FINAL REPORT
PHASE I

VOLUME II OF IV
BOOK 2 OF 4

ASSESSMENT OF UNDERGROUND COAL GASIFICATION IN BITUMINOUS COALS

• POTENTIAL UCG PRODUCTS AND MARKETS

prepared for the
U.S. DEPARTMENT OF ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
UNDER CONTRACT NO. DE-AC05-80MC 14584

PROCESS DIVISION
OF
WILLIAMS BROTHERS ENGINEERING COMPANY

A Resource Sciences Company

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January 31, 1982

U.S. Department of Energy
Morgantown Energy Technology Center
P.O. Box 880
Collins Ferry Road
Morgantown, West Virginia 26505

Attention: Mr. Joe Martin, Technical Officer (13)

Re: Final Report Phase I
Assessment of UCG in Bituminous Coals
Volume II of IV
Book 2 of 4
Contract No. DE-AC05-80MC14584
WBEC-4389-T-44

Gentlemen:

Williams Brothers Engineering Company is pleased to submit fifteen (15) copies and one (1) reproducible master of the Final Report Phase I - Assessment of UCG in Bituminous Coals, Bituminous Coal Resource Evaluation.

Sincerely,

Process Division
WILLIAMS BROTHERS ENGINEERING COMPANY

Martin M. Siegel

Martin M. Siegel
Manager of Alternate Fuels Processing

Attachment

MMS:skn/4389/

cc: Steven Grumbach (2)

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This technical report is being transmitted in advance of DOE review and no further dissemination or publication shall be made of the report without prior approval of the DOE Project/Program Manager.

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3.8 POTENTIAL UCG PRODUCTS AND MARKETS

This section identifies the potential products and markets for UCG facilities located near certain target areas in the Eastern U.S. where bituminous resources amenable to UCG have been located. The identification of potential markets and uses for the gas near designated target areas will help to substantiate suitability of these sites for development.

In subsection 3.8-1, the products are discussed, then in subsection 3.8-2 the markets are evaluated.

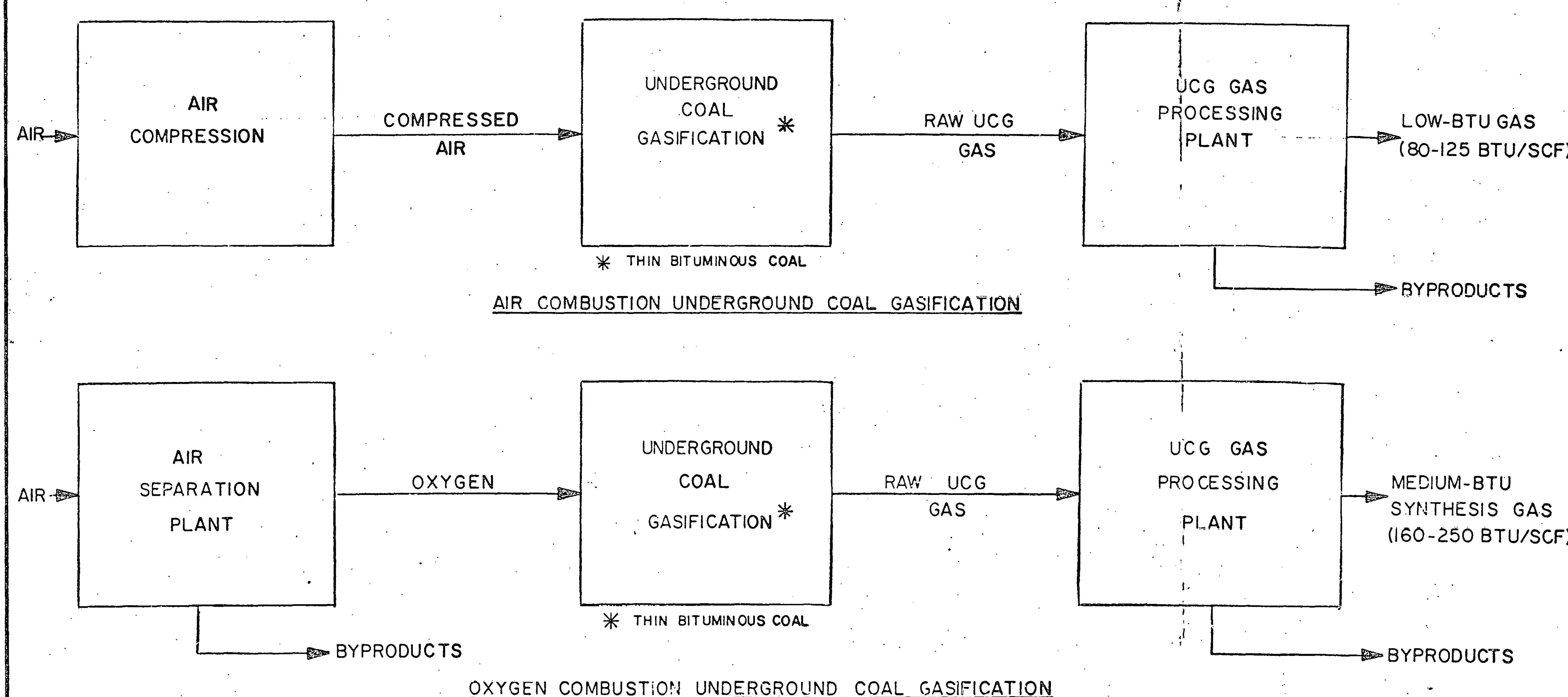
3.8.1 Description of UCG Products and Their Potential Application

Underground Coal Gasification (UCG) of thin bituminous coals will produce either low-BTU gas (80 - 125 BTU/SCF) or medium-BTU gas (160 - 250 BTU/SCF) depending on which oxygen source, air or pure oxygen, is used for combustion. The low Btu product gas can be used as a fuel directly once sulfur and other contaminants are removed. The medium BTU gas can also be used as a fuel or it can be used as a synthesis feed gas for higher value products. Figure 3.8-1 illustrates the two different product schemes.

3.8.1.1 Low BTU Fuel (LBG)

Low BTU gas is generated by UCG when air is injected downhole as the feed gas. The produced gases can be burned after cleaning without further upgrading. As indicated in Table 3.8-1, the LBG from UCG in thin bituminous coal beds is similar to product gas from air blown surface gasifiers although the heating value of the in situ LBG is somewhat lower. The range of 80 to 125 BTU/SCF is expected to present no significant combustion problems.

A recent study was sponsored by the U.S. DOE [1], on combustion of low BTU gases (116 - 287 BTU/SCF). The report indicates that fuel gas produced by an air blown Winkler gasifier (116 BTU/SCF) could produce a stable flame without assistance using a high-forward-momentum burner while nozzle mix and premix tunnel burners needed a continuous pilot light to maintain a stable flame. Fuel injection modifications were required to achieve stable flames on a forward-flow baffle, kiln and boiler burners. Based on this study, it does not appear that there is any major technological problem to the use of low BTU gas down to 116 BTU/SCF. Other operating experience suggests that even heating values down to the lower end of the low BTU gas from UCG scale at 80 BTU/SCF may be combustible.



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ALTERNATE GASIFICATION STRATEGIES IN UCG

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FIGURE 3.8-1

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TABLE 3.8-1

UCG VERSUS SURFACE GASIFIER DERIVED GASES

Process Composition	Air, Mole %					Oxygen, Mole %				
	UCG-Air*	Winkler (Air)	STOIC	McDowell-Wellman	Woodall-Duckham	UCG-O_2**	Synthane	Winkler	Texaco	Lurgi
CO	6-17	22	30	25	28	12-34	9	35	51	25
CO_2	9-28	7	3	6	4	18-56	53	19	13	25
H_2	10-15	14	15	19	17	20-30	28	42	36	40
CH_4	1.5-3.5	.8	3	.6	3	3-7	10	3	.1	9
HHV, Btu/SCF	80-125	124	172	148	175	160-250	221	279	281	301

* Basis: Range of data from Lisichanskaya, Yuzhnoabinsk and Pricetown

** Composition assumes that values double when O_2 rather than air is used.

A report[2] on the use of low BTU oil shale by-product gas states: "Many Brown Boveri blast furnace installations operate on 80 to 90 BTU/SCF (712 to 801 Kcal/Nm^3) fuel, with the lowest reported heating value being 76 BTU/SCF (676 Kcal/Nm^3)."

In any event, if the heating value of the LBG dropped significantly below the point of efficient combustion, a small percentage of oxygen could be added to the feed gas to the gasifier to increase the heating value of the product. A small increase in oxygen content could be added to the existing air supply without major modifications to injection piping specifications.

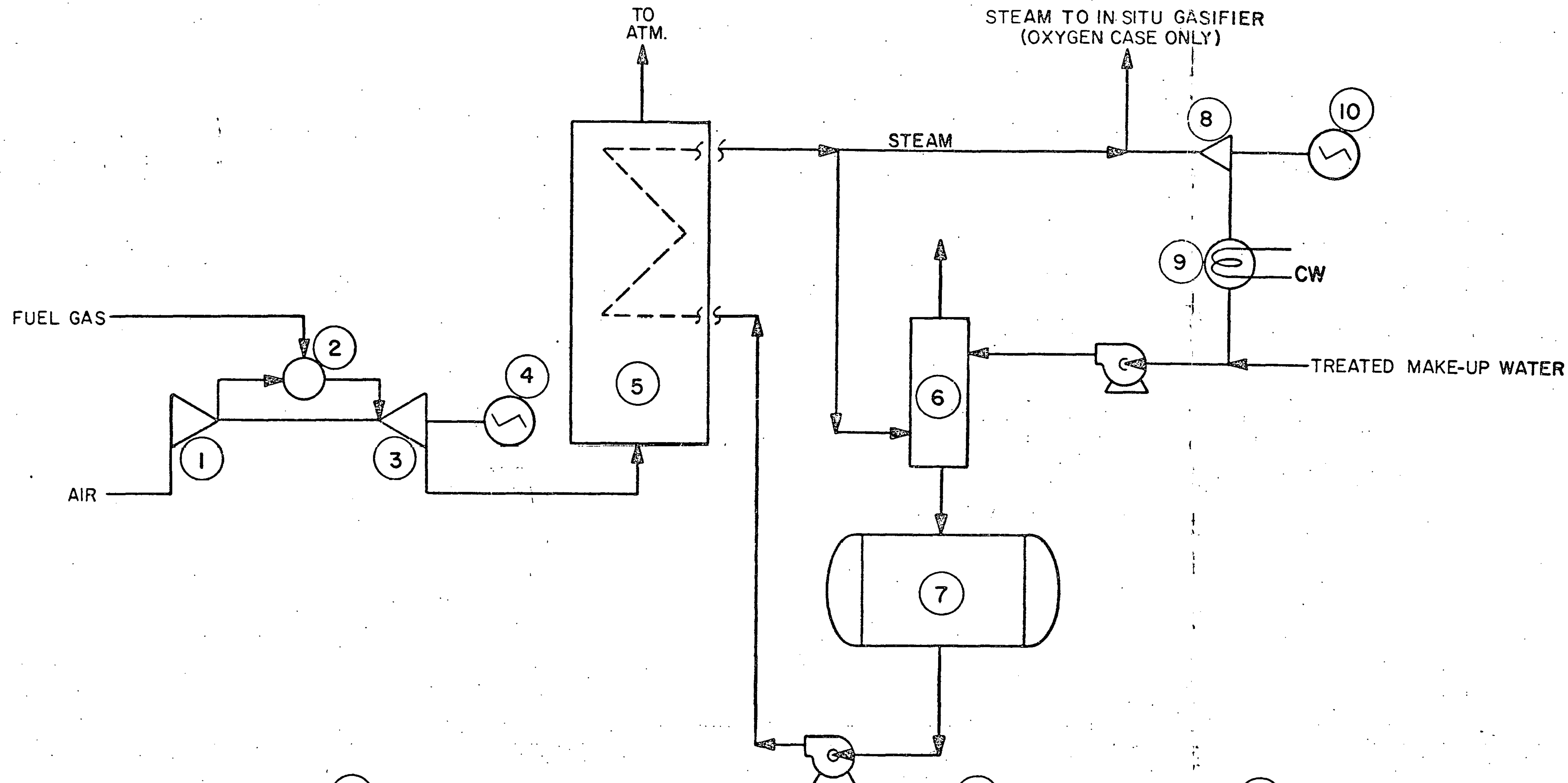
Compression energy requirements for transmission of LBG may represent a substantial fraction of the total available energy in the gas. It is generally conceded that LBG is uneconomical to transport more than five to ten miles. Therefore, the product must be used within a short distance of the site where the gas is generated.

Potential uses for the LBG include power generation, industrial heating, and steam generation. The LBG fuel can be used to generate power in either existing power plants where it replaces coal, oil, or natural gas; or, in combined-cycle plants which could be located on-site. Since it is unlikely that an existing power station would be located sufficiently close to a UCG site or would be willing to accept the necessary derating with LBG this option is reserved for MBG or SNG.

A combined-cycle power generator has definite advantages over a conventional coal fired power plant for the combustion of LBG. These advantages include modularization, higher efficiency, lower installed cost per kilowatt, less construction time, and less environmental impact.[3]

In a combined-cycle system, the LBG is mixed with compressed air and burned ahead of a gas turbine. Normally a common shaft off of the turbine is supplied to the air compressor and primary power generator. For higher value fuels, excess air must also be compressed and bypassed into the turbine to keep the temperature below that which could damage the blades. The exhaust gases from the turbine are then used to generate steam which drives a steam turbine connected to a secondary power generator, see Figure 3.8-2. Production of process steam in the economizer as well as secondary power will raise the overall efficiency of the system.

This type of equipment is conducive to skid-mounting and modularization. Once skid-mounted, the units can be moved to a UCG site as required by increased electrical demand or as the field develops to its optimum size. It is only necessary that a grid line be present to transport the energy. Of course, the



1. AIR COMPRESSOR
2. COMBUSTOR
3. GAS TURBINE EXPANDER
4. POWER GENERATOR #1
5. WASTE HEAT BOILER
6. DEAERATOR
7. CONDENSATE DRUM
8. STEAM TURBINE
9. CONDENSER
10. POWER GENERATOR #2

WILLIAMS BROTHERS ENGINEERING COMPANY A Resource Sciences company TULSA, OKLAHOMA	TYPICAL COMBINED CYCLE POWER GENERATION SCHEME	
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location of the site would depend on electric demand within the economic transmission radius of the power plant.

LBG can also be used in place of natural gas in most industries which currently use natural gas for heating; particularly, the steel, glass, cement, and brick industries. It may be that an industrial park could be established adjacent to a UCG facility to take advantage of a captive energy supply.

Combining LBG with natural gas should not improve the economics of transporting it. However, if the pneumatic transport of fine coal over long distances ever becomes a reality, it will be worth investigating the use of LBG as the transport medium.

3.8.1.2 Medium BTU Gas (MBG)

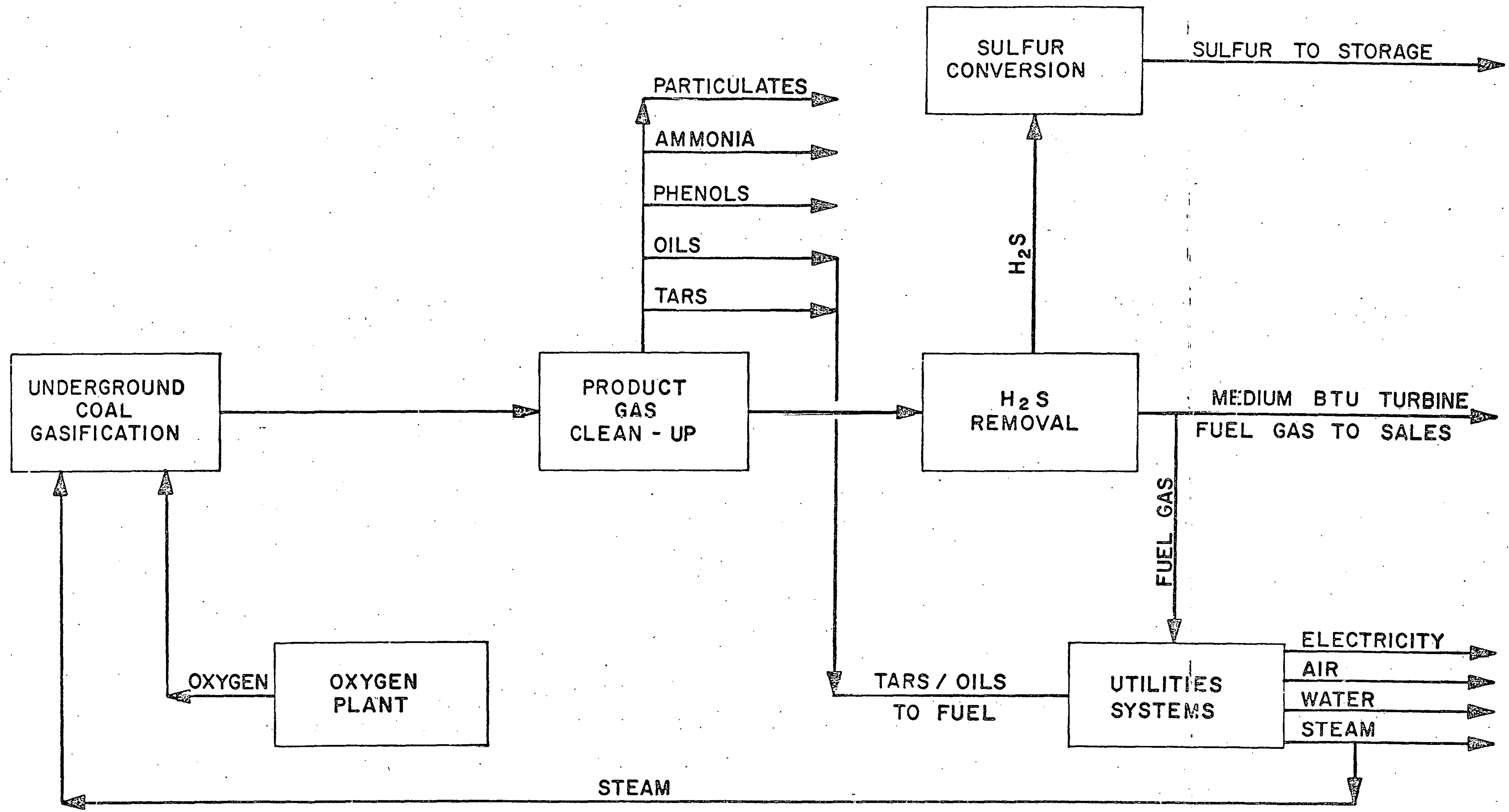
Medium Btu gas is generated from UCG when oxygen and steam are used as the feed gas, see Figure 3.8-3. MBG can be used, in most cases, as a substitute for whatever fuel has been traditionally used with only a modest derating of the combustion system. However, MBG may be worth more as a synthesis gas for higher value products.

MBG from thin bituminous coal seams is lower in heating value than MBG from surface gasifiers, see Table 3.8-1. However, a heating value of 160 - 250 BTU/SCF should be combustible under even adverse conditions. The higher end of the range should derate existing boilers by no more than 5-10%. The derating comes about as a result of the larger volume of flue gas which must be handled and the longer flame length.

The higher heating value of MBG will permit economic transportation of the gas beyond the limits imposed on LBG. Its higher heating value, moreover, will make it acceptable by a larger share of industries. It may be possible to find a power plant which is close enough to the proposed site to receive the gas and back out part of its base fuel. The MBG will be low in sulfur and will burn without ash disposal requirements. There may be a scenario where this combination results in favorable economics.

3.8.1.3 Synthesis Gas

As oil and natural gas based feedstocks become more difficult to recover and thus more expensive, it is increasingly important to find suitable substitutes. A syn gas substitute can be at least part of the solution when the gases are derived from coal. Syn or synthesis gas is a mixture of hydrogen, carbon monoxide and generally carbon dioxide which is used in the preparation of higher value products. Because nitrogen is normally not tolerable, particularly at the levels experienced



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MEDIUM BTU GAS FROM UCG

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FIGURE 3.8-3

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in LBG, the choice of suitable product gas is generally limited to MBG only.

As indicated in Table 3.8-1, product gas from UCG has a ratio of H_2 to CO near 1.0. This represents a relatively high ratio which is more favorable to syn gas utilization than product gas from most surface gasifier technologies. The lower the H_2 to CO ratio, the more shift reaction is required in a subsequent process step to shift the CO to H_2 by the reaction:

$$CO + H_2O \rightarrow H_2 + CO_2$$

The high hydrogen ratio in UCG product gas is primarily a result of the higher than required water influx characteristic of a UCG system and the catalytic nature of the coal ash. This effect, while beneficial from a syn gas viewpoint, is also a major reason for the lower than desirable heating value of the gas.

While the H_2 to CO ratio is favorable, the methane content is not, unless SNG is to be produced. The high methane content (3-7%), in both ammonia and methanol synthesis, must be reformed to additional hydrogen and carbon oxides or separated out and used as fuel. In either case, additional processing steps are required.

