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Coal Gasification and Its Alternatives

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COAL GASIFICATION AND ITS ALTERNATIVES

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Abstract

This paper presents the importance and need for coal gasification to the homeowner in light of the available alternatives. The status of coal gasification and announced projects are outlined citing the regulatory and financial problems which have caused unnecessary and unreasonable delays. Present energy systems are compared showing the efficiency and cost advantages of natural gas to the consumer over electricity. Energy projections stress the importance of coal and nuclear energy for the future. In this regard, utilization of U.S. coal resources for coal gasification and electric power generation are compared. These comparisons show that synthetic gas from coal is less expensive, more efficient, and less capital intensive than electricity made from the same coal for the residential consumer and point out the need for homeowners to question the legislative and regulatory dawdling going on and insist the new synthetic gas industry be supported and launched.

INTRODUCTION

Big things were predicted for coal gasification in the early 1970's. Dwindling reserves of natural gas were going to be supplemented with trillions of cubic feet of synthetic gas produced from vast coal reserves of the western states thus maintaining adequate supplies of gas energy for residential and commercial use as well as those industries depending on natural gas. It wasn't going to be cheap back then. The estimated cost was about $2.50/MMBTU delivered compared to less than 50¢/MMBTU for natural gas, $1.50/MMBTU for fuel oil, and 30¢/MMBTU for coal. But even so, incrementally, synthetic gas was cheaper than electricity made from natural gas which then cost about 1.5¢/KWH or $4.40/MMBTU. Rolling-in the cost of synthetic gas with the existing gas supplies would have increased the overall cost of gas by less than 10¢/MMBTU, still making gas energy the best bargain in the country outside of the direct use of coal.

But, direct use of coal was dirty and undesirable environmentally, suitable only for industrial use, and enormous capital outlays were required by industry to convert from gas or oil to coal. On the other hand, gas was clean, transportable via existing pipeline systems, storable for use during peak demands, and producible from coal by commercially demonstrated and environmentally acceptable technology.

Thus the stage was set for coal gasification.

In the meantime, the oil embargo left us with a painful awareness of our dependence on cheap foreign oil -- it hasn't been that long ago that foreign oil cost less than $2.00/Bbl -- and the resulting inflation of the mid-1970's more than doubled the estimated cost of proposed gasification projects from nearly $500 million to over $1 billion for a plant that would supply less than 1/2 of 1% of the present U.S. energy demand.

STATUS

At least six groups announced plans for Lurgi coal gasification plants, each with a capacity of about 250 MMCFD of synthetic gas. All of these projects went through various stages of project development including contractor selection, preliminary engineering, environmental impact, and preparation for FPC filing. Unfortunately, all of these projects have been delayed.

1. The Wesco Project in New Mexico is considered the leader. Technically, it is almost ready for construction . Construction and mining permits have been obtained and a conditional approval has been received from the Federal Power Commission. Financing is required, however, before this project can move forward.

2. American Natural Gas Co.'s Coal Gasification Project in North Dakota is technically almost ready for construction. The first 250 MMCFD plant is planned to be built in two "phases" to reduce environmental and financial impact. PGC Coal Gasification, a subsidiary of Natural Gas Pipeline, has joined the project. The Environmental Impact Statement is complete, and FPC hearings are progressing. The potential for completing the first phase looks promising.

3. El Paso's New Mexico project has been filed with the FPC, but further consideration has been delayed at El Paso's request.

4. Panhandle Eastern prepared an FPC filing for its Wyoming project but it has been shelved. The environmental report was filed but no action taken. Panhandle is currently developing a project with the City of Wichita, Kansas.

5. Natural Gas Pipeline's affiliate, PGC Coal Gasification, joined the ANG Coal Gasification Project. The original North Dakota project has been postponed indefinitely.

6. Cities Service/Northern Natural completed preliminary engineering for the proposed Wyoming project in 1975. The project has been abandoned and coal dedications released.

What has delayed the construction of these projects or caused their abandonment? And why aren't other major commercial coal gasification projects being seriously considered?

