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METHANOL AS A MAJOR FUEL

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CONTENTS

TABLES

CONVERSION AND EQUIVALENCY FACTORS

1 bbl (barrel) = 42 gallons

1 bbl gasoline = 5.4×10^6 Btu

1 bbl methanol = 2.7×10^6 Btu

1 ton methanol = 20×10^6 Btu

1 ton methanol = 7.4 bbl methanol and is equivalent to 3.7 bbl gasoline

1 Tcf (trillion cubic feet) of natural gas = 10^{15} Btu

1 Km^3 (cubic kilometer) of natural gas = 35.3×10^9 cf (cubic feet)

1 Km^3 of natural gas = 35.3×10^{12} Btu

Density of gasoline = 5.8 lb/gal

Density of mehtanol = 6.6 lb/gal

A 25,000 ton/day methanol plant produces 8.2×10^6 ton/yr which is equivalent to 30.3×10^6 bbl of gasoline.

Motor gasoline consumption for the U.S. was $2,566 \times 10^6$ bbl in 1979. This is equivalent to 13.48×10^{15} Btu. This amounts to 7.0×10^6 bbl/day.

Oil imports for 1979 were 8.3×10^6 bbl/day. This included refined petroleum products (much of which is residual oil) amounting to 1.9×10^6 bbl/day (3.8×10^{15} Btu/yr) and crude oil amounting to 6.4×10^6 bbl/day (12.8×10^{15} Btu/yr).

Natural gas consumption in the United States in 1979 was 20 Tcf, which is equivalent to 20×10^{15} Btu or 10×10^6 bbl/day of crude oil.

INTRODUCTION

The objective of this investigation of methanol as a major fuel was to provide perspective for officials of the U.S. Environmental Protection Agency's Industrial Environmental Research Laboratory at Research Triangle Park regarding possibilities for commercialization and the environmental implications associated with wide use of methanol as a substitute for petroleum-derived fuels.

It is recognized that the future of methanol fuel will ultimately be determined by economics. To gain widespread acceptance, methanol will have to be cheaper than competitive fuels after all advantages and disadvantages have been considered. No attempt is made here, however, to assess the competitiveness of methanol fuels at present prices for crude oil or to project the price at which they could be competitive. Such evaluations would be far beyond the scope of the study. Instead, the methanol fuels are considered relative to other fuels that might be used if an effort is launched to apply available technology to displacement of petroleum fuels as soon as possible. The major factors considered are:

1) Potential environmental consequences of introducing methanol.

2) Status of development of methanol fuel technology.

3) Cost and efficiency of synfuel processes.

4) Potential markets.

5) Prospects for commercialization of methanol fuels.

The intent is to develop an overview perspective by identifying all important factors in each category and presenting enough quantitative data to permit relative comparisons, without excessive detail.

BACKGROUND

At present there is concern over the rate of progress in development of advanced coal conversion processes for a synthetic fuels industry. One of the principal impediments is the inflation associated with a cost-spiral driven by continuing increases in the cost of oil and other fuels, including coal.

Because of the inflationary trend, many believe that plants that coùld be built now to use available technology will be cheaper to operate than plants built later to use improved processes that might come onstream in a few years. Also there is an increasing concern over America's continuing dependence on foreign oil. These factors have combined to create widespread interest in utilizing immediately applicable coal conversion technology.

The only proven coal conversion technology is indirect liquefaction; that is, the conversion of coal to synthesis gas and subsequent conversion of this gas to liquid fuel. The proven routes for coal conversion include (1) the Fischer-Tropsch process, which converts synthesis gas directly to gasoline and other byproducts, and (2) a number of catalytic processes, which convert synthesis gas to methanol. Althouth the Fischer-Tropsch process has the advantage of producing gasoline directly, it has the disadvantage of producing many coproducts and byproducts, which must be marketed. Methanol may be used directly, as a premium fuel, in some applications, but may have to undergo subsequent conversion to gasoline, at some added cost, for use as a transportation fuel.