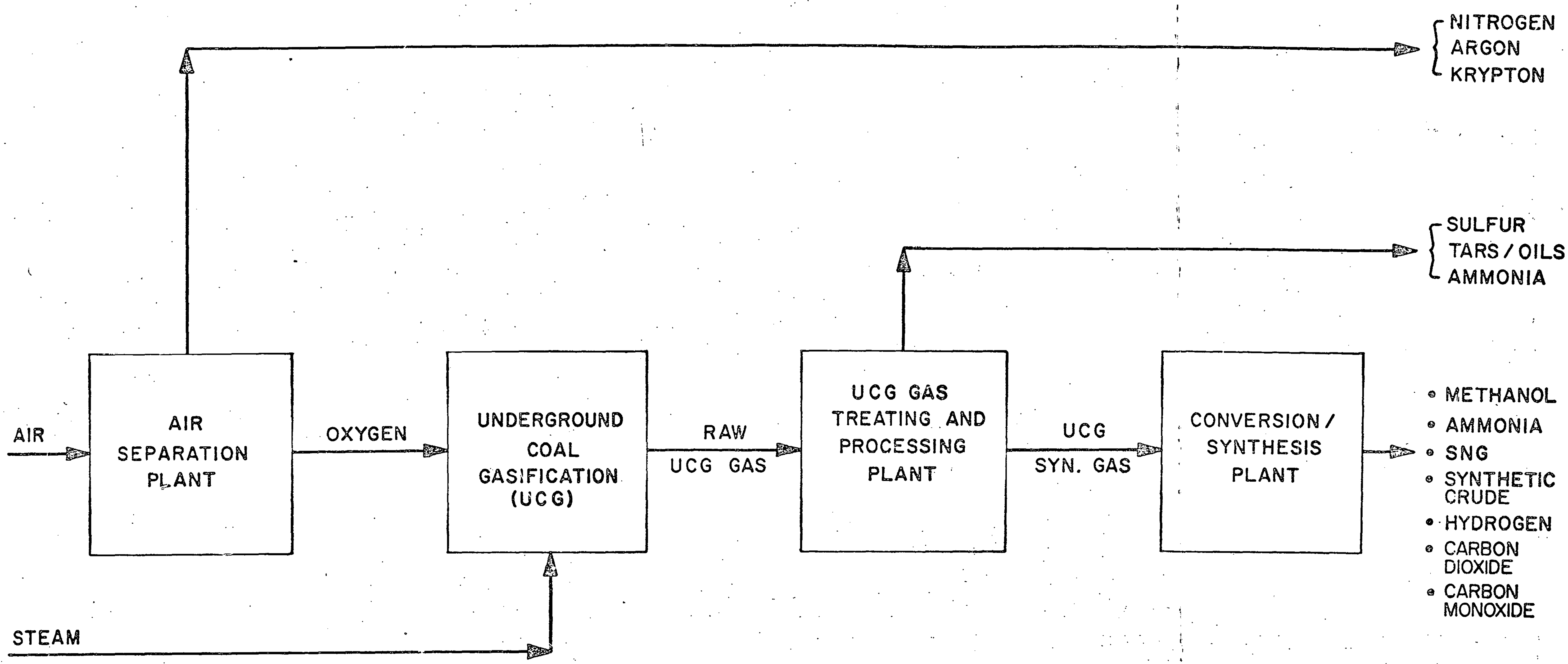
Before any coal derived gas can be shifted or utilized, it must first be treated to remove particulates, ammonia, phenols, tars and oils, and sulfur. The synthesis processes generally tolerate very little sulfur even to the extent of requiring a zinc oxide guard. Some modern shift processes, however, use a sulfur tolerant catalyst which permits the acid removal to take place totally on the downstream side.

Products which can be produced directly from coal derived syn gas include primarily: (See Figure 3.8-4)

- o Methanol
- o Ammonia
- o SNG
- o Synthetic Crude
- o Hydrogen
- o Carbon Monoxide
- o Carbon Dioxide

Other processes are available to produce the following:

- o Glycols
- o Higher Alcohols
- o Acetic Anhydride



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POTENTIAL PRODUCTS FROM UNDERGROUND COAL GASIFICATION

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FIGURE 3.8-4

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Further, many processes are available to convert primary products into secondary and tertiary products, such as:

- Urea
- MTBE
- Olefins
- Vinyl Acetate
- Acetonitrile
- Ethylene
- Propylene
- Butane
- Formaldehyde
- Ethanol
- Terephthalic Acid
- M-Gasoline
- Ethylbenzene-Styrene
- Methyl Methacrylate

The synthesis products are not subject to the small economic transportation radius of the low to medium Btu gases. If SNG or methanol were produced, it is likely that existing natural gas or crude pipelines could be used. This could make the synthesis route attractive; however, the installations visualized for eastern bituminous coals may not be large enough to justify the magnitude of expenditure required.

Of all the synthesis products, methanol may be the most versatile.

3.8.1.3.1 Methanol

Methanol may become the liquid fuel of the future. Because it is a liquid, it is not subject to the same distance limitations imposed on low to medium BTU gases. Existing oil pipelines could be used to transport methanol.

Methanol can be used as a fuel or chemical feedstock. As a fuel, it has been shown to be an excellent turbine fuel and with engine modifications a potential gasoline substitute for the internal combustion engine.

- Automobile Fuel

Methanol as a fuel substitute for gasoline has both advantages and disadvantages. The advantages include:

- lower NOX emission
- lower CO emission
- lower unburnt hydrocarbon emission
- low residue formation
- very high octane 110/92 R/M
- high density vapor

The high octane permits a compression ratio of 12 to 14 versus the average compression ratio of 9 in present engines. The increased compression ratio should result in better thermal efficiency. Thermal efficiencies should be comparable to those experienced in diesel engines.

Theoretical temperature drop at stoiciometric air ratio and abiabatic evaporation is 20°C for gasoline and 122°C for methanol. While the gaseous mixture is not possible without auxilliary heating systems, a high mixture density caused by the temperature drop can result in better cylinder filling and resultant higher engine power.

There are several negative factors which should be taken into account if methanol is to replace gasoline. They are listed as follows: [4]

- low vapor pressure
- high heat of vaporization
- low heat of combustion
- corrosivity

The low vapor pressure and high heat of vaporization combine to make starting difficult. In carburetted engines, formation of a gaseous mixture is not possible without a heating system for the carburetor and suction tube systems.

The low heat of combustion of methanol is due to the oxygen content which comprises 50% of the methanol molecule. As a result of this, the stoiciometric air requirement is lower which necessitates modifications to the carburetor. Fuel nozzles and fuel pumps must be increased relative to gasoline operation. Of course, fuel tanks must be doubled to provide a range comparible to gasoline.

Corrositivity of methanol can be troublesome particularly in the presence of water. Even certain plastics and aluminum are susceptible to corrosive attack.

Other factors must be accounted for when using mixtures of methanol and gasoline; for example: phase separation and azeotrope formation. Water can cause almost complete phase separation if it is present in quantities as low as 0.5%. Settling will occur and the engine, designed to run on gasoline, will receive a methanol-water mixture instead. Other problems result from the formation of a high vapor pressure mixture which can cause vapor lock problems in current engines.

- Turbine Fuel

Methanol has been shown to be an effective turbine fuel in tests conducted by the Florida Power Commission. The turbine operated in the range of 18 MW output. In general, the only negative factor noted was the requirement for higher flow rates to accomplish the same amount of work. Due to the larger volume requirement it is unlikely that methanol will ever be used to replace jet fuel.

- Chemical Feedstock

Methanol can be used in place of many petroleum based feedstocks. By using technology developed by Mobil methanol can be converted into a synthetic gasoline, see Figure 3.8-5. Some other products which can use methanol as feedstock include: MTBE, ethylene, propylene, ethylene glycol, acetic acid, methyl acetate, ethanol, styrene, and ethylbenzene.

3.8.1.3.2 Other Synthesis Products

As listed earlier, the major synthesis products include: methanol, ammonia, SNG, synthetic crude, hydrogen, carbon monoxide, and carbon dioxide. Methanol has been discussed in the previous subsection. The remaining major products will be discussed briefly below.

- Ammonia

Ammonia is formed by the reaction of hydrogen and nitrogen. The air separation plant which supplies the oxygen would perform a double duty by supplying the nitrogen as well, see Figure 3.8-6.

The process to produce ammonia requires that all of the CO be catalytically shifted to hydrogen and carbon dioxide. The bulk of the carbon dioxide is typically removed by a conventional acid gas removal system followed by a cold liquid nitrogen wash step prior to the catalytic ammonia conversion. Ammonia is a precursor for urea and ammonium sulfate or can be used directly as a fertilizer.

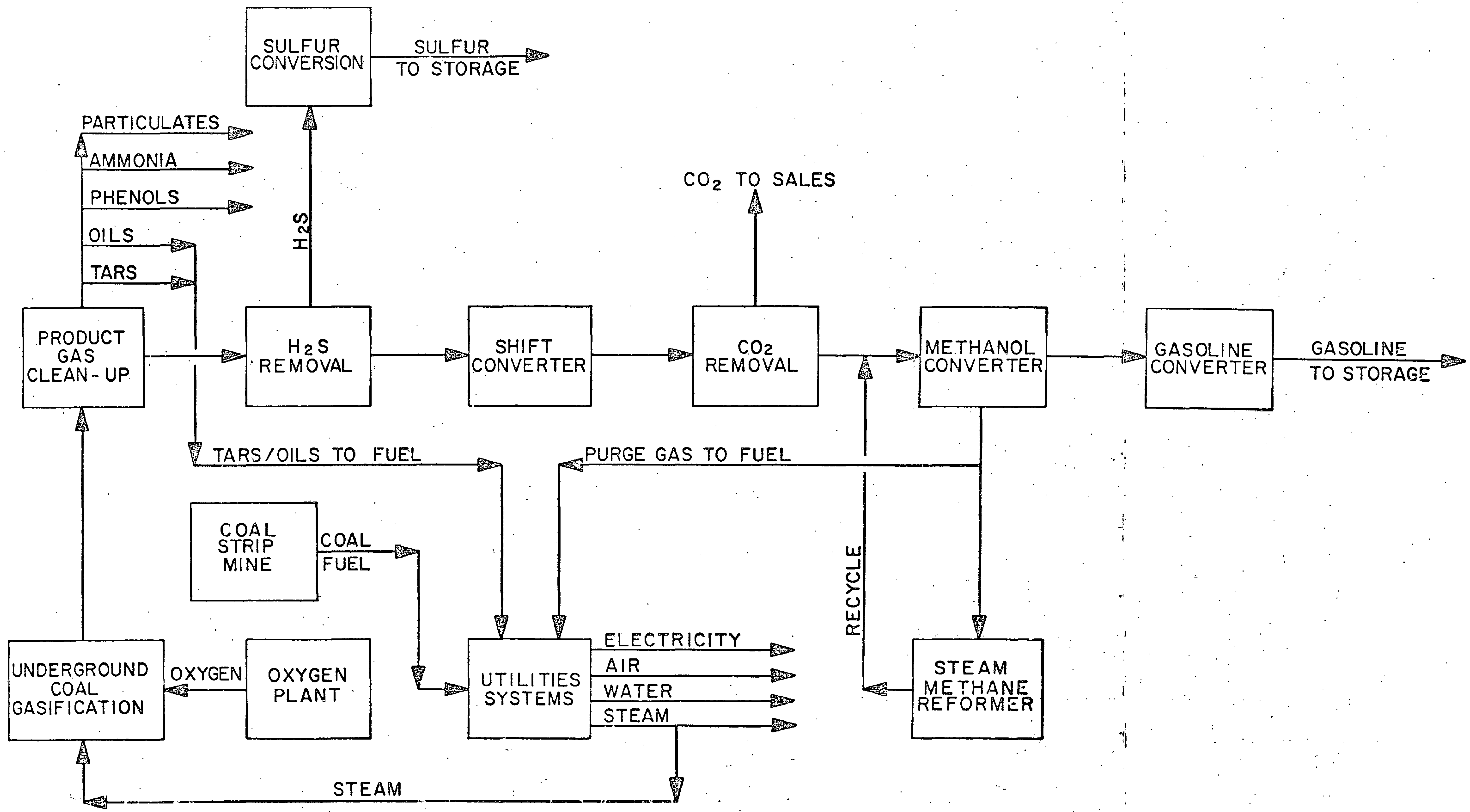
- SNG

Substitute natural gas (SNG) is primarily methane. It is produced in a methanation reactor by combining hydrogen and carbon monoxide according to the following reaction: (see Figure 3.8-7).

$$CO + 3\ H_2 \rightarrow CH_4 + H_2O$$

The hydrogen to carbon dioxide ratio required for favorable kinetics will obviously be greater than 3:1.

Producing methane has advantages over electrical power production using a low or medium BTU gas. One advantage is the



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M-GASOLINE FROM UCG

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FIGURE 3.8-5

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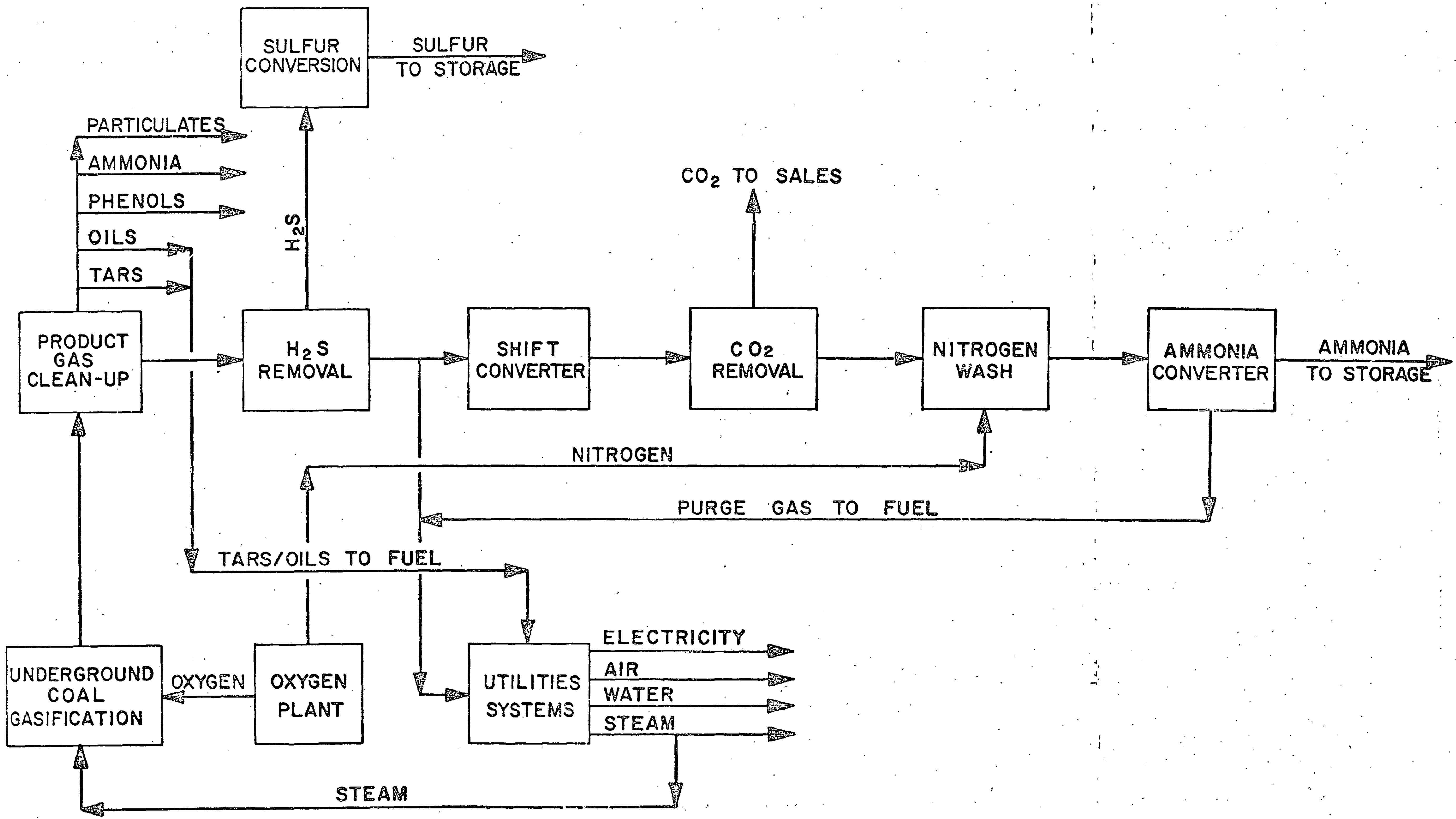

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AMMONIA FROM UCG

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FIGURE 3.8-6

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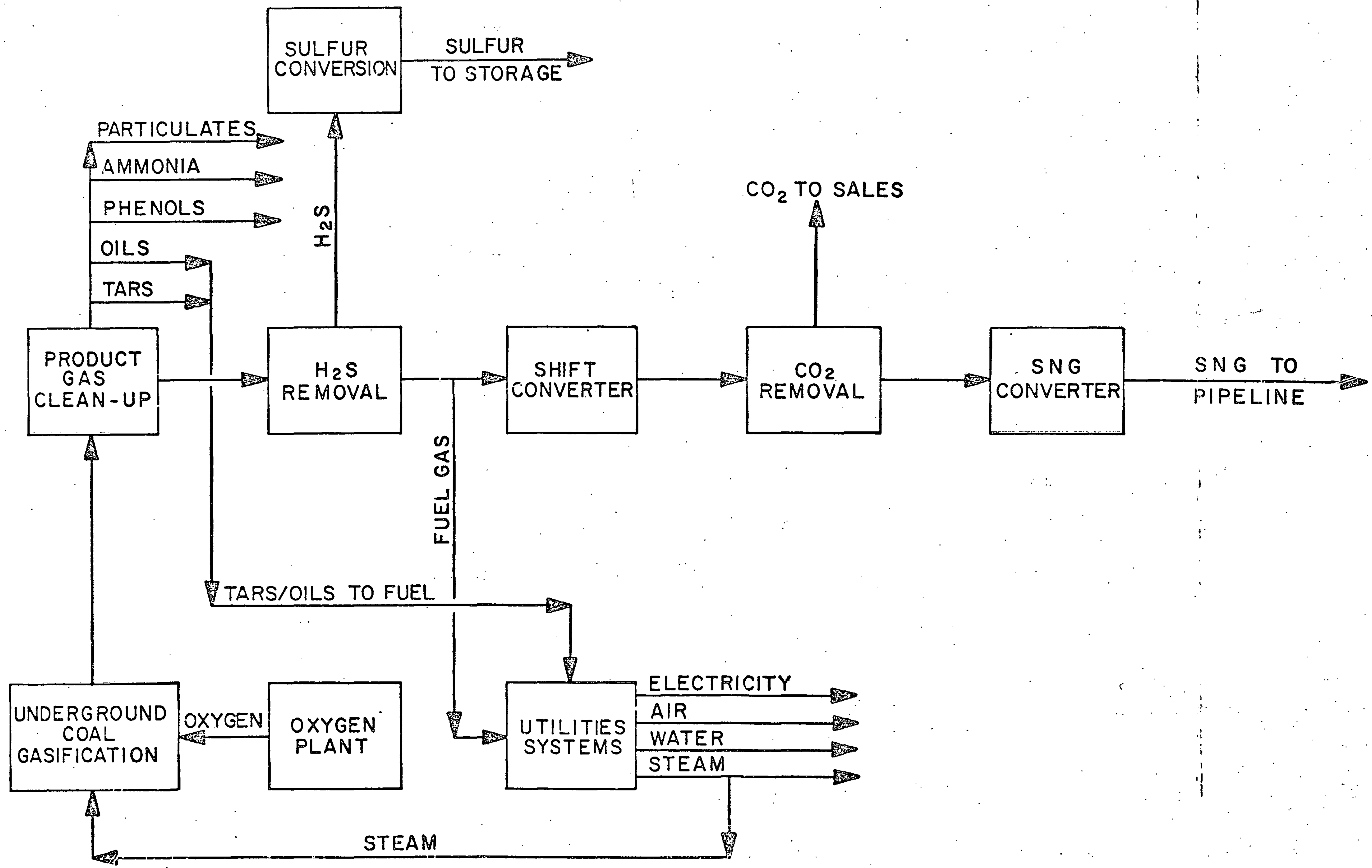

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SNG FROM UCG

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FIGURE 3.8-7

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ability to use existing pipeline distribution systems without effecting the natural gas heating value. Another advantage is the distribution to residences and industries where the conversion to heat is direct and will result in much improved thermal efficiencies over the generation of electricity which is at best a 42% conversion.

- Synthetic Crude

The Fischer-Tropsch Process (F-T) produces a wide range of petroleum-type liquids from syn gas. The process was discovered in the early 1900's and was used to fuel the German military during World War II. For the past twenty-five years South Africa has been supplementing their crude oil supplies using F-T technology in their SASOL plants.

The major problem with F-T technology has been that it results in a multitude of products. This is becoming less of a problem due to the advent of more selective catalysts and the operating experience which SASOL has acquired. At SASOL II, which has recently started up, 60% wt. of the output is gasoline. The remainder of the products include: diesel fuel (10%), ethylene (8%), alcohols(4%), tar products (8%), ammonia (2%), and sulfur (10%). Approximately 10,000 tons of product are recovered with an input of 30,000 tons of coal on a daily average. Overall plant thermal efficiency is 55%.[5]

Recent work by Brookhaven National Laboratory, Chem Systems, Mobil, and others to develop improved Fischer-Tropsch catalysts will result in greater selectivity than has been heretofore possible. Primary emphasis will be to maximize the straight-chain paraffins under a variety of conditions.[6]

- Hydrogen

The hydrogen produced from a UCG facility can be maximized by shifting all of the carbon monoxide to hydrogen and carbon dioxide. The carbon dioxide formed by the shift can be removed using either standard acid gas removal facilities, hollow fiber membrane technology, or cryogenically.

