CHAPTER 13

INTRODUCTION TO PART V

The transportation and electric utility markets are usually cited as the prime targets for new methanol producers simply because they offer a chance at large quantities of sales. But the petrochemical industry, while a much smaller energy consumer, must also be considered when projecting future methanol demand. This industry, with the impetus of rising petroleum and natural gas prices plus supply uncertainties, is in search of new feedstocks. It is the purpose of Part V to examine the possibility of using coal as a new feedstock for the methanol that will be used by chemical plants in the future.

At present, natural gas serves as the feedstock for the methanol used in petrochemical production. In the rest of this chapter methanol's current role is put into perspective by identifying the amount of and purpose for current methanol production capacity and output. In Chapter 16 cost comparisons are presented for the production of methanol from natural gas and from coal. Finally, Chapter 17 discusses the market potential for coal-based methanol over the period from 1990 to 2010.

CURRENT PRODUCTION

Methanol production over the past fifteen years is listed in Table 13-1. Over that period, production grew at an average annual rate of 6 percent, but clearly most of that growth occurred in the eight years prior to the Arab oil embargo in 1973. Indeed, production fell sharply with the recession and only regained its 1973 level by 1979.

In terms of annual production, methanol ranked twenty-first in 1979 among all chemicals (tenth when only organic chemicals are considered). Methanol's output of 7.41 billion pounds in 1979 puts it well behind first ranked sulfuric acid with 84 billion pounds as well as behind the next four chemicals in the top forty - lime (39 b.lbs.), ammonia (36 b.lbs.), oxygen (35 b.lbs.), and nitrogen (30 b.lbs.).

TABLE 13-1

U.S. PRODUCTION OF METHANOL, 1965-1980

Year	Million Pounds
1965	2,869
1966	3,268
1967	3,432
1968	3,817
1969	4,206
1970	4,932
1971	4,950
1972	6,472
1973	7,064
1974	6,878
1975	5,176
1976	6,242
1977	6,453
1978	6,433
1979	7,411
1980	7,209

Sources: 1965-1968: Arthur M. Brownstein, Trends in Petrochemical Technology: The Impact of the Energy Crisis; 1969-1979: Chemical and Engineering News, p. 38, June 9, 1980; 1980: Chemical Marketing Reporter. The estimate for 1980 is based on production in the first six months.

CURRENT USES

Historically, principal uses for methanol have been in adhesive polymers, fibers, and engineering plastics. The demand pattern for methanol in the U.S. in early 1980 is illustrated in Table 13-2. More than 40% of methanol demand stems from the production of formaldehyde, for which the largest use is in the production of resins for the manufacture of plywood and particle board. This has resulted in a significant link between the fortunes of methanol and that of the housing industry. Markets for other principal derivitives, such as polyester fibers, are also closely tied to the general business cycle.

TABLE 13-2

CHEMICAL USES OF METHANOL

Use	% of Total
Formaldehyde	42
General Process Solvent	10
Acetic Acid	7
Methyl Halides	7
Gasoline Related Uses	5
Methylamines	5
Methyl Methacrylate	5
Dimethylterephthalate (DMT)	4
Miscellaneous	15
	100

Source: Chemical Marketing Reporter, January 28, 1980. Gasoline related uses include MTBE.

CURRENT CAPACITY

Present industry production capacity is detailed in Table 13-3. Individual plant capacities, ownership, and location are noted. Plants range in size from approximately 450-2,100 tons per day with an average of 1,260 T/D. Notice that all plants are located in Gulf Coast states. This reflects the geographical distribution of natural gas supplies, the principal feedstock for the industry, as well as the location of plants using chemical methanol. In this regard, it should be noted that much of the methanol currently produced is for captive consumption rather than for resale.

With the exception of the new DuPont plant in Deer Park, Texas, which opened in 1979 and is using oil as a feedstock, there were no capacity additions to the industry throughout most of the 1970's. Within the last several years there have been a number of announcements of planned capacity additions. These are noted in Table 13-4. The impetus for industry expansion at this time stems from both final recovery from the 1974/75 recession and the possibility of new uses of methanol.