If a decision is made to begin a synthetic fuels industry with presently available technology, the Fischer-Tropsch process and methanol fuel processes will likely be used. The Fischer-Tropsch products are essentially the same as petroleum-derived fuels, so that their introduction into commerce would not require significant adjustment. In contrast, the introduction of methanol as a major fuel would require significant adjustment.

METHANOL AS FUEL: ENVIRONMENTAL IMPLICATIONS

Although some testing has been carried out to evaluate the use of methanol as a major fuel for automobiles and stationary sources, work to evaluate the potential environmental effects has not been extensive. Whereas some properties of methanol make it attractive as a fuel, others present problems. Experimental work to date has been encouraging, but many questions remain unanswered. Following are some of the more important environmental considerations.

1) Methanol has a lower flame temperature than petroleum-derived products. It also has wide limits of combustibility. These properties combine to make either automobiles or stationary sources that are deisgned for methanol fuels relatively lower emitters of nitrogen oxides.

2) Methanol combustion is essentially particulate-free. No carbon-to-carbon bonds are present to promote soot formation, which is associated with burning of petroleum-derived fuels.

3) Because sulfur in the feedstocks for methanol is removed in processing, combustion of methanol generates no sulfur emissions.

4) Because of its high octane rating, methanol can be used in motor vehicles without additives, eliminating the emissions associated with additives to petroleum-derived fuels.

5) Methanol's low heat content (about half that of gasoline on a volumetric basis) necessitates the use of twice the volume and over twice the weight of fuel when it is substituted for gasoline or distillate oil.

6) Some methanol properties such as corrosivity, toxicity, and explosivity call for careful consideration. Although

they have not caused problems in the closely controlled situations where methanol has been used as a commercial chemical, they must be given careful attention if it is widely used as a major fuel.

7) Other environmental considerations that have not been evaluated are the reactivity, persistence, and sensory detectability of methanol in the environment. These factors could be of great importance for a chemical with potential for release in large amounts to the environment, as illustrated by the experiences with oil spills. The high solubility of methanol in water suggests that spills of methanol would not persist as oil spills do. On the other hand, the contamination of lakes or major rivers with a toxic material that disburses into water could cause fish kills and also could produce water contamination that would not be readily detected without special precautions.

The most extensive body of experimental work on methanol as a fuel has dealt with its use as a gasoline substitute. Most attention has been given to methanol-gasoline mixture, but consideration has also been given to the use of 100 percent methanol fuel for automobiles. Although it has been established that methanol could be substituted for gasoline, there is considerable controversy over advantages and disadvantages of doing so. Some researchers expect that methanol will give higher efficiency, improved performance, and reduced pollution.[1] Others claim the opposite on all or some of these points.[2,3] It is generally accepted, however, that the use of methanol in engines designed to take advantage of its high octane and unusual combustion characteristics would give performance as good as, or superior to that of gasoline on an equivalent Btu basis.

Experimental work with methanol as a fuel for use by stationary sources has been encouraging. Tests in which methanol fuel was fired in a utility boiler designed to burn natural gas or distillate oil showed methanol to be a superior fuel.[4] Concentrations of pollutants in the combustion gases were very low (no particulates, no sulfur oxides, and low nitrogen oxides). Also, thė methanol fuel burned efficiently with a stable flame, and carbon previously deposited by oil burning was burned off of heat transfer surfaces with a resultant improvement in heat transfer. Tests of methanol fuels in commercial combustion turbines were also promising. Performance was excellent, and nitrogen oxide emissions were lower than those produced by firing natural gas. Studies of methanol as a turbine fuel for combined-cycle plants were also promising, and it has been suggested that such plants could be designed to be virtually pollution free.[5]

Consideration of methanol as a fuel for nonutility stationary sources led to the conclusion that it could replace distillate oil in home heating and would give increased efficiency. This study also concluded that methanol fuels could replace gas or distillate oil in commercial and industrial applications if due consideration is given to potential problems associated with its toxicity and flammability.[6]

In summary, past work indicates that methanol has potential for wide use a a high-quality environmentally attractive fuel. The studies also show clearly, however, that its use as a fuel will require special measures for environmental protection.