Hydrogen can be used by refineries to upgrade heavy crudes, coal liquids, and shale oils to high value products. There are three functional areas in which hydrogen performs in a refinery; these are:

  - desulfurizing
  - denitrogenating
  - hydrocracking

As the crude slate of most refineries changes toward the heavier, higher sulfur, and consequently more available feedstocks the hydrogen balance of the refinery normally requires that hydrogen be generated in addition to that amount supplied by the reformer. This increased generation is normally obtained by reforming available natural gas, plant fuel gas, or even naphtha stocks. Heavy crude can be hydrocracked to produce a better slate of products than can be obtained by coking if sufficient hydrogen is available.

Refineries which process syncrudes will have an even greater need for hydrogen due to the high nitrogen content of these feedstocks. Nitrogen is a catalyst poison particularly for catalytic reforming and cat cracking. It must be removed to produce stable distillate fuels and to reduce the NOX which would be produced upon burning. To produce a syncrude with 800 ppm nitrogen from oil shale will require about 1350 SCF of hydrogen per barrel. A coal liquid by H-coal technology will use up to 2700 SCFB depending on end products requirements.[7]

o Carbon Monoxide

Carbon monoxide is a basic building block in synthetic chemistry. It can be recovered from either LBG or MBG using the COSORB process.

The COSORB process selectively extracts carbon monoxide through formation of a complex with cupreous aluminum chloride.

o Carbon Dioxide

Carbon dioxide is becoming a desirable product for use in enhanced oil recovery (EOR). There are many areas of the world where the viscosity of the heavy oil can be reduced in situ using carbon dioxide.

Carbon dioxide can be separated from LBG or MBG cryogenically or in a 2-stage absorption process.

The amount of carbon dioxide formed is a function of the inefficiency of the gasifier. In wet coals, such as lignite, carbon dioxide might be the principle product with the by-product flammable gas used only to provide on-site power requirements.

o <u>Miscellaneous Products</u>

The main purpose of the air separation plant, as shown in Figure 3.8-1, is to provide oxygen for gasification. However, five by-products (Nitrogen, Neon, Argon, Krypton, and Xenon) can also be provided by the separation plant. Nitrogen may be used for inerting and for enhanced oil recovery. Argon has applications in the steel industry. Krypton and Xenon are used in the manufacture of high intensity lamps and headlights.

In the gas processing plant, hot raw UCG gas is washed, cooled, and treated. During this processing, several by-products can be extracted: ammonia, tars/oils and sulfur. Ammonia is used directly as a fertilizer or as a solid fertilizer precursor. Sulfur is used in the manufacture of sulfuric acid and recently as a road building material. Tars/oils, a by-product of UCG, has potential application as a supplement to fuel oil. It may be either fired directly or blended with other fuel oil and then fired. The tars/oils produced could provide a portion of the on-site fuel requirements.

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3.8.2 Potential UCG Markets

A detailed market evaluation of the type which will be required to develop a comprehensive strategy is beyond the scope of this report. However, preliminary information indicates that there is currently or will soon be a large potential market for UCG derived products in the United States and in the East-North-Central United States, in particular. Furthermore, the markets include, in descending order of probable adoption, the following users:

- o Single-user LBG or MBG utilities on-site
- o Single-user LBG industrial plants near site (<10 miles)
- o Single and multiple-user MBG industrial plants off-site
- o Single-user MBG utilities off-site
- o Multiple-user methanol for vehicle fleet and peaking power generation off-site
- o Multiple-user LBG industrial near site.

The primary driving force for acceptance of coal derived gas as a fuel and feedstock is the predicted shortfall of energy supplies to energy requirements. While current supplies of natural gas appear plentiful, long-range projections predict that new gas discoveries will not keep up with requirements. Price increases for oil and gas will predictively continue to exceed the rate of inflation. In addition, as long as the U.S. is not energy self-sufficient, the threat of politically motivated curtailment is always possible.

Factors which will promote the use of UCG over surface gasifier technology in the Eastern United States, in particular, include:

Regulatory Factors:

- o Clean Air Act - This act of Congress adds more to the cost of using higher sulfur coal than to the cost of using low sulfur coal.
- o Coal Mines Health and Safety Act - This act of Congress protects the health and safety of miners. It also reduces the productivity of miners and thus increases the cost of coal.

- o Surface Mines Reclamation Act - This act of Congress protects the environment. It raises the cost of mining coal in the process.

- o Deregulation of Railroads - Higher prices for transporting coal will raise the price of delivered coal.

Other Factors:

- o Environmental

  - High cost of ash disposal
  - High cost of cleaning coal
  - High cost of fuel gas desulfurization.

- o Transportation of Gas

  - Pipeline transportation cost relative to the value of delivered product.

The negative factors which will limit the rate of adoption of UCG derived gases are similar to the factors which limit coal gasification in general. Among these factors are the following:

- o Uncertainty over government involvement

- o Lack of operating experience

- o Environmental regulations

- o Transport of product from coal field to end user

- o Uncertainty over conventional fuel supply forecasts

- o Large capital investment requiring shared risk or, in the case of utilities, the need for a substantial rate hike to offset new capital expense

- o Current lack of clear economic advantage and the perception that alternate fuels will always be more expensive than conventional fuels.

Factors which will influence the adoption of UCG technology in the Eastern United States include:

- o The terrain which varies from alluvial flatlands to high relief contour hill country,

- The labor unions who may view UCG as competing for coal supplies with conventional labor intensive underground mining technology, and

- The negative psychological impact caused by existing coal seam fires which have burned out of control for many years creating an environmental and safety hazard.

3.8.2.1 Product Demand

The future demand for clean fuels and chemical feedstocks in the United States is sufficient to justify development of UCG technology. This demand will result from the growth of new utility power and industrial plant requirements, and the decline of conventional fuel and feedstock availability.

Favorable economics are absolutely essential to acceptance. The potential for mitigating environmental, social, and health effects of conventional mining should provide the incentive to continue to develop UCG technology in the Eastern United States as an option to surface gasification.

Fuel and Feedstock Availability

Even though price increases for energy supplies since 1973 have been substantial, the increase has not been sufficient to reverse the trend toward lower proved reserves of conventional fuels in the United States, see Table 3.8-2. In addition, while the recent trend has been toward a lower rate of energy consumption, the trend is nevertheless upward, see Table 3.8-3. Coal output has increased over three quads since 1972 and as such is the leading contender for the new energy market, see Table 3.8-4. Nuclear energy which was to have supplied the lion's share of the market has dropped to second place with 2.5 quads of new output. Antinuclear sentiment is expected to keep nuclear plant start-ups down in the future and the pressure on coal to fill the gap.

Most of the coal will need to come from the western states of Wyoming and Colorado which contain thick, strip minable, low sulfur coal. The problem is one of transporting the coal to markets. The railroads currently have a monopoly on moving coal although slurry pipelines may soon remedy that, if sufficient water can be found and legal hurdles can be cleared.

An alternative to western coal, in some areas of the country, would be to try to utilize local energy resources. High sulfur, underground mined coal is at an economic disadvantage when environmental and safety controls are imposed. Even the front-end costs of mining continue to increase as the productivity declines, see Figures 3.8-8 and 3.8-9. When New

TABLE 3.8-2

U.S. PROVED ENERGY RESERVES: NATURAL GAS OIL, AND NATURAL GAS LIQUIDS [5]

	Natural Gas million CF	Crude Oil 1000 bbl	Natural Gas Liquids 1000 bbl
12-31-70	290,746,408	39,001,335	7,702,941
12-31-71	278,805,618	38,062,957	7,304,227
12-31-72	266,084,846	36,339,408	6,786,559
12-31-73	249,950,207	35,299,839	6,454,707
12-31-74	237,132,497	34,249,956	6,350,449
12-31-75	228,200,176	32,682,127	6,267,830
12-31-76	216,026,074	30,942,166	6,401,967
[6]12-31-76	213,278,000	33,502,000	
12-31-77	208,877,878	29,486,402	5,994,365
[6]12-31-77	207,413,000	31,780,000	
12-31-78	200,301,707	27,803,760	5,925,852
[6]12-31-78	208,033,000	31,355,000	6,772,000
12-31-79	194,916,624	27,051,289	5,655,323
[6]12-31-79	200,977,000	29,810,000	6,615,000

TABLE 3.8-3

U.S. ENERGY CONSUMPTION

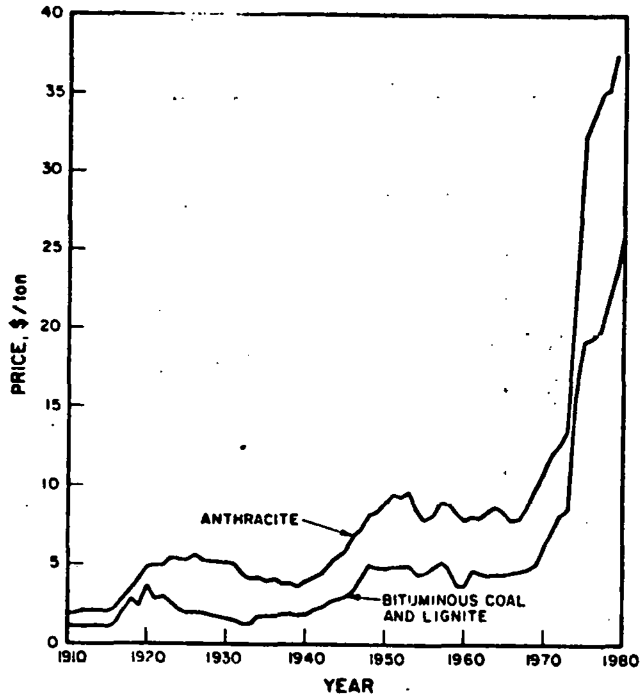
	Energy Consumption (EC)		
	DOE[7]	DOE[8]	DOE[9]
	10^{15} BTU/yr		
1971		68.30	
1972	71.643	71.63	
1973	74.609	74.61	74.61
1974	72.759	72.76	72.76
1975	70.707	70.71	70.71
1976	74.510r	74.51	74.51
1977	76.332r	76.33r	76.39
1978	78.150r	78.15	78.15
1979	78.968r	78.97r	78.02p
1980	76.201r	76.27p	

p = preliminary
r = revised

TABLE 3.8-4

U.S. ENERGY CONSUMPTION BY PRIMARY ENERGY TYPE

	Coal			Petroleum			Natural Gas-Dry			Hydro			Nuclear		
	DOE[7]	DOE[8]	DOE[9]	DOE[7]	DOE[8]	DOE[9]	DOE[7]	DOE[8]	DOE[9]	DOE[7]	DOE[8]	DOE[9]	DOE[7]	DOE[8]	DOE[9]
	10^{15} Btu/year														
1971		12.01			30.56			22.47			2.86			0.41	
1972	12.461	12.45		32.966	32.95		22.699	22.70		2.929	2.94		0.577	0.58	
1973	13.300	13.30	13.30	34.840	34.84	34.84	22.512	22.51	22.51	3.010	3.01	3.01	0.910	0.91	0.91
1974	12.876	12.88	12.88	33.455	33.45	33.45	21.732	21.73	21.73	3.309	3.31	3.31	1.272	1.27	1.27
1975	12.828	12.82	12.82	32.731	32.73	32.73	19.948	19.95	19.95	3.219	3.22	3.22	1.900	1.90	1.90
1976	13.733	13.73	13.73	35.175	35.17	35.17	20.345	20.35	20.35	3.066	3.07	3.07	2.111	2.11	2.11
1977	13.965	13.96	13.96	37.122	37.12	37.18	19.931	19.93	19.93	2.515	2.51	2.52	2.702	2.70	2.70
1978	13.846	13.85	13.85	37.965	37.97	37.97	20.000	20.00	20.00	3.164	3.16	3.17	2.977	2.98	2.98
1979	15.109	15.11	15.08	37.123	37.12	37.07	20.666	20.67	19.86	3.166	3.17	3.16	2.748	2.75	2.75
1980	15.603	15.67		34.196	34.25		20.495	20.44		3.125	3.13		2.704	2.70	



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Average Price of Coal
(in current dollars)

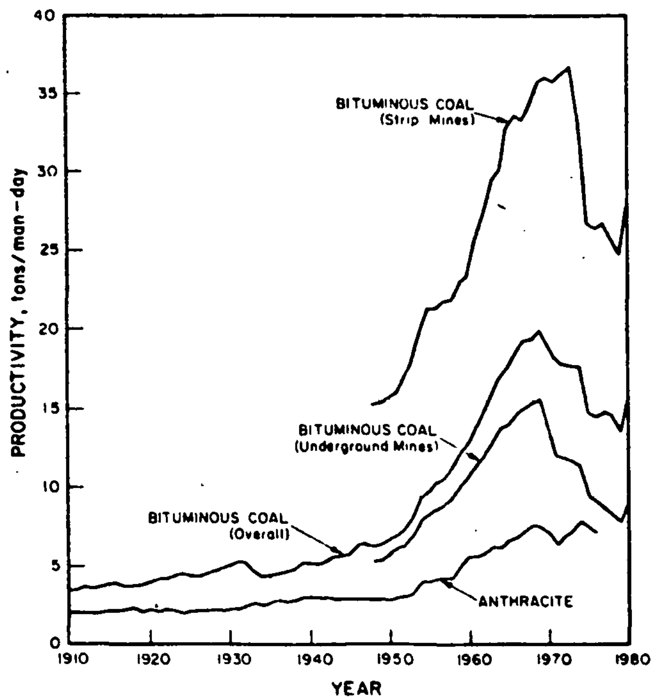
Ref [25]

Date

Approved

Figure 3.8-8

DES-F-A1000



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Productivity Per Man Day in Coal Mining

Date

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Figure 3.8-9

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Source Performance Standards (NSPS) of 1979 are fully applied, Illinois Basin coal will suffer a $0.40 per million Btu penalty over lower sulfur coal; this adds about $9 per ton to the cost of using coal.[10]

A method of utilizing the high sulfur coal without the economic disincentives associated with coal washing and flue gas desulfurization might be to gasify it in situ and utilize a relatively inexpensive acid gas clean-up on the surface. Using UCG technology, much of the sulfur would never even leave the seam. Coal and ash handling problems would be essentially eliminated.

Product Price Estimation

This contract did not include funds to determine a product price beyond estimating the combined linking and well costs per million Btu of gas produced for the purpose of comparing alternate linking concept strategies. Therefore, only a brief attempt to estimate the price is made using the available open literature.

Prices predicted in the literature for product from UCG vary extensively. Estimates for UCG product from thin bituminous coal are almost non-existent. However, if one assumes that bituminous coal will be as easy to gasify as subbituminous coals, once the permeability has been established by using specific technologies such as directional drilling, then it should be reasonable to extrapolate the literature estimates down to the seam thicknesses of most bituminous seams. There are several factors, none of which are well understood, which might balance out any discrepancies in this assumption; namely, the relative competance of the overburden of deeper seams in the Eastern United States, the higher heating value of the coal and the potential for minimal water influx. A range of price for LBG or MBG from $2.90 to $5.70/MMBTU (50%-65% Equity Basis) can be inferred by combining information provided in several studies and scaling the prices to 1980 dollars [26][27][28][29]. No distinction can be made between LBG and MBG price requirements since some studies show LBG to be costlier and in others MBG is the more expensive. This method is obviously subject to error; however, it does point out the possibility that the products of UCG may be competitive with fuel oils and naphthas.

The price is highly dependent on the type of financing, oxygen utilization efficiency, well spacing, and sweep width. In the Phase II report, the cost of linking and well preparation per million BTU's was evaluated for various linking concepts. For the Open Borehole concept, a simple cost from $1.31 to $5.16/MMBTU was determined in varying the thickness from 8 to 4 feet at a depth of 500 ft. The sweep was assumed to be equal to ten times the coal seam thickness and the well spacing at 150 ft. Assuming $3.00/MMBTU for field piping plus a processing facility, a total cost of $4.31 to $8.16/MMBTU results. Of course, interest, depreciation, rate of expenditure, and rate of return all need to be accounted for to arrive at a true DCF value. By doubling the well spacing to 300 ft., the well cost would be reduced by $0.32 to $1.26/MMBTU for a new range of $3.99 to $6.90/MMBTU. The greater well spacing has an obviously more pronounced effect on the thinner 4 ft. seam than on the 8 ft. seam.

Utility Power Demand

LBG and MBG can be used to fuel conventional power plants without a requirement for coal cleaning, flue gas desulfurization or ash disposal. While direct substitution for coal in power boilers is technically feasible, the most likely use of LBG will be in intermediate load gas turbines located at the UCG facility.

Utility power growth is projected to be about 3.4% per year between now and 1990, see Table 3.8-5. This is about 1/2 of the 6% per year growth rate which occurred between 1940 and 1973. Most of the new base load increase will be met with new coal production rather than nuclear energy as once predicted. Increased coal use will result in an increase in environmental problems, such as: atmospheric contamination with SOx, NOx, and particulates; and surface landfill requirements for coal ash. Much of this environmental problem can be mitigated using UCG technology.

TABLE 3.8-5

U.S. ELECTRICITY DEMAND

10^{15} BTU's/Year [1]

	1979	1985	1990
Residential	2.40	2.9	3.3
Commercial	1.77	2.1	2.5
Industrial	2.88	3.6	4.4
Total	7.05	8.6	10.2

Along with the increase in base load, new intermediate and peak load requirements will need to be met. The intermediate and peak load requirements are typically 30% and 20% of the total installed capacity. This should result in increased requirements of approximately 1 quad for intermediate and 0.6 quad for peaking power by 1995. Just to meet the intermediate requirements over 18 very large (150 x 10^9 BTU/day) UCG installations would be required. It is unlikely that a facility of this size would be built outside of the western states. In the Eastern United States, facilities down to 2-3% of that size may actually be developed which would be sufficient to supply a 25 MW facility (230 · 10^6 BTU/hr).

The Fuel Use Act of 1978 precludes the use of fuel oil and natural gas in combined-cycle plants for intermediate load service and restricts their use to peaking requirements (less than 1500 hours per year) [2]. LBG is not restricted from such use. In fact, it would be more suited for intermediate load service than for peaking use which requires response to a cyclic load.

The advantages of using a combined-cycle or cogeneration unit result principally from the higher efficiency and the lower cost per unit of capacity. If the waste heat generated steam can be used to help process the UCG gas, the efficiency of power generation can be as high as 80%. A coal derived gas, such as LBG, should be utilized at the highest possible efficiency to optimize the economics.

MBG can be used in existing oil and gas fired power plants with minimum to no derating.[3] Provided the penalty for transporting MBG is not excessive, this use may provide the type of load requirement needed until higher value uses develop.

Industrial Plants Demand

Industrial plants can utilize UCG products to both supply their heating and internal power requirements, and as feedstock for chemical products manufacturing. LBG will require that an industrial park be established near the UCG facility or that one very large consumer develop a field as a captive supply. MBG is suited to distribution to a limited number of users.

Currently, there are twenty surface-type coal gasifiers which are in operation or under construction which will be used to provide fuel to industrial plants. Ten of these will be to single-users.[4]

The fact that the market for coal derived gases is large enough to justify development of the industry was recently determined in a government sponsored study.[4] This study concluded that the industrial market for LBG and MBG exceeds three quads. A potential exists for 3500 single-user LBG plants, 550 single-user MBG plants, and 300 multi-user MBG plants. Early adopters were concluded to be principally the steel, chemical, and brick companies.

A further incentive for the use of cogeneration by industrial firms has recently been provided by the Public Utility Regulatory Policy Act (PURPA). Section 210 of PURPA, promulgated by Congress in March 1980 and administered by the Federal Energy Regulatory Commission (FERC), eliminates regulatory and economic obstructions to industrial cogeneration by requiring utilities to purchase cogenerator electricity at the utilities "avoided cost". A utility must, therefore, pay the cogenerator what it saves by not generating the energy itself from its most expensive facility, either by increasing power output or adding to capacity. Utilities are furthermore limited to a 50% ownership in the facilities. In addition, industrial cogenerators are eligible for a 10% tax credit on all energy saving equipment. The utilities are not exactly pleased with the limitations imposed on them by Purpa. State plans for implementation of the act were due March 20, 1981.

Synthesis Products

Certain synthesis products might best be produced at the UCG site to optimize energy efficiency and to improve economics of transporting product to market. Only the largest UCG facilities projected for the East will be sufficient to carry the cost of additional process units on-site. While the future cost of natural gas might dictate production of ammonia and urea, or SNG as viable UCG based products, current potential for new transportation fuels makes methanol attractive.

Energy efficiency should be a principle consideration to assure maximum utilization of natural resource. The primary product of coal gasification contains hydrogen and carbon monoxide. It makes little thermodynamic sense to convert this gas to methane just to move it, then reconvert it to hydrogen and carbon monoxide at some remote location to make a synthesis product. Locating the site near a petrochemical complex, within the economic transport radius of a medium Btu gas, will make better use of the resource.

Using UCG derived gases as synthesis feed gas rather than fuel has merit. Other energy sources, i.e., nuclear, low sulfur coal, geothermal, etc., might be better suited to fuel the utilities due to the inherently low conversion efficiency (30-42%) to electricity. Conversion to SNG makes sense from the standpoint that, as a fuel which can be used in residence, methane may eventually become too valuable to be used to generate base load power.

Methanol Markets

Methanol has much to offer as a fuel and petrochemical feedstock. Economic studies have indicated that when produced in sufficiently large scale facilities methanol can be competitive with gasoline. But, before methanol can be produced in large scale projects, a market needs to be assured. Recent actions in the United States and in Europe are leading in this direction.

Fuel uses for methanol include both internal combustion and gas turbine options as previously discussed in Section 3.8.1. Chemical uses include feedstock for higher homologs and solvents.

