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ALTERNATIVE FUELS--COAL GASIFICATION:
RATIONALE AND POSSIBILITIES

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Alternative Fuels - Coal Gasification

Dwindling supplies and rising prices of oil and gas increase attractiveness of using extensive resources of coal which exist in the U.S.; but coal is considered to be a dirty fuel.

Considerable effort has and is being directed toward developing processes which will convert coal to clean fuels, either gaseous, liquid, or solid. There are some two dozen methods for clean-coal-from-coal conversion.

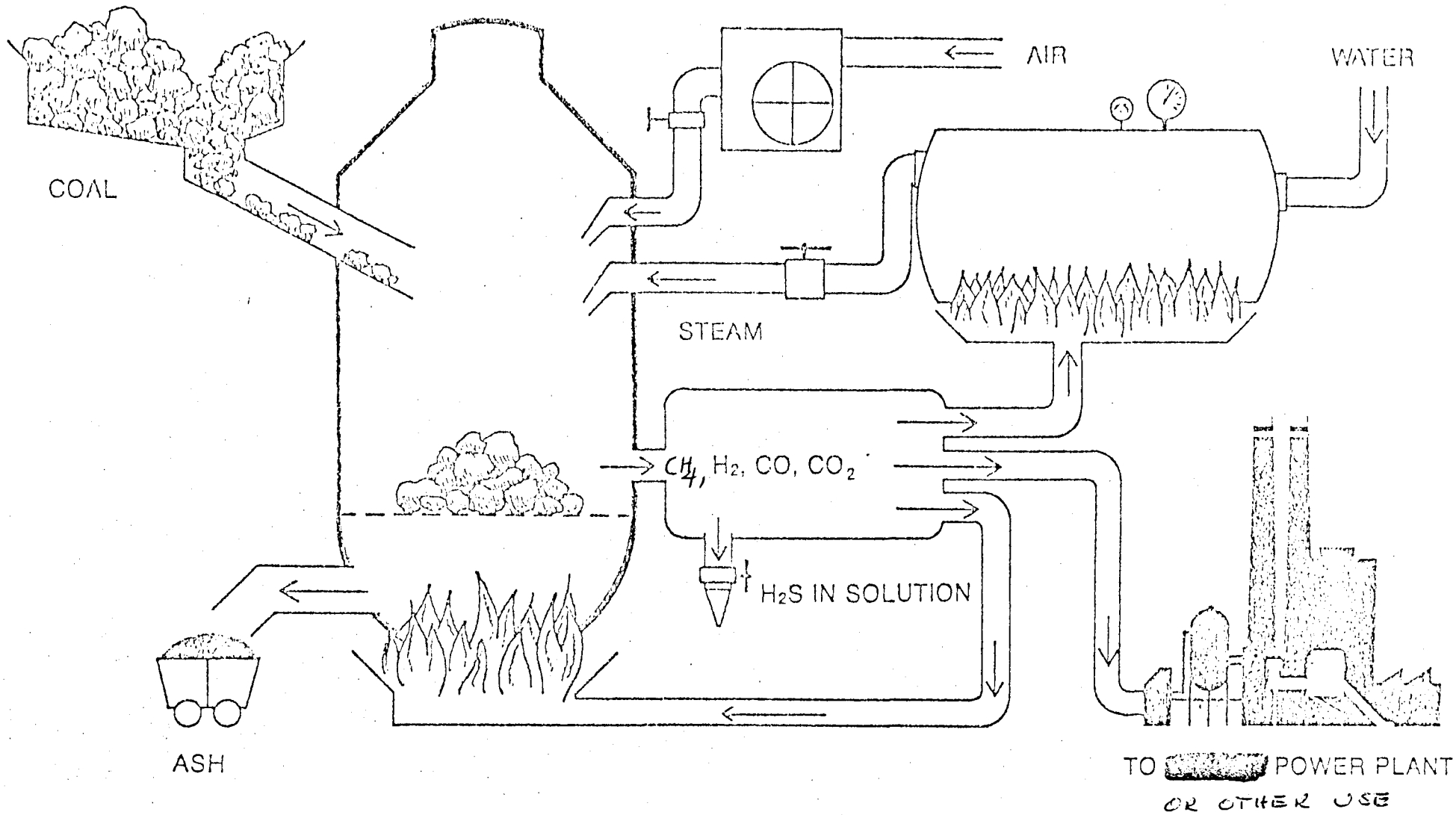
Selection of a preferred course for coal conversion depends upon a number of factors, including coal characteristics, process development and investment requirements and operating costs. Gasification plants vary from small portable units used to generate gas to drive internal combustion engines to large multi-unit installations in Europe and South Africa.