STATUS OF DEVELOPMENT FOR METHANOL FUEL PRODUCTION PROCESSES

All of the technology necessary to produce methanol for fuel use is proven. At present chemical-grade methanol is produced in amounts estimated at 30,000 ton/day. Most is produced from synthesis gas made from natural gas. The largest plant in operation today is a 2500-ton/day single-train plant, which has been operational for 10 years. Plants twice this large are now considered feasible. It is claimed that because of reduced quality requirements and improvements in technology, a 5000-ton/day plant for production of fuel-grade methanol would be only slightly larger than the operating plant producing 2500 ton/day. It is further suggested that methanol fuel plants should consist of 5 trains of 5000 ton/day each in capacity.[7]

Technology for production of synthesis gas from coal is also being applied widely outside of the United States. Lurgi and Koppers coal gasifiers are the most discussed for use in commercial production of liquid fuel from coal. Both types have a long history of application in service of the general type required for production of methanol fuels, and both have been incorporated in planned installations.

The development of the Mobil-M process, which is claimed to convert methanol to gasoline with an efficiency of 95 percent and incremental cost of 5¢/gal, may be the key to avoidance of distribution and handling problems that might otherwise impede the application of methanol fuel technology. The process was announced in 1976. Since then a 4-bbl/day pilot plant has been operated. Economic comparisons with commercially established Fischer-Tropsch units are claimed to show that the Mobil process is the most promising route from coal to gasoline.[8] Construction of a plant to convert methane-derived methanol to 12,500 bbl/day of gasoline is expected to begin in late 1981 in New Zealand. The plant, to be completed in the mid-1980's, will supply an estimated 1/3 of that country's transportation fuel.

Although all major components for production of methanol fuel from coal are proven technology, no plant has yet been built. Construction of such a plant would involve making the connection between coal gasifiers producing synthesis gas and methanol plants for the first time. Also, economy of scale would require the design of methanol trains larger than any yet built. And coal would be gasified on a scale unprecedented except in South Africa, where the "Sasol I" plant employing Fischer-Tropsch technolgoy has operated since 1955. This plant employs thirteen gasifiers, each 12 feet in diameter. Proposed ~~plants will~~ be even larger. Sasol II, scheduled to come on stream in 1980, will employ 36 gasifiers.[9] The problem associated with adaptation of processes and large scale operation should not present serious technical problems, but any element of risk has potential for making investors cautios about investing in multi-billion dollar plants.

COST AND EFFICIENCY OF METHANOL FUEL PROCESSES

The attractiveness of methanol fuels over fuels from alternative processes will depend primarily on cost. The thermal efficiency of the conversion process will be an important factor in the final production cost. Comparisons of both cost and efficiency of alternative production rutes are complicated by the dependence of both on the quality of feed materials and the markets for potential products and coproducts. This is illustrated in Table 1, which shows a comparison of plants for production of methanol, Mobil-M, and Fischer-Tropsch processes with and without coproduction of SNG.[10] The column for efficiency shows the percentage of the input Btu that comes out as product. The last column shows investment cost in dollars per million Btu output per year. The lower efficiency and higher cost shown where SNG is not a product reflect losses associated with conversion of methane formed in gasification to synthesis gas for conversion to additional liquid product.

