methane. Another popular process, the Winkler route, yields some methane, but no liquids (*Chem. Eng.*, July 22, 1974, pp. 91-92).

Products obtained from synthesis gas, besides ammonia and methanol, include acetic acid, ethylene and ethylene glycol. Monsanto and BASF have both operated commercial acetic-acid ventures feeding on a methanol/carbon monoxide feedstock. Ethylene can be worked up from synthesis gas via a number of schemes, including Fischer-Tropsch synthesis, methanol homologation to ethanol, followed by dehydration, dimethyl ether cracking, and direct synthesis from CO/H_2, and possibly someday via the Mobil route. Chem Systems Inc. (New York City) has identified methanol homologation as the ethylene route with the "best potential," though the method nevertheless rates poorly against conventional steam cracking of naphtha or gas oil.

But that's not all. Old-timers like Du Pont's Carnell (he joined the firm in 1942) remember that before World War II the world chemical industry was largely coal-based. Even Du Pont's first polyethylene was made from ethylene derived from coke-oven gas (though the process would hardly be worthwhile at today's production scale). Du Pont products based on ammonia and methanol at that time are listed in the table.

When coal gasification attracted renewed attention a few years ago, initial thinking centered on the large "first-generation" plant providing pipeline-quality gas for fuel use only. Since "first-generation" meant Lurgi in many cases, some chemical byproducts were also foreseen, though much of these byproducts are considered plant fuel.

A number of such substitute natural gas plants were announced earlier this decade, though only one seems still alive today, and barely alive at that. This is American Natural Resources' North Dakota lignite gasifier, recently reorganized under the name Great Plains Gasification Associates, a consortium including American Natural and four other utilities. However, last month the Federal Energy Regulatory Commission declined to certify construction of a 137.5-million-Btu/d unit, arguing that no five firms alone should bear the heavy financial risk involved.

CHEMICAL RECOVERY—Chem Systems has performed an economic analysis of chemical byproduct output from Lurgi-type SNG plants, while recognizing the uncertain outlook for this manner of coal utilization. The firm found that the recovery of benzene, toluene and xylenes from the crude gas-naphtha stream of Montana sub-bituminous and Illinois bituminous appears economic. Sulfur and ammonia, while not profitable, would usually be recovered also, in order to meet environmental constraints. Recovery of anything else appears marginal for chemicals, more likely for fuel. Whatever the degree of chemicals recovery, substances obtained this way would barely dent U.S. supply needs—filling no more than 7% of demand in the year 2000, assuming 25 coal-based SNG plants, 75% of which would employ the Lurgi process.

For chemicals obtained not as direct byproducts but by processing synthesis gas, Chem Systems believes that ammonia and methanol produced via "second-generation" gasifiers, such as the Texaco and slagging Lurgi versions now being investigated with DOE support, could compete with steam-methane reforming in the 1980s. However, the success of this competition depends on a trade-off between coal's lower raw material cost, and a coal-based plant's higher capital risk. Synthesis-gas-based ethylene glycol, for example, is not now competitive with either conventional ethylene-oxide-derived glycol, or that obtained from the newer acetoxylation route, though the picture might change if ethylene prices take off, Chem Systems indicates. And ethylene synthesis itself, as already noted, cannot yet compete with steam cracking of naphtha or gas oil.

In the area of coal liquefaction, Chem Systems points out that even if 25 plants rated at 100,000 bbl/d capacity were to come onstream by the year 2000, the contribution to U.S. feedstocks supply would be small. Benzene production could meet only 9% of projected demand. The C_2/C_4 feedstocks obtainable for ethylene production could meet only 15% of estimated demand for the olefin.

FINANCING—Joseph P. Leonard, of Chem Systems, points out that financing methods are one of the greatest determinants of economic viability of coal conversion projects. What's generally needed, he says, is a highly leveraged utility-style financial package, comprised of about 75% or more debt. Such financing not only lowers costs, but also spreads the risks. Considering the high price tag on coal gasification projects—an estimated $2 billion for Exxon's East Texas complex, for example—risk reduction is especially important.

H. James Michaels and Howard F. Leonard, of Koppers Co.'s Engineering & Construction Div. (which builds K-T units)—in a paper presented at last June's 85th national meeting of AIChE, in Philadelphia—call the financing method the "largest single factor," at least when it comes to determining the cost of hydrogen made by coal gasification.

C. Edward Lorenz, director of the feedstocks division of Du Pont's Central Research & Development Dept., observes that in order to put together projects of this sort, clear policy decisions are also needed from the federal government. Whether Du Pont would want to get involved in a utility-style project, presumably tied in with an assortment of credit guarantees and regulatory restrictions, poses a "legal muddle" that cannot be answered today, Lorenz states.

Whatever the financial arrangement, the concept of a centralized medium-Btu-gas facility, as embodied in Exxon's East Texas project, fits the organizational pattern of a utility.

At the Fifth Annual International Conference on Coal Gasification, Liquefaction and Conversion to Electricity, held at the University of Pittsburgh, Aug. 1-3, Carter Oil's John P. Racz described the thinking that went into the plan, starting in 1974.

The company placed its highest priority on an assured outlet for products. Some of the other chief criteria: a low-cost, reliable and suitable source of coal, proven technology, favorable public attitudes at chosen sites for such facilities, and fairly close proximity of mine and gasification plant to markets. Carter Oil has made lignite discoveries in Texas that meet these criteria.

Realizing that industrial natural gas users would be the first affected by shortages, and that a good many of these users are concentrated in the Gulf Coast area, Exxon's thinking gravitated naturally to the medium-Btu utility-style project.

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