TABLE 13-3

U.S. METHANOL INDUSTRY PLANT CAPACITY

Producer	MM Gal/Yr
Air Products, Pace, FL	50
Allemania, Plaquemine, LA	80
Borden, Geismar, LA	150
Celanese, Bishop, TX	150
Celanese, Clear Lake, TX	230
DuPont, Beaumont, TX	225
DuPont, Deer Park, TX	200
Georgia-Pacific, Plaquemine, LA	126
Monsanto, Texas City, TX	100
Tenneco, Pasadena, TX	80
Total	1,391

Source: Chemical Marketing Reporter, January 28, 1980. DuPont has a unit rated at 115 MM gal/year on standby at Orange, Texas. Rohm and Haas has a 22 MM gal/year plant on standby at Deer Park, Texas. Allemenia is a joint venture between Ashland and IMC.

TABLE 13-4

ANNOUNCED CAPACITY ADDITIONS TO THE U.S. METHANOL INDUSTRIES

	MM Gal/Yr	Start-up Date
Expansions		
Borden, Geismar, LA	30	late 80
Tenneco, Pasadena, TX	50	mid 81
Allemania, Plaquemine, LA	50	3rd qtr 81
New Plants		
ARCO[a/]	200	83
Eastman Kodak, Kingsport, TN[b/]	N.A.	83

a/ The ARCO plant is to be located on the Gulf Coast to produce methanol for MTBE, a gasoline additive.

b/ The Eastman Kodak plant is to produce methanol from coal as an intermediate in the production of acetic anhydride.

Sources: Chemical Marketing Reporter, January 28, 1980; March 31, 1980. The above list is for capacity additions which appear relatively certain at this date. Getty Refining is reported to be studying the feasibility of a 100 MM gal/yr refinery integrated methanol plant in Delaware City, Delaware for start-up in 1983. Several companies including W. R. Grace and Celanese have indicated potential interest in coal to methanol plants.

CHAPTER 14

COST COMPARISONS OF METHANOL FROM COAL AND NATURAL GAS

In Chapter 7, the cost of using methanol and gasoline in cars was compared. This chapter will use similar tools to compare the costs of using as a chemical feedstock methanol from natural gas and methanol from coal.

As with methanol for automobiles the costs of methanol used as chemical feedstock derive from three major factors: cost of production; cost of shipment and distribution; and cost of use. Since most methanol produced from natural gas is synthesized at the site of consumption, distribution and shipping costs are negligible. Coal based methanol would, however, incur these costs. In contrast to automobiles, the use of coal based methanol as feedstock in place of natural gas based methanol would require no additional equipment or capital investments.

It is assumed here that all the methanol for chemical plants is used in Houston. As noted methanol is assumed to be produced from natural gas at the chemical plant so there are no transportation or distribution costs. In contrast, methanol is assumed to be produced from coal in Illinois and therefore considerable transport cost will be incurred. The effect of this approach is to bias the comparisons against coal based methanol.

Table 14-1 compares the cost of coal and natural gas based methanol in 1990 assuming rail transport; Table 14-2 does the same assuming the coal-based methanol is shipped by pipeline. In all cases, the coal based methanol has a cost advantage.

To show how this comparison changes over time, Tables 14-3 and 14-4 provide data for 2000. As expected, methanol's cost advantage grows.

All of these comparisons are based on a particular path for natural gas prices. These prices are assumed to track oil prices which in turn are assumed to rise 2 percent in real terms each year. To demonstrate how sensitive the comparisons are to changes in gas price assumptions, Table 14-5 displays what can be termed breakeven natural gas prices. That is, the gas price at which coal-based methanol starts to be cheaper. As can be seen in the table, the breakeven gas prices are far below the projected gas prices in each of the three years. That is, gas prices would have to be 30 to 40 percent lower than projected in 1990 in order to find gas-based methanol to be cheaper; by 2000, the gas prices would have to be 50 to 60 percent lower than projected.

TABLE 14-1

PETROCHEMICAL COST COMPARISON:
METHANOL FROM ILLINOIS IN 1990
DELIVERED TO HOUSTON BY RAIL

	Koppers-Totzek Methanol	Badger Methanol	BGC/LURGI Methanol	Texaco Methanol	Steam Reforming
Plantgate Cost	8.94	7.02	6.16	7.10	11.68
Long Haul Transport Cost	2.15	2.15	2.15	2.15	0
Local Distribution Cost	.87	.87	.87	.87	0
Total ($/MMBTU)	11.96	10.04	9.18	10.12	11.68

TABLE 14-2

PETROCHEMICAL COST COMPARISON:
METHANOL FROM ILLINOIS IN 1990
DELIVERED TO HOUSTON BY PIPELINE
($ 1980 per MMBtu)