Table 1. Efficiency and Investment Cost
Indirect Coal Liquefaction[10]

	Efficiency, %	Investment Cost, $\$/10^6$ Btu/yr
Methanol from Syn Gas		
Methanol	50.8	28.2
Methanol + SNG	60.4	21.8
Methanol - Mobil M		
Gasoline	48.7	34.3
Gasoline + SNG	58.2	24.0
Fischer-Tropsch		
Gasoline + diesel	35.7	45.3
Gasoline + diesel + SNG	50.8	25.2

The cost of production of liquid fuels is frequently given in dollars per million Btu in all products. Because this approach fails to account for differences in the value of the end products, however, it can give a distorted perspective of the potential for a given technology to satisfy present needs. Also, costs are often compared without due consideration of uncertainties attributable to stage of development. One recent study, however, generated data that give some feeling for the importance of these uncertainties in comparison of technologies.[11] Data from that report are shown in Table 2. The confidence index in Column 1 has two components: a letter indicating stage of development and a number indicating the estimated reliability of the cost. The energy cost is based on the total energy value for all products. The "reference price" is based on Btu outputs,

TABLE 2. COST COMPARISON FOR ALTERNATIVE PROCESSES FOR PRODUCTION OF LIQUID FUELS FROM COAL[11]

	Confidence index*	Energy cost, $\$/10^6$ Btu	Reference price, $\$/10^6$ Btu
Fischer-Tropsch	A-2	4.99	5.52
Methanol	A-2	4.32	4.54
M-Gasoline	C-3	4.84	4.91
Exxon donor solvent	C-3	3.96	5.40
H-coal	C-2	3.58	4.81
SRC II	B-4	3.62	5.59

* Confidence index factors:

Process development

D - Exploratory stage - not beyond simple bench tests

C - Development stage - operated on small integrated scale only

B - Pre-commercial - successful pilot plant operation

A - Complete - process demonstrated sufficiently to insure commercial success

Economic reliability

4 - Screening estimate, very approximate

3 - Incomplete definition for estimates used

2 - Firm basis for values developed

1 - Values considered to be satisfactory for commercial venture

adjusted downward in proportion to their value relative to gasoline for all products that are less valuable.

Data such as these must be considered approximations subject to variation not relating to the skill or objectivity of the estimators. They do, however, highlight several important points that are creating pressure to use presently available technology as a basis for beginning the development of a synthetic fuels industry:

1) Fischer-Tropsch and methanol fuels are more costly than new processes are expected to be. The estimated costs, however, are more reliable (as indicated by the confidence index) than those for the four developmental processes.

2) The cost advantages of developmental processes are not great. Unforeseen circumstances or inflation during the developmental period could cause them to be more expensive than plants that could be built now.

3) When credits are applied for quality of product, the relative economics change significantly. The net result is that methanol shows the lowest reference price and a confidence index better than that for any other process except Fischer-Tropsch.

It is not intended to suggest that these data indicate superiority of any given process. Many situation-specific factors (type of coal, markets served, transportation modes available) will influence process selection for commercial projects. The results do, however, illustrate the potential advantages of applying available technology now.

POTENTIAL MARKETS FOR METHANOL FUEL

Methanol fuels have been demonstrated in a variety of applications:

1. Fuel for motor vehicles, alone, or in combination with gasoline.
2. Fuel for electric utilities, to be burned as supplemental fuel in coal-fired boilers and in combustion turbines.
3. Fuel to replace distillate oil and residual oil being burned in boilers and furnaces for space heat in the residential and commercial sectors.
4. Fuel to replace distillate oil for industrial boilers and direct-fired processes.

FUEL FOR MOTOR VEHICLES

Opinions differ on the ease with which the methanol could be introduced as fuel for motor vehicles. Many believe that methanol could be utilized, with adaptation of the engines, in all types of motor vehicles. Also, many believe that a fuel consisting of up to 10 percent methanol in gasoline could be used in gasoline engines with only minor changes in present practices.[3] Even at the 10 percent level, the market would be significant. Further, even if it is determined that the use of methanol pure or at higher concentrations in gasoline, will require time-consuming adjustments, the feasibility of converting methanol to gasoline with the Mobile-M process could open the way for substituting synthetic fuels for unlimited amounts of our gasoline consumption.