The current U.S. market for methanol is approximately 3.4 MM m.t. By 1990, the market is expected to exceed 8 MM m.t.[11] Essentially all of this methanol is projected to be used as chemical feedstock with minimal use as a fuel. Should methanol be used to replace gasoline, the market could be many times greater than projected capacity.

Gasoline consumption in the U.S. dropped dramatically starting in 1978 when deregulation allowed prices to rise to import levels. A total drop of 8.9% across the U.S. during 1979 and 1980 reversed a trend which had increased gasoline consumption 3.5% per year the previous four years.[12] The price of gasoline, however, is expected to continue to increase at a rate exceeding the cost of living. Thus, even while demand is down for gasoline the economic driving force for a substitute fuel has rarely looked better.

However, substituting methanol for gasoline will not be an overnight proposition. To gain acceptance as a gasoline replacement, methanol will need to be tested under fleet conditions. Only recently have automobile manufacturers begun to build large numbers of test vehicles specifically designed to burn methanol. The California Energy Commission, anxious to reduce exhaust emissions and avoid another gasoline shortage, has purchased 40 Volkswagon Rabbits and 40 Ford Escorts equipped to burn methanol. The three-year $2 MM project, if successful, may result in the conversion of the state fleet of 15,000 cars to methanol.[13]

Blends of gasoline and methanol do not have all the advantages of methanol alone. The additional disadvantages of high vapor pressure and phase separation are significant disincentives. Other ways of introducing methanol to the transportation industry might initially be through conversion to methyl tertiary butyl ether (MTBE), an octane enhancing additive, which does not suffer the limitations of methanol-gasoline blends. However, the size of the market for MTBE is difficult to project. The production of unleaded-only engines and the higher compression ratios of these engines has increased demand for octane number. Conversely, the soft gasoline market should make more octane barrels available. But, even as the first MTBE plants are coming on-line, the average octane numbers of regular and premium gasolines are dropping.

A recent study [14] points up the difficulty methanol may face in replacing gas as a peaking fuel. Regulatory uncertainity over the use of methanol instead of gas may hold up utility fuel switching. By 1990, utility methanol demand, it is predicted, will total only 54 MM gal/yr. Another paper [15] takes a somewhat regional view of Los Angeles and other smog-prone areas when it claims that the utility gas turbine is the "key" to successful methanol marketing. They are secure, stable, and centralized. As a case in point, Southern California Edison has announced its intent to burn methanol as soon as it becomes available in reliable quantities.

Other new, potential markets for methanol while not as important as the fuel use of methanol, may help to build capacity; these markets include conversion of methanol to M-gasoline, treatment of acid gas with refrigerated methanol, feedstock for protein production, fuel cell fuel, and mixtures of methanol and coal.

A huge potential user market will not be enough to assure acceptance, the price must also be competitive.[16][17] Several studies have indicated that methanol when produced in large enough quantities can have a price parity with existing fuels; particularly, when a reduction in environmental control requirements and efficiency improvements are accounted for. While most of these studies have been based on conventional coal gasifiers, other studies have shown that UCG can be more economical than a surface based system [18][19].

Prices vary significantly with capacity. Various studies were used to produce Table 3.8-6 which indicates that prices in 1981 dollars can be expected to drop from $0.99/gallon to $0.28/gallon when the capacity increases from 4000 B/D to 415,000 B/D. A study by Davy McKee Corp. [20] indicates that the cost of producing 5000 ton/day methanol will be $0.80 per gallon using either $1.75/MMBtu coal ($30/ton) or $5.00/MMBtu natural gas.

In order to understand the equivalent price for methanol, one must take into account the relative energy contents and efficiency of use. Methanol has only 45% of the combustion energy present in gasoline, but could give overall efficiencies 45% higher than gasoline when compression ratio and pollution controls are accounted for.[24] Therefore, at $1.03 per gallon for premium, unleaded (wholesale), methanol would need to sell

TABLE 3.8-6

METHANOL FROM COAL PRICE ESTIMATES

Ref.	Study	Methanol Tons/day	Methanol (Bbls/day)	Price Requirement $/Bbl	Price Requirement (¢/gal)	Coal Tons/day	Equity %	ROI %	Coal $/ton	Other Basis	Total Coal Requirement MM Ton
[17]	Pritchard/UCG Green River, Wyoming	553	(4,000)	37.9-41.7	(90-99) 1981$	-	-	12		$.41-.66/MSCF ($1.39-2.25/MMBtu)	14.4
		1660	(12,000)	27.2-29.6	(65-70) 1981$	-	-	12		$.22-.47/MSCF ($.75-1.60/MMBtu)	43.3
[21]	EPRI/Texaco & ICI Southern Illinois	8541	(61,800)	10.4±30%	(49±30%) 1985$	14,400	100	20	24.25		-
[20]	J. H. Marten (Davy McKee)	5000	(36,200)	22.7-31.5	(54-75) 1981$		100	15	-	$.29-1.75/MMBtu	-
[22]	Badger		(415,000)	11.8(-5%+20%)	(19)1977$ (28)1981$	74,000	35	12	25		-
[16]	Oak Ridge-Modified by WBEC Using 2.6 factor/UCG (very rough)	5000	(36,200)	12.7-21.2	(30-50) 1978$ (40-66.6) 1981$	20,000	30 9% on debt	15	5		130
[23]	Peat Methanol		(4,400)		(116) 1985$						

for $0.67 per gallon at the plant gate. With the exception of the two cases under 5000 bbls. per day all estimates in Table 3.8-6 are economically acceptable.

3.8.2.2 Regional Demand

Areas of the country where the net energy flow is projected to be inward, or where the cost of energy is highest, are good candidates for new energy sources. If UCG amenable coal resources are located within these energy poor areas, UCG technology should be able to offset at least part of the import demand.

The East-North-Central United States has both high projected energy demand and a base of coal potentially amenable to UCG. The East-North-Central demand region, as defined by the Census Bureau, contains Ohio, Indiana, Illinois, Wisconsin, and Michigan. Illinois and Ohio both have UCG target areas which were identified in the Site Selection section.

Energy Balance

As indicated in Table 3.8-7, the region of the country which imports the greatest quantity of energy is the East-North-Central census region. (The census regions are defined in Figure 3.8-10.) This region contains over 9 billion tons of coal potentially amenable to UCG recovery.

There are advantages to using UCG on higher sulfur content coals as well as higher ash content coals. The average sulfur content of mined coal in 1978 in Illinois and Ohio was 3.1 and 3.4%, respectively. Figure 3.8-11 illustrates the sulfur levels of major coal shipments by state in 1978.

Acid (low pH) rain has been a problem in the Northeast United States and Southeast Canada for quite some time. Many of the lakes no longer support aquatic life. While no strong correlation has been determined between the coal sulfur content of the coal burned in the East-North Central United States and the pH of rainfall in the effected areas, it is reasonable to suspect that some of the acidity is directly a result of the high sulfur content of the coals. UCG technology could be instrumental in reducing atmospheric sulfur dioxide if high sulfur coal burned directly could be replaced with clean UCG derived fuel gas.

A comparison of the energy balances for the four states with UCG target areas is presented in Table 3.8-8. As shown, Illinois and Ohio import over 2 quads each while Kentucky and West Virginia are net exporters. While it is likely that Kentucky and West Virginia could use UCG product to offset some

Ref. [30]

TABLE 3.8-7

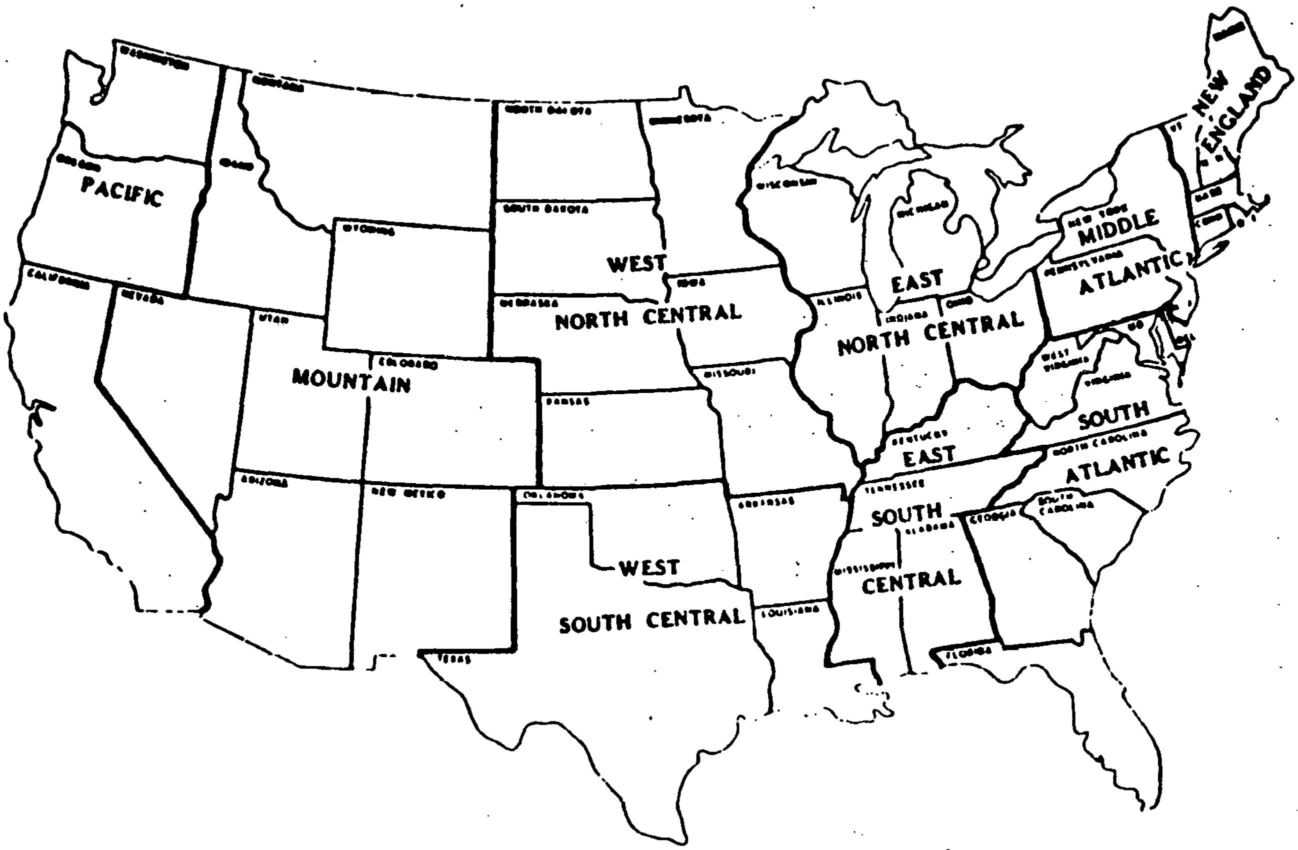
PROJECTED NET ENERGY IMPORTS 10^{12} BTU's

Census No.		Dist. Oil	Res. Oil	Gaso-line	Other Hyd.	Crude Oil	Nat. Gas	Coal	Elect.	Total
1	New England									
	1985	726.5	795.5	531.5	242.9	616.5	284.9	231.1	-4.6	3,424
	1990	-305.8	533.9	-606.4	-45.2	3454	308.2	224.3	-10.3	3,552
2	Mid Atlantic									
	1985	544.7	1239	523.2	595.6	3663	1272	299.5	-66.2	8,071
	1990	850.4	1213	937.9	1021	2853	1264	148.5	-23.3	8,265
3	E.N. Central									
	1985	655.3	150.5	345.4	918.5	5194	2628	1779	-17.5	11,652
	1990	996.4	93.7	362.1	1114	5443	2464	1954	-57.0	12,370
4	W.N. Central									
	1985	368.0	-1.7	572.7	385.7	1250	293	1557	26.8	4,451
	1990	464.5	32.7	625.4	538.1	1394	283.7	1724	37.9	5,101
5	S. Atlantic									
	1985	1134	1191	2490	1240	-259	577.3	-1006	168.4	5,537
	1990	1179	1071	2738	1444	-66.4	498.4	-335.9	289.5	6,817
6	E.S. Central									
	1985	191.2	70.8	446.2	-66.1	1033	768.7	-2270	-106.1	7.9
	1990	196.6	66.1	482.0	-115.7	1242	720.9	-1923	-177.6	419.3
7	W.S. Central									
	1985	-2766	420.9	-4483	-1580	5209	-819	783.8	55.1	-3179
	1990	-2766	420.9	-4483	-1580	5209	-819	783.8	55.1	-3179
8	Mountain									
	1985	40.8	35.1	267.4	167.4	-200	-475.9	-3343	84.9	-3543
	1990	130.5	24.9	201.0	-15.9	388.6	-323.5	-4936	98.5	-4447

Ref. [30]

TABLE 3.8-7 (con't.)

Census No.		Dist. Oil	Res. Oil	Gaso-line	Other Hyd.	Crude Oil	Nat. Gas	Coal	Elect.	Total
9	Pacific									
	1985	-145.8	-52.9	-364.4	-157.3	-40.1	-2622	50.2	28.9	-3,303
	1990	-114.3	13.3	-279.1	-90.1	-676.1	-5205	97.0	-7.1	-6,262
10	United States									
	1985	799.4	3848	330	1747	16,465	1907	-1918	0	23,178
	1990	799.4	3848	330	2884	20,893	2089	-2089	0	29,253



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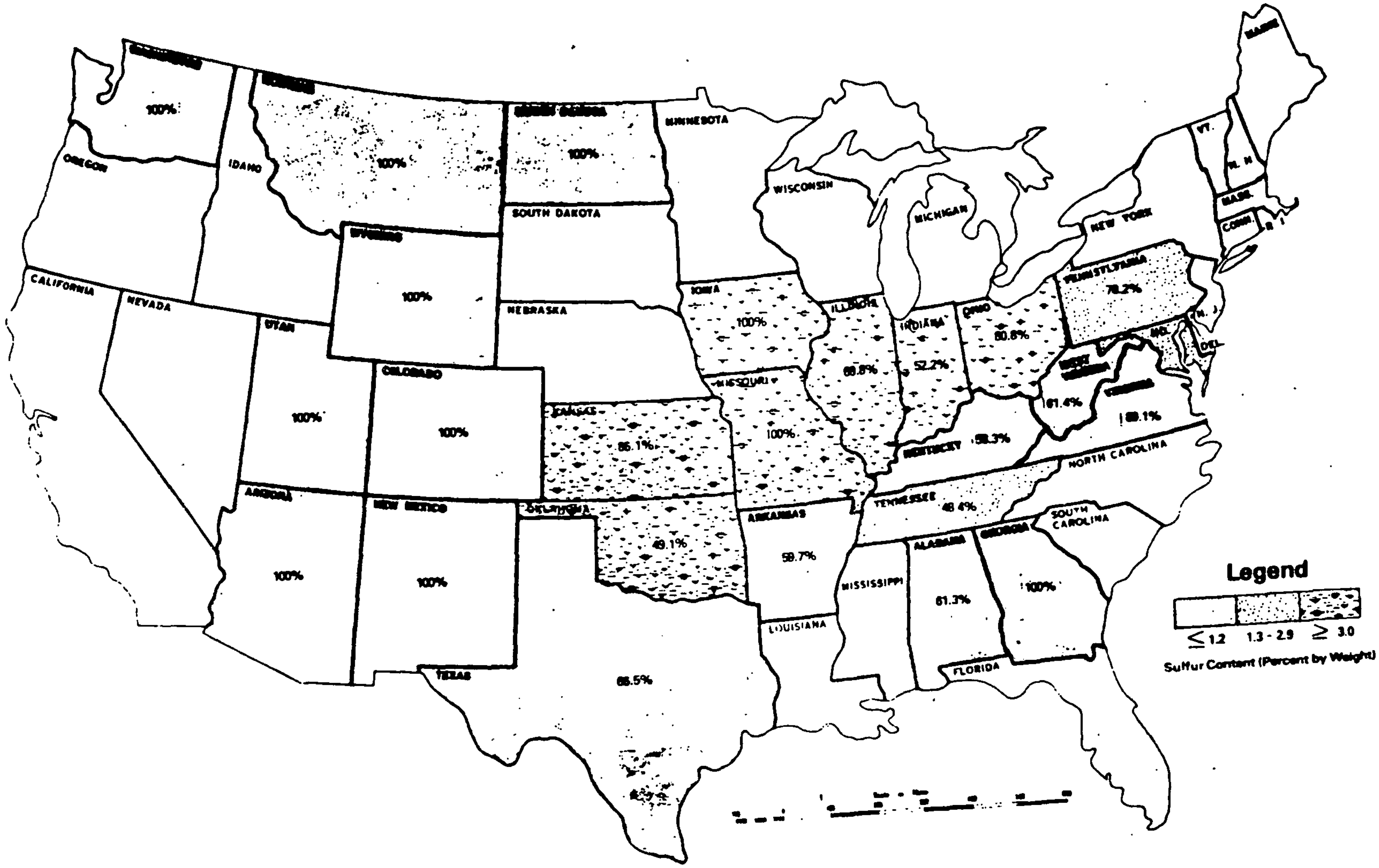
Census Bureau/Demand Regions

Date

Approved

Figure 3.8-10

DES-F-A1000



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Sulfur Levels of Major Coal Shipments by State in 1978

Ref. [31]

Date

Approved

Figure 3.8-11

3.8.2.-15c

DES-F-A1000

Ref. [30]

TABLE 3.8-8

PROJECTED NET ENERGY IMPORTS BY STATE 10^{12} BTU'S

State	Dist. Oil	Res. Oil	Gaso-line	Other Hyd.	Crude Oil	Nat. Gas	Coal	Elect.	Total
Illinois									
1985	22.2	-35.2	-471.9	-32.9	2481	913.0	-675.5	-70.2	2,087
1990	68.2	-55.8	-534.9	16.3	2622	829.1	-744.2	-122.3	2,078
Ohio									
1985	46.6	46.2	143.2	150.2	1182	787.5	522.2	-4.1	2,782
1990	125.1	-41.6	149.5	200.6	1233	753.6	549.9	-3.4	2,967
Kentucky									
1985	46.6	-10.1	86.0	8.9	310.5	171.9	-3414	-40.5	-2,841
1990	58.5	-13.9	101.3	17.9	288.9	146.9	-3666	3.3	-3,063
West Virginia									
1985	38.3	6.9	88.6	27.0	1.9	-2.9	-2607	-96	-2543
1990	48.4	8.9	104.9	36.5	8.3	31.0	-2935	-76.5	-2773

of their liquid or gaseous fuel requirements, Illinois and Ohio appear to have the greater need.

Energy Prices By Region

In order for a synthetic fuel to be marketable, it must be competitively priced. Certain areas of the country pay more for energy than other areas. If a region has both high prices for conventional fuels and a resource base for an alternate fuel technology, it is a good candidate for use of that technology. The East-North-Central region meets these criteria better than any other region in the country with respect to underground coal gasification.

UCG derived gases could displace a portion of the high sulfur coal currently used to generate power; but until the cost of mining, transporting and cleaning coal, scrubbing the flue gases, and disposing of the ash exceeds the cost of burning oil or gas, it is unlikely that this will happen. Rather, it is more likely that UCG gases will displace oil and gas in certain specific applications. Therefore, those regions where oil and gas are priced the highest and a potential UCG base is located will be prime potential areas for early commercial development of UCG technology.

The highest priced oil and gas in the country is in the Pacific region followed by the East-North-Central region, see Table 3.8-9. Of these two regions, only the East-North-Central region has identified potential bituminous UCG resources. The Mountain region is the next highest area with identified UCG resources but as indicated earlier in Table 3.8-7 the overall demand is negative there.

As discussed in Section 3.8.2.1 (Product Price Estimation), the price of UCG product from thin bituminous coals is estimated to be between $2.90 and $5.70/MMBTU. The price of coal, even if a $0.40/MMBTU penalty over lower sulfur coal is incurred due to NSPS requirements, will still be less than $2.00/MMBTU, see Table 3.8-9. Gas is still less than $3.00/MMBTU although in some areas of the country new, deep, deregulated gas (Section 107 of NGPA) is going for up to $11/M cu. ft. although most new, intrastate gas is in the $7-9 range [33]. Currently, deregulated fuel oil is delivered in the $5-6/MMBTU range in the East-North Central United States. Therefore, it appears that UCG gas is almost, if not already, a competitive substitute for fuel oil. Transportation costs may make the difference.

3.8.2.3 Transportation Factors

The distance a product can be transported economically is determined by the total cost of competing products, the price

Ref. [32]

TABLE 3.8-9

PRICES OF FUELS DELIVERED TO UTILITIES - AUG. 1980

Census District	UCG Coal(2)	(1)	Coal	Fuel Oil	Natural Gas	Average Usage		Coal	Fuel Oil	Nat. Gas
	MM ton		¢/MMBTU	¢/MMBTU	¢/MMBTU	¢/MM	Rank	Rank	Rank	Rank
New England	<3.5	High	194.6	677.6	449.8					
		Avg.	172.9	410.9	345.8	389	1	1	6	2
Middle Atlantic	<3.5	High	180.3	479.3	317.5					
		Avg.	137.2	440.4	278.8	236	3	5	4	4
East North Central	9216	High	161.6	562.1	300.7					
		Avg.	146.7	498.8	291.0	163	6	4	2	3
West North Central	<3.5	High	138.7	607.1	242.3					
		Avg.	111.3	456.8	187.2	119	8	7	3	7
South Atlantic	265	High	180.0	629.8	347.2					
		Avg.	153.1	387.9	167.5	219	4	2	7	9
East South Central	1645	High	183.8	697.9	261.6					
		Avg.	150.1	344.2	218.3	158	7	3	9	6
West South Central	257	High	195.5	529.5	215.4					
		Avg.	124.8	367.0	177.8	168	5	6	8	8
Mountain	20,124	High	113.8	697.7	460.9					
		Avg.	79.6	430.8	252.8	107	9	9	5	5
Pacific	<3.5	High	141.2	633.2	417.9					
		Avg.	104.4	502.8	353.2	393	2	8	1	1

Notes: 1. Highs refer to the average of the highest priced state in each district.
2. Bituminous coals only per Appendix B.

