# COAL LIQUIDS: MILESTONES TOWARD COMMERCIALIZATION

David T. Wade

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Remarks made by David T. Wade
Exxon Research & Engineering Company

I'd like to summarize today's session by commenting on the broader context of development of coal liquids processes.

This slide shows a hypothetical example of what might be required for coal liquids development, if it were to proceed through the steps which have been typical of development in the petroleum industry in the past. Five years of development are shown prior to the design and construction of a large pilot plant needed to demonstrate a syn fuels technology. Design and construction of such a large pilot plant can require three to four years. If a year of operation of the large pilot plant is allowed before beginning the design of a commercial plant, a minimum of nine to ten years from the time an idea comes out of exploratory research to the time it is possible to start the design of the first commercial or "pioneer" plant will have elapsed. The pioneer plant is, by definition, a first of its kind commercial plant. It is designed to be a stand-alone facility which can operate commercially for twenty to thirty years. Its location and size are based upon commercial and technical considerations. Most of the syn fuels technologies around today have been in the R&D stage even longer than this. However, the primary reason has not been related to the difficulty of the technology so much as to the uncertain business prospects which have faced syn fuels commercialization.

Referring back to this schedule, 6 or 7 years will probably be needed to design and construct the first pioneer plant. Perhaps another year might go by in getting the plant started up and running smoothly.

This chart shows the investors waiting a year until the first plant is running well before beginning the design of multiple plants to follow the first one. Hence, 20 to 25 years can elapse between the time development starts on a particular technology and the time multiple plants begin to come onstream and supply significant volumes of synthetic oil or gas.

What can be done to speed up these individual steps is to overlap the steps more or simply bypass the pioneer plant step completely. However, anytime a step is by-passed, the technological and business risks increase. Thus far, most if not all developers of syn fuels technologies have been unwilling to do this. Once a technology has been shown to work in the lab, all the rest of the steps up to multiple commercial plants involve trying to reduce risk by increasing knowledge and reducing uncertainty to the point where a commercial plant can be designed at some acceptable level of risk. In a like manner, the role of the pioneer plant is to reduce the business uncertainty to the point where investment in multiple plants represents an acceptable risk. The following example of the role of a pioneer plant serves to illustrate what reducing risk means.

The pioneer plant establishes the cost and value of the products in the marketplace. It confirms solutions to community and social problems caused by the new technology. It charts a path through regulatory and environmental requirements, and it sets the basis for the growth of a supporting infrastructure and logistics system for feed and products. Clearly, bypassing the pioneer stage and proceeding directly with multiple commercial plants represents an increase in risk.

This slide shows where direct and indirect coal liquefaction technologies stand today. Direct coal liquefaction is in the large pilot stage. For example, as you heard today, the EDS coal liquefaction pilot plant is about halfway through its planned program and the Ruhrkohle Bottrop plant has just begun start-up. The H-Coal process is also in the large pilot plant stage. On the other hand commercial methanol synthesis plants based mainly on natural gas feed are in operation worldwide, and Fischer-Tropsch plants are in operation in South Africa. Therefore, indirect liquefaction technology based on gasification of low ranked coals appears ready for the design of multiple commercial plants.

In today's session we heard about another important milestone for coal liquids development: definition of suitable product qualities. It is apparent that different technologies make different products and these products can have different values. Even the value of a given product can depend on which kind of market it moves into. Thus one process may look more attractive than an alternative in one situation and yet be less attractive in another situation.

This slide shows a matrix of the direct and indirect coal liquids against the major conventional liquid fuel product categories--gasoline, jet fuel, diesel, home heating oil, turbine fuel and boiler or utility fuel.

Direct coal liquids, as you heard today, yield a fraction which makes an excellent blending stock for high octane gasoline.

In addition, heating oil and a stationary turbine fuel can also be produced but direct coal liquids are too aromatic for use in jet fuel or automobile diesel fuel without substantial upgrading. Some of the direct processes produce heavy fuel oil also.

Methanol, on the other hand, can be used to supplement gasoline supplies in two different ways: Methanol can be blended into gasoline as an extender, as you heard today. In addition, 100% methanol can be used as an engine fuel. In fact, methanol fuel can be used very efficiently in modified internal combustion engines with compression ratios in the vicinity of 14 to 1. Its optimum use would, however, require a new, dry distribution system, either on a broad scale or for dedicated fleets and a vehicle designed to take optimum advantage of its special properties. Methanol would also be an excellent fuel for stationary turbines used in peaking service in electric generating plants. The smaller number of customers could minimize problems of incompatibility with the present distribution system.

Methanol converted to gasoline serves the transportation market. It is not useful in other products, except perhaps as boiler fuel. Of course, any of the fuels I've mentioned could be burned under a boiler, but that does not seem like a very good way to use valuable fuels when coal could be burned directly in many cases with appropriate environmental controls.

