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Low/Medium BTU Coal Gasification Assessment of Central Plant for The City of Philadelphia, Pennsylvania

Executive Summary

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Preface

This report is one of a series that was sponsored by the Office of Coal Resource Management, Resource Applications, Department of Energy, based on responses to a Program Interest Notice (PIN) (RA-21) issued March 15, 1979. The purpose of the Program Interest Notice was to obtain a realistic assessment of the feasibility (from the owner/user's point of view) of utilizing low or medium-Btu gas from coal in a variety of industrial or commercial applications.

Although processes for producing environmentally acceptable gas from coal are available commercially, the lack of commercial operating experience in the United States requires that the pioneer users of this technology to principally rely on engineering and economic analysis. The uncertainty of costs, operating reliability and retrofit impacts; effect of gas on product quality and plant processes; plant siting and environmental factors; gas distribution costs and safety; regulatory impacts; coal supply and transportation; capital/financing arrangements, etc., are all considerations which a potential owner/user must weigh when seriously considering the use of low/or medium-Btu coal gas as an alternative fuel option. This series of studies, by emphasing site specific applications, was aimed at developing answers to some of these concerns.

Coal Resource Management
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EXECUTIVE SUMMARY

The objective of this study is to assess the technical and economic feasibility of producing, distributing, selling, and using coal gas for industrial applications in Philadelphia.

The primary driving force for the assessment is the fact that oil users are encountering rapidly escalating fuel costs, and are uncertain about the future availability of low sulfur fuel oil. The situation is also complicated by legislation aimed at reducing oil consumption and by difficulties in assuring a long term supply of natural gas. The result is a threat to the continued well-being of industrial activity in Philadelphia.

At the present time gas utility companies are not operating coal gasification plants in the United States. Although Philadelphia Gas Works (PGW) can draw upon valuable past experience, technologies and economic conditions have changed significantly since coal gas was last distributed. As a result, many issues must be investigated prior to committing large amounts of capital to the implementation of a central coal gasification plant.

Of the various decisions to be made, one of the most important is the trade-off between economic and operational requirements. Such a trade-off cannot be established in a single step. For this reason a sequential approach was used as follows:

a. Market-Analysis Considerations

During the early stages of the study it was decided to rate each site from a gas distribution point of view. At the same time a survey was conducted to assess user preferences. As a result a number of similarly satisfactory gasifier sites were selected. A tentative plant capacity of 20 billion Btu per day was established based on interviews with some preferred potential users - Rohm and Haas, Allied Chemical, and National Sugar.

From the 15 sites considered, the Philadelphia Gas Works and Riverside sites were considered excellent candidates. For the purpose of completing the conceptual design phase, the old gas works site was selected. However, no final conclusion can be reached at this time as to whether the PGW site should be firmed-up or the Riverside site acquisition investigated further. During the feasibility study it was determined that a new and entirely separate distribution system would be installed. This determination was made on the basis of PGW's operational requirements and past experience.

b. Preliminary Economic/Operational Analyses

Early in the gasifier selection study it was decided that the level of risk associated with the gasification process should be minimal. It was therefore determined that the process should be selected from those commercially proven. The following processes were considered:

- Lurgi,
- KT,
- Winkler, and
- Wellman-Galusha.

From past experience and a knowledge of the characteristics of each gasifier, a list of advantages and disadvantages of each process was formulated. The Galusha process offered the least capital and operating costs for low Btu gas (approximately 150 Btu per cu ft), and the KT and Lurgi emerged as the better processes for medium Btu gas (approximately 300 Btu per cu ft).

c. Heating Value Considerations

A retrofit study was carried out to assess the impact on users having to switch from oil or natural gas to low or medium Btu gas. Although low Btu gas could be used in the primary distribution system (Rohm and Haas, Allied Chemical, and National Sugar), the cost of distributing low

Btu gas would be high. In addition, should one or more of these three companies choose to use coal directly, then it would be necessary for PGW to install and maintain a larger distribution system. To a large extent, such a system would be required to supply energy to package boilers and similar units which could not easily use low Btu gas. Medium Btu gas was selected in order to service many users with gas having generally useful combustion characteristics. For the production of 20 billion Btu per day two gasifiers are required, each gasifying about 500 tons per day.