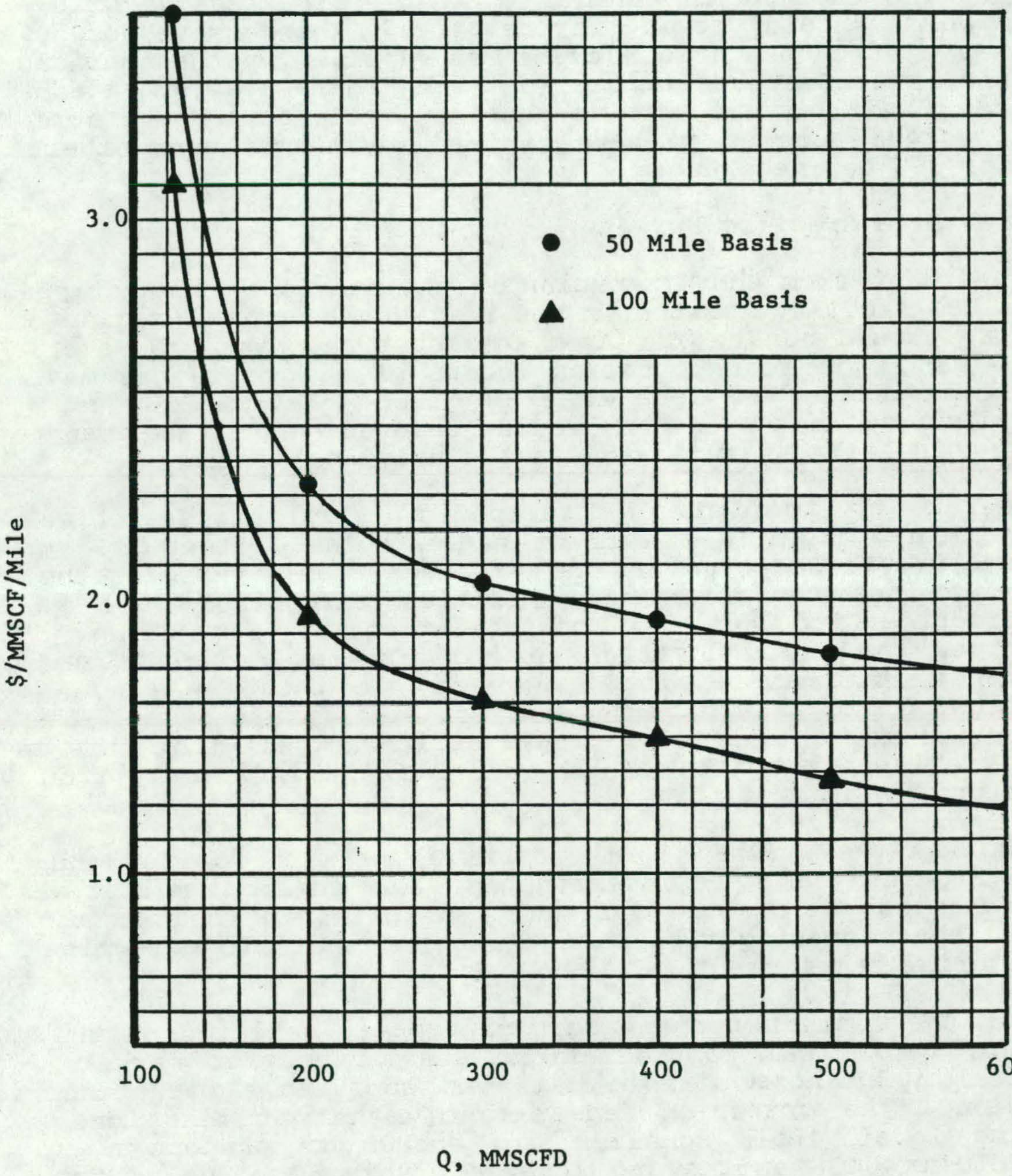
of producing the product, and the cost of transporting it. If it can't be delivered to the customer at a competitive price it will not normally be the fuel of choice. Other factors, such as inflation, environmental considerations, supply assurance, government regulations, guarantees, subsidies, etc. must all enter the equation. It is not an easy task to determine the maximum distance a new product can be moved before the value added causes the product to exceed its market value. However, if we assume that transportation can equal up to 20% of the cost of producing the fuel a radius of transport can be calculated. It is obvious that when the value of the product increases at a faster rate than the cost of transporting it the radius increases.

As indicated in Figure 3.8-12 the cost of moving a unit volume of gas by pipeline is dependent on the distance as well as on the total quantity to be moved. A large quantity can generally be moved more economically than a smaller quantity. It is evident that if the gas can be sold at the gate for $5/MMBTU and if a total delivered price of $6/MMBTU is competitive the approximate transport radius is 40 miles for LBG at 100 BTU/SCF, 100 miles for MBG at 250 BTU/SCF, and 150 miles for upgraded MBG at 350 BTU/SCF. Small quantities of gas (less than 100 MMSCFD) will have a smaller transport radius than those indicated.

The use of existing transportation systems should not be overlooked. It makes good economic sense to use older in-place paid-out systems. However, use of existing modes will require product compatibility.

An extensive network of pipelines exist in the United States for transport of crude, natural gas and petroleum products. Several of these pipelines pass near target areas identified as having coal amenable to UCG. Liquid products, such as, methanol, M-gasoline, or a Fischer-Tropsch crude could potentially be moved in crude or product liquid pipelines. Liquids could also be moved over rails and highways or barged down waterways. SNG could easily be transported in an existing natural gas line.

Could MBG or LBG be transported in a natural gas pipeline? This would depend, in part on the resulting properties of the mixture. Air is routinely added to natural gas in small quantities (below the explosive limit) to dilute the gas and bring it into heating value specification. The effect of blending hydrogen, carbon monoxide and carbon dioxide into a natural gas line may not be compatible with pre-existing end-uses particularly in the chemical industry. The effect of a toxic gas such as carbon monoxide being introduced into residential uses also may not be acceptable; although, 'town gas', which contains carbon monoxide, has been used in this



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Cost of Pipelining UCG Product Gas

Date

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Figure 3.8-12

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capacity in the past. A pilot light which goes out could result in a greater potential safety hazard than methane alone.

Another existing transport mode is the electric transmission system. The East North Central U.S. has an extensive grid system which should provide for relatively inexpensive access. An example of such a grid network was supplied by the American Electric Power Service Corporation, see Figure 3.8-13. Again, the use of modular gas turbine combined cycle or co-generation power systems appears to have certain advantages over other uses for UCG derived gases.

3.8.2.4 Site Specific Markets

It is evident from the discussion in the previous sub-sections that a UCG facility located in the East-North-Central region of the U.S. should not be far from an industrial base. However, the low economic transportation radius of a low BTU gas may limit distribution to less than 50 miles. Medium BTU gas, particularly with the carbon dioxide removed, should be able to exceed this limit as indicated in the previous section.

In order to try to identify site specific markets a search was made within a 50 mile radius of each of the fifteen (15) originally defined potential target areas. Only existing fuel users in the industrial and utilities categories were identified. Site specific possibilities of attracting industries into an industrial park complex or the need for additional intermediate load power in the future was not investigated and should be the subject of a future study. The residential market was not reviewed as it was felt that this is not a viable market although it will benefit indirectly from any natural gas tradeoff.

To simplify the analysis only potential markets for low and medium BTU fuel gas were investigated. The chemical market was not addressed due to the difficulty of obtaining meaningful data without investigating each plant in detail to determine raw material requirement.

Each of the fifteen target areas previously selected on the basis of geological considerations was tested for market potential by using available data and applying a marketing criterion. The criterion requires only that at least one existing fossil fuel consumer big enough to support a 230 MMBTU/hr UCG facility be located within 50 miles of the selected target area. This criterion assumes that an existing industry would be willing to switch or incorporate fuel gas from a UCG facility when it became available.

A 230 MMBTU/hr facility is roughly equivalent to a 3.5 MM ton resource utilized over a 20 year period. While the economics

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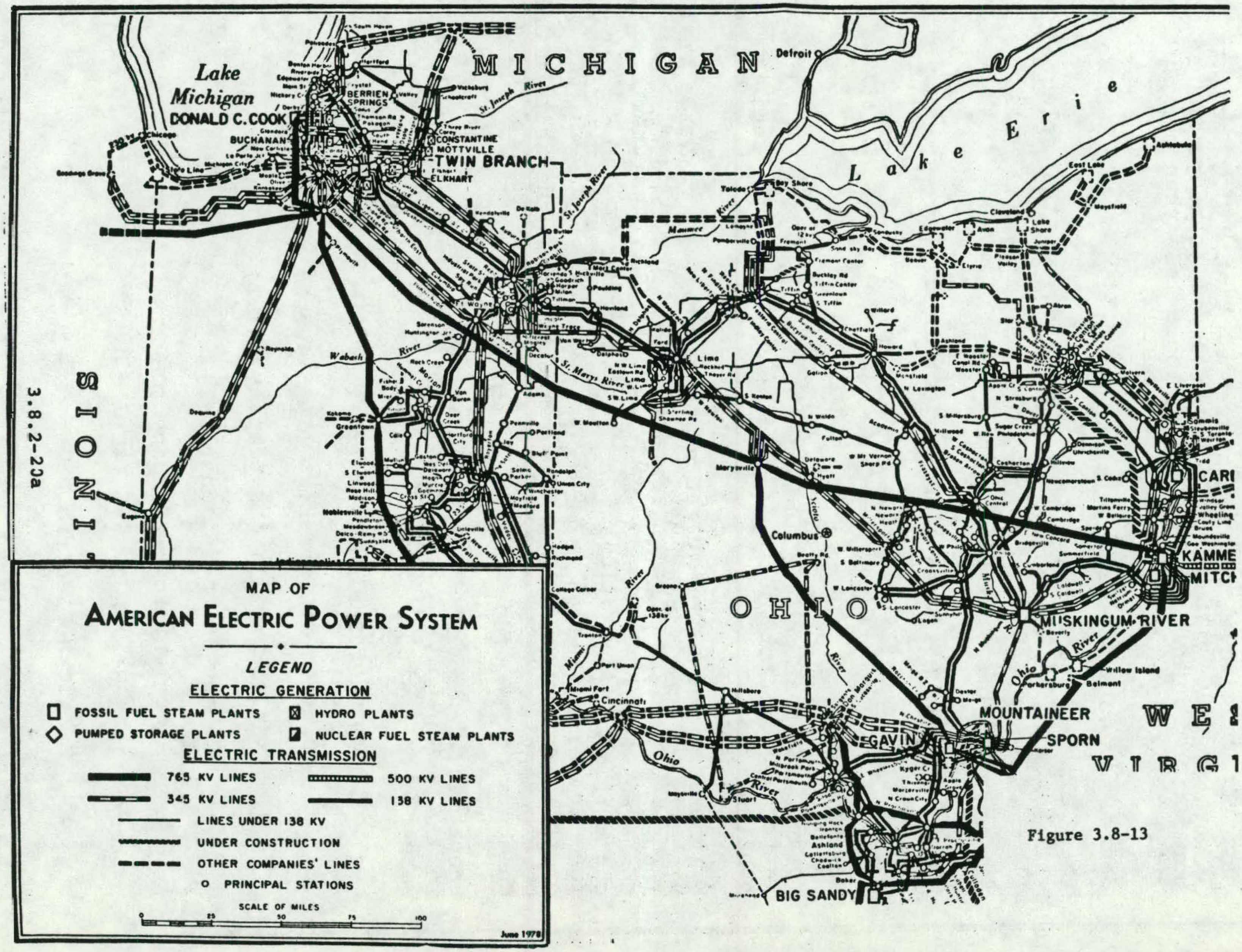

Figure 3.8-13

have not been developed it is assumed that a UCG facility of this size will allow gas to be produced (concept and site permitting) which is priced equal to or less than the price of available conventional energy sources.

Sources of data used for this analysis were:

1. Computer search of the industries in the selected counties.

2. Natural Gas/Fuel Forecast. [34]

3. Inventory of Power Plants in the U.S. [36]

4. Electric Utility Directory. [35]

Market Survey

Market information was obtained by phone calls, inquiry letters, computer searches and government and regional publications.

Written inquiries were directed to chambers of commerce in the vicinity of the target areas to ascertain interest. This inquiry met with very limited success. Only two Chambers of Commerce indicated enthusiasm in their response. Out of twelve chambers to which letters were sent, only four replied. The form letter mailed and addresses used are attached to the end of this section as well as the responses from the Eastern Ohio Development Council, and the Greenville and Central City Chambers of Commerce, see Attachment I.

Phone calls were placed to several power utilities with units in the vicinity of the target areas. Among these utilities were the following:

- o City of Springfield (IL-2)
- o City of McCleansboro (IL-3,4,5,6)
- o Kentucky Utilities Company (KY-1)
- o Commonwealth Edison (IL-2)
- o Allegheny Power Company (OH-2,3)
- o Illinois Power (IL-1)
- o American Electric Power (OH-1,2,3)

Most replied that they would be interested, if the price was competitive with their existing fuel. The City of Springfield is interested because much of their generating capacity will need replacing in the early 1990's. Kentucky Utilities has already assessed using a low or medium BTU gas from coal gasifiers (surface). The transportation costs made it more expensive than coal bought at $23-32/ton delivered. As a means of allowing higher sulfur coals to be burned the study suggested that a low BTU gas would present reliability problems. Commonwealth Edison may be interested if the price is competitive with #6 oil which is currently used in their peaking units. However, these units only have an operating factor of about 30%. In addition, there would have to be sufficient price differential to justify breaking an existing 20 yr. oil contract. Illinois Power is currently evaluating the use of the Allis-Chalmers Kilngas coal gasification process. They are sharing an investment of $5.5 million for the construction and demonstration phases of this process. The objectives of the program include demonstrating the feasibility of power generation with environmentally acceptable low BTU gas derived from Illinois coal. They have reviewed UCG technology with Texas Utilities, the licensor for Soviet UCG technology in the United States.

Fuel Gas Consumers

The counties in which a majority of the land area falls within the 50 mile radius of the target area are listed in Table 3.8-10. These counties were used as the basis for a search for current natural gas users.

Attachment 2 is a compilation of most major industrial natural gas consumers in the counties identified. Other data given in Attachment 2 includes: names of suppliers, volume of natural gas delivered in 1978, and potential substitute fuels.

The 230 MMBTU/hr required to justify a target area is approximately equivalent to 2 billion cu. ft./yr. On the entire list there are only 11 industrial consumers out of the 147 listed that meet this minimum requirement for a potential market. These 11 potential markets are listed separately on Table 3.8-11.

Power Plants

The search for existing power plants was limited to counties at least a portion of which fell within an arbitrary 50-mile radius around each site. These counties are identified in Table 3.8-10. All of the power plants identified are listed on Attachment 3. As indicated in Table 3.8-12, there are sixteen power plants above the 25 MW criterion (approximately equivalent to 230 MMBTU/hr assuming an efficiency of 37%). Power plants located within ten miles of a site were considered

TABLE 3.8-10
COUNTIES WITHIN A 50 MILE RADIUS OF
IDENTIFIED TARGET AREAS

WEST VIRGINIA				OHIO	
County	Sites	County	Sites	County	Sites
Roane*	WV-1,3,4	Harrison	WV-4	Monroe	OH-1,2,3*
Calhoun*	WV-1,3,4	Randolph	WV-4	Belmont	OH-1,2,3*
Wirt	WV-1,3	Pocahontas	WV-4	Guernsey	OH-1,2,3
Jackson	WV-1,3	Greenbriar	WV-4	Muskingum	OH-1,2,3
Mason	WV-1,3	Cabell	WV-2	Morgan	OH-1,2,3*
Putnam	WV-1,2,3	Wayne*	WV-2	Washington	OH-1,2,3*
Kanawha*	WV-1,2,3	Lincoln*	WV-2	Noble	OH-1,2,3*
Clay*	WV-1,3,4	Logan *	WV-2	Harrison	OH-1
Fayette	WV-1,3,4	Mingo *	WV-2	Perry	OH-2,3
Nicholas *	WV-1,3,4	Wyoming	WV-2	Athens	OH-2,3
Webster *	WV-1,3,4	Pleasants	OH-1,2,3	Meigs	OH-2,3
Braxton *	WV-1,3,4	Tyler*	OH-1,2,3		
Gilmer *	WV-1,3,4	Wetzel*	OH,1,2,3		
Ritchie	WV-1,3,4	Marshal*	OH-1,2,3		
Boone	WV-1,2,3	McDowell*	KY-2		
Wood	WV-1,3				
Lewis	WV-1,3,4				
Doddridge	WV-3,4				
Upshur	WV-3,4				

ILLINOIS				KENTUCKY			
County	Sites	County	Sites	County	Sites	County	Sites
Christian*	IL-1,2	Jefferson*	IL-3,4,5,6	Muhlenberg*	KY-1	Pike*	KY-2
Sangamon*	IL-1,2	Franklin *	IL-3,4,5,6	Ohio*	KY-1	Martin	KY-2
Menard *	IL-1,2	Hamilton *	IL-3,4,5,6	McLean	KY-1	Floyd	KY-2
Logan *	IL-1,2	Wayne *	IL-3,4,5,6	Hopkins	KY-1	Lawrence	KY-2
Mason *	IL-1,2	Marion	IL-3,4,5,6	Christian	KY-1	Johnson	KY-2
Tazewell	IL-1,2	Clay	IL-3,4,5,6	Todd	KY-1	Magoffin	KY-2
McLean	IL-1,2	Washington	IL-3,4,5,6	Logan	KY-1	Knott	KY-2
DeWitt	IL-1,2	Perry	IL-3,4,5,6	Butler*	KY-1	Letcher	KY-2
Macon *	IL-1,2	Jackson	IL-3,4,5,6	Grayson	KY-1		
Fulton	IL-1	Williamson	IL-3,4,5,6	Hancock	KY-1		
Cass	IL-1,2	Saline	IL-3,4,5,6	Daviess	KY-1		
Peoria	IL-1	Gallatin	IL-3,4,5,6	Henderson	KY-1		
Woodford	IL-1	White	IL-3,4,5,6	Webster	KY-1		
Shelby	IL-2	Edwards	IL-3,4,5,6	Caldwell	KY-1		
Moultrie	IL-2			Simpson	KY-1		
Piatt	IL-1,2			Warren	KY-1		
				Edmundson	KY-1		

*Indicates that these counties are within a 10-mile radius of the identified target areas.

TABLE 3.8-11

SUMMARY OF EXISTING INDUSTRIAL CONSUMERS
THAT MEET MINIMUM REQUIREMENT*

Site(s)	Company	Quantity (MCF/yr)
IL-2	Keystone Steel & Wire	2,443,000
IL-2	Nat. Distillers & Chem. Corp.	15,268,032
IL-1,2	A.E. Staley	7,416,777
IL-1,2	Archer Daniels Midland-West	2,478,228
IL-1,2	Hopper Paper Co.	6,691,538
KY-1	Martin Marietta Aluminum Co.	2,246,096
OH-1,2,3	Anchor Hocking Corp.	2,105,000
OH-1,2,3	Consolidated Aluminum Corp.	4,048,157
WV-1,2,3,4	Du Pont	3,035,769
WV-1,2,3,4	Du Pont	13,931,348
WV-1,2,3,4	Libbey Owens Ford	2,341,000

* 2 billion SCF/yr: equivalent to approximately 230 million BTU/hr.

TABLE 3.8-12

POWER PLANT LOCATION RELATIVE TO SITES

ILLINOIS

A. Havana Unit
35 mi from I-1

B. Kincaid Unit
25 mi from I-2

C. Dallman Units, Factory Units
Lakeside Units, & Reynolds Unit
18 mi from I-2

KENTUCKY

A. Green River Unit
12 mi from K-1

OHIO

A. Berger R.E. Units
23 mi from 0-1

B. Krammer Units
23 mi from 0-1

C. Mitchell Units
21 mi from 0-1

D. Willow Island and Pleasants Units
10 mi from 0-2

E. Muskingum River Units
9 mi from 0-3

WEST VIRGINIA

A. John E. Amos Units
32 mi from WV-1

B. Cabin Creek Units
23 mi from WV-1

C. Kanawha River Units
20 mi from WV-1

primary targets. Only three of these power plants are actually located within a ten mile radius of any of the target areas.

The locations of each of the power plants which meet the minimum marketing criterion relative to location of the target areas are listed in Table 3.8-12 and are illustrated in Figures 3.8-14, 15, 16 and 17.

One utility has stated that it is involved in a current project to utilize low-BTU gas. It may be possible to work out an arrangement for a power company to purchase the coal field out-right and aid them in developing the field by placing a UCG gas burning plant on-site. As discussed earlier, combined-cycle or co-generation gas turbines have advantages in this application:

Chemicals

Current consumers of synthesis gas, methanol, tars/oils, and chemicals were investigated using a computer search of industrial listings and resource literature from chambers of commerce. A search was made only in the counties where the potential sites were located. The result was inconclusive.