Fischer-Tropsch liquids are suited for making jet fuel, diesel fuel, heating oil and fuel for stationary turbines. The gasoline boiling range material has a very low octane number and requires expensive upgrading to make gasoline. Sasol in South Africa makes gasoline this way but it really is not the best route to gasoline. The material boiling in the gasoline range is, however, an excellent feedstock for olefin manufacture for petrochemicals and may have greater value in that use.

Thus, you can see that some coal liquids are better suited for certain products than for others. No one coal liquids process by itself is capable of economically producing a full slate of products.

This brings us to the final milestone necessary for commercialization of coal liquids. Namely, they must be economically competitive vs. other alternatives. Our work in evaluating alternative options for producing synthetic liquids has shown that it is essential for the options to be compared using consistent bases which consider the real options available to the owner. In this context not only direct coal liquids but other synthetics (e.g. shale) and conventional petroleum most be considered as options.

Some examples of common bases are:

- economic factors e.g. inflation rate, tax treatment which have a direct impact on the absolute and relative costs of the products;

- product demands/value/quality which depend heavily on assumptions about future end use developments and use patterns;

- co product values which are important where a large fraction of the Btu's may be produced as gas or other products, which are not prime liquid fuels;

- design criteria e.g. allowances for state of development, sparing philosophy;

- resource availability/location which may impact on the process selected as well as the costs of construction and operation;

- Timing, which may foreclose some options because the technology is not available;

- Infrastructure requirements such as housing for workers.

In our studies of alternatives typical variations in the above bases from one study to another generally far out-weigh the impact of alternative processing technologies on the economics of various alternatives. Thus, it appears that many different technologies and product slates have a potential role in future commercial projects.

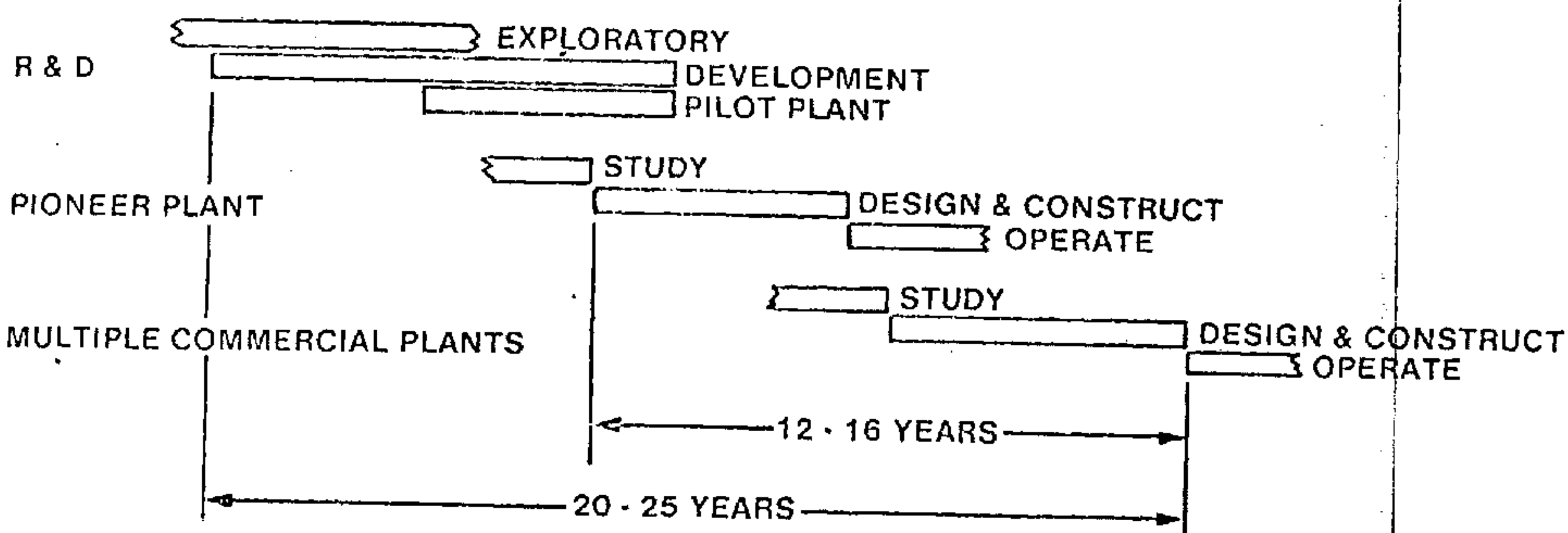
Returning to the topic of today's session, "Coal Liquids Milestones Toward Commercialization", my conclusions are:

Direct coal liquids process developments are approaching a critical milestone, namely successful completion of the large pilot plant programs. When those programs are completed the next logical milestone is design and construction of a pioneer plant.

Indirect liquefaction processes to produce methanol and Fischer-Tropsch liquids have passed the pioneer plant milestone and further development appears to depend primarily on marketplace factors.

