, who in his youth was an assistant to Fischer and Tropsch, showing conclusively that the process would be uneconomical in the Federal Republic of Germany. On top of everything else, it can be added that the Synthol process requires large amounts of water and it is therefore not exactly advisable in a region like the Transvaal where the water supply is unreliable although, as yet, there have been no known problems.

Fischer-Tropsch-Synthol technology has low thermal efficiency

25. The major point on which Fischer-Tropsch liquefaction technology has been found wanting the so-called thermal efficiency. Thermal efficiency is the energy value of the hydrocarbons left over after conversion as a percentage of the same in the original coal. Thermal efficiency in the original Sasol plant is probably around 58 per cent, but that plant also produced methane which could be sold to industrial users. The two new plants route the methane back into the synthesis reaction to produce more motor fuels. In the opinion of one of the most authoritative experts, this lowers the thermal efficiency to 40 per cent, while other experts have occasionally put it at as low as 32 per

cent. Hydrogenation methods of liquefaction invariably have higher thermal efficiencies, and the most likely alternatives in the second-generation hydrogenation processes have thermal efficiencies at around 60 per cent.

Accelerated depletion of non-renewable resources

26. Thermal efficiency of about 40 per cent means that from a mass of coal which could produce 100 joules of heat one derives an amount of petrol which can produce 40 joules of heat. A process with 60 per cent thermal efficiency would produce enough petrol to create 60 joules worth of heat. From this example it is patently clear that thermal efficiency is not merely a technical detail of interest to process engineers. Low thermal efficiency means that South Africa's non-renewable coal resources are depleted faster to produce the same effect in fuel or energy. The new Sasol plants require 32 million tons of coal per year. Plants working on a hydrogenation process at the 60 per cent thermal efficiency level could save 11 million tons of coal per year, or a total of 275 million tons in a 25-year useful life of the plant. This amount of coal would be worth about $4 billion at current price levels. The precipitous decision of the minority Government to opt for this antiquated and thermally inefficient process technology results in an atrocious squandering of a non-renewable mineral resource.

Claims and counter claims regarding Sasol plants' capacity

27. The capacity of the original Sasol plant was a trade secret for purely commercial reasons. The capacity of the two new ones is a State secret for the most obvious strategic reasons. The most absurd claims advanced have been aimed at boosting the morale of the white minority at home. Transnational corporations which collaborated in the project have been more modest in their claims, but they too have been excessive. In addition, official or semi-official claims are not always internally consistent: in fact, inconsistencies and absurd claims led to too much critical analysis on the part of outside experts, as a result of which the minority Government now shies away from public discussion of the subject. The most common official claim was that the two new plants produce 50,000 barrels of motor fuels per day, in addition to 10,000 barrels from the old Sasol plant. The best impartial calculation has been provided by Mr. Martin Quinlan, a co-editor of the prestigious Petroleum Economist, and was arrived at largely by extrapolating from the official figures on coal consumption at the plants, and by exploiting an indiscretion contained in the annual report of Sasol Ltd. for 1975, which gave a precise ratio of synthesis gas to liquid fuels in the original Sasol plant. According to his calculations, Sasol 1 has a capacity of 4,250 barrels per day, Sasol 2 of 31,000 barrels, and Sasol 3 of 32,750 barrels, thus bringing all three plants to a total motor fuel production of 68,000 barrels per day. This present expert, who believes that Mr. Quinlan's calculations contained a slight error, would put the capacity of the new plants anywhere between 25,000 and 36,000 barrels per day each. Adding to this a further 6,000 barrels per day from Sasol 1 which is presently being overhauled, would put the total South African synthetic fuel production capacity at between 55,000 and 78,000 barrels per day. Operationally, an estimate of 70,000 barrels per day would seem easiest to handle. It should be noted in this connection that certain estimates of cost in this report use 70,000 barrels per day as a base.

Profitability is vulnerable to production cutbacks

28. The new liquefaction plants run at a loss whose exact magnitude is unknown, but it was foreseen by those who built them. Even so, the average loss is based on the assumption that the plants produce at average capacity. However, because they are capital-intensive and have high fixed costs which are incurred even if nothing is produced and make up at least one third of the unit price of the product, they are peculiarly sensitive to the exact level of production. Even slight dips in the throughput result in sharp rises in the unit price. Since purchasing crude oil clandestinely abroad and processing it in the South African refineries can still produce motor fuels at a price below what Sasol-produced fuels cost, the racist authorities, when faced with a particularly favourable climate on the spot market, probably buy up as much crude as possible and reduce their purchases of Sasol fuels. Globally speaking, the national economy saves money. But Sasol Ltd. probably loses money because the internal compensation mechanism, whereby the Goverbnment subsidizes Sasol's losses, is probably based on the assumption that average loss is incurred at average throughput levels. This is presumably the explanation for the recurrent squabbling between the minority Government and Sasol's management whose exact nature has never been made explicit to outsiders.