3.8.2.5 Evaluation

As indicated in Table 3.8-13 there are several existing energy consumers near the identified target areas.

Power plants, even though currently consumers of coal, oil, and natural gas are targets for early conversion to MBG. Many indivdual power plants as indicated in Attachment 3 are of sufficient size to handle the entire output of a 230 MMBTU/hr facility. Due to the high cost of transporting LBG and the necessity to derate a boiler significantly the use of MBG is recommended.

There are three previously identified target areas which have power plants near them: KY-1; OH-2; and OH-3. The KY-1 target area is in Muhlenberg County, the Chamber of Commerce of which responded to a written inquiry in an extremely positive manner. The OH-2 and 3 areas may require that a pipeline cross the Muskingum River and/or the Ohio River, see Figure 3.8-18. It may be that the cost of crossing a river, particularly one as large as the Ohio River, would justify an alternate longer route.

Other target areas which have both industry and power plants within a 50 mile radius are as follows: IL-1, IL-2, OH-1 and WV-1, and WV-3.

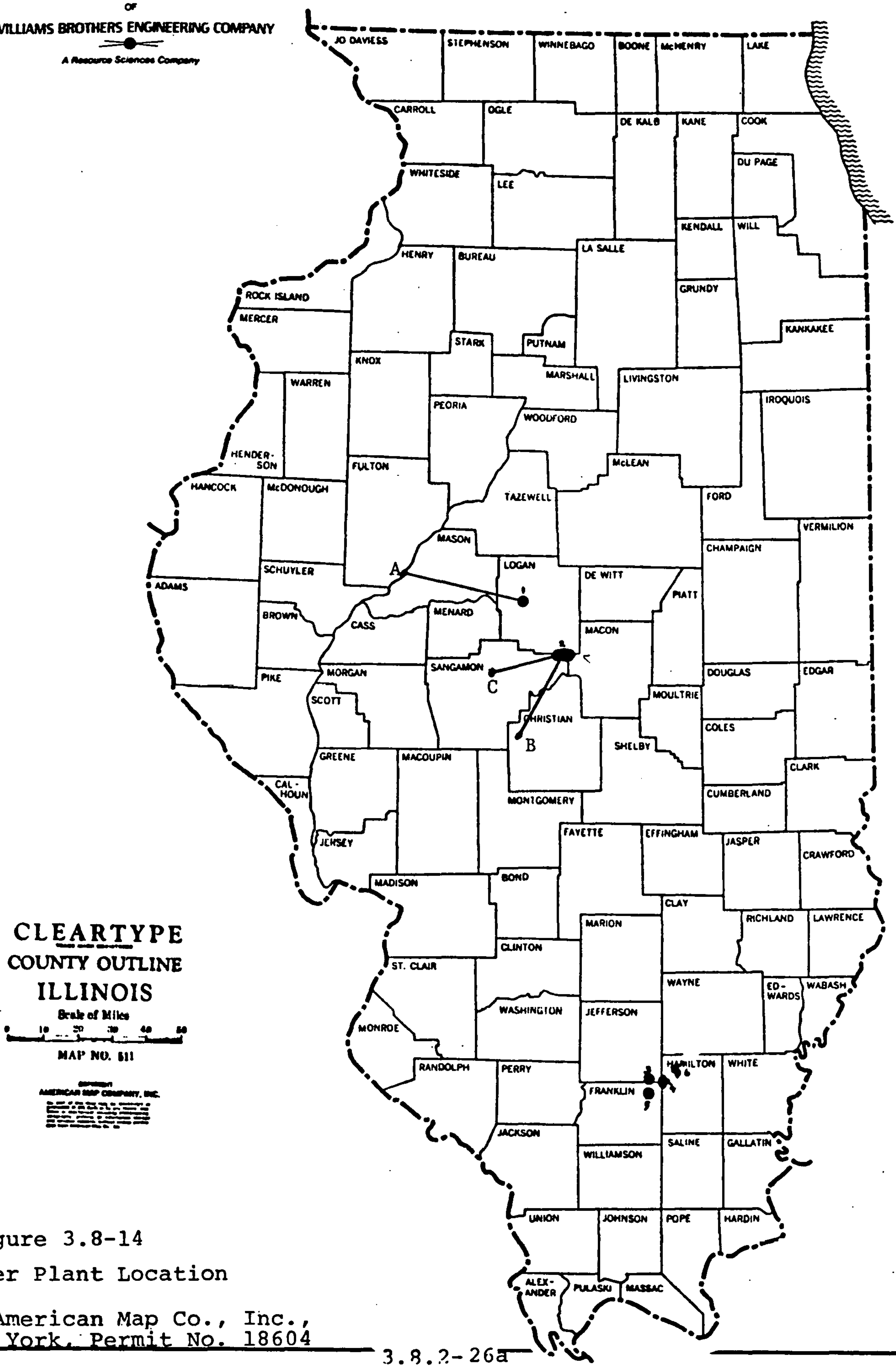

Figure 3.8-14
Power Plant Location

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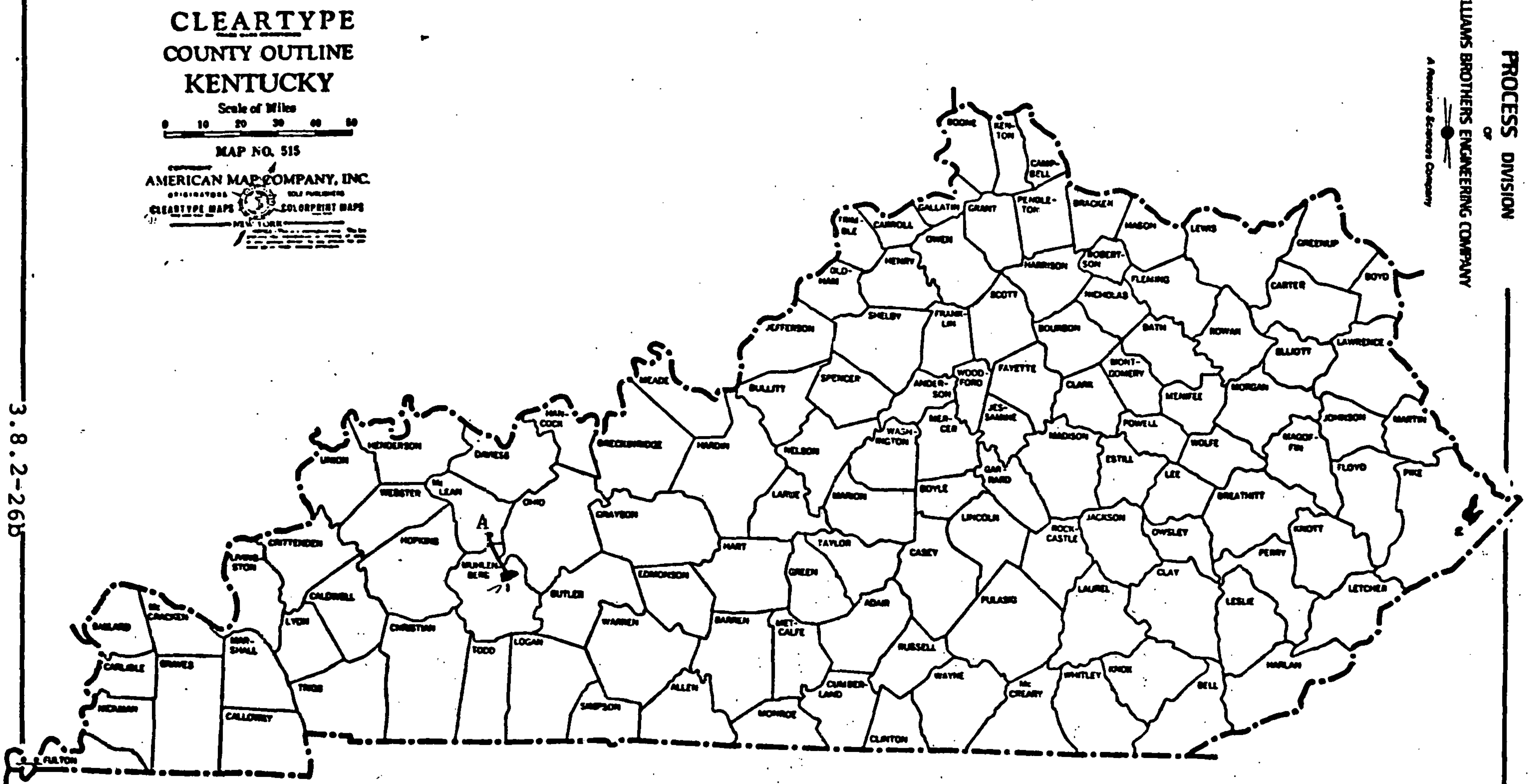

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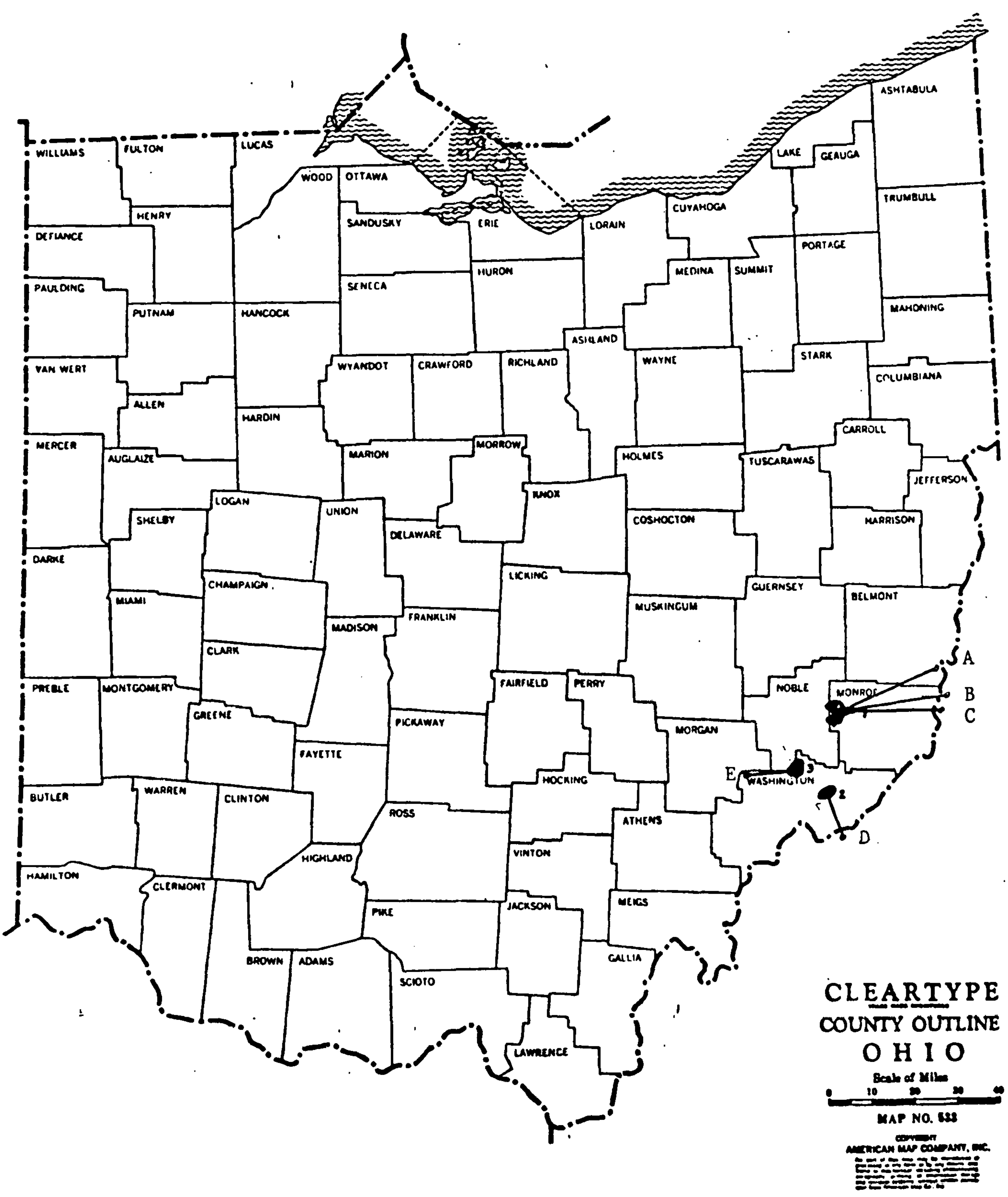
Figure 3.8-15
Power Plant Location



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WILLIAMS BROTHERS ENGINEERING COMPANY *A Resource Sciences company* TULSA, OKLAHOMA	Power Plant location
Date	
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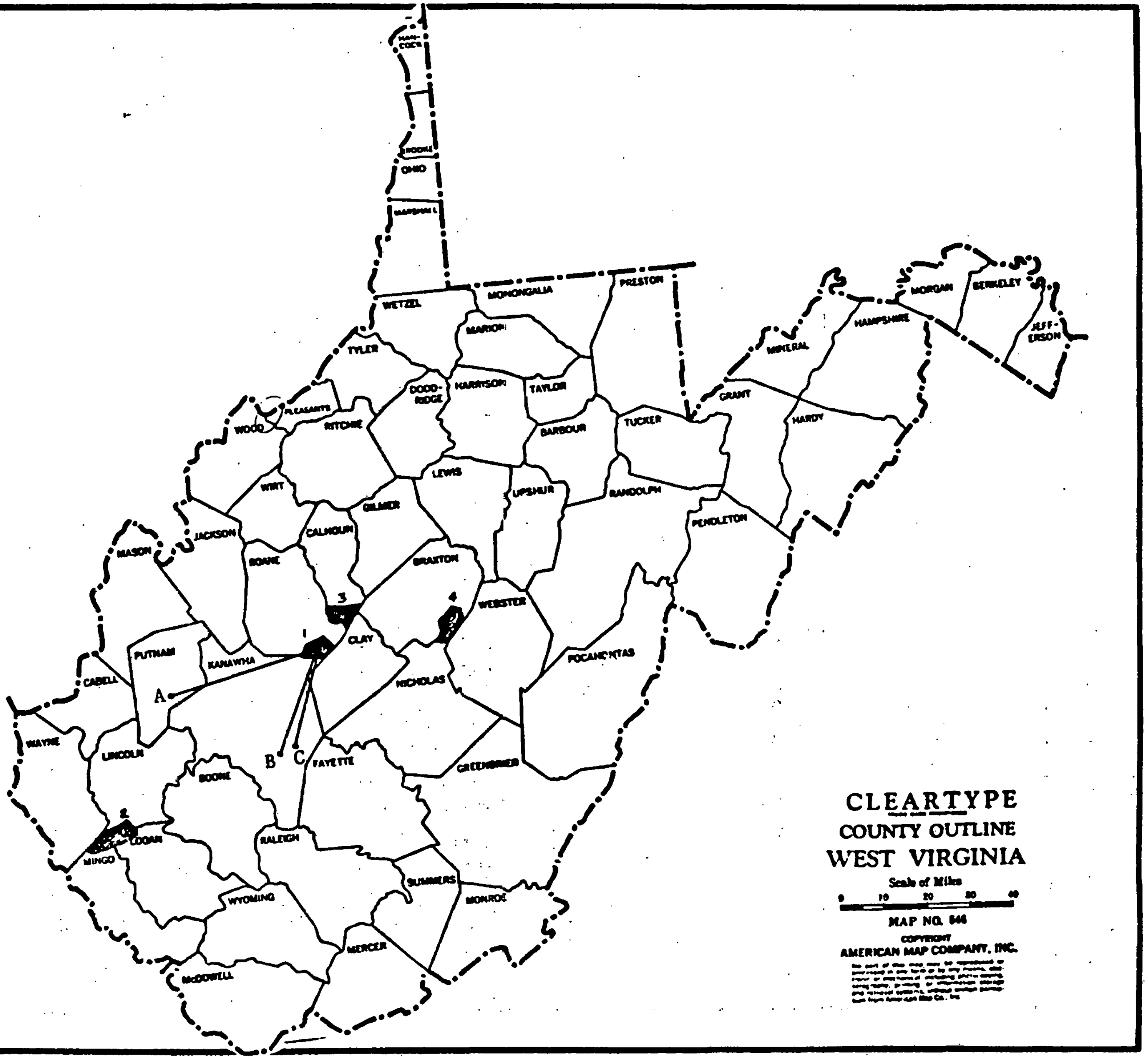

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TULSA, OKLAHOMA

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: Power Plant Location

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Figure 3.8-17

TABLE 3.8-13

SUMMARY OF MAJOR INDUSTRIAL AND UTILITY ENERGY CONSUMERS

NEAR TARGET AREAS

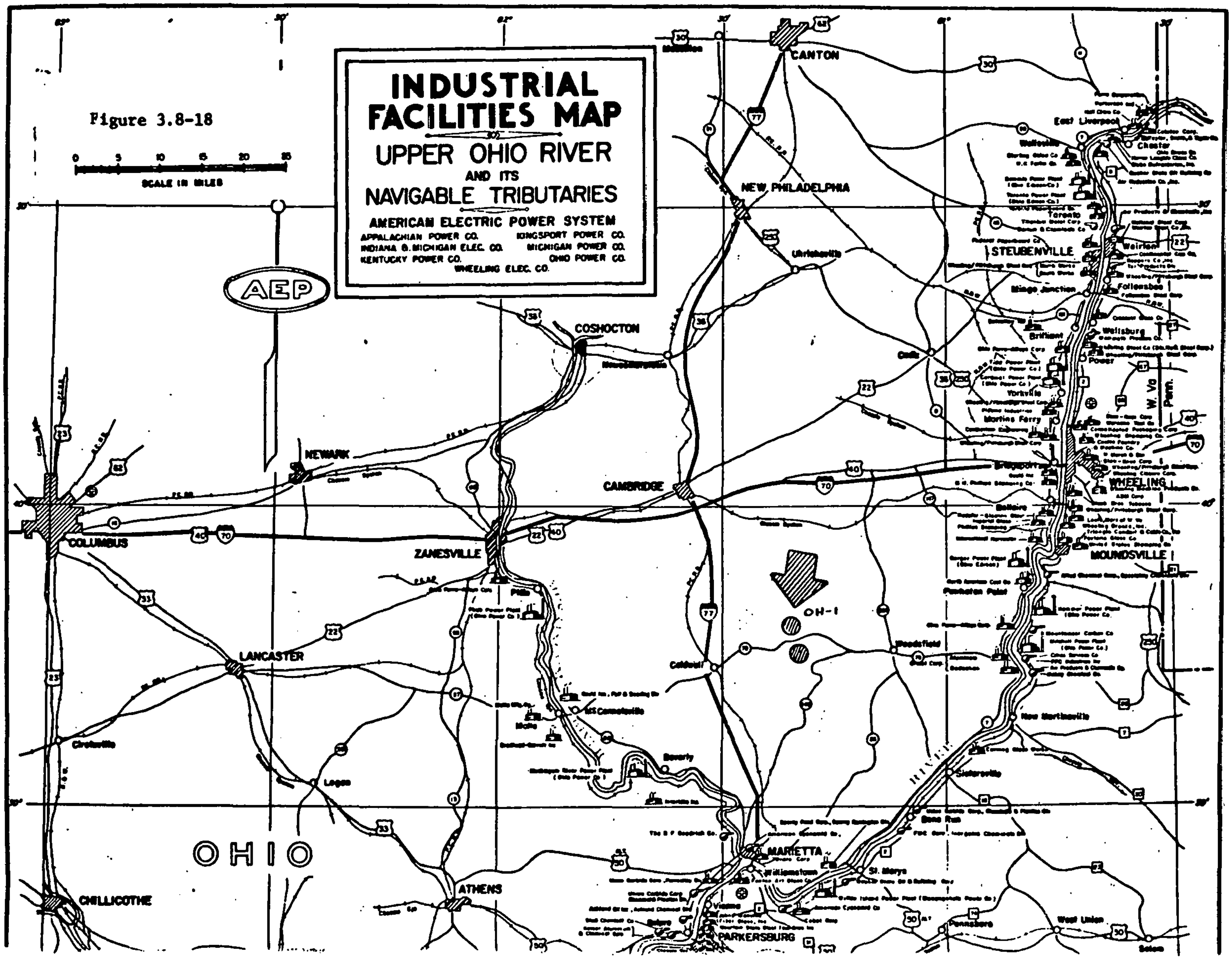
Target Areas	Existing Natural Gas Consumers		Existing Power Plant Units 1)	
	No.	Total MCF/yr	No.	Total MW
IL-1	4	19,029,543	1	680 2)
IL-2	4	31,854,575	4	1065 3)
IL-3,4,5,6	0	--	0	--
OH-1	2	6,153,157	3	2416
OH-2,3	2	6,153,157	3	3090
KY-1	1	2,246,096	1	220
WV-1,3	3	19,309,903	3	3256
WV-2,4	3	19,309,903	0	--

1) All Power plants are coal fired steam turbine units except as noted.

2) Includes 230 MW oil fired steam turbine.

3) Includes 77 MW oil fired gas turbine.