Finally, within the range of coal types available and product demand forecasts, there appears to be no single process or product which clearly dominates all other processes or products. Therefore, it is desirable to continue to pursue a broad range of process and product options.

# DEVELOPMENT & COMMERCIALIZATION OF A SYN FUELS TECHNOLOGY IS A LENGTHY PROCESS



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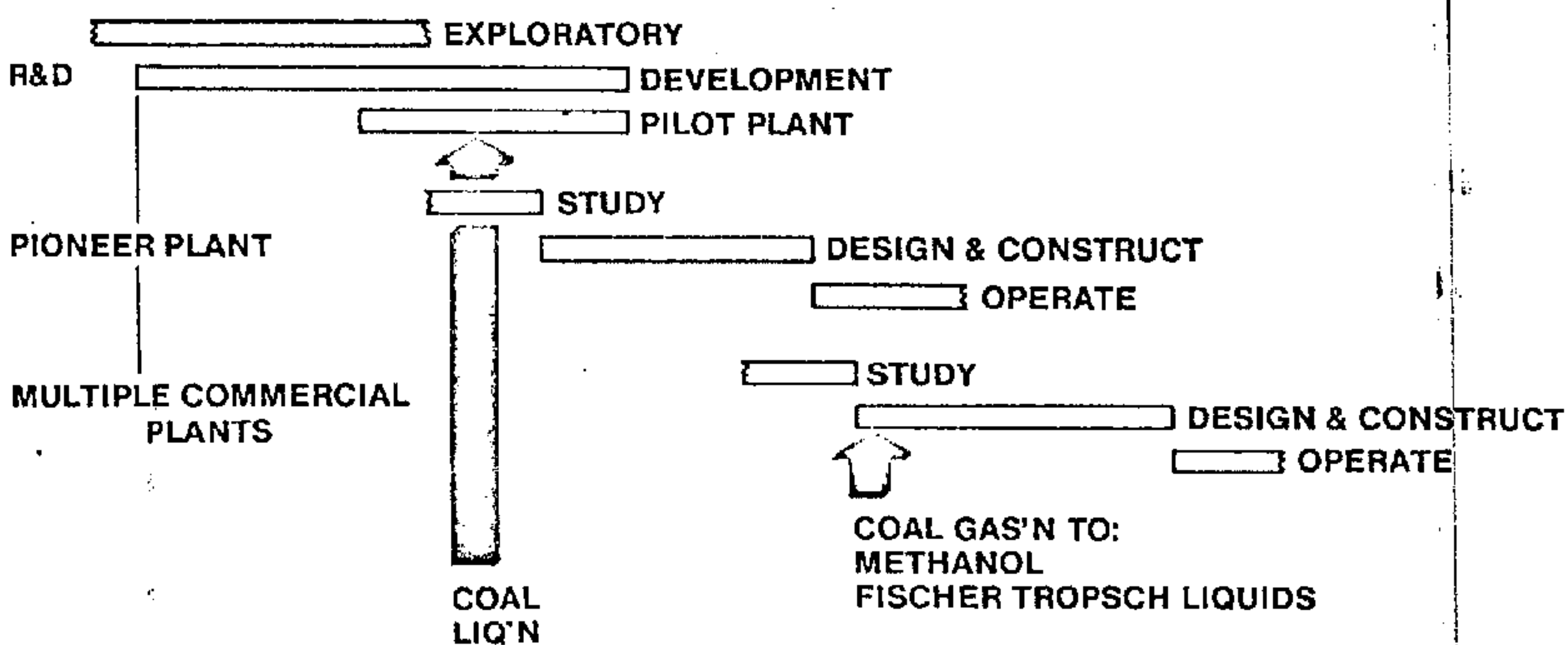

# POTENTIAL USES FOR SYNTHETIC LIQUID FUELS

| | GASOLINE | JET FUEL | DIESEL FUEL | HEATING OIL | STATIONARY TURBINE FUEL | BOILER FUEL |
|---|---|---|---|---|---|---|
| DIRECT COAL LIQUIDS | | | | | | |
| METHANOL | | | | | | |
| METHANOL TO GASOLINE | | | | | | |
| FISCHER-TROPSCH | | | | | | |

# COMPARISON OF SYNTHETIC LIQUID FUELS ALTERNATIVES

## REQUIRES COMMON BASES

- ECONOMIC FACTORS
- PRODUCT DEMANDS/VALUE/QUALITY
- CO PRODUCT VALUE
- DESIGN CRITERIA
- RESOURCE AVAILABILITY/LOCATION
- TIMING
- INFRASTRUCTURE REQUIREMENTS

# CONCLUSIONS

NEXT MAJOR STEP FOR DIRECT LIQUEFACTION IS PIONEER PLANT

RANGE OF RESOURCE TYPE/PRODUCT DEMANDS PROVIDES OPPORTUNITIES FOR BROAD RANGE OF OPTIONS INCLUDING BOTH DIRECT AND INDIRECT COAL LIQUEFACTION