Sasol--a long-term white elephant

29. This dilemma is only a prelude to the general dilemma of tragic proportions which looms on the horizon for the day when apartheid falls and the oil embargo is lifted. The Sasol plants not only represent an unprofitable overinvestment under present conditions, they only make sense in the present, purely transient context of the apartheid system and the oil embargo. When normal conditions are restored and unimpeded access to foreign crude oil is reinstituted, they will make no sense at all. But they have been built at enormous cost, which must still be paid for, and have useful lives of at least 25 years. In a post-apartheid South Africa they will simply emburden the national economy as unprofitable white elephants. The decision of the minority Government to build them traded off the transient strategic problems of the white minority against the long-term development needs of the national economy.

Sasol plants--a clear misinvestment

30. Judged in the immediate context of the present situation, where the minority Government is threatened by an effective oil embargo, the new Sasol plants appear as an unprofitable overinvestment because they provide marginal alleviation to oil supply problems of the minority Government despite excessive cost. Judged in the global context of the long-term development of the national economy, they are total misinvestments altogether. The reason is that they make no economic sense outside the present transient political context. It must be borne in mind that there are two independent reasons for this which contribute to each other. For one thing, if apartheid did not exist, there would be no reason for South Africa to produce motor fuels by coal liquefaction. In addition, if the decision to move into coal liquefaction could have been taken at a less precipitous speed, a process technology with a higher thermal efficiency could have been used.

Coal liquefaction is not a step in the right direction

31. This is important because it could be argued that, whatever reprehensible and reactionary aims the minority Government may have had in constructing coal liquefaction plants, the latter nevertheless represent a shift towards synthetic fuel production technologies of the future and would still be useful in the long run. This argument could only be valid under the very unlikely condition that the oil price rises so soon and so rapidly that it is unable to pull the coal price up with it at the same speed. Under all other scenarios - and this one seems extremely unlikely now - the Sasol coal liquefaction plants will prove to be a disastrous misinvestment. Even if South Africa, a country with no oil but with abundant coal reserves, finds it economically meaningful to shift to coal liquefaction in the future, hydrogenation technologies with better thermal efficiencies will then be available. In other words, not only did the minority Government decide to shift to coal liquefaction too soon, it chose an antiquated, inappropriate and unprofitable technology.

Fluor Corporation-the major beneficiary

32. While Sasol coal liquefaction has not been, and cannot be, profitable to the South African national economy, it has been enormously profitable to Sasol Ltd.'s general contractor, the Fluor Corporation, which has its headquarters in Irvine, California. Indeed, Fluor has been the largest single beneficiary of the decision by the minority Government to build these plants. Fluor was awarded this large contract in 1975, just as it was about to enter a period of considerable expansion. In 1981, Sasol provided the company with $632 million in revenues, representing about 10 per cent of the total. Fluor needed this contract because it has invested heavily in research and development of synthetic fuels. But synthetic fuels are not profitable alternatives at current price levels. There is therefore a general unwillingness for major Western companies to invest in synfuels projects at present. But the minority Government is in the strategic dilemma and therefore profit considerations have no place in its thinking and decision-making. Most innovatory technologies need such extraordinary non-profit-related conditions to provide them with the critical breakthrough. After 1981, the new Government in the United States began to cut back on synthetic fuel research subsidies. Precisely at this point, the South African contracts for the new liquefaction plants began to provide Fluor with the revenues needed to continue the development of synthetic fuels. In this sense, Fluor is profiting from the lack of options by the minority Government. Because of its strategic dilemma, South Africa needs to buy services and technologies which the less harried OECD countries still reject out of profitability considerations. Worst of all, the Fluor Corporation and its recently deceased chief executive officer have actively taken up the cudgels for the apartheid régime and disseminate pro-apartheid propaganda throughout the United States business community.