Figure 3.8-18


INDUSTRIAL FACILITIES MAP
UPPER OHIO RIVER
AND ITS
NAVIGABLE TRIBUTARIES
AMERICAN ELECTRIC POWER SYSTEM
APPALACHIAN POWER CO.
KINGSPORT POWER CO.
INDIANA & MICHIGAN ELEC. CO.
MICHIGAN POWER CO.
KENTUCKY POWER CO.
OHIO POWER CO.
WHEELING ELEC. CO.
AEP
SCALE IN MILES
0
5
10
15
20
25
CANTON
NEW PHILADELPHIA
COSHOCTON
NEWARK
COLUMBUS
ZANESVILLE
CAMBRIDGE
LANCASTER
OH-1
East Liverpool
Chester
Wellsville
Toronto
Weirton
STEUBENVILLE
Follansbee
Mingo Junction
Brilliant
Wellsburg
Power
Yorkville
Martins Ferry
Bridgeport
WHEELING
Bellaire
MOUNDSVILLE
Powhatan Point
Woodsfield
Caldwell
Beverly
New Martinsville
Sistersville
Cadiz
Uhrichsville
W. Va.
Penn.
RIVER
MARIETTA
Williamstown
St. Marys
PARKERSBURG
Vienna
Belpre
Pennsboro
West Union
Salem
ATHENS
Logan
Circleville
CHILLICOTHE
OHIO

Price, reliability of supply and compatibility with existing equipment will be key ingredients to getting acceptance by the utility sector.

Sites such as IL-3, 4, 5 and 6 which are not in industrial areas will either need to produce transportable fuels such as SNG or methanol, or at least high grade MBG into a 350 + BTU/SCF product by carbon dioxide removal. Industrial complexes such as St. Louis are within a 100 mile radius.

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27. D. L. Biblack, "The Economics of Four Options to Utilize Underground Gasification of Kaiparowits Coal to Generate Electricity", Presented at 4th UCC in Steamboat Springs, Colorado, July 1978.

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3.8.3 Conclusions

The following conclusions were drawn from the preceding study.

1. The U.S. will continue to require new sources of energy fuels and substitutes for petrochemical feedstocks into the foreseeable future. Most of this requirement will be met using coal. However, the cost of mining, transporting, cleaning, and preparing coal, disposing of ash or slag and scrubbing stack gases continues to rise; particularly, in the Eastern U.S. where the need is greatest. UCG avoids these pitfalls and, as such, should be considered a viable alternative to the mining of deeper coals.

2. Of the two possible product gases LBG and MBG, MBG is the most versatile. (It may actually be the least expensive option for projects of sufficient scale.)

3. The most logical use for UCG product in the Eastern U.S. is to generate power on-site using a combined-cycle or co-generation system. Either low or medium BTU gas (LBG or MBG) can be used. PURPA will provide incentive for industrial firms to install the co-generation facilities.

4. UCG should be an option whenever surface gasification is considered; particularly, in areas where deeper, higher sulfur coal is located.

5. There are environmental and social benefits to use of UCG over surface gasification in the Eastern U.S.

6. The East-North-Central Census Region is the most logical section of the country to site an alternate fuels project based on underground gasification of bituminous coal. Potentially amenable coal resources, high prices for fuel oil and natural gas, and a large imported energy flow form the basis for this conclusion.

7. A site could be chosen almost anywhere in the Illinois and Ohio area where amenable UCG coal has been determined due to the existance of existing transportation or transmission systems. The potential radius of up to 150 miles for an upgraded MBG gas using a new pipeline would put Columbus and Pittsburgh in range of OH-1 and St. Louis within range of IL-4, 5, and 6. However, the closer a site could be located to its intended market, the better the chances for economic parity with competitive fuels.

8. The technology needs to be demonstrated and the potential economic viability determined at a site in the

East-North-Central U.S. which has commercial quantities of amenable bituminous coal before utilities will show significant interest. To bring about timely adoption of the technology, state or federal government will need to sponsor the basic research and initial field testing.

9. While methanol has excellent potential as a marketable product which can be produced from UCG product gas, the economies of scale required to produce it at a competitive price may dictate production in the western states using thicker sub-bituminous coals.

PROCESS DIVISION of WILLIAMS BROTHERS ENGINEERING COMPANY
A Resource Sciences Company

RESOURCE SCIENCES CENTER | 6600 S. YALE AVE. | TULSA, OKLAHOMA 74177
PHONE (918) 496-5020 | TELEX 49-7493 WBEC-TUL

January 13, 1981

Addresses of Chambers of Commerce listed in Attachment Ia(2)

Re: Contract DE-AC05-80MC14584
Assessment of UCG in Bituminous Coals

Gentlemen:

Williams Brothers Engineering Company is currently working on a contract for the Department of Energy to evaluate underground coal gasification technology in bituminous coals. One of our contract tasks is to locate sites in the 48 lower continguous states which appear suitable for this technology. We are pleased to inform you that as a result of an initial geological screening, a potential site has been identified in your area.

In order for a site to be commercially viable, a minimum number of criteria must be met. These criteria involve: resource, land availability/accessibility, political climate, environmental considerations, indigenous workforce, and market potential. To date, all we have is an indication that a resource meeting certain geological/technical criteria is present in your vicinity and that there is a likelihood that other criteria can be met.

Williams Brothers is hereby requesting information on your city, county and region, particularly with regard to industries which could use a source of fuel or chemical feedstock. Fuels and feedstocks which could easily be provided from an underground coal gasification facility include: low heating value gas (70 - 170 BTU/SCF) and medium heating value gas (270 - 400 BTU/SCF). By further upgrading, synthetic natural gas (SNG), methanol, and gasoline can be produced. Certain byproducts, such as, ammonia and sulfur might also be available in limited quantity. Chemical plants (including pulp and paper, steel mills, metallurgical, petrochemical, etc.), oil refineries, power plants, and large factories are typical types of consumers we need to know about.

In short, we believe that underground coal gasification might benefit the nation and your region in particular by providing productive employment, a local source of energy, and a new tax base.

Our timing is such that for your input to be incorporated into our report, it will be necessary for you to respond to this inquiry by February 7, 1981.

Please submit names, addresses and phone numbers of responsible people in local industry, whenever possible.

Since it is unlikely that people outside of the synthetic fuels industry will know much about underground coal gasification, a copy of a recent Wall Street Journal article is enclosed for your information.

Sincerely,

Process Division
WILLIAMS BROTHERS ENGINEERING COMPANY

Martin M. Siegel

Martin M. Siegel
Manager of Alternate Fuels Processing

Enclosure

PROCESS DIVISION of WILLIAMS BROTHERS ENGINEERING COMPANY

Chambers of Commerce:

Site:	
IL-1	600-1/2 Broadway P.O. Box 418 Lincoln, IL 62656 217-735-2385
IL-2	102 S. Washington Mount Pulaski, IL 62548 217-792-5251 and 1 Civic Center Plaza P.O. Box 1031 Decatur, IL 62525
IL-3	Rt. 15 West & I-57 P.O. Box 1047 Mount Vernon, IL 62864
IL-4 & 6	P.O. Box 456 McLeansboro, IL 62859 618-643-3633
IL-5	500 W. Main St. P.O. Box 574 Benton, IL 62812 618-438-2121
KY-1	P.O. Box 552 Central City, KY 42330 502-754-2360
KY-2	101 Huffman Ave. P.O. Box 897 Pikeville, KY 41501 606-432-5504
OH-1	120 Hillcrest Dr. Woodsfield, OH 43793 614-472-5392
OH-2 & 3	310 Front St. Marietta, Oh 45750 614-373-5176
WV-1, 3, & 4	818 Virginia St. East Charleston, W.Va. 25301 304-345-0770
WV-2	P.O. Box 218 Logan, W.VA 25301 304-752-1324

W. Va. State Chamber of Commerce
1101 Kanawha Valley Building
P.O. Box 2789
Charleston, W.Va. 25330
304-342-1115

Eastern Ohio Development Council

107 S. Marietta St.

St. Clairsville, Ohio 43950

February 26, 1981

Mr. Martin M. Siegel
Manager of Alternate Fuels Processing
Williams Brothers Engineering Co.
6600 South Yale Avenue
Tulsa, Oklahoma 74177

Dear Mr. Siegel:

I was very interested to hear of your interest in "in-site" coal gasification. I've long thought it was the ideal method of utilizing some of our deeper seams of coal that can't be mined economically.

To address the problem of market potential, I have included an Industrial Facilities Map of the upper Ohio Valley prepared by American Electric Power about ten years ago. As you can see there are many potential users of a low to medium BTU synthetic natural gas, and I have, in the past six years, developed such users.

The other questions you stated require considerably more work. We can handle the problem of resource through our own Ohio Department of Natural Resources. A considerable amount of new information has been made available in the past year concerning our Ohio coal reserves. For land availability and accessibility I have to know more of your particular requirements. The political and environmental considerations should pose no problem unless you anticipate an extreme condition. The indigenous work force will have to be evaluated on a site to site basis as will the environmental considerations.

Give us some additional guidance on your immediate needs and we will be more than happy to work with you.

With regards,

James D. Diehl
C.I.D.

JDD:bo
Enclosure

Copy: Mr. W. B. Moore
Switzerland Chamber of Commerce
Woodsfield, Ohio 43793

GREENVILLE CHAMBER OF COMMERCE

P. O. Box 313

Greenville, Kentucky 42345 **Phone (502) 338-5422**

"Friendly People in a Progressive Town"

FEB 6 1981

February 4, 1981

Williams Brothers Engineering Company
Process Division
Resources Sciences Center
6600 South Yale Avenue
Tulsa, Oklahoma 74177

ATTN: Martin M. Siegel

Dear Mr. Siegel:

The Chambers of Commerce of Greenville and Central City, Kentucky, have met jointly through their Board of Directors to review your interest in our county with regard to a possible site for underground coal gasification. Our Chambers believe that Muhlenberg County is a prime location for you to consider for this facility. The county has an abundance of coal, land, manpower, transporation facilities, and the time is right to act. Our environmental situation is improving and we believe that we can meet the criteria for you to locate here. We are very much interested.

To give an idea of what is here we enclose a brochure prepared by the State Department of Commerce indicating the type of county we are from an economic standpoint. I hope this will be of assistance to you.

There is a local need for new energy in this county. In particular the City of Drakesboro needs fuel to heat the homes of its citizens. There are other industries here which could be heated by this type of fuel.

Kentucky Utilites, Tennessee Valley Authority, and Big Rivers Electric Plant are all utility companies in the area which are potential customers for your fuel to reduce electricity. The headquarters of Tennessee Valley Authority at Knoxville, Tennessee, should be contacted concerning the Paradise Steam Plant located here in Muhlenberg County. James Hunt at the Kentucky Utilities Building, Court Square, Greenville, Kentucky, may be contacted regarding the potential interst of Kentucky Utilities. His phone number is 502-338-3606. In Central City, Kentucky, contact the plant manager at 502-754-4541. The Big Rivers Power Plant is still under construction at this time and we are not aware as to the person in charge at this time. I am sure any communication could be directed by letter to Calhoun, Kentucky, and it would get to the proper source.

Locally here, you may contact our County Judge, Honorable Robert Draper, 502-338-2520. You may also contact the Chamber offices directly, Central City being 754-2360, and Greenville being 338-5422. The Chamber President in Central City is Mike Payne and his number is 754-3300. The Chamber President in Greenville is Rev. Charles Midkiff and his office number is 338-3453.

Again we are very much interested in considering your proposal and talking to you. Please contact us if you have any questions and we hope to hear from you soon concerning this matter. If you would like to meet with us feel free to contact us.

Sincerely,

Charles W. Midkiff

President

Central City Chamber of Commerce

CENTRAL CITY, KENTUCKY

PRESIDENT SECRETARY

February 4, 1981

FEB 6 19

WILLIAMS BROTHERS ENGINEERING CO.

Williams Brothers Engineering Company
Process Division
Resources Sciences Center
6600 South Yale Avenue
Tulsa, Oklahoma 74177

ATTN: Martin M. Siegel

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Again we are very much interested in considering your proposal and talking to you. Please contact us if you have any questions and we hope to hear from you soon concerning this matter. If you would like to meet with us feel free to contact us.

Sincerely,

Michael Payne

President

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1	Cass	IL	Oscar Mayer Co.	Food, Kindred Prod.	Central Ill. Public Service Co.	109,284	Propane	6 Interruptable
I-1	Peoria	IL	Allied Mills Inc.	Food, Kindred Prod.	Central Ill. Light Co.	153,200	-	3 Firm
I-1	Peoria	IL	Hiram Walker & Sons	Food, Kindred Prod.	Central Ill. Light Co.	945,000	-	5 Firm
I-1	Peoria	IL	Pabst Brewing Co.	Food, Kindred Prod.	Central Ill. Light Co.	1,258,345	#1, #2, oil	0 Interruptable
I-1	Peoria	IL	Bremis Bros. Bag Co.	Paper	Central Ill. Light Co.	0	#5, #6, Residual oil, Coal	6 Interruptable
I-1	Peoria	IL	Caterpillar Tractor	Primary Metal	Central Ill. Light Co.	1,251,000	-	3 Firm
I-1	Peoria	IL	Keystone Steel & Wire	Fabricated Metal	Central Ill. Light Co.	2,443,000*	-	3 Firm
I-1	Fulton	IL	International Harvester	Machinery	Central Ill. Public Service Co.	311,878	#1 & #2 oils	6 Interruptable
I-1	Peoria	IL	Caterpillar Tractor	Machinery	Central Ill. Light Co.	168,000	-	4 Firm

*Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1	Peoria	IL	WABLD	Machinery	Central Ill. Light Co.	215,000	-	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-2	Christian	IL	Continental Grain Co.	Food, Kindred Prod.	Central Ill. Public Service Co.	341,298	#1, #2, #5, #6 Residual oil	7 Interruptable
I-2	Douglas	IL	National Distillers and Chemical Corp.	Chemicals	Panhandle Eastern Pine Co.	15,268,032*	Propane; Coal	0 Interruptable
I-2	Montgomery	IL	Eagle-Picher Ind.	Chemicals	Illinois Power Co.	327,624	Propane	0 Interruptable
I-2	Montgomery	IL	Hillsboro Glass	Glass	Illinois Power Co.	347,338	#5, #6, Residual	0 Interruptable
I-2	Montgomery	IL	American Smelting	Primary Metal	Illinois Power Co.	64,826	#1 & #2 oils	0 Interruptable
I-2	Champaign	IL	Clifford - Jacobs Forging	Fabricated Metal	Illinois Power Co.	300,216	#5, #6 & Residual oil	0 Interruptable

* Sufficient to meet minimum 230 million BTU/hr requirement.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1 or I-2	Tazewell	IL	Ashland Chemical Co.	Agr. Livestock	Central Ill. Light Co.	388,500	-	3 Firm
I-1 & I-2	McLean	IL	6-36-77-1010	Food, Kindred Proc.	Northern Ill. Gas Co.	344,898	-	0 Firm
I-1 & I-2	Macon	IL	A.E. Staley	Food, Kindred Prod.	Illinois Power Co.	7,416,777*	-	0 Firm
I-1 & I-2	Macon	IL	A.E. Staley Mfg. Co.	Food, Kindred Prod.	Illinois Power Co.	837,876	#5, #6 Residual oil	0 Interruptable
I-1 & I-2	Macon	IL	Archer Daniels Midland	Food, Kindred Prod.	Illinois Power Co.	195,980	-	0 Firm
I-1 & I-2	Macon	IL	Archer Daniels Midland-East	Food, Kindred Prod.	Illinois Power Co.	758,153	#5, #6 Residual oil	0
I-1 or I-2	Macon	IL	Archer Daniels Midland-West	Food, Kindred Prod.	Illinois Power Co.	2,478,228*	#5, #6 Residual oil	0
I-1 & I-2	Morgan	IL	Anderson Clayton and Co.	Food, Kindred Prod.	Panhandle Eastern Pipe Co.	108,369	#5, #6, #1 Residual oil, Propane	0 Interruptable
I-1 & I-2	Morgan	IL	Carnation Co.	Food, Kindred Prod.	Panhandle Eastern Pipe Co.	195,644	Propane	0 Interruptable

* Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTIRAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1 & I-2	Sangoman	IL	Pillsbury Co.	Food, Kindred Prod.	Central Ill. Public Service Co.	211,000	-	3 Firm
I-1 & I-2	Tazewell	IL	American Distilling Co.	Food, Kindred Prod.	Central Ill. Public Service Co.	484,500	-	3 Firm
I-1 & I-2	Tazewell	IL	CPC International Inc.	Food, Kindred Prod.	Central Ill. Light Co.	613,100	-	3 Firm
I-1 & I-2	Morgan	IL	Capital Records	Lumber, Wood Products	Illinois Power Co.	121,025	#1 & #2 Oil	0 Firm
I-1 & I-2	Christian	IL	Hopper Paper Co.	Paper	Central Ill. Public Service Co.	6,691,538*	#5 & #6, Residual oil	0 Interruptable
I-1, I-2	Tazewell	IL	Quaker Oats Co.	Paper	Central Ill. Light Co.	252,000	-	3 Firm
I-1 & I-2	Morgan	IL	National Starch Prod.	Chemicals	Central Ill. Public Service Co.	161,753	-	3 Firm
I-1 & I-2	Sangamon	IL	Bordon Co.	Chemicals	Illinois Power Co.	461,237	#5, #6 & Residual	0 Interruptable
I-1 & I-2	McLean	IL	6-33-78-2760	Rubber	Northern Ill. Gas Co.	170,364	-	0 Firm

* Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1 & I-2	Macon	IL	Firestone Tire & Rubber Co.	Rubber	Illinois Power Co.	586,581	#5, #6 & Residual oil	0 Interruptable
I-1 & I-2	Logan	IL	Obear-Nester Glass	Glass	Central Ill. Light Co.	829,000	–	3 Firm
I-1 & I-2	Logan	IL	PPG Industries	Glass	Central Ill. Light Co.	205,500	–	3 Firm
I-1 & I-2	Macon	IL	Pittsburgh Plate Glass Co.	Glass	Illinois Power Co.	1,275,867	#1 & #2 oil	0 Firm
I-1 & I-2	DeWitt	IL	Revere Copper & Brass	Primary Metal	Illinois Power Co.	149,281	#1 & #2 oils, Propane	0 Interruptable
I-1 & I-2	Macon	IL	Wagner Casting	Primary Metal	Illinois Power Co.	388,288	–	0 Firm
I-1 & I-2	McLean	IL	6-15-77-0950	Machinery	Northern Ill. Gas Co.	224,737	–	0 Firm
I-1 & I-2	Macon	IL	York Div. Borg Warner	Machinery	Illinois Power Co.	119,633	#5, #6, Residual	0 Interruptable
I-1 & I-2	Sangamon	IL	Fiat-Allis Construction Machinery	Machinery	Central Ill. Light Co.	0	#5, #6, Residual oil	6 Interruptable

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-1 & I-2	Sangamon	IL	Fiat-Allis Construction Machinery	Machinery	Central Ill. Light Co.	330,000	-	3 Firm
I-1 & I-2	Tazewell	IL	Caterpillar Co.	Machinery	Morton Mun Gas Co.	86,190	#1 & #2 oils	0 Firm
I-1 & I-2	Tazewell	IL	Caterpillar Co.	Machinery	Central Ill. Light Co.	1,232,000	-	3 Firm
I-1 & I-2	McLean	IL	6-08-80-5290	Electrical, Electronic Mach.	Northern Ill. Gas. Co.	128,829	-	0 Firm
I-1 & I-2	Sangamon	IL	Sangomo Weston	Precision Eg.	Central Ill. Light Co.	116,400	-	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
I-3,4,5,6	Perry	IL	Duquoin Packing Co.	Food, Kindred Prod.	Central Ill. Public Service Co.	75,639	#1, #2 oil	6 Interruptable
I-3,4,5,6	Williamson	IL	Libby Canning Co.	Food, Kindred Prod.	Morton Mun Gas Co.	25,310	#1, #2 oil	0 Firm
I-3,4,5,6	Jackson	IL	Tuck Industries	Textile Mill	Central Ill. Public Service Co.	84,270	#5, #6 Residual	6 Interruptable
I-3,4,5,6	Williamson	IL	Allen Industries, Inc.	Finished Fabrics	Central Ill. Public Service Co.	99,204	Propane	6 Interruptable
I-3,4,5,6	Richland	IL	American Machine & Foundry	Fabricated Metal	Eastern Ill. Gas & Electric	92,973	#1 & #2 oils, Propane	2 Firm
I-3,4,5,6	Williamson	IL	Horge Co. Div. - Fedders Corp.	Electrical, Electronic Mach.	Central Ill. Public Service Co.	167,102	Propane	6 Interruptable