Very simply, the gas industry is faced with the problem of raising extremely large sums of capital to launch this brand new industry, and with continued cost to the consumer, $13/MMBTU, as a new coal-fired power plant. Comparative costs are shown in Table 12. The present average U.S. residential cost for electricity is about $10/MMBTU. As more power comes from coal and nuclear energy and gas and oil-fired power plants are phased out, the cost of electricity will continue to increase.

There are very few parts of the country that have not experienced a rapid increase in electric rates due to escalating fuel and construction costs. In fact, for many areas the cost of electricity today has already exceeded the $13/MMBTU expected for new power plants beginning construction.

In 1970, the cost of electricity was about $4/MMBTU more than natural gas. Today electricity costs the average homeowner $8/MMBTU more than gas. Indications are this cost differential between electricity and gas energy is going to increase even more.

Even if new, more costly gas supplies caused the price of gas to increase at twice the rate the price of electricity is now increasing, by the time electricity reaches $13/MMBTU, gas would still be only $3/MMBTU.

At this $10/MMBTU difference, the typical Kansas City homeowner heating with gas appliances would pay about $700 less per year in homeowner costs than his all-electric neighbor with a heat pump. If additional gas supplies are not available, however, this cost savings will mean little to prospective owners of new homes.

NEED FOR COAL GASIFICATION

With all the efficiency and cost advantages of synthetic gas, why aren't coal gasification plants being built? Why has construction been delayed? There's really no good reason. Some congressmen today do not feel that coal gasification plants are justified for supplementing future gas supplies.

Certainly, LNG, Arctic gas, and new discoveries will help fill the gap between existing supplies and future demand for gas, but it's not enough. The demand for energy will continue to grow. The transition to more costly energy will not be an easy one for the homeowner and small businessman to make; however, to give the homeowner no alternative but electricity in making this transition is just plain ridiculous.

Quite frankly, as a homeowner, I resent the shortsighted positions that Congress and the regulatory commissions have taken toward satisfying future residential energy needs. The bargain of low cost gas energy will not mean much to any of us if the FPC shuts the door on new gas hook-ups for homeowners.

If billions of dollars can be invested in coal and nuclear power plants now to satisfy future demands with expensive electricity, then financial and regulatory support should also be available now to launch a viable coal gasification industry -- an industry which can supply future demands for gas at less than half the delivered cost for electricity on an equivalent basis.

Coal gasification is the only alternative for meeting the future energy needs of the nation utilizing an existing pipeline network unsurpassed by any other energy transportation system. Its role is an important one, that of assuring you and me uncertainty in federal regulatory policies for marketing the synthetic gas produced, the risk of going ahead with these projects is just too great. Consequently, enthusiasm for commercialization of coal gasification has dwindled.

Instead, gas companies have concentrated on other means of supplementing supplies such as LNG, Arctic gas, and deep formation gas development. Concurrent with the development of these alternatives, coal gasification has received support from both industry and the Energy Research and Development Administration (ERDA) for development of new technology. It now appears that unless the federal government assists major commercial projects by providing loan guarantees or some other means of financial or regulatory assistance, coal gasification will be delayed on and on.

How would coal gasification compare today with the alternate gas supplies, assuming these projects had not been delayed?

It would have been a bargain! If the coal gasification industry had been launched in the early 1970's and a plant were ready to be put on stream in 1978, the cost of synthetic gas would be about $2.50-3.00/MMBTU to the consumer. This is comparable to natural gas from deep formations. Other alternate sources such as LNG or Arctic gas will cost more.

I once heard an old wrestler turned actor say, "If only I had of knew!"

Of course coal gasification didn't happen. The earliest that plants can start now is about 1983. Synthetic gas from these plants using present technology would cost the consumer about $5.50/MMBTU in today's dollars.

The question is, "Can this gas be competitive with the alternate sources of energy in the next decade?"

PRESENT ENERGY SYSTEMS

Since the cost of new supplies of energy have always been rolled-in with existing supplies, it will be useful to review the present efficiencies and costs of natural gas and electricity before comparing synthetic gas to its alternatives. As shown in Table 1, the efficiency of delivering gas energy to the consumer today is over three times more efficient than delivering electric energy when production, transmission and distribution losses are considered.