	Koppers-Totzek Methanol	Badger Methanol	BGC/LURGI Methanol	Texaco Methanol	Natural Gas Based Methanol
Plantgate Cost	8.94	7.02	6.16	7.10	11.68
Long Haul Transport Cost	.57	.57	.57	.57	0
Local Distribution Cost	.87	.87	.87	.87	0
Total ($/MMBTU)	10.38	8.46	7.60	8.54	11.68

TABLE 14-3

PETROCHEMICAL COST COMPARISON:
METHANOL FROM ILLINOIS IN 2000
DELIVERED TO HOUSTON BY RAIL
($ 1980 per MMBtu)

	Koppers-Totzek Methanol	Badger Methanol	BGC/LURGI Methanol	Texaco Methanol	Natural Gas Based Methanol
Plantgate Cost	10.36	8.09	7.10	8.19	17.02
Long Haul Transport Cost	2.15	2.15	2.15	2.15	0
Local Distribution Cost	.87	.87	.87	.87	0
Total ($/MMBTU)	13.38	11.11	10.12	11.21	17.02

TABLE 14-4

PETROCHEMICAL COST COMPARISON:
METHANOL FROM ILLINOIS IN 2000
DELIVERED TO HOUSTON BY PIPELINE
($ 1980 per MMBtu)

	Koppers-Totzek Methanol	Badger Methanol	BGC/LURGI Methanol	Texaco Methanol	Natural Gas Based Methanol
Plantgate Cost	10.36	8.09	7.10	8.19	17.02
Long Haul Transport Cost	.57	.57	.57	.57	0
Local Distribution Cost	.87	.87	.87	.87	0
Total ($/MMBTU)	11.80	9.53	8.54	9.63	17.02

TABLE 14-5

NATURAL GAS PRICES NECESSARY TO MAKE
GAS-BASED METHANOL AND COAL BASED METHANOL
EQUAL IN COST
($ 1980 Per MMBtu)

	Year		
	1990	2000	2010
Projected Gas Prices	5.39	8.45	10.33
Breakeven Gas Prices			
Badger Methanol			
Rail Shipment	4.34	4.69	5.08
Pipeline	3.34	3.68	4.08
BGC-Lurgi Methanol			
Rail Shipment	3.80	4.05	4.36
Pipeline	2.79	3.05	3.36
Texaco			
Rail Shipment	4.39	4.75	5.19
Pipeline	3.39	3.74	4.18
Average			
Rail Shipment	4.18	4.50	4.88
Pipeline	3.17	3.49	3.87

CHAPTER 15

MARKET POTENTIAL FOR METHANOL AS A PETROCHEMICAL FEEDSTOCK

An indication of the industry's views on future methanol demand is given in Table 15-1. Shown are projections by Celanese, one of today's leading producers. Almost half of the growth projected for the 1980-1990 period would be for methanol-gasoline blends. Another 16 percent is expected to go to the electric utility sector. Growth in methanol production for traditional chemical uses accounts for twenty-five percent or tne increase; if this rate of growth continued through the 1990's on to 2010, methanol use for petrochemicals would grow to 3,300 million gallons by 2000 and 5,800 million gallons by 2010.

TABLE 15-1

CELANESE PROJECTIONS OF U.S. METHANOL DEMAND
(Million Gallons)

	1980	1985	1990
Chemical Uses	1,100	1,501	1,915
MTBE	80	180	225
MTBE/TBA Blends	10	150	300
Gasoline Blending	10	10	1,500
Peak Power Shaving	3	25	500
Total	1,203	1,866	4,400

Source: Chemical Engineering News, April 7, 1980.

While the primary focus of this section of the study is on chemical markets for methanol, it is important to appreciate Celanese's belief that fuel applications could surpass chemical uses within a relatively short period of time. Currently, the fastest growing fuel applications for methanol is in the production of MTBE which is used as an octane booster in gasoline in the wake of EPA restrictions on more traditional additives. Although only small commercial amounts of MTBE were produced in 1979, demand for methanol in MTBE production is estimated to have grown to 5% of total methanol demand by the beginning of 1980 and to approximately 10 percent by year's end. Further, substantial growth of MTBE and other fuel uses are projected by many throughout the 1980's.