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
K-1	Daviess	KY	Owensboro Grain Co.	Food, Kindred Prod.	Western Kentucky Gas Co.	263,457	#1, #2 oils, Propane	3 Firm
K-1	Daviess	KY	Pinkerton Tobacco Co.	Tobacco Mfg.	Western Kentucky Gas Co.	76,594	#1, #2 oil	3 Firm
K-1	Warren	KY	Firestone Synthetic Fibers and Textile	Textile Mill	Western Kentucky Gas Co.	124,836	Propane	2 Firm
K-1	Hancock	KY	Western Kraft Corp.	Paper	Western Kentucky Gas Co.	701,315	#5, #6 & Residual oil	5 Firm
K-1	Daviess	KY	W.R. Grace & Co.	Chemicals	Western Kentucky Gas Co.	207,843	#1, #2 oil	3 Firm
K-1	Caldwell	KY	General Tire & Rubber Co.	Rubber	Western Kentucky Gas Co.	0	#1, #2 oils	5 Firm
K-1	Daviess	KY	Owensboro Brick and Tile Co.	Stone	Western Kentucky Gas Co.	482,570	#1 & #2 oils	2 Firm
K-1	Hancock	KY	American Olean Tile Co.	Stone	City of Lewisport Natural Gas	212,648	#1 & #2 oils	2 Firm
K-1	Christian	KY	Phelps Dodge Corp.	Primary Metal	Western Kentucky Gas Co.	425,128	-	2 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
K-1	Daviess	KY	Aluminum Service Co.	Primary Metal	Western Kentucky Gas Co.	130,942	#1 & #2 oils	3 Firm
K-1	Daviess	KY	Green River Steel Corp.	Primary Metal	Western Kentucky Gas Co.	847,156	#1 & #2 oils	2 Firm
K-1	Daviess	KY	Ohio Valley Forging	Primary Metal	Western Kentucky Gas Co.	153,327	#1 & #2 oils, Propane	3 Firm
K-1	Hancock	KY	Martin Marietta Aluminum Co.	Primary Metal	Western Kentucky Gas Co.	2,246,096*	#1 & #2 oils	2 Firm
K-1	Hancock	KY	National Steel Corp.	Primary Metal	Orbit Gas Co.	449,266	#1 & #2 oils	3 Firm
K-1	Logan	KY	Rockwell Manufacturing Co.	Primary Metal	Western Kentucky Gas Co.	181,554	#1 & #2 oils	2 Firm
K-1	Caldwell	KY	Grinnell Corp.	Fabricated Metal	Western Kentucky Gas Co.	90,098	#1 & #2 oils	2 Firm
K-1	Hancock	KY	National Southwire Aluminum Co.	Fabricated Metal	Orbit Gas Co.	367,584	#1 & #2 oils, Propane	3 Firm
K-1	Hancock	KY	Southwire Co.	Fabricated Metal	Orbit Gas Co.	59,150	#1 & #2 oils, #4 oil	3 Firm

* Suffiecient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
K-1	Christian	KY	Thomas Ind.	Electrical, Electronic Mach.	Western Kentucky Gas Co.	150,744	Propane	2 Firm
K-1	Logan	KY	Can-Tex Ind.	Electrical, Electronic Mach.	Western Kentucky Gas Co.	187,797	Propane	2 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
K-2	Lawrence	KY	Louisa Carpet Mills, Inc.	Textile Mill	Columbia Gas of Kentucky, Inc.	86,666	Propane #5, #6 oil, residual oil	0 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
O-1	Tuscarawas	OH	Foremost Foods	Food, Kindred Prod.	East Ohio Gas Co.	138,646	#1, #2 oils	2 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
O-1,2	Belmont	OH	Imperial Glass	Glass	Columbia Gas of Ohio	314,969	#1 & #2 oils	0 Firm
O-1,2	Belmont	OH	Rodefer Glass Co.	Glass	Columbia Gas of Ohio	151,575	Propane	0 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
O-1,2,3	Washington	OH	Sperry Remington	Furniture	River Gas Co.	937,658	#1 & #2 oil	3 Firm
O-1,2,3	Washington	OH	American Cyanamid Co.	Chemicals	River Gas Co.	162,065	#1 & #2 oil	0 Firm
O-1,2,3	Washington	OH	Ashland Chemical Co.	Chemicals	River Gas Co.	116,485	#1 & #2 oil	0 Firm
O-1,2,3	Washington	OH	Shell Chemical Co.	Chemicals	River Gas Co.	391,399	-	0 Firm
O-1,2,3	Harrison	OH	Bowerston Shak Co.	Stone	Ellis T. Myers Gas Co.	104,327	#1 & #2 oils	2 Firm
O-1,2,3	Harrison	OH	Scio Pottery Co.	Stone	Columbia Gas of Ohio	196,760	Propane	0 Firm
O-1,2,3	Muskingum	OH	Brockway Glass Co.	Glass	National Gas & Oil Corp.	1,577,000	#1 & #2 oils	2 Firm
O-1,2,3	Muskingum	OH	Nelson McCoy Pottery	Stone	National Gas & Oil Corp.	173,000	-	2 Firm
O-1,2,3	Washington	OH	Anchor Hocking Corp.	Stone	Gas Transport Inc.	2,105,000*	#1 & #2 oils	2 Firm
O-1,2,3	Belmont	OH	Wheeling Martins	Primary Metal	Columbia Gas of Ohio, Inc.	464,595	-	0 Firm

* Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
0-1,2,3	Monroe	OH	Consolidated Aluminum Corp.	Primary Metal	Columbia Gas of Ohio, Inc.	4,048,157*	#1 & #2 oils, Propane	0 Firm
0-1,2,3	Muskingum	OH	Ohio Ferro Alloy	Primary Metal	National Gas & Oil Corp.	124,500	#1 & #2 oils	2 Firm
0-1,2,3	Washington	OH	Union Carbide Metals & Plastics	Primary Metal	River Gas Co.	686,287	#1 & #2 oils	0 Firm
0-1,2,3	Guernsey	OH	Cyclops Corp.	Fabricated Metal	Columbia Gas of Ohio, Inc.	100,095	-	0 Firm
0-1,2,3	Muskingum	OH	Armco Steel Corp.	Fabricated Metal	National Gas & Oil Corp.	355,000	-	2 Firm
0-1,2,3	Muskingum	OH	Burnham Corp.	Fabricated Metal	National Gas & Oil Corp.	131,000	#1 & #2 oils	2 Firm
0-1,2,3	Guernsey	OH	National Cash Register	Machinery	Columbia Gas of Ohio, Inc.	31,380	#1 & #2 oils	0 Firm
0-1,2,3	Guernsey	OH	Champion Spark Plug Co.	Electrical, Electronic Mach.	Columbia Gas of Ohio	100,000	-	0 Firm
0-1,2,3	Guernsey	OH	Hamilton Beach Div.	Electrical, Electronic Mach.	Columbia Gas of Ohio	73,853	-	0 Firm

* Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 5.) MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
O-3,2	Perry	OH	Central Silica Co.	Non-Metalic Min.	National Gas & Oil Corp.	218,500	-	2 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,2	Cabell	WV	Chemetron	Chemicals	Inland Gas Co.	315,873	#1 & #2 oils	3 Firm
WV-1,2	Cabell	WV	Novamont Corp.	Chemicals	Columbia Gas of W.V., Inc.	22,911	-	0 Firm
WV-1,2	Wood	WV	Borg-Warner Chem.	Chemicals	Consolidated Gas Supply Corp.	971,627	#1 & #2 oils	5 Firm
WV-1,2	Wood	WV	DuPont	Chemicals	Consolidated Gas Supply Corp.	369,701	#1 & #2 oils	3 Firm
WV-1,2	Cabell	WV	Barboursville Clay	Clay	Cumberland Gas Co.	139,000	-	2 Firm
WV-1,2	Cabell	WV	Blenko Gas Company	Glass	Southern Public Service Co.	130,701	Propane	2 Firm
WV-1,2	Cabell	WV	Kerr Glass Co.	Glass	Cumberland Gas Co.	379,000	-	2 Firm
WV-1,2	Cabell	WV	Owens Illinois Inc.	Glass	Industrial Gas Corp.	1,867,000	-	3 Firm
WV-1,2	Cabell	WV	Rainbow Art Glass Co.	Glass	Columbia Gas of W.V., Inc.	94,109	-	0 Firm

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INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,2	Cabell	WV	Conners Steel Co.	Primary Metal	Cumberland Gas Co.	292,000	-	2 Firm
WV-1,2	Cabell	WV	Huntington Alloy	Primary Metal	Industrial Gas Corp.	753,850	-	3 Firm
WV-1,2	Cabell	WV	Houdaille Ind. Inc.	Transportation Eg	Columbia Gas of W.Va., Inc.	92,300	-	0 Firm
WV-1,2	Cabell	WV	ACF Industries	Misc. Mfg.	Inland Gas Co.	167,876	#1 & #2 oils	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-2	Wayne	WV	Pilgrim Glass Corp.	Glass	Columbia Gas of W.Va., Inc.	240,055	Propane	0 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,3	Wood	WV	AB Chance Co.	Glass	Consolidated Gas Supply Corp.	193,082	-	3 Firm
WV-1,3	Wood	WV	Corning Glass-Parkersburg	Glass	Consolidated Gas Supply Corp.	479,875	#1 & #2 oils	2 Firm
WV-1,3	Wood	WV	Demuth Glass Works	Glass	Consolidated Gas Supply Corp.	240,515	Propane	2 Firm
WV-1,3	Wood	WV	Fenton Art Glass	Glass	Consolidated Gas Supply Corp.	519,358	-	2 Firm
WV-1,3	Wood	WV	Johns Manville	Glass	Consolidated Gas Supply Corp.	1,363,100	#1 & #2 oils	2 Firm
WV-1,3	Wood	WV	Universal Glass	Glass	Consolidated Gas Supply Corp.	517,685	#1 & #2 oils	2 Firm
WV-1,3	Jackson	WV	Kaiser Aluminum & Chemicals	Primary Metal	Columbia Gas of W.Va. Inc.	811,836	#1 & #2 oils	0 Firm
WV-1,3	Wood	WV	O Ames Co.	Fabricated Metal	Consolidated Gas Supply Corp.	512,130	#1 & #2 oils	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-3	Pleasants	WV	American Cyanamid	Chemicals	Consolidated Gas Supply	1,277,265	#1 & #2 oils	3 Firm
WV-3	Pleasants	WV	Cabot-Ohio River Plant	Chemicals	Cabot Corp.	839,251	-	2 Firm
WV-3	Pleasants	WV	Quaker State Oil and Refining Div.	Petroleum Refining	Consolidated Gas Supply Co.	310,719	#1, #2, #5, #6 Residual oils	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,2,3	Mason	WV	Goodyear Tire & Rubber Co.	Chemicals	Columbia Gas of W.Va., Inc.	660	#1 & #2 oils	0 Firm
WV-1,2,3	Mason	WV	Pantasote Co.	Chemicals	Columbia Gas of W.Va., Inc.	59,439	#1 & #2 oils	0 Firm
WV-1,2,3	Mason	WV	Stauffer Chemical Co.	Chemicals	Columbia Gas of W.Va., Inc.	168,684	#1 & #2 oils	0 Firm
WV-1,2,3	Mason	WV	W.Va. Malleable Iron Co.	Primary Metal	Columbia Gas of W.Va., Inc.	90,124	–	0 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,2,3,4	Kanawha	WV	Diamond Shamrock	Chemicals	Columbia Gas of W.Va., Inc.	131,321	#1 & #2 oil	0 Firm
WV-1,2,3,4	Kanawha	WV	DuPont	Chemicals	Cabot Corp.	3,035,769*	-	2 Firm
WV-1,2,3,4	Kanawha	WV	DuPont	Chemicals	Columbia Gas of W.V. Inc.	13,931,348*	-	0 Firm
WV-1,2,3,4	Kanawha	WV	FMC-Bisulfide	Chemicals	Cabot Corp.	705,237	-	2 Firm
WV-1,2,3,4	Kanawha	WV	FMC-Ind. Chem.	Chemicals	Cabot Copr.	1,353,308	-	2 Firm
WV-1,2,3,4	Kanawha	WV	Ind. Chemicals-Div. Allied	Chemicals	Columbia Gas of W.V., Inc.	110,801	Propane	0 Firm
WV-1,2,3,4	Kanawha	WV	Monsanto Chem. Co.	Chemicals	Columbia Gas of W.V., Inc.	165,318	#1 & #2 oils, Propane	0 Firm
WV-1,2,3,4	Kanawha	WV	N.L. Industries	Chemicals	Cabot Corp.	203,209	-	3 Firm
WV-1,2,3,4	Kanawha	WV	Pennzoil United-Elk Refining Div.	Petroleum Refining	Columbia Gas of W.Va., Inc.	61,166	#1 & #2 oils	0 Firm

* Sufficient to meet minimum requirement of 233 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,2,3,4	Kanawha	WV	Libbey Owens Ford	Glass	Industrial Gas Corp.	2,341,000*	-	3 Firm
WV-1,2,3,4	Kanawha	WV	True Temper Corp.	Fabricated Metal	Cabot Corp.	163,774	-	3 Firm

* Sufficient to meet minimum requirement of 230 million BTU/hr.

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-4	Harrison	WV	Brockway Glass Co.	Glass	Consolidated Gas Supply Corp.	1,701,363	-	3 Firm
WV-4	Harrison	WV	Fourco Glass Co.	Glass	Consolidated Gas Supply Corp.	1,178,470	-	3 Firm
WV-4	Harrison	WV	Meadowbrook Corp.	Primary Metal	Consolidated Gas Supply Corp.	489,820	-	2 Firm
WV-4	Harrison	WV	UCC Carbon Div.	Electrical, Electronic Mach.	Consolidated Gas Supply Corp.	283,438	-	3 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-1,3,4	Lewis	WV	Louie Glass	Glass	Consolidated Gas Supply Corp.	136,711	–	2 Firm
WV-1,3,4	Lewis	WV	W.Va. Glass Specialties	Glass	Consolidated Gas Supply Corp.	281,272	–	2 Firm
WV-1,3,4	Fayette	WV	Union Carbide Corp.	Primary Metal	Cabot Corp.	137,655	–	2 Firm

INDUSTRIAL FUEL GAS CONSUMERS WITHIN 50 MILES OF TARGET AREAS

Coal Site	County	State	Company	Type of Company	Supplier	Quantity Units MCF/YR	Alternate Fuels	Priority
WV-3,4	Upshur	WV	Corhart Refractories	Stone	Equitable Gas Co.	373,000	-	0 Firm

POWER PLANTS

Coal Site	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt. Fuel
K-1	KY	181	Ohio	None						
K-2	WV	047	McDowell	None						
K-2	WV	059	Mingo	None						
K-2	KY	195	Pike	None						
WV-1,3	WV	007	Braxton	None						
WV-1,3	WV	013	Calhoun	None						
WV-1,3	WV	015	Clay	None						
WV-1,3	WV	021	Gilmer	None						
WV-1,3	WV	039	Kanawha	Amos, John E. Unit 1,2 Amos, Jonh E. Unit 3 P.O. Box 4000 St. Albans, WV 25177 1-304-755-5301	AEP: Appalachian Power Co. 301 Virginia St. E. Charleston, WV 25302 1-304-348-4700	3 mi North of St. Albans on Winfield Road (Route 35).	816.3 ea 1300.0	ST ST	Coal Coal	Non Non
WV-1,3	WV	039	Kanawha	Cabin Creek Unit 3,4 Cabin Creek Unit 8,9	AEP: Appalachian Power Co.		25.0 85.0	ST ST	UNK Coal	UNK Non
WV-1,3	WV	039	Kanawha	Clayton Unit 1-4	AEP: Appalachian Power Co.		18.8	HY	Water	Non
WV-1,3	WV	039	Kanawha	Kanawha River Unit 1,2 P.O. Box 110 Glasgow, WV 25086 1-304-595-3480	AEP: Appalachian Power Co. 1-304-348-4700	20 mi East of Charleston	213	ST	Coal	Non

POWER PLANTS

Coal Site	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt. Fuel
I-1	Ill.	107	Logan	None						
I-1	Ill.	125	Mason	Havana Units 1-5 Havana Unit 6 Route 78, Box 368 Zip 62644 1-309-543-2227	Ill. Power Company 500 S. 27th St. Decatur, Ill. 62525 1-217-424-6600	35 mi West of Site 0-1 on Ill. River	46 ea. 450	ST ST	Oil Coal	Non
I-1	Ill.	129	Menard	None						
I-2	Ill.	021	Christian	Kincaid Unit 1 & 2 P.O. M Kincaid, Ill. 62540 1-217-237-4311	Commonwealth Edison Company P.O. Box 767 Chicago, Ill. 60690 1-312-294-4321	4 mi West of Kincaid	459.7 ea.	ST	Coal	Non
I-2	Ill.	107	Logan	None						
I-2	Ill.	115	Macon	None						
I-2	Ill.	167	Sangamon	Dallman Unit 1-2 Dallman Unit 3 3100 Stevenson Dr. Springfield, Ill. 62757 1-217-789-2141	City of Springfield	Springfield	90 ea. 192	ST ST	Coal Coal	Non Non
I-2	Ill.	167	Sangamon	Factory Unit 1 Factory Unit 2 3100 Stevenson Dr. Springfield, Ill. 62757 1-217-789-2141	City of Springfield 1-217-789-2147	Springfield	27 50	GT GT	Oil Oil	Non Non
I-2	Ill.	167	Sangamon	Lakeside Unit 1 Lakeside Units 2 & 3 Lakeside Units 4 & 5 Lakeside Units 6 & 7 3100 Stevenson Dr. Springfield, Ill. 62757 1-217-789-2141	City of Springfield 1-217-789-2147	Springfield	10 15 ea. 20 ea. 38 ea.	ST ST ST ST	Coal Coal Coal Coal	Non Non Non Non

POWER PLANTS

Coal Size	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt, Fuel
I-2	Ill.	167	Sangamon	Reynolds	City of Springfield	Springfield	18	CT	Oil	Non
I-2	Ill.	167	Sangamon	Undesignated (Start-up 1986)	City of Springfield	Springfield	192	ST	Coal	UNK
I-3,4,5,6	Ill.	055	Franklin	None						
I-3,4,5,6	Ill.	065	Hamilton	McLeansboro Unit 1 McLeansboro Unit 1 McLeansboro Unit 2-4	City of McLeansboro 1-618-643-2224	City of McLeansboro	1 1 1&2	IC GT IC	UNK UNK UNK	UNK UNK UNK
I-3,4,5,6	Ill.	081	Jefferson	None						
I-3,4,5,6	Ill.	191	Wayne	Fairfield Unit 1 Fairfield Unit 2 Fairfield Unit 3 Fairfield Unit 4 Fairfield Unit IC1 Fairfield Unit IC2	Fairfield Municipal Light Plant 1-618-842-4821 1-618-842-3445	City of Fairfield	1.5 2.5 4.0 5.0 2.0 2.0	ST ST ST ST IC IC	Coal Coal Coal Coal Gas Gas	Non Non Non Non FO2 FO2
K-1	Ky.	031	Butler	None						
K-1	Ky.	177	Mulenburg	Green River Unit 1&2 Green River Unit 3 Green River Unit 4 Box 191 Central City, Kentucky 1-502-754-4541	Kentucky Utilities Co. P.O. Box 616 Central City, Kentucky 1-502-754-4272	9 mi. N. of Central City on Green River or about 4 mi N. of Site K-1	30 ea. 60 100	ST ST ST	Coal Coal Coal	Non Non Non

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POWER PLANTS

Coal Site	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt. Fuel
0-1	WV	051	Marshall	Mitchell Unit 1,2 1-614-845-7211	AEP: Ohio Power Company 1-614-676-4121		816 ea.	ST	Coal	No
0-1	WV	095	Tyler	None						
0-1	WV	103	Wertzel	None						
0-2,3	Ohio	111	Monroe	None						
0-2,3	Ohio	115	Morgan	Muskingum River Unit 1,2 Unit 3,4 Unit 5 P.O. Box 158 Beverly, Ohio 45715 1-614-984-2321	AEP: Ohio Power Company 1-614-676-4121	Across River 5 mi N. on Muskingum River from Beverly	220 ea. 238 ea. 591	ST ST ST	Coal Coal Coal	Non Non Non
0-2,3	Ohio	121	Noble	None						
0-2,3	Ohio	167	Washington	None						
0-2,3	W.V.	073	Pleasants	Pleasants Unit 1,2 P.O. Box 9 Willow Island, WV 26910 1-304-665-2431	APS/Allegheny Power Systems, Inc. 1-412-837-3000	12 mi.out of Parkersburg Route 2	684 ea.	ST	Coal	Non
0-2,3	W.V.	073	Pleasants	Willow Island Unit 1 Willow Island Unit 2 P.O. Box 18 Willow Island, WV 26910 1-304-665-2411	(APS/Allegheny Power) Systems, Inc. 1-412-837-3000	12 mi.out of Parkersburg on Route 2	50 165	ST ST	Coal Coal	Non Non

POWER PLANTS

Coal Site	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt. Fuel
O-2,3	W.V.	095	Tyler	None						
O-2,3	W.V.	107	Wood	None						

ST - Steam Turbine
GT - Gas Turbine
HY - Hydroelectric
IC - Internal Combustion

POWER PLANTS

Coal Site	State	County Code	County	Plant/Address	Company/Address	Plant Location	Size MW	Type Unit	Fuel	Alt. Fuel
WV-1,3	WV	087	Roane	None						
WV-2	WV	043	Lincoln	None						
WV-2	WV	045	Logan	None						
WV-2	WV	059	Mingo	None						
WV-2	WV	099	Wayne	None						
WV-4	WV	007	Braxton	None						
WV-4	WV	067	Nicholas	None						
WV-4	WV	101	Webster	None						
O-1	Ohio	013	Belmount	Martin's Ferry Unit 1-3 No Longer Exists	AEP: Ohio Power Company 1-614-676-4121		2.0 ea.	IC	Oil	Non
O-1	Ohio	013	Belmount	Burger, RE Unit A Burger, RE Unit 1,2 Burger, RE Unit 3 Burger, RE Unit 4,5 Burger, RE Unit B 1,2 P.O. Box 57 Shady Side, Ohio 43947 1-614-676-4551	Ohio Edison Company Acron, Ohio 1-216-384-5100		2.7 63.0 ea. 100.0 160.0 ea. 2.7 ea.	IC ST ST ST IC	FO2 Coal Coal Coal FO2	Non Non Non Non Non
O-1	Ohio	111	Monroe	None						
O-1	Ohio	121	Noble	None						
O-1	WV	051	Marshall	Kammer Unit 1-3 1-614-845-7211	AEP: Ohio Power Company 1-614-676-4121		238. ea.	ST	Coal	Non