Lurgi GmbH-the second major beneficiary

33. The second major beneficiary and collaborator was the Lurgi GmbH of the Federal Republic of Germany, a wholly-owned subsidiary of Metallgesellschaft AG. The parent company has many other interests in South Africa, inter alia in mining fluorspar. Lurgi had collaborated on the original Sasol plant and has provided the enourmous gasifiers used in the first stage of the Fischer-Tropsch process. Lurgi components in the Sasol plants are said to come to a total value of DM 4 billion. An unfortunate aspect of Lurgi's collaboration is that Lurgi made use of the staff and expertise of its Japanese subsidiary. Japanese law prohibits economic collaboration with South Africa but the law does not apply to the wholly owned subsidiaries of foreign companies such as Lurgi.

Lesser collaborators

34. There were a number of smaller collaborators worthy of note. Linde AG, a company from the Federal Republic of Germany chosen by Lurgi as its subcontrator, provided many of the tanks, vessels and heat-exchangers used. L'Air Liquide of France was responsible for designing and building an oxygen plant which is said to be the largest in the world. Honeywell of the United States provided major portions of the process control system. Südchemie AG of Munich, Federal Republic of Germany, has formed a joint South African subsidiary with Sasol Ltd. to produce catalysts used in the plants. In turn, this company has a standing purchase agreement with the South African subsidiary of Hoechst AG of the Federal Republic of Germany. This latter has another subsidiary, Uhde GmbH which, in turn, has been active in South Africa for many years and has built many of the auxiliary plants in Sasolburg connected with the original Sasol plant.

Sasol tries unsuccessfully to export technology

35. There is also a reverse type of collaboration in which Sasol Ltd. has tried to sell its technology abroad. It has not, however, been very successful. Fluor has exclusive marketing rights to Sasol technology in the United States, but has not as yet found any buyers. Sasol has also tried to develop and market a hydrogenation technology which could be used for converting lignite, which South Africa does not have. This was developed together with a Japanese-Australian consortium, but the project was eventually shelved. Sasol has at various times negotiated with Phillips Coal of Texas and Ashland Oil of Kentucky in the United States, as well as with the Great Plains Gasification Project in North Dakota, in which Lurgi is also involved. All of these projects have been abandoned, either because they were unprofitable, or because Sasol technology was not suitable for the coals used. In the case of Ashland Oil, there is the additional possibility that a public outcry in the United States discouraged management from pursuing any further collaboration with Sasol.

Transnational corporations exploit the lack of options by the Pretoria régime

36. It could even be argued that, in promoting coal liquefaction and constructing the new Sasol plants, the minority Government has itself been exploited by Western transnational corporations. If the production of motor

fuels from coal has not exactly been profitable to South Africa, it has been enormously profitable for Lurgi GmbH and Fluor Corporation, as well as to others involved in this project. In this way, the Government of South Africa is providing much needed research and development funds for synthetic fuel industries in OECD countries. In addition, it has to pay high interest to international banks on their over-borrowing in connection with the plants. The minority Government was lured into an incredible overinvestment by the transnational corporations which wished to gain experience and know-how in mammoth projects and maintain momentum in coal coversion technology while it is still not profitable on their own home markets. The minority Government has increased its dependence on OECD for capital and technology while in return it receives only such small amounts of technology as are really necessary to run the plants. It must also deplete its reserves in coal and specialized minerals at unrealistically low prices in order to pay for the imports of advanced technology and its own extravagant borrowing habits. This is another subsidy for OECD. In this way, South Africa, a developing country in Africa, is actually providing development aid to the United States and the Federal Republic of Germany to help them develop their synthetic fuel industry.

Disputes over future coal liquefaction plants

37. Whatever segment of the motor fuel market Sasol production now covers, its segment can only decrease in the future as total demand increases. Therefore, further plants will be necessary if present conditions persist. Here the authorities are obviously undecided amongst themselves as to the course of action to be taken. In addition, there has been much wrangling between the Government and Sasol, as well as between them and another conglomerate, Gencor. Sasol wavered on the issue and for a while spoke of building a fourth plant. But in 1982 it backed out of further coal liquefaction engagements. The Government does not want another Sasol-type Fischer-Tropsch plant because it would not solve one of the worst problems in South Africa, the diesel fuel shortage.