TABLE 1
PRESENT EFFICIENCY OF DELIVERED ENERGY TO CONSUMER

	NATURAL GAS	ELECTRICITY
PRODUCTION EFFICIENCY	97%	33%
TRANSMISSION AND DISTRIBUTION	96%	90%
DELIVERED ENERGY EFFICIENCY	93%	30%

Following delivery, this energy must then be utilized by the consumer. Table 2 compares the overall resource efficiencies for home space heating appliances. Although the appliance efficiency for a gas furnace is lower than that for electric resistance space heating or an electric heat pump, the gas furnace has the highest overall resource efficiency.

TABLE 2
PRESENT RESOURCE EFFICIENCY IN SPACE HEATING

	NATURAL GAS	ELECTRICITY	
	GAS FURNACE	ELECTRIC RESISTANCE	ELECTRIC HEAT PUMP
DELIVERED ENERGY EFFICIENCY	93%	30%	30%
EFFICIENCY IN SPACE HEATING	65%	97%	1.7 %*
OVERALL RESOURCE EFFICIENCY	61%	29%	50%

* COEFFICIENT OF PERFORMANCE (COP)

Of primary importance to the homeowner, however, is the total cost of energy. Table 3 identifies the present day cost for heating and cooling equipment capable of satisfying the requirements for a typical home in Kansas City with about 1,800 square feet of living area. This cost to the homeowner is based on:

(1) Installed cost
(2) Expected equipment life
(3) Annual equipment cost
(4) Annual maintenance cost

TABLE 3
COST OF SPACE HEATING & COOLING EQUIPMENT

ITEM	INSTALLED COST ($)	EXPECTED LIFE (YR)	ANNUAL EQUIP COST ($)	ANNUAL MAINT COST ($)
GAS FURNACE	700	20	75	20
ELECTRIC FURNACE	800	20	90	10
ELECTRIC HEAT PUMP	2,400	10	370	60*
CENTRAL AIR CONDITIONER	1,100	15	135	20
DUCTWORK	400	30	40	--
CHIMNEY	50	30	5	---

* $30/YR HEATING SEASON: $30/YR COOLING SEASON

The annual equipment cost assumes that 100% of the installed cost is borrowed at 9% interest and the annual payments are made over the expected life of the equipment. In order to determine the "owning" cost, the annual maintenance cost is added to the annual equipment cost.

Utilizing this information, the cost of owning space heating equipment is shown in Table 4. Since the electric heat pump serves a dual purpose of both heating and cooling, only a fraction of its equipment cost based on operating hours is included for comparing space heating costs. In addition to owning costs for space heating, energy costs are also shown based on the average energy demand and cost for gas and electricity in Kansas City today. The seasonal heating demand in a typical Kansas City home is 56 MMBTU's; current energy costs are $1.50/MMBTU for gas and $9.50/MMBTU for electricity. The energy cost alone shows a savings for gas of over $400 annually compared to resistance heat, and nearly $200 when compared to the electric heat pump. Owning costs add nearly $200 annually to the difference between the gas furnace and the heat pump.

TABLE 4
PRESENT HOMEOWNER COST FOR SPACE HEATING IN KANSAS CITY

	NATURAL GAS	ELECTRICITY	
	GAS FURNACE ($/YR)	ELECTRIC RESISTANCE ($/YR)	ELECTRIC HEAT PUMP ($/YR)
OWNING COST	120	120	300
ENERGY COST	130	550	310
TOTAL HOMEOWNER COST	250	670	610

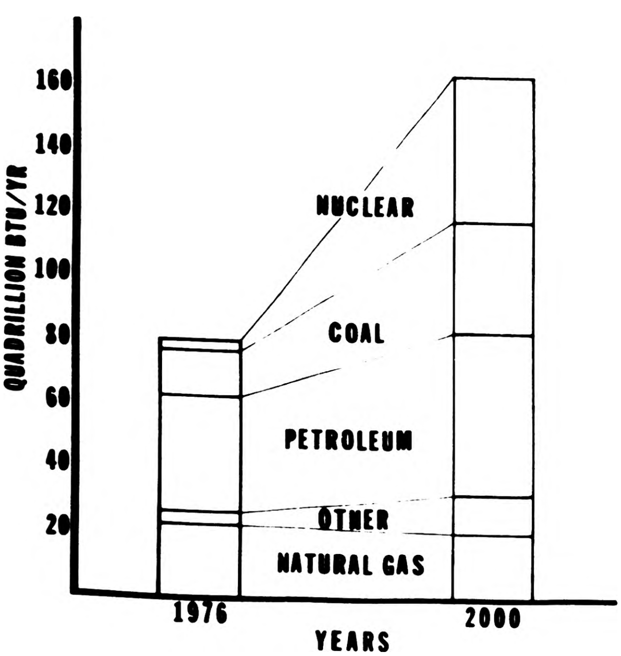
Clearly, natural gas is a real bargain for the Kansas City homeowner today compared to electricity. In fact, at today's cost for energy, the all-electric homeowner in Kansas City using resistance heat could switch to gas and the savings would pay out the equipment replacement costs in about two years. Similarly, the savings resulting from a gas furnace installed in a newly constructed home would pay for the equipment in about one year when compared to resistance heating, and two years when compared to a heat pump.