The gasification process converts a mixture of air, steam, and coal (or other carbons) to methane, hydrogen, carbon monoxide, and carbon dioxide. Steam for the gasification process is produced and heated by burning a part of the gas generated. In the process, sulfur is converted to hydrogen sulfide and can be removed. The gas produced is a virtually sulfur free, low (130-650 BTU) or medium (300-500 BTU) BTU gas. Figure 1 illustrates schematically the basic process.

If it is desirable, the low or medium BTU gas can be upgraded by a methanation process, i.e., essentially increasing the methane content of the gas to produce pipe line quality gas of 900-1000 BTU per cubic foot content, the same as natural gas. Figure 2.

The data on Table 1 represents a sampling of estimated operating

FIG 1: THE GASIFICATION PROCESS



- The product gas is a medium-Btu gas of 340 Btu per cubic foot.
- Natural gas contains 1,000 Btu per cubic foot.

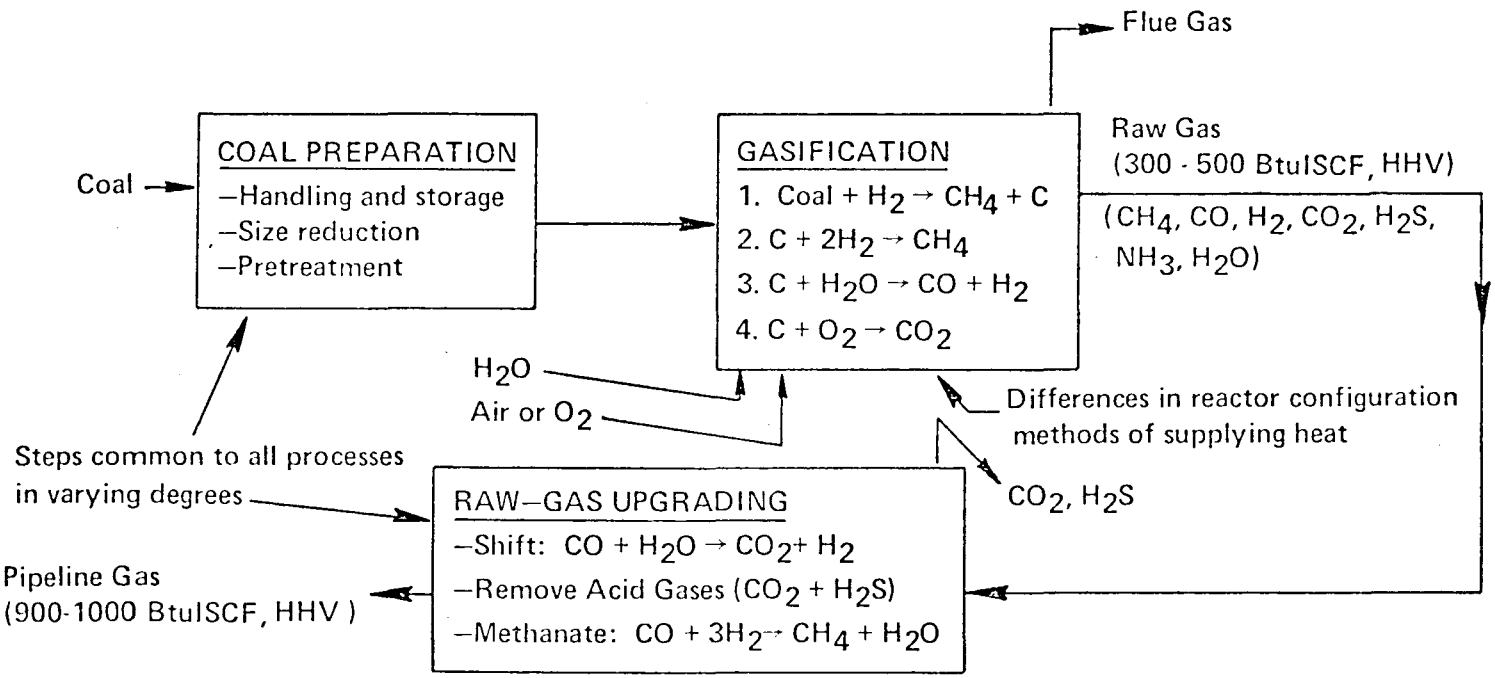


Figure 2: GENERAL PROCESS SCHEME FOR PRODUCING SNG FROM COAL
(after Siegel and Kalina, *Mechanical Engineering 95*(5))