Gasoline consumption in 1979 was 2566 x 10^6 bbl (13.48 x 10^{15} Btu). Ten percent of this total is equivalent to almost 70 million tons of methanol. This demand alone would consume the output of eight 25,000-ton/day plants* of the type that has been suggested as an optimum size.[7]

FUEL FOR ELECTRIC UTILITY BOILERS

Utilities currently burn a substantial amount of both distillate oil and residual oil; the distillate is used mostly as a supplemental fuel for startup and for flame stability in coal-fired boilers or in oil-fired combustion turbines. Residual oil is burned as a base fuel in large boilers. Methanol has been demonstrated to be applicable as a substitute for both types of fuel and has been used to fire utility boilers. The 1979 consumption of distillate by electric utilities was 70 x 10^6 bbl (0.41 x 10^{15} Btu)† and their consumption of residual oil was 493 x 10^6 bbl (3.10 x 10^{15} Btu). Replacement of the distillate with methanol would represent a valuable use as a premium fuel and would consume about 20 x 10^6 tons per year of methanol at present levels of consumption.

Although methanol could be substituted for residual oil as a bse fuel, this probably would not be the best application of a premium fuel in light of other possible uses. Substitution for the portion of residual oil that is imported would operate to reduce dependence on foreign oil. But with refineries worldwide

*Assumed to be operated at 90 to 95 percent of capacity.

†All fuel consumption data taken from Reference 12.

necessarily continuing to produce residual oil (as they will for many years), outlets will be needed. Utilities and industrial combustion may be the most effective way to utilize the residual oil, especially that fraction produced in the United States, which is the dominant portion.

FUEL FOR RESIDENTIAL AND COMMERCIAL SPACE HEAT

The residential and commercial sectors consume large amounts of distillate and residual oil, which is used almost exclusively for space heat and could beneficially be replaced by methanol. Substitution for residual oil in these sectors would offer advantages in that the more complex equipment for burning heavy oil in commercial establishments could be eliminated, air pollution reduced, and dependence on foreign oil reduced. Consumption levels in the residential and commercial sectors in 1979 were distillate, 513 x 10^6 bbl (2.99 x 10^{15} Btu), and residual, 152 x 10^6 bbl (0.96 x 10^{15} Btu). This is equivalent to 197 x 10^6 tons of methanol at present levels of consumption.

FUEL FOR INDUSTRIAL BOILERS AND DIRECT-FIRED PROCESSES

Methanol also appears to be a satisfactory substitute for distillate oil in industrial boilers. Distillate oil burned in the industrial sector goes both into boilers and into direct-fired processes such as dryers and kilns. Even though direct-fired processes are highly heterogeneous, it seems reasonable to assume that methanol could be used in almost any situation where distillate is direct-fired. For reasons discussed in connection with utility boilers, the industrial combustion of residual oil is not included as a potential market for methanol fuel, even though it could be used in such applications.

The industrial consumption of distillate oil in 1979 was 185 x 10^6 bbl (1.11 x 10^{15} Btu), the equivalent of 55 x 10^6 tons of methanol.

Table 3 shows a summary of the major applications in which methanol appears to be substitutable.

TABLE 3. SUMMARY OF METHANOL-SUBSTITUTABLE OIL CONSUMPTION (1979)

	Consumption, 10^{15} Btu	Methanol equivalent, 10^6 tons	Oil equivalent, 10^6 bbl
Distillate oil, utility sector	0.41	21	70
Distillate oil, res/comm sectors	2.99	149	513
Residual oil, res/comm sectors	0.96	48	152
Distillate oil, industrial sector	1.11	55	191
Motor gasoline (10%)	1.35	67	257
	6.82	340	1183

The total consumption shown in Table 3 amounts to almost 20 percent of the total U.S. oil consumption of 37.0 x 10^{15} Btu in 1979. This figure would be considerably larger if it were assumed that methanol converted to gasoline with the Mobile-M process could be substituted for the entire gasoline consumption of 13.48 x 10^{15} Btu. Also, amounts for consumption of diesel fuel (2.43 x 10^{15} Btu in 1979) are not included, even thought it is said to be replaceable with methanol with appropriate engine modifications.