But what will happen to the efficiencies and costs of gas and electric energy systems as new supplies are rolled-in? And where will these new energy supplies come from?

FUTURE ENERGY SYSTEMS

As shown in Figure 1, the U.S. consumption of energy in 1976 was about 80 quadrillion BTU's (80 quads). According to the U.S. Bureau of Mines, by the turn of this century consumption is expected to more than double, representing a growth rate of about 3% per year. Increased use of nuclear and coal energy is expected to account for over 75% of this growth, with nuclear accounting for 50% and coal 25%.

FIGURE 1
U.S. ENERGY CONSUMPTION BY MAJOR SOURCES



Whereas nuclear energy will be applied primarily to the production of electric power, the alternatives for coal are three-fold:

(1) Direct use by industry
(2) Generate electric power
(3) Produce synthetic fuels

As far as the residential and small business consumers are concerned, coal can serve their future energy needs with both gas and electricity.

To evaluate future energy needs, an incremental comparison is made between producing synthetic gas from coal and generating electricity from coal. This comparison is made with respect to efficiency, capital intensiveness, and homeowner costs.

To evaluate the efficiency of new gas and electric systems, Table 5 shows the efficiency of delivering energy to the consumer from synthetic gas and electricity from coal. In delivering synthetic gas from coal, almost 60% of the resource energy is recovered. This is nearly double the resource energy recovered when electricity from coal is delivered to the consumer.

TABLE 5
EFFICIENCY OF DELIVERED ENERGY TO CONSUMER

	SYNTHETIC GAS FROM COAL	ELECTRICITY FROM COAL
CONVERSION PROCESS	60%	35%
TRANSMISSON AND DISTRIBUTION	96%	90%
DELIVERED ENERGY EFFICIENCY	58%	32%

Upon delivery, this energy must then be utilized by the consumer. The results of comparing the overall resource efficiency of home space heating from synthetic gas and electricity from coal are shown in Table 6. Considering conventional appliances, the gas furnace has an overall resource efficiency of 37% versus 31% for electric resistance heat, or nearly a 20% resource savings in favor of synthetic gas when considering all losses. Considering only heat pump appliances, the "new" gas-fired heat pump has an overall resource efficiency of 75% versus 54% for the electric heat pump, or nearly 40% less resource usage when synthetic gas is used.

TABLE 6
RESOURCE EFFICIENCY IN SPACE HEATING

	SYNTHETIC GAS FROM COAL		ELECTRICITY FROM COAL	
	GAS FURNACE	"NEW" GAS HEAT PUMP	ELECTRIC RESISTANCE	ELECTRIC HEAT PUMP
DELIVERED ENERGY EFFICIENCY	58%	58%	32%	32%
EFFICIENCY IN HOME SPACE HEATING	65%	1.3*	97%	1.7*
OVERALL RESOURCE EFFICIENCY	37%	75%	31%	54%

*COEFFICIENT OF PERFORMANCE (COP)

The "new" gas heat pump is shown here because commercial equipment is expected to be on the market by the time the first coal gasification plants are in operation.

In evaluating capital intensiveness, it is evident that the development of clean energy sources from coal will put an enormous burden on the financial sector. Costs have escalated for both gasification plants and coal-fired power plants. As shown in Table 7, at current costs for comparable capacity plants, the total capital required for a coal-fired power plant is approaching $2 billion ($650/KW) which is nearly 75% greater than the capital required for a coal gasification plant.

