SYNFUELS FROM COAL LESSONS: FROM SOUTH AFRICA

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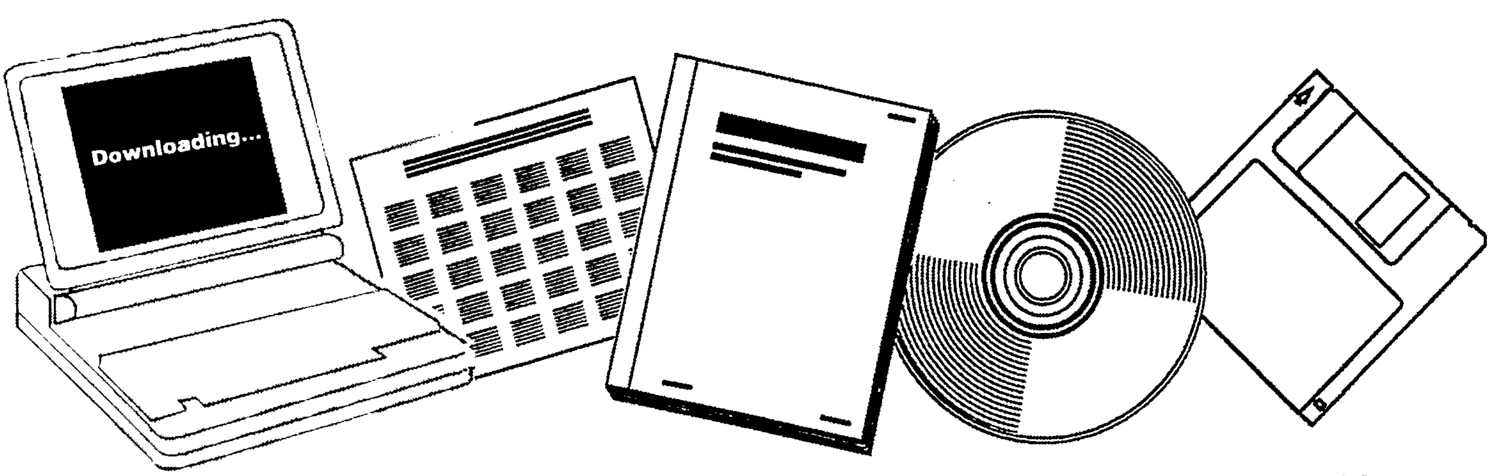
JUL 1980



Synfuels from Coas
Lessons from South Africa

R. S. Thurston

Los Alamos Scientific Laboratory
Los Alamos, New Mexico

July 1980

LASL-80-13

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Synfuels from Coal

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Rodney S. Thurston

University of California

LOS ALAMOS SCIENTIFIC LABORATORY

Post Office Box 1663 Los Alamos, New Mexico 87545 505/667-5061

UNITED STATES
DEPARTMENT OF ENERGY
CONTRACT W-7405-ENG. 36

The technology for the liquefaction of coal to produce synthetic fuels (synfuels), such as gasoline, diesel fuel, and aviation jet fuel, has become popular because of OPEC price rises, turmoil in the the Middle East, and gasoline shortages. Yet, the Republic of South Africa is currently the only nation with experience in the commercial operation of a coal-liquefaction plant, and it has more commercial plants under construction. However, its international relations are poor because of its racial policies. This has caused many people to dismiss South Africa's coal-liquefaction technology as a special case, which is subsidized by the government, supported by the labor of low-paid black miners, and allowed to continue only because of its strategic political value. The coloration of truth in such statements is of varying hues, and other nations, including the United States, could benefit from the research and experience in South Africa.

SASOL

About 1947, a South African company investigated a commercial venture for the liquefaction of coal. The coal and the production technology that had been developed in Nazi Germany were available, but the capital required was too large for the private company. Consequently, the government of South Africa decided to form a government-owned corporation that would be operated and taxed like a private corporation. The corporation was originally called South African Synthetic Oil Limited (SASOL), but in the post World War II period, the association of "synthetic" with "ersatz" revived memories of questionable quality. Thus, the corporate name was changed to South African Coal, Oil and Gas Corporation Limited. The acronym "SASOL" was kept as the company name, and its plants are identified as "Sasol I," "Sasol II," etc.

Construction of the first commercial coal-liquefaction plant began in 1951 at the new town of Sasolburg, about 80 miles southwest of Johannesburg near the Vaal River. The plant, now called "Sasol I," was operational in 1955, and in 1960 it made a profit—five years ahead of schedule. A large part of the economic success of Sasol I is credited to its scientific and engineering staff. The coal they had was of such poor quality that it was described as "carbon-contaminated real estate;" it was 35% ash. But SASOL was able to process and sell just about everything in the coal except the ash. In addition to gasoline and diesel fuel, the plant at Sasolburg produced over 100 by-products from coal. The mix of products was varied, depending upon market conditions, to optimize the plant's profits.