Replacement of the oil products indicated in Table 3 with methanol would require building about forty 25,000-ton/day plants at a cost of about $100 billion. In terms of oil consumption, this comes to a little over 3 million barrels per day, or about 40 percent of our imports. An additional 70 to 75 plants costing around $175 to 200 billion would be required to produce gasoline in amounts equal to 1979 consumption.*

*Plant sizes assumed and costs estimated are from Reference 7.

PROSPECTS FOR COMMERCIALIZATION OF METHANOL AS FUEL

It is widely accepted that nontechnical problems such as lack of assured markets, unclear policies in regulatory agencies, potential siting difficulties, and related social, economic, and institutional problems are the main barriers to commercialization of methanol fuel or other fuels produced by presently available technologies. Growing pressure for the use of present technology to replace petroleum-derived fuels should alleviate these problems. If it does, the prospects for methanol fuels will depend primarily on advantages they offer over competitive fuels. Following is a discussion of methanol relative to the other fuels that might be produced by present technology to compete, directly or indirectly, with methanol fuels in replacement of petroleum-derived liquid fuels. These are the principal options:

1. Natural gas.
2. Low- or medium-Btu gas made from solid fossil fuels with existing technology.
3. Gasoline derived directly from synthesis gas from coal using Fischer-Tropsch technology.
4. Gasoline produced by subsequent processing of methanol, derived from fossil fuels, using the Mobile-M process.
5. Ethanol produced by fermentation of agricultural crops.
6. Shale oil.

It might be argued that synthetic natural gas (SNG) and fuels produced from direct liquefaction should be considered along with those listed above. They are not, however, because these technologies are in important ways not equivalent to the others in terms of potential application. Although one SNG plant is reported under construction, this plant will produce supplemental fuel for existing natural gas distribution systems and will not be in direct competition with the fuels being considered. Moreover, the facts do not indicate that direct liquefaction technologies are presently utilizable in the same sense as those used for the above fuels.

METHANOL VERSUS NATURAL GAS

Methanol and natural gas both have potential for replacement of petroleum-derived fuels. Gas can be used directly or as a feedstock for production of methanol. Whether or not natural gas should be used in either way depends on the adequacy of supplies for other critical uses. Until recently the expanded use of natural gas would have been impossible because of short supplies. Since passage of the Natural Gas Policy Act of 1978, which provides for progressive deregulation of natural gas prices, drilling has been greatly increased so that supplies are no longer short. Although the proven reserves for the lower 48 states were only 195 trillion cubic feed (Tcf) at the end of 1979 (a 10-year supply at 1979 rates of consumption), the total remaining conventional gas resources have been estimated to be 563 to 1219 Tcf.[13]

The higher figure is the most recent estimate. In addition, natural gas is known to be recoverable from "unconventional" domestic sources, which include geopressure zones, Western "tight sands", methane from coal seams, and devonian shales underlying Appalachia.[14,15] Estimates of recoverable natural gas from these resources were recently summarized; these data are presented in Table 4.[15] The wide range of values reflects our present poor understanding of the character of the resources.

TABLE 4. ESTIMATED UNCONVENTIONAL GAS RESOURCES FOR THE UNITED STATES[15]

Resource	Estimated total resource in place, Km^3 (Tcf)	Recoverable resources, Km^3 (Tcf)
Western tight gas sands	1,400-17,000 (49-600)	710-8,860 (25-313)
Eastern devonian gas shales	2,100-20,000 (74-706)	280-14,300 (10-505)
Methane from coal seams	2,000-24,000 (71-847)	450-13,800 (16-487)
Geopressured methane	85,000-1,400,000 (3,000-49,420)	4,200-57,000 (148-2,012)
	90,500-1,461,000 (3,794-51,573)	5,640-93,960 (199-3,317)