characteristics of a variety of coal gasification schemes. The Lurgi, Koppers-Totzek, and Wellman-Galusha systems are operational systems that are now being used mostly in Europe or South Africa. The remaining systems are hypothetical but intended to represent working systems. In this table the output is expressed in standard cubic feet per ton of coal changed. It can be noted this output drops considerably when manufacturing pipe-line quality gas.

The 12% ash figure is intended to represent an average for high-volatile bituminous coal such as is available in the midwest.

Water requirements data are scarce. The figures given are intended to cover process, all cooling and steam generation.

Capital costs for coal gasification plants show a wide range of estimates. Table 2 lists one set of figures that could be useful for an order-of-magnitude type of assessment.

A more recent cost analysis was conducted by Arthur G. McKee for the U.S. Bureau of Mines with the results as shown in Table 3 for investment and gas-produced costs.

Table 2: Estimated Capital Expenditures for Coal Gasification Plants

Type Gas and Coal	1973[1] Total Capital	Tons Coal/Day	Capital Per Daily Ton Coal	Output Billion BTU/Day	Capital Per Million Daily BTU
High BTU Gas	334-390	14,700-17,900		250	
			Average		
From Bituminous Coal[2]	362	16,300	$22,209		$1,448
Low BTU Gas	195-208	12,500-14,300		250	
			Average		
From Bituminous Coal[2]	201	13,400	$15,000		$804

Source: Project Independence: An Economic Evaluation
MIT Energy Laboratory Policy Study Group 1974

[1] Includes onsites, offsites, auxiliaries, 5% startup, 15% interest during construction, 7-1/2% working capital.

[2] 25 million BTU per ton coal at $8.00 per ton.

Table 3: Coal Gasification Plant Costs Estimates 1975

	Tons Coal Used per day	Tons Coal Used per hour	SCF gas per day (million)	Investment cost (million dollars)	Gas[1] Price (dollars per million BTU)
Wellman-Galusha (157 BTU/SCF gas)	270	11.25	34.0	$8.7	$2.74
Koppers-Totzek (296 BTU/SCF gas)	3400	142	136.0	$173.2	$4.66

[1]To provide an 8% discounted cash flow rate of return.

Reported in the September 1976 issue of Pipe Line Industry are some interesting figures developed by Pacific Gas and Electric Co. from a study to compare cost and efficiency of natural gas, coal gas and electrical energy for certain residential appliances. Actual 1974 operating and financial data were used. During this time the average costs to P.G. and E. customers for delivered energy were $7.68/MM BTU for electricity and $1.13/MM BTU for natural gas.

Table 4 compares electric costs with natural gas while table 5 compares SNG and electric costs within the P.G. and E. system.

One of the most pressing problems is the cost of new facilities to meet future energy demands. Cost comparisons by P.G. and E. are given in Table 6. Total capital investment for equivalent energy delivery is 2.5 times as much for electricity produced from coal as for SNG produced from coal.

A natural question is what role coal gasification could or might play in Kansas. Also how would Kansas coal fit into the picture.

One definite plus for gasification is the fact there already exists a complete pipeline distribution system in Kansas by which industry, commerce, and residents could be easily serviced with pipe line quality synthetic gas.

The record for 1975 shows that of 846,164 million cubic feet of natural gas produced in Kansas that year, 285,000 million was exported. Of a net of 561,211 million cu. ft. remaining, 372,282 million was consumed by electric utilities, industry (other than ammonia plants), commercial, and residential.