Two possible technologies for the future

38. While no decision has been made, the most likely technology for the next plant will be a type of hidrogenation known as Integrated Two-State Liquefaction, sometimes abbreviated as ITSL or TSL. This has been developed by C-E Lummus Co., a subsidiary of the Lummus Co. from the United States. This technology has never been tested in an experimental plant, something which makes it very risky for the minority Government. But its major advantage is that it can handle coals with high ash content. Moreover, this technology produces diesel fuel. Since the procedure is largely untested, little is known about its thermal efficiency, capital-intensity or profitability. It has to be noted, however, that the de-ashing technology might not be suited to southern hemisphere coals, because the dispersion of the ash in these coals is dissimilar to that of the northern hemisphere coals for which the Integrated Two-Stage Liguefaction technique was originally developed. But the major obstacle to deciding on further conversion plants is a dispute which has now broken out between Sasol and Soekor (which are now totally unrelated companies) over coal versus natural gas. Soekor's experts

believe that the cost of South African coals will soon rise very steeply and that natural gas will soon be preferable to coal as a feedstock for fuel conversion plants, provided enough can be produced from offshore gas fields.

By-products stimulate the growth of the chemical industry

39. The Sasol plants inevitably produce large amounts of certain by-products which are useful in the chemical industry. In addition, methanol and fertilizers are produced since they are there for the asking. In the long run this may provide a subsidy or impetus for the development of the chemical industry. In addition, methanol and fertilizers are produced from coal in South Africa. The Sasol by-products have no price since they are there for the asking. In the long run, this may provide a subsidy or impetus for the development of the chemical industry. In fact, the racist authorities may have been lured into the Sasol project in the belief that profits from by-product-based chemical industries would mitigate the loss on petrol production. A certain modest boom in the chemical industry in South Africa therefore seems probable. This would further re arrange the country's position in the constellation of transnational corporations patterns. The reason is that the South African chemical industry has always been largely dominated by British-owned companies. This would further eclipse them in favour of transnational corporations from the United States and the Federal Republic of Germany. Whatever the case, at the basis of this chain of products and industries lies the low price of coal due to the under-payment of black labour in the collieries. This foundation is an integral part of the apartheid system. When apartheid falls, all profitability structures built on top of it will collapse, and the chemical industry will be no exception. Because the authorities have embarked on a course which develops the chemical industry for transient reasons and on a basis which will eventually be removed, the ultimate readjustment when apartheid falls will be all the more abrupt and traumatic.

Offshore oil exploitation

40. Other major response of the minority Government has been to explore for oil in offshore areas. Heretofore all such exploration has been conducted by the Southern Oil Exploration Corporation (Soekor) which is now an independent Government-owned company. Until 1983 it was a wholly owned subsidiary of Sasol. Total South African expenditure on oil exploration is officially put at R561 million for the entire period since drilling began in the late 1960s. Of this, R511 million has been spent for offshore exploration. No onshore exploration has occured since 1978. Soekor's portion of this expenditure is set at R499 million. Since these figures are rather low in relation to the total number of drillings, it is assumed that they exclude certain costs which a normal private oil company would include in its exploration expenses. As of the beginning of 1985, 90 drillings had been completed, of which only four showed non-commercial quantities of oil. There have been more frequent gas discoveries, but none of these had commercial value either.

South Africa's two new offshore drilling rigs

41. At present, two offshore drilling rigs of a type known as "semi-submersibles" are operating in South African territorial waters.

Drilling rigs of this type normally cost about $65,000 to 75,000 per day to lease and additional operating expenses come to about $10,000 per day. In order to ensure continued access to such exploration equipment, the minority Government has had two such semi-submersibles built abroad. The Government is assumed to own major interest in them. They were called Actinia and Nymphea and are almost identical. They were designed by the marine architects Friede and Goldmann of New Orleans in the United States, which, in turn, is a branch of a firm with headquarters in the Federal Republic of Germany. They were built according to specifications required for operation in the North Sea; conditions in waters off the southern coast of South Africa resemble those in the North Sea. They were built at Hitachi Zosens's Ariake Works in Japan. The French firm of Foramer managed the construction and it is the formal operator of the rigs. It has also admitted to part ownership. They are registered in the names of dummy companies in Panama. Their cost is estimated at $85 to $90 million a piece. The Actinia has been drilling in South African territorial waters since early 1983; the Nymphea is leased to a subsidiary of Shell Oil and will be doing exploratory work in the Bass Straits in Australia until March of 1985 at least.