GERMAN AND AMERICAN TECHNOLOGIES

To liquefy the coal, SASOL uses an indirect process called "Fischer-Tropsch" after its German inventors. In the process, coal is gasified by reacting it with steam, purified, and then synthesized into the building blocks from which the plant's refinery products are made. An advantage of indirect processing is that in the purification step, the environmentally harmful substances can be removed before the marketable products are formed. This minimizes the formation of carcinogens and mutagens in the products.

The gasification units in the SASOL plants are of German origin and are manufactured in West Germany or under the license of the West German manufacturer, who has maintained close collaboration with SASOL. At the Sasol I plant, two types of synthesis units are in operation; one, which is based on German technology, uses catalysts in a fixed bed, and the other, which is based on American technology, uses a catalyst in a moving bed. The SASOL engineers found the American unit more attractive, but SASOL management was concerned that the American design represented unproven technology. A compromise was made, and the synthesis load was divided between the German and the American designs. The only synthesis units at the Sasol II and III plants currently under construction are those derived from the American design.

FINANCIAL HEALTH

SASOL's financial statements have shown a profit since 1960, as well as a healthy debt-equity ratio of 60:40. South Africans showed their support of SASOL in July 1979 when the company first offered stocks to private shareholders. All shares were bought within a few hours of their offering.

Approximately 20% of SASOL's revenues come from the sale of chemical by-products from the coal-liquefaction process. Those sales represent the difference between a subsidized operation and a profitable one. In addition, the tailgas from the final liquefaction process contains gaseous hydrocarbons that can be used like natural gas as a clean fuel in homes and as a fuel and feedstock for process industries. Judging from the number of satellite industries around the SASOL gas pipeline, SASOL's tailgas must be one of the best energy bargains in South Africa.

The South Africans do use many low-paid workers to mine the coal for the SASOL plants. Even though the wages of these miners have risen dramatically in recent years, they are still so lowly paid by American standards that this issue alone had convinced many that a SASOL-type operation could not be profitable in the United States. However, South African coal generally comes from considerable depths and is mined mostly by underground methods. Consequently, the cost of mining it with cheap labor is comparable to the cost of strip mining coal in the United States. Furthermore, the cost of coal is a relatively small contributor to the gate price of SASOL's liquid fuels.

GASOLINE COST

The gate price of gasoline is the cost for the manufacturer to deliver gasoline at his plant gate for shipment to market. Sasol II has a capital cost of $3 billion for a rated capacity of 50 000 barrels per day. Dr. George Skaperdas produced a study in June 1976 for the United States Senate on the production of aviation jet fuel from coal. By scaling his excellent analysis of a projected US plant to Sasol II, the gate price of gasoline at Sasol II, when it starts production in 1980, is estimated to be about $30 to $35 per barrel (72¢ to 83¢ per gallon). This cost is probably less than what South Africa now pays for crude oil on the world's spot market!

An increase of 100% in capital-return costs would increase the gate price of gasoline by 66%; a 100% increase in by-product revenues would decrease it by 25%; a 100% increase in operating costs would increase it by 21%; and a 100% increase in coal costs would increase it by only 19%. This last consideration dilutes the validity of the charge that the SASOL operation cannot be applied to the United States because in South Africa it is based on mining coal with cheap labor.

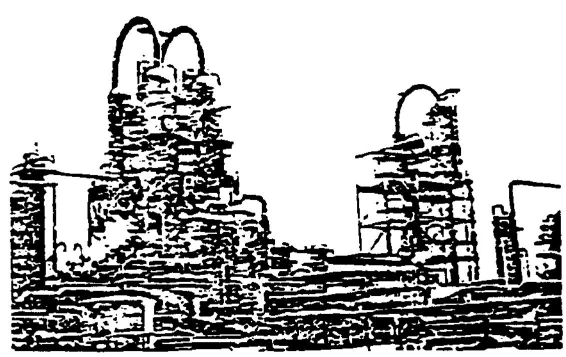
A key assumption that led to the $30 to $35 per barrel price is that SASOL's shareholders will supply all the necessary capital for the plant and that their investment will return 15% for 20 years. Another assumption that led to this estimate is that the taxes paid on Sasol II will correspond to the same proportion of revenue as the rest of the SASOL operations. This is an important departure from Dr. Skaperdas' analysis, which followed a standard planning procedure of applying a 48% tax to the difference between revenues and operating costs. The result was a tax burden that was 31% of revenues. This seems excessively high because the 1976 and 1977 representative taxes paid in the United States were about 4% of revenues in the chemical industry, 5.5% in the oil industry, and 4% in the coal industry. The tax used for the Sasol II estimate was 3.7% of revenues, which corresponds to what SASOL has been paying.

The cost of gasoline produced from coal in a capital intensive plant is not as sensitive to inflation as the cost of gasoline produced from feedstock intensive plants such as refineries of crude oil. The principal effects of inflation on capital intensive plants are difficulties in obtaining long-term loans and increased equipment-replacement costs. Inflation also tends to devalue the effect of research on gasoline costs for capital intensive plants because the longer the plant construction is postponed, the higher its cost will be. Thus, gasoline produced in a plant based on current technology may be cheaper ten years from now than gasoline produced in a plant that uses a more efficient technology after an additional five years of research.