The projected chemical demands assume a continuing moderate growth in present markets as well as expanded use of methanol in acetic acid production. Acetic acid traditionally has been produced from butane or ethylene which is made from both oil and gas. The low pressure methanol-to-acetic acid process developed by Monsanto has proven to be more economic than conventional technology, and a significant, if gradual, shift to the methanol based process route for acetic acid production can be expected.1/

Currently, acetic acid is produced from methanol in two plants in the U.S., Celanese's new 600 million pound/year unit in Clear Lake, Texas and National Distillers Chemical Corporation's new 600 million pound/year facility in Deer Park, Texas. Total U.S. acetic acid production capacity is shown in Table 15-2 on a plant-by-plant basis.

For chemical uses of methanol to significantly exceed that indicated in Table 15-1, substantial, new uses of methanol would need to be developed. This could occur as a result of prospective shifts in the relative availability and prices of alternative feedstocks (coal, shale, oil, and natural gas), as these may induce changes in the preferred feedstocks and process routes for the manufacture of a range of chemicals.

It is interesting to note, in this regard, that the first new commercial plant to be built in the U.S. for the manufacture of chemicals from coal will produce methanol as an intermediate, using Texaco gasification technology.2/

1/ In the longer term the methanol based process route must compete against technology being developed for the direct production of acetic acid from synthesis gas.

2/ Chemical Engineering News, January 14, 1980.

TABLE 15-2

U.S. ACETIC ACID INDUSTRY PLANT CAPACITY

Producer	Million Pounds/Year
Borden, Grismar, LA[a/]	115
Celanese, Bay City, TX	200
Celanese, Clear Lake, TX	1,100
Celanese, Pampa, TX	550
Eastman, Kingsport, TN	450
FMC, Bayport, TX	40
Monsanto, Texas City, TX	400
Union Carbide, Brownsville, TX	600
Union Carbide, Taft, LA	40
U.S.I., Deer Park, TX	600
Total	4,095

a/ Borden will expand to 155 million pounds/year at Grismar by the end of 1980. Publicken has an acetic acid unit rated at 80 million pounds/year in standby at Philadelphia.

Source: Chemical Marketing Reporter, April 7, 1980.

Tennessee Eastman, an operating unit of Eastman Kodak's chemical division, is scheduled to begin construction this year of a plant to make acetic anhydride from coal via methanol. The plant is scheduled to go on-stream in 1983 in Kingsport, Tennessee. Also planned for the acetic anhydride complex is a coal fired steam plant for cogeneration of steam and electricity. The combined coal feed rate to the planned coal gasification units and steam plant is 1,600 T/D. Completion of the new acetic anhydride complex will allow cost reductions in the present process for manufacturing acetic anhydride, which is based on ethylene as a feedstock.

While considerable attention has been given to the development of alternative process routes for the production of specific chemicals, as illustrated in part by the Tennessee Eastman project noted above, in many ways it would be simplest for the industry to develop new routes for the manufacture of the principal petrochemical building blocks, such as olefins and aromatics. In this way, relatively little change would be required for the production of derivitive chemicals.

Methanol is a potential starting point for the production of both olefins and aromatics. For example, one route proposed for the production of ethylene, a widely used olefin building block, is to mix methanol with synthesis gas to yield ethanol (a process called homolgation) followed by the dehydration of ethanol to ethylene.

The key to the commercialization of this process route is the homolgation reaction. The dehydration reaction is technically feasible and is commercially practiced in some areas of the world. Literature reports on the homolgation reaction have been few but indicate potential promise.1/

In contrast to olefin production, there are few technical obstacles to overcome in the production of aromatics from methanol. As described previously, methanol can be used as a feedstock to produce gasoline quality liquids via the Mobil-M technology. Gasoline produced in this manner contains significant concentrations of aromatics, as does conventional gasoline, and could serve as a source of aromatics to the chemicals industry in the same fashion that aromatics derived from the refinery gasoline do today.

If either or both of the uses described above for methanol should develop on a significant scale, methanol would become one of the foremost chemical intermediates. Whether this will occur depends, of course, on the technical feasibility and economics of these particular process routes relative to those few other alternatives. These include not only conventional petrochemical technology but a range of possibilities being examined to utilize coal and shale oil as chemical feedstocks. Which process routes and feedstocks will eventually win out is not clear at this time.

1/ A more detailed discussion of the possibilities for the production of ethylene from methanol can be found in a report by Chem Systems for NSF. Chem Systems, Inc., Chemicals From Coal and Shale Oil Analysis for the National Science Foundation, PB-243393, June, 1975.