TABLE 4: Comparative Costs of natural gas and electricity, $/MM BTU of useful energy from appliance

Appliance	Electric	Gas	
		w/o pilot	with pilot
Cooking range	10.97	2.51	4.40
Clothes dryer	11.82	1.88	2.99
Water heater	8.53	1.74	2.12
Space heater	8.08	1.74	1.96

TABLE 5: Comparative costs of electricity and SNG from coal, $/MM BTU of useful energy from appliances[1]

Appliance	Electric	Gas	
		w/o pilot	with pilot
Cooking range	17.50	7.98	13.97
Clothes dryer	18.80	5.98	9.50
Water heater	13.60	5.52	6.74
Space heater	12.90	5.52	6.28

[1]These are based on estimated first year 1975 costs of SNG and electricty from coal. The electric production cost is based on a 1975 capital cost for a direct fired coal power plant of $495 per KW and also includes the cost of coal delivered by unit train at $19.00 per ton or $1.18/MM BTU. A SNG production cost of $3/MM BTU is based on a 1975 Lurgi plant capital of $825 million for a 250 MM sefd mine-mouth facility and includes a coal cost at the plant site of $650 per ton or 39¢/MM BTU. There is also a pipe line gas transportation cost of 52¢/MM BTU to deliver the SNG.

TABLE 6: Capital intensiveness of SNG or electricity from coal, 1975 $ capital/MM yearly BTU

Energy:	SNG	Electricity
Coal and mine development[1]	1.40	2.00
Transport to service area	2.80	0.90
Conversion	9.20	20.70
Distribution Cost	1.50	13.50
Delivered Cost	14.90	37.10

[1]Based on Western U.S. strip mine.

Using the following assumptions:

BTU of syngas per cu. ft.		1000
Gasification plant output	MMSCF/Day	250
	MMSCF/Year	91,250
Coal required per plant MM tons annually		9.13
Water requirements GPM per plant		6000
Ash produced at 10% MM tons annually		.913

the number of plants to supply the 372,282 million cubic feet would be 4.

This translates into the following annual requirements for the 4 plants:

Coal, million tons	36.5
Water, gallons per minute	24,000
Employment, persons (estimated)	3,000
Waste (ash) MM tons	3.6

It is obvious such a program would require substantial resources and if carried out at all would require being gradually implemented.

Kansas coal could be used in the gasification process but since they are of the high swelling, high sulfur type special treatment is indicated. There are some 2,815 million tons of Kansas coal, demonstrated and inferred under 100 feet of overburden. At the annual rate of 36.5 million tons with no further growth there reserves would have a theoretical life time of 78 years.

Undoubtedly, coal gasification could play an important and decisive role for energy in Kansas. Given the pipeline distribution system that now exists in Kansas it would seem natural to utilize this and at

the same time prolong the indigenous Kansas natural gas supplies.

It would seem reasonable and appropriate for the state to adopt some sort of programs and time schedules when alternate fuel systems ought to be placed into the state energy system.

TABLE 1: Some Coal Gasification Comparisons

System	Input					Output-Product Gas			
		Total Water	Coal					Per 1.0 Ton Coal	
	Coal	MM Gal/Hr	Tons/ Hr	MM BTU/Hr	BTU/CF	MM SCF/Hr	MM BTU/Hr	SCF	BTU
1) Lurgi-High BTU	Coal		1177.0	20,395	954.0	12.03	11,471.9	10,220	9.7×10^6
2) Lurgi-SNG-Western Gasification Company Plant		0.306	1042.0	25,000	900-1000	10.42	10,410.0	10,000	10.0×10^6
3) Koppers-Totzek High BTU	Coal				962.0			16,164	15.5×10^6
4) Pipe Line Quality Gas (No Specified System)	Coal	0.360	1281.0	30,744	900-1000	10.4	10,410.0	8,132	8.1×10^6
5) Wellman-Galusha Low BTU (for 1000 MW Plant)	Coal		402.0	8,889.0	106.4	44.5	7,144.2	110,700	17.8×10^6
6) Wellman-Galusha Low BTU Estimated	Coal	.058	3.5	84.0	150.0	0.500	67.5	129,000	19.3×10^6
7) Air Blown 4-Stage Gasifier Low BTU (for 500 MW Plant)	Coal		277.0		175.0	28.4	4,980.0	102,426	18.0×10^6
8) FPC Report - Synthetic Gas from Coal, April 1973	Coal	3.5	625.0	15,000	900.0	11.0	9,900.0	17,600	15.8×10^6
9) U. of Ill. Projected Retrofit System, Medium BTU (for 2×10^9 lbs steam)	Coal	0.644	23.0		340.0	0.924	314.2	40,350	13.7×10^6
10) USGS Estimate from (Jan. 1976 Environmental Science and Technology)		0.370 1.500			150.0 900		10,000 10,000		

MM = Million (10^6)
SCF = Standard Cubic Feet