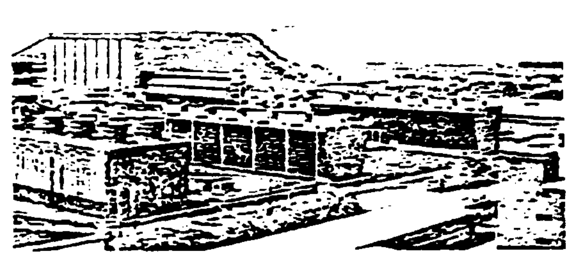
ENVIRONMENT

Americans who had visited Sasol I reported that in its early years of operation its sky was polluted—but that has changed. SASOL has installed electrostatic precipitators in their coal-burning power and steam plants and has thereby stopped polluting the air at Sasolburg. SASOL has extensively treated and recycled liquid effluents at Sasol I and claims that the new plants, Sasol II and III, have been designed for zero discharge of liquid effluents. The seriousness of SASOL's efforts with this environmental problem is underscored by the fact that these new plants lie upstream of Johannesburg's main watershed.

The two new plants are expected to generate about 20 000 tons of ash per day. SASOL plans to follow procedures developed at Sasol I, which involve separating the ash into "coarse" and "fines," using the fines in the treatment of liquid effluents, and placing all residual ash in conventional dumps that are planted with grass. At Sasol I, the ash dump looks like a grassy hill, and SASOL reports no leaching problems. Dr. H. Eric Nuttal of the University of New Mexico was impressed by the extensive corn fields growing near Sasol I. He said it was like seeing a big petrochemical complex set down in the middle of Iowa.



Sasol I synthesis units that use a process based on an American design.



Grass-stabilized ash mound behind the cooling towers and raw material silos of the Sasol I plant.

The US Environmental Protection Agency would like to make a study of the environment and the health of workers at Sasol I. They are convinced that such a study would be useful for identifying hazards and specifying protective practices for possible American synfuel plants.

SASOL'S STRATEGY

The strategy for building SASOL plants reflects a commitment to long-range planning. The first plant, which represented a large investment for a moderate production capacity, was built to establish a technology for reducing South Africa's dependence on imported motor fuels. After the surprisingly rapid success of the plant, SASOL made plans for a larger plant, which had to be justified solely on economic grounds. At that time, petroleum crude was cheap and plentiful, and the second plant was cancelled. But when OPEC formed and the price of petroleum crude was increased, the South African government reconsidered the plans for another SASOL plant. Furthermore, because the cost of fuels produced at Sasol I proved to be significantly insensitive to inflation and future OPEC price increases were expected, SASOL projected that a new, larger plant should make a profit within a few years after its initial operation. But OPEC prices and inflation have risen even faster than anticipated, and the products of Sasol II sell at market prices. Therefore, the new plant will probably make a profit during its first year of operation.

The attractiveness of Sasol II to South Africa was shown when a sudden decision was made in February 1979 to build a duplicate of Sasol II adjacent to it. Together, these plants should provide for half of South Africa's current consumption of motor fuels. These plants will reduce South Africa's international balance of payments problems not only by reducing the amount of imported fuels, but also by increasing the amount of exports from the plants' petrochemical by-products. In addition, South Africa would be less vulnerable to the spot market and to third-party suppliers of petroleum crude. We can expect more coal-liquefaction plants to be built in South Africa because eventually this alternative fuel source will force a limit on the price of gasoline and diesel fuel there.

LESSONS FOR THE UNITED STATES

The most significant lessons provided by these developments at SASOL are the importance of long-range planning and the need for establishing a commercialized technology base in synfuels. These are necessary to reduce our dependence on foreign energy sources and can be accomplished with suitable cooperation between government and private industry and between agencies within the government.

The Fischer-Tropsch process is not the only method for producing gasoline from coal, but so far it is the only one commercially proven. Another process, which produces gasoline from methanol, has been considered for commercialization. The government of New Zealand decided in December 1979 to build a commercial-size plant using its abundant natural gas as the feedstock in a natural gas to methanol to gasoline process. Because methanol can also be produced from gasified coal, this process may be an attractive option for the production of gasoline from coal in the United States.

South Africa has demonstrated that a nation can respond quickly to a deteriorating energy situation by making a long-term commitment to the establishment of an alternative energy technology. Their commitment went beyond the planning, research, and pilot-plant stages. They built a commercial-size plant to develop the appropriate production, marketing, and environmental expertise to use the alternative technology with confidence. For the United States to be prepared to bring an alternative energy technology on-line quickly, it too will have to make long-term commitments by building commercial-size plants.

ABOUT THE AUTHOR

Rodney S. Thurston holds a doctorate in mechanical engineering and is presently with the International Technology Office at LASL. He has been at LASL for about 20 years, working primarily in research activities associated with energy and defense programs.

Note: Figures provided by Dr. H. Eric Nuttal, Department of Chemical and Nuclear Engineering, University of New Mexico.

★ U.S. Government Printing Office: 1980-677-179/29

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