TABLE 7
CAPITAL INTENSIVENESS OF COAL GASIFICATION AND POWER GENERATION FROM COAL

	* LURGI COAL GASIFICATION	** COAL-FIRED POWER PLANT
PLANT CAPACITY (BILLION BTU/DAY)	246	246
CAPITAL COST (MILLIONS DOLLARS)	1,125	1,950
LOAD FACTOR (PERCENT)	90	70
ANNUAL PLANT OUTPUT (TRILLION BTU)	81	63
CAPITAL INTENSIVENESS (DOLLARS PER MILLION BTU)	14	31

*ONE 250 MMCFD PLANT
**THREE 1000 MW UNITS

In addition to this, the annual output from the power plant is less than 80% of the output from the gasification plant due to differing load factors. This results in a capital requirement per equivalent unit of energy produced of more than twice as much for electric power than for synthetic gas from coal, or $31/MMBTU produced annually for electricity versus $14/MMBTU for synthetic gas. Putting this relationship on an individual homeowner basis for utilizing heat, a capital expenditure of $2,800 is required to provide electric heating service to one typical Kansas City home compared with only $1,800 for providing synthetic gas heating. Besides the investment, the homeowner will pay more for electric energy as well.

Assuming these plants are located near the market area, a comparison of the cost of service is shown in Table 8. The cost of the delivered synthetic gas at $5.50/MMBTU is less than 1/2 the cost of delivered electricity from coal at $13/MMBTU (4.5¢/KWH).

TABLE 8
RESIDENTIAL ENERGY COST FOR SYNTHETIC GAS AND ELECTRICITY FROM COAL

	SYNTHETIC GAS FROM COAL ($/MMBTU)	ELECTRICITY FROM COAL ($ MMBTU)
CAPITAL COST	2.60	5.90
COAL COST AT $1/MMBTU	1.70	3.00
OTHER EXPENSES	.80	1.10
TRANSMISSION AND DISTRIBUTION	.40	3.00
TOTAL DELIVERED COST TO CONSUMER	5.50	13.00

If this incremental energy were utilized by the homeowner for space heating, as shown in Table 9, a gas furnace operated with synthetic gas would cost $595 annually. This is $135 per year less than an electric heat pump operating on electricity from coal, and $275 per year less than electric resistance heat. At these savings, the all-electric homeowner with resistance heat could switch to gas and pay out the equipment replacement costs in about four years. The savings for a gas furnace in a new home would pay for the equipment in about three years.

TABLE 9
HOMEOWNER COSTS FOR SPACE HEATING IN KANSAS CITY

	SYNTHETIC GAS	ELECTRICITY FROM COAL	
	GAS FURNACE ($/YR)	ELECTRIC RESISTANCE ($/YR)	ELECTRIC HEAT PUMP ($/YR)
OWNING COST	120	120	300
ENERGY COST	475	750	430
TOTAL HOMEOWNER COST	595	870	730

The total outlook for the homeowner is not complete, however, unless the efficiencies and costs for the home's total heating and cooling requirements are compared for gas/electric and total electric homes using synthetic gas and electricity from coal.

TABLE 10
RESOURCE EFFICIENCY IN HOME HEATING/COOLING SYSTEMS IN KANSAS CITY FROM SYNTHETIC GAS AND ELECTRICITY FROM COAL

		ANNUAL COAL CONSUMPTION (MMBTU)*			
		GAS/ELECTRIC HOMES		TOTAL ELECTRIC HOMES	
	ANNUAL USEFUL ENERGY (MMBTU)	GAS FURNACE/ CENTRAL AIR	"NEW" GAS HEAT PUMP	ELECTRIC RESISTANCE/ CENTRAL AIR	ELECTRIC HEAT PUMP
HEATING					
SPACE HEAT	56	150	75	183	105
WATER HEAT	18	48	48	64	64
COOKING	4	17	17	17	17
CLOTHES DRYING	4	11	11	20	20
TOTAL HEATING	82	226	151	284	206
COOLING					
TOTAL COOLING	38	50	66	50	60
TOTAL ENERGY REQUIREMENT	120	276	217	334	266
OVERALL RESOURCE EFFICIENCY		43%	55%	36%	45%