In recent months natural gas advocates have argued for "the natural gas option" as a worldwide approach to reducing dependence on oil. They point out that proven worldwide reserves of conventional gas are 2200 Tcf. Estimated remaining undiscovered reserves are said to be 7500 Tcf, giving a total resource that is believed adequate for 50 years even if the present annual worldwide consumption rate of 50 Tcf is doubled. Even if one accepts a lower estimate made in 1975 of 6000 Tcf for total recoverable conventional reserves,[17] the world supplies seem impressive. Utilization of the worldwide gas supplies will, however, require capture of the gas and transport to remote demand points. Some propose that this be accomplished with pipelines and ships transporting liquid natural gas (LNG). Others suggest that where pipelines must be over 5000 miles long or ship transport exceeds 3000 miles, conversion to methanol for shipment is more economical. In addition, the methanol advocates cite the advantages of liquid fuels in markets such as transportation fuels, where natural gas is not widely applicable.

In summary, it appears that natural gas may become increasingly important as a direct substitute for petroleum. At the same time, it also seems appropriate to consider conversion of substantial quantities to methanol by present technology to produce direct substitutes for some of the liquid fuels that we are now consuming in amounts equivalent to about 34×10^{15} Btu per year. These fuels are now produced partly from domestic oil supplies and partly from about 17×10^{15} Btu of imported oil. The magnitude of these numbers is illustrated by comparison with the present natural gas consumption of 20 Tcf/yr, which represents approximately 20×10^{15} Btu. No single approach will provide more than a partial solution. Even if the use of natural gas is greatly expanded, there might still be a role for methanol fuels.

METHANOL VERSUS LOW- AND MEDIUM-Btu GAS FROM COAL

Low- and medium-Btu gas can be produced with existing technology and used on-site. Medium-Btu gas, which can be moved by pipeline for short distances, can be produced for use in plants within about 100 miles. Hence, where coal is available near a point of demand, there may be little incentive to produce methanol from coal-derived gas rather than burn the gas directly. Supplies of solid fuel in remote locaticns, however, might be profitably gasified, converted to methanol, and shipped to distant demand points. This is especially true of low-grade fuels, which are expensive to ship (on a Btu basis) and are more effectively gasified than high-grade coal. Several such plants are being designed to utilize lignite in the United States.[18] Peat, which has little value as fuel except on-site, has also been suggested to be an excellent gasification feedstock. One report indicates that 11,000 and 37,000 square miles of peat bogs with thicknesses of 5 to 25 ft are located in the U.S. and Canada, respectively. The data suggest that the U.S. supply might be equivalent to 6.5 billion tons that could yield about 2.0 billion tons of methanol or 80 x 10^6 ton/yr for 25 years. This annual amount is almost 12 percent of our total gasoline consumption in 1979.[19]

METHANOL VERSUS GASOLINE FROM COAL (FISCHER-TROPSCH)

Production of gasoline from coal by the Fischer-Tropsch process might be an attractive alternative for production of nonimported liquid fuels. This technology has been used for many years in South Africa and is being greatly expanded in new capacity. The process, however, produces a wide variety of products for which markets must be available. Further, the quality of the fuel as produced is low relative to methanol fuel or Mobil-M gasoline. Additional processing is required to produce high-octane gasoline. Also, the Fischer-Tropsch process appears to be relatively lower in efficiency and higer in cost, as discussed earlier, when the value of the products is considered. The process does, however, produce a significant amount of gasoline directly, and unless the Mobil-M process is successful, it will be the only currently available option for doing so.