Offshore exploration drilling

42. Drillings have been performed off the northern coast of Natal since about March 1983. They have thus far shown nothing. In fact, any drilling in this area is a sign of sheer desperation. The sea floor off much of the South Africa's eastern coast would make oil production very expensive, if any should be found. There is still interest in the areas off the western coast where some vaguely promising finds had been made in the 1960s and 1970s, but it is off the southern coast where activity has been concentrated. If there is any oil, it would probably have to be there. Exploration on the western coast off Hondeklip Bay and off the southern coast by Plettenberg Bay in the 1960s and 1970s indicated widespread occurrence of natural gas reserves. Originally, foreign oil companies explored in the South African waters at their own financial risk, but the last one, Chevron, pulled out in the mid 1970s. They were undoubtedly discouraged by the consistently poor results of exploration, but they may also have been deterred by adverse public pressure on their home office.

Drilling results remain disappointing

43. Besides drilling, seismic exploration has also been conducted from time to time. In February and March 1983 such seismic surveying was being done off the western coast at a point given as 29 degrees south and 16 degrees east. The results of such surveying have never been divulged. But the area is disturbingly close to Namibian waters. However, it now appears that this seismic testing was an attempt to see if natural gas reserves on the Namibian side of the border could be reached from South African territorial waters. Significantly enough, most drillings have been very far offshore and with the passage of time it is going on further and further from shore, a sign that nothing promising has been found closer in. This means that the cost of exploration is increasing and the potential cost of production even more so. From drilling positions reported in the press, it appears very much that exploration drilling is taking the form of "groping around " for likely

reservoirs rather than trying to "close in" on an established hydrocarbon reservoir. The fact that no private oil company wants to risk money on exploration speaks for itself and the international oil industry does not take South African exploration very seriously.

Geology of the offshore area is not encouraging

44. These offshore drillings are being conducted in four distinct geological "provinces", three of which are rated by authoritative offshore publications as "basins tested by exploratory wells without significant discoveries" and with "fair to poor prospects for finds". The new exploration area off the Natal coast is rated as a "basin yet to be explored, generally with only reconnaissance seismic surveys", but it too is believed to have only "fair to poor prospects for discovery". In the area considered most "promising", the discovery pattern shows a large number of sporadic natural gas and condensate finds with occasional discoveries of extremely light oil. This suggests that the area is a "young" province with reservoirs lying flat like pancakes rather than extending downwards like a well-shaft. Such formations, even if they do contain petroleum, would be extremely expensive to develop because they would necessitate a greater number of wells and drillings spread out over a greater distance. They would also require artificial pressure-maintenance measures sooner, and this would also increase development costs.

Foreign companies collaborate in offshore exploration

45. Seismic surveying off the western coast of South Africa has been conducted by the firm of Prakla-Seismos GmbH of Hannover, Federal Republic of Germany. For this purpose this company has chartered special research ships from the Sloman-Neptun Shipping Company of Bremen, Federal Republic of Germany. Most offshore drilling since the early 1970s has been conducted by Sedco Inc. of Dallas, United States, which at present has one semi-submersible drilling rig on lease to Soekor. Sedco Inc. has recently been taken over by another company, Schlumberger Ltd. Actinia and Nymphea are assumed to be largely owned by South African interests, probably the State, and partially owned by the French company Forasol/Foramer. There may be, however, additional part owners. Forasol and its wholly-owned subsidiary Foramer, are headquartered in Vélizay-Villacoublay near Paris, France. The parent company specializes in drilling in general, the subsidiary in offshore drilling. It is owned 34 per cent by another French company, Soletanche, headquartered in Nanterre near Paris and specializing in civil engineering and drilling. Another 33 per cent is owned by Industrieële Handelscombinatie Holland (IHC) headquartered in Rotterdam and concerned with naval construction, offshore drilling and marginally interested in sea bed mining. The final 33 per cent of Forasol/Foramer is owned by SA Ackermans & van Haaren NV, a very old family-owned Belgian shipbuilding, naval and civil engineering firm with headquarters in Antwerp. In South Africa itself, all offshore exploration is supposed to be the monopoly of Soekor, but it is surmized that Soekor has formed dummy subsidiaries inside the country and abroad in order to be able to operate more discreetly.