*ACCOUNTS FOR EFFICIENCY LOSSES IN GENERATION, GASIFICATION, TRANSMISSION AND DISTRIBUTION, AND APPLIANCES

Neglecting lighting and small appliance requirements served by electricity, the overall resource efficiency for home heating and cooling systems in the typical Kansas City home is shown in Table 10. In addition to space heating, gas is assumed to satisfy water heating, cooking and clothes drying requirements in the gas/electric homes. Electricity is assumed to satisfy these requirements in the total electric homes. The overall resource efficiency in the gas furnace/central air home is about the same as in the electric heat pump home. However, the potential exists to improve the overall efficiency of a gas/electric home by over 25% through commercialization of the "new" gas-fired heat pump.

What about the homeowner cost involved to satisfy all of these home heating and cooling requirements?

Once again, the homeowner cost is comprised of owning costs and energy costs. As shown in Table 11, when considering all applicable costs, the gas/electric home is about 20% cheaper to own and operate than either of the total electric homes.

Is this the real outlook for the consumer?

OUTLOOK FOR THE CONSUMER

Incremental energy comparisons for coal based energy supplies are not meant to frighten the homeowner. The average cost of delivered gas will not reach \$5.50/MMBTU unless, of course, the consumer is asked to shoulder the entire cost of producing synthetic gas supplies as a "new" customer. More likely, new gas supplies will be rolled-in to existing supplies of natural gas. Then the homeowner would pay a lower, weighted average price for the delivered gas. At present, the average U.S. residential and small business gas price is about \$2/MMBTU. If synthetic gas supplied 10% of this market, which is equivalent to eight 250 MMCFD plants, the average cost of gas to the consumer would be \$2.35/MMBTU or about a 20% increase over today's cost.

Electricity, on the other hand, will reach nearly \$13/MMBTU (4.5¢/KWH) because coal-fired power plants and nuclear power plants will rapidly become the primary electric power sources. Nuclear plants will produce power at about the same delivered

TABLE 11
HOME HEATING/COOLING COSTS IN KANSAS CITY FROM SYNTHETIC GAS AND ELECTRICITY FROM COAL

	GAS/ELECTRIC HOME	TOTAL ELECTRIC HOME	
	GAS FURNACE/ CENTRAL AIR ($/YR)	ELECT RESIS/ CENTRAL AIR ($/YR)	ELECTRIC HEAT PUMP ($/YR)
COST OF OWNERSHIP			
SPACE HEATING	120	120	300
SPACE COOLING	175	175	170
OTHER HEATING*	200	180	180
TOTAL OWNING COST	495	475	650
TOTAL ENERGY COST	920	1,365	1,085
TOTAL HOMEOWNER COST	1,415	1,840	1,735

*INCLUDES WATER HEATING, COOKING AND CLOTHES DRYING

TABLE 12
COMPARATIVE RESIDENTIAL ENERGY COSTS FROM NEW ENERGY SOURCES

	SYNTHETIC GAS FROM COAL ($/MMBTU)	ELECTRICITY FROM COAL ($/MMBTU)	ELECTRICITY FROM NUCLEAR ($/MMBTU)
CAPITAL COST	2.60	5.90	8.50
FUEL COST	1.70	3.00	.90
OTHER EXPENSES	.80	1.10	.60
TRANSMISSION & DISTRIBUTION	.40	3.00	3.00
TOTAL DELIVERED COST TO CONSUMER	5.50	13.00	13.00

as homeowners of a continued supply of gas -- the least costly of our energy alternatives well into the next century.

ACKNOWLEDGMENT

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BIOGRAPHY

Mr. Huffman is currently Manager of Synthetic Gas Projects with Cities Service Gas Company in Oklahoma City. He is a graduate of Purdue University with a B.S. in Chemical Engineering. Mr. Huffman joined Cities Service in 1958 as an engineering trainee and has since held several positions in the Oil Company and Research Division of Cities before joining the Gas Company in 1973 as Chief Process Engineer in the Synthetic Gas Supply Division. Since this time, Mr. Huffman has been involved in the development of gasification projects for Cities Service Gas Company and the evaluation of future prospects for synthetic gas.