METHANOL FUEL VERSUS GASOLINE FROM METHANOL (M-GASOLINE)

It may be debatable whether the M-Gasoline process can be considered available technology, since no full-scale process in in operaton. It is, however, further along in development than other processes in that a commercial plant is to be built. Some consider that processing of methanol in an additional step, as this process does, is unnecessary because methanol is claimed to be usable in amounts of 10 percent or more with gasoline in motor vehicles of conventional design and to be usable ~~pure in~~ motor vehicles of modified designs. Others argue that this is an oversimplification, claiming that certain properties of methanol, including its corrosiveness, toxicity, and affinity for water, constitute problems that would require time-consuming modifications of present practices if methanol is to be widely used in motor vehicles. The M-Gasoline process in claimed to have 95.5 percent thermal efficiency in conversion, which is said to add 5¢ per gallon to the output fuel.[20] If this performance is attainable, the technology could be quite useful in attaining faster penetration for coal-derived fuels in the transportation fuel market.

METHANOL VERSUS ETHANOL FROM FERMENTATION OF CROPS

Ethanol from fermentation of crops is being used as motor fuel both in the United States and abroad. Problems and advantages associated with its use are in many ways similar to those associated with the use of methanol. Ethanol is, however, subject to certain unique limitations, primarily associated with availability of raw materials. Thus, even though ethanol production is a useful technology, it may be more limited in applicability than that for methanol fuels, in the long run.

Ethanol plants are expected to be relatively small so that they can be located near raw material supplies (such as corn) and near outlets for byproduct animal feed, the sale of which is essential to process economics. Also they effectively remove land from food production at a time when there ~~is already~~ concern over the rate at which farm land is being lost to other uses. Experience to date suggests that ethanol will play a role in replacement of petroleum fuels but is not likely to be a dominant contributor.

METHANOL VERSUS FUEL FROM OIL SHALE

Fuels from shale oil, ~~such as~~ like M-Gasoline, have not been produced commercially, but plans have been made for commercial plants. There is a considerable body of pilot plant data to support the scaleup of oil shale processes. The technical risk for commercial plants appears to be minimal. Further, oil shale deposits are very extensive and could supply our oil needs for hundreds of years. Because of economic uncertainties, however, developers are reluctant to make firm committments without such incentives as guaranteed markets. Hence, prospects are poor for near-term production of large amounts of synfuel from oil shale. Also, crude feedstocks from oil shale are of low quality compared with methanol. Thus, it appears that markets for methanol fuel should exist even if shale oil ventures are highly successful.

CONCLUSIONS

Methanol fuel technology appears to be very cost-competitive with other technologies that could be applied in a synthetic fuels industry today. Although the projected cost of methanol fuels is somewhat higher than today's prices for distillate oil and gasoline, methanol fuel plants built now could prove to be highly profitable at prices that may prevail when they come on stream.

The "clean burning" characteristics of methanol make it potentially atrractive from the standpoint of combustion system design and control of environmental impacts associated with its use. Also, methanol is easily transportable and could be produced from abundant supplies of low-grade fossil fuels located in regions of the United States remote from points of demand for premium fuels. Hence, technology for production of methanol could be applied to utilize energy supplies that would otherwise be of limited usefulness.

Methanol fuels seem to be an attractive alternative to premium fuels in several critical applications that are expected to grow in importance. One of the most important involves replacement of gas and distillate oil fired in turbines used by utilities for peaking, in combined cycles, or "repowering" to increase the capacity of existing power plants.

The use of methanol fuel technology to convert natural gas to liquid fuels as a short-term solution for oil shortages should be given serious consideration. Markets in which methanol fuels could be substituted are large and represent a significant portion of our current oil imports. The amounts of natural gas that could be produced over the next 20 years are highly controversial. The optimistic estimates suggest that allocation of significant quantities to production of liquid fuels could be helpful in solution of short-term problems.

A thorough study of problems associated with the use of methanol fuels on a wide scale is needed. Such a study should begin with analysis of gaps in the available information, which has been developed in piecemeal studies conducted over the past 10 to 15 years. This full-scale analysis should lead to definitive conclusions with respect to the policies to be adopted in future energy programs.

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