Two recent discoveries

46. In October 1982 the then South African Minister of Energy and Mineral Affairs, Mr. du Plessis, created a sensation by disclosing that an important "discovery" of oil has been made the previous month off the southern coast. This led to an outburst of euphoria and even property speculation. The reason was that an exploratory drilling was flowing at the rate of 900 barrels per day of 50 degree API gravity crude oil (this is an extremely 'light' oil) in addition to a certain amount of condensate. But the position was almost 250 kilometers from the operational base in Mossel Bay in about 180 meters of water. The distance from the point of discovery to the nearest landfall was about 200 kilometres. All of this would have made it a very "marginal" and expensive field, similar to the Argyll Field in the North Sea, if the initial discovery had been confirmed by further testing. The bubble burst in April 1983, after several further drillings disclosed no more oil in the area. In February 1985, while performing evaluation drilling on natural gas reserves off the southern coast of South Africa, Soekor unexpectedly discovered 36 degree API gravity oil flowing at a rate of 2,600 barrels a day. A flow rate of this magnitude has to be taken seriously, and the gravity of the oil makes it quite useful for South African needs. But Soekor tended to play down the discovery, possibly because the formations in the area are believed to be quite small, and nothing has been said of this discovery since.

High cost of developing oil fields

47. It was while the euphoria over the previous discovery still persisted that a spokesman for Soekor disclosed some interesting figures which shed light on the strategy and level of expectations of the minority Government. He said at that time that it would require a production flow rate of about 20,000 barrels per day for 15 years to provide a return on investment. This translates into 110 million barrels of recoverable reserves, which suggests that the total reserves would have to be close to 200 million barrels. There are few places in the southern hemisphere with such concentrations of petroleum in one place and it is totally unrealistic in view of the fact that there is no evidence of appreciable oil reserves in, or anywhere near South Africa. In addition, the assumed shape of reservoirs would seem to require several platforms for production purposes. Such an offshore platform in such water depths under these conditions would cost about $350 million. Even in the unlikely case that this much oil could be produced from a single platform, the ratio of fixed capital equipment to barrel of daily output capacity would be $17,000. This is higher than the normal North Sea costs which amount to $14,000, though still lower than the cost of Alaskan Oil, which amounts to $25,000. While much of this discussion is probably nothing but pipe-dreaming on the part of the minority Government, the extremely costly and unprofitable nature of their pipe-dreams clearly indicates the extent of their desperation. The reason is obvious: however costly and unprofitable, oil produced from such offshore fields and refined onshore would still be cheaper than fuels produced by Sasol.

Plans for conversion of natural gas to fuel

48. In 1984, the Minister for Energy Affairs, Mr. Steyn, commissioned feasibility studies on proposals to produce motor fuels from natural gas.

Existing production technologies are all more expensive and less thermally efficient than the one used by the new Sasol plants. It can be roughly estimated that the production of fuel from natural gas would cost the equivalent of about $90 per barrel, as opposed to about $75 for Sasol fuels. These same technologies also suffer from the same disability of producing more petrol than diesel, thus exacerbating rather than mitigating the imbalance in South Africa's petroleum product slate. Soekor, which sees natural gas conversion as the most appropriate means of getting the edge on its now privatized rival Sasol, argues, however, that the currently lower price of oil-from-coal will shortly be reversed when decent pay for coal miners drives the cost of coal way beyond that of natural gas. In addition, Soekor claims that a modified form of the ARGE process technology, which was used in the second track of the original Sasol plant, could be adapted to natural gas conversion. This technology produces more diesel than petrol. The offshore gas fields from which the gas would be produced are closer to shore and in shallower waters than the oil field discussed later on, and a conversion plant with a capacity of between 19,000 and 25,000 barrels per day could be built near Mossel Bay for a cost said to be about R2 billion. There is reason to be suspicious of these unusually low cost claims, and, even so, the capital intensity of this production-coversion system would be inadvisably high, amounting to around $90,000 per barrel of daily fuel output capacity. In January 1985, Soekor also proceeded with evaluation drilling in the Kudu gasfield off the coast of Namibia, only 2.8 kilometres north of the territorial divide. If gas could be produced there in commercial quantities and piped to South Africa, it could also be converted to motor fuels. In this case, there is talk of locating the coversion plant in the Capetown area. In addition, it has to be noted that there looms the promise of even larger gas reserves off the coast of Mozambique. Like many other such projects, its viability has been greatly enhanced by desperation and wishful thinking. The results of the feasibility studies have been delayed because of increasing domestic unrest. But these plans will have to be watched in the future, especially in view of their potentially unfavourable complications for Namibia and other countries in the region.

South Africa's petroleum consumption

49. South Africa's current domestic consumption of refined products is a state secret, but estimates by different experts do not vary greatly. They range from 250,000 to 320,000 barrels per day. By extrapolating from certain assumptions about the effectiveness of rationing measures taken during the crisis of 1979 and of vehicle use and demand growth since then, this expert estimates it at around 280,000 barrels per day. Almost the same estimate has been given by Bailey and Rivers on the basis of economic growth factors. Assuming 70,000 barrels per day for total synthetic fuel production in all three plants, it only covers one fourth of total refined product consumption. It has to be noted, however, that the total amount transiting and being processed by South Africa is slightly higher because a small amount is re-exported.

Three unknowns in the South Africa's oil equation

50. In order to calculate the amount of time for which South Africa could withstand an oil cut-off, we need to know three things: the Sasol plants' capacity, the level of domestic petroleum consumption, and the extent of

strategic oil stockpiling. All three of these things are official secrets and can only be estimated; but the first two can be estimated within sufficiently narrow margins. Therefore, in the future, clarification of this question will depend upon further investigation of the stockpiling situation. The minority Government has long made absurd claims about the amount of petroleum stored in disused mineshafts, presumably in the form of crude. The original official claims put the total amount at three years' worth of supplies. This has been widely discussed in the oil industry, where the general consensus has been that these claims are exaggerated.

Probable extent of strategic stockpiling

51. In 1979, Bailey and Rivers came to the conclusion that the total amount of stockplied oil could only be half of this. This present expert believes that the maximum possible amount is 17.5 million tonnes, which is the equivalent of 15 months of consumption. This is, however, to be understood as a maximum and it is quite possible that the real figure is considerably lower. First of all, there is no evidence that any such storage facilities have ever been built in South Africa. It is also questionable if it is technically feasible to do so to this extent. The assumed cost of the storage facilities and the loss by tying up such amounts of oil and capital over long periods of time would also be considerable. This expert further suspects that a good portion of the South African strategic oil stockpiling facilities are located near Secunda and were only built in connection with the coal liquefaction plants.

Survival in case of an oil cut-off

52. A viable estimate of the "period of grace", the amount of time for which the white minority Government could survive an oil cut-off, can therefore be reached by simply crossing these three variables, as shown in the table below. These estimates are also arrived at under certain simplistic assumptions which, however, are not unrealistic. It is, in any case, important to point out that the estimates in the table are a heuristic fiction because they show the amount of time which could pass before the "last drop" of motor fuels would be used up and the entire society would come to a "grinding halt". In real life, serious dysfunctions would begin to occur even earlier. In addition, it is no-one's intention to destroy the South African economy by bringing it to a "grinding halt". The strategy of an effective oil embargo is based on the notion that once South Africa is trapped and has no more access to petroleum beyond what it already possesses or can produce, in other words, once its "days are numbered" to something relatively modest like 22 months (652 days), then its financial collaborators and backers abroad will lose all confidence in its ability to survive and will withdraw further co-operation and financing. This could easily happen at a very early period before major damage had been done to the national economy.

Table showing possible length of time a/ South Africa could withstand an oil cut-off under varying liquefaction, storage and consumption conditions

if consumption is: / If stockplies are:	55,000b/d			65,000 b/d			75,000 b/d		
	6 months	1 year	15 months	6 months	1 year	15 months	6 months	1 year	15 months
320,000 b/d	220	441	551	229	458	573	238	477	596
280,000 b/d	227	454	568	238	475	594	249	499	623
250,000 b/d	234	468	585	247	493	617	261	521	652

a/ in number of days

Macroeconomic costs of an oil embargo

53. This expert would like to risk a rough estimate of the probable cost of Government countermeasures to the oil embargo threat. Let us assume that the Sasol plants produce 70,000 barrels per day of motor fuels at $75 per barrel of oil equivalent, and that the total refined product consumption is 280,000 barrels per day. The rest is purchased on the international spot market at a "pariah penalty" of $5 per barrel over spot. Let us further assume that the Sasol plants and the storage facilities cost $6.3 billion of which only $1 billion has as yet been paid: the rest bears interest at a rate of 12.5 per cent, which is about 1.5 per cent over current Libor. The final assumption made is that about 17.5 million tonnes of crude are held in stockpiled storage. This would mean that South Africa incurs an opportunity loss of $1.175 million on Sasol production; it then must pay an additional $383 million in "pariah penalties" for foreign oil, in addition to storage losses of $480 million and interest cost of $660 million. This would bring the total annual operating loss in their energy sector to about $2.7 billion. This excludes capital investment losses as well as money wasted on offshore exploration. It is clear that South Africa's economy cannot operate normally and expand in the long run if economic burdens of this type persist. The oil embargo by the international community may have been unsuccessful in preventing the continued oil flow to South Africa, but it has not been without effect; in fact, it has forced the minority Government to restructure its entire energy sector at horrendous costs. Such costs incurred in defence of apartheid increase foreign indebtedness and inflation.

Refineries

54. South Africa has four major refineries, three of which belong to foreign oil companies, the fourth belonging to Sasol and the Government. Total refinery capacity is variously estimated at 423,000 to 476,000 barrels per day. Total refining plant was originally geared to cracking relatively heavy Middle East oils down to petrol. It is clear that these refineries were not operating anywhere near capacity in 1978, and estimated Sasol production of

70,000 barrels per day has now made a significant dent in their normal business. In addition, it is clear that the one refinery owned by Sasol and the Government, at Sasolburg will not be closed because it is presently being revamped by Fluor Corporation, undoubtedly in order to adapt it to a broader spectrum of crude oils, especially lighter crudes. Thus if there are any refinery closures, it will be one of the other three.

Possible losses for foreign oil companies

55. This serious refinery overcapacity and other developments will necessarily tend to change the commercial relations of the minority Government with major foreign oil companies. They are potentially interested in offshore oil discoveries, because this would provide crude oil that would have to go through their refining plants. But they are not interested in risking any money on exploration. The problem of refinery overcapacity means serious long-term losses for their refining activities. At the same time, the drop in the oil price internationally reduces their interest in the South African coal reserves; it has largely been their interest in coal, in expectation of increased coal consumption and/or massive coal substitution for petroleum that has led them to oppose the oil embargo and co-operate with the minority Government. They also have an interest in the distribution network and, in addition, they own blocks of shares in Sasol Ltd. and other relevant South African companies. But the current trends do not suggest that they will become more attached to the minority Government in the future. If they lose interest in coal and incur persistent losses in the refining sector, they may eventually write off the minority Government as a bad investment. One of the major obstacles to an effective oil embargo would then be removed.

Short term responses by the minority Government

56. The minority Government has thus far been very flexible and resourceful in response to the oil embargo threat. It, however, lacks any global long-term strategies or possibilities. It has thus far shown a ruthless willingness to incur foreign debts, waste money and squander non-renewable resources. Moreover, it has not hesitated to prejudice the future development of the national economy by diverting investment to its own transient strategic needs. The production of motor fuels from coal at the Sasol plants is a marginal, but inadequate response; the minority Government must soon decide on a new plant, a new mammoth project involving mammoth foreign borrowing. As yet, no technology is available which would permit the régime to create an additional margin of security at a better cost-effectiveness ratios. Indeed, the suspicion is very strong that further measures will only be possible at even more adverse cost-effectiveness ratios. Offshore exploration increasingly confirms the general suspicion that there is simply no petroleum in the area.

Problems of the South Africa's energy sector

57. The attempts to obtain oil from Angola could be less costly in economic terms but more costly in political and diplomatic ones. Should an oil cut-off come about anywhere in the next 5 to 10 years, it is certain that it could not

meet with an effective response. The entire energy sector is now fraught with diseconomies and complications, including diesel shortage and lack of flexibility in substitution, though slight mitigation might be obtained if more rational use is made of by-products in the chemical sector. In general, dependence has been shifted but not eliminated. Coal liquefaction lessens dependence on foreign oil, although only marginally, while it heightens dependence on black labour in the collieries and on capital and technology from a select group of OECD countries. As the options of the minority Government decrease, it becomes a more attractive customer to transnational corporations because it is willing to accept worse conditions and pay higher prices. But the same trend makes South Africa less interesting as an area of equity investment.

No long-term solution in sight

58. In general, the fuel-strategic situation of the minority Government can only deteriorate. Nothing as yet indicates that the Government has anything even approaching a global long-term strategy for its energy and transportation sector. Only a dismantling of the apartheid system would permit restoration of normal operations and growth in these sectors, but, even so, a certain amount of permanent damage to the national economy is inevitable and this can only increase the longer the minority Government holds out. By the same token, the inevitable transition to non-racist economic structures will be more abrupt and traumatic if it is put off until a later stage.

-***-