d. Conceptual Design of the Gasification Plant

Having already generated a set of capital and operating costs for all of the gasifiers considered in Step b, it was decided to adopt a conservative approach (in terms of back-up) toward the conceptual design. Between the Lurgi and KT processes (which are competitive in terms of capital costs), the KT process shows a lower operating cost and is more flexible in terms of coal feed selection. In addition, the Lurgi (and the Galusha) gasifiers produce tars, phenols, and ammonia. Effective removal of these by-produces adds to the complexity and operating inconvenience of the overall process. Therefore, the KT process (which is unique in its ability to gasify many coals) was selected.

e. Recommended Economic/Operational Trade-Offs

For the purpose of carrying out the preliminary economic analyses a trade-off between economic and operational considerations was assumed which was biased in favor of providing minimal back-up capability at the gasification site. The question of back-up capability was not ignored. It was assumed, for gasifier selection purposes, that each user would prefer to maintain oil backup in return for a lower gas cost. During the conceptual design phase a more conservative approach toward backup was followed which resulted in an additional gasifier and additional interface piping.

In view of the fact that a marketable solution to the economic/ operational trade-off problem must be sought, it was decided to concentrate on a two-gasifier solution, and to solve the peaking and maintenance shutdown problems by means of liquid fuel backup. It was decided that the logical point in time to discuss backup and peaking would be at the time that the PGW gas cost estimates are presented to each user. At this point it can be expected that the users would be willing to compile and release details of their load profiles. It is probable that most users would prefer to install dual fuel burners, and would prefer to retain some capability to store fuel oil. Oil storage costs are small, known to each user but vary from one user to another. For this reason they will be considered during the definitive design phase after each potential user has been presented with gas costs developed during this study.

f. Conclusions

The discussion in Section 6 indicates that the final cost of gas can fall somewhere within a broad range. The maximum costs reported in this study are based upon three gasifiers and $45 per ton coal, whereas the minimum costs are based on $35 per ton coal. In view of this wide range it is imperative that the coal search task be initiated as proposed in the definitive design proposal.

The gas cost estimates developed during this study are based on Table I, and the gas costs based on municipal financing are summarized in Figure I. As shown in Figure I, there is a substantial variance in gas costs as a result of possible changes in coal cost and required backup. The potential range of gas costs does compare favorably with No. 6 fuel oil as an energy source. Although there exists an element of risk and uncertainty which must be bounded carefully during the next phase of the study, there also exists some potential for reducing the rather conservative cost estimate which represents the high case.

TABLE I

BASIS FOR SENSITIVITY ANALYSES

(Mid 1980 $ (000's)

	Base Case	Low Case	High Case
Number of Gasifiers	2	2	3
Production Rate BTU/Day	20×10^9	20×10^9	20×10^9
Operating Days	330	330	330
Capital Investment			
Battery Limits	89,300.0	89,300.0	109,605.0
Distribution	5,400.0	5,400.0	10,000.0
Engineering	5,600.0	5,600.0	6,576.0
Construction Management	4,700.0	4,700.0	5,480.0
Contingency	9,000.0	-	10,961.0
Start-Up	4,170.0	3,280.0	4,510.0
Working Capital	3,120.0	2,[illegible]0.0	3,320.0
Total	121,290.0	111,240.0	150,452.0
Operating Cost/Year (Minus Coal Costs)	7,120.0	6,410.0	7,120.0
Coal Cost			
$/Ton	40	35	45
1980 Cost (MM$/yr)	13,720.0	12,000.0	15,430.0

The base case system referenced in Figure I and Table I will provide the starting point for the definitive design study which will follow. With respect to ownership, the municipal option, which is summarized in Table II, was selected in order to provide a common basis for comparison purposes. The private ownership results summarized in Table III are preliminary. Other commercial options will be evaluated during the definitive design study.

It is concluded that a medium Btu KT gas can be manufactured and distributed at a lower average price than the conservatively projected average price of No. 6 oil, provided that the plant is operated as a base load producer of gas.

g. Recommendations

It is recommended that a definitive design study be completed in order to:

a. Increase the confidence level of the investment analyses.

b. Present gas cost estimates to potential users.

c. Define a specific distribution system.

d. Develop a definitive design and cost estimate.

e. Explore the possibility of reduced gas costs.

f. Develop a commercialization plan which PGW can use as a basis for a GO/NO GO decision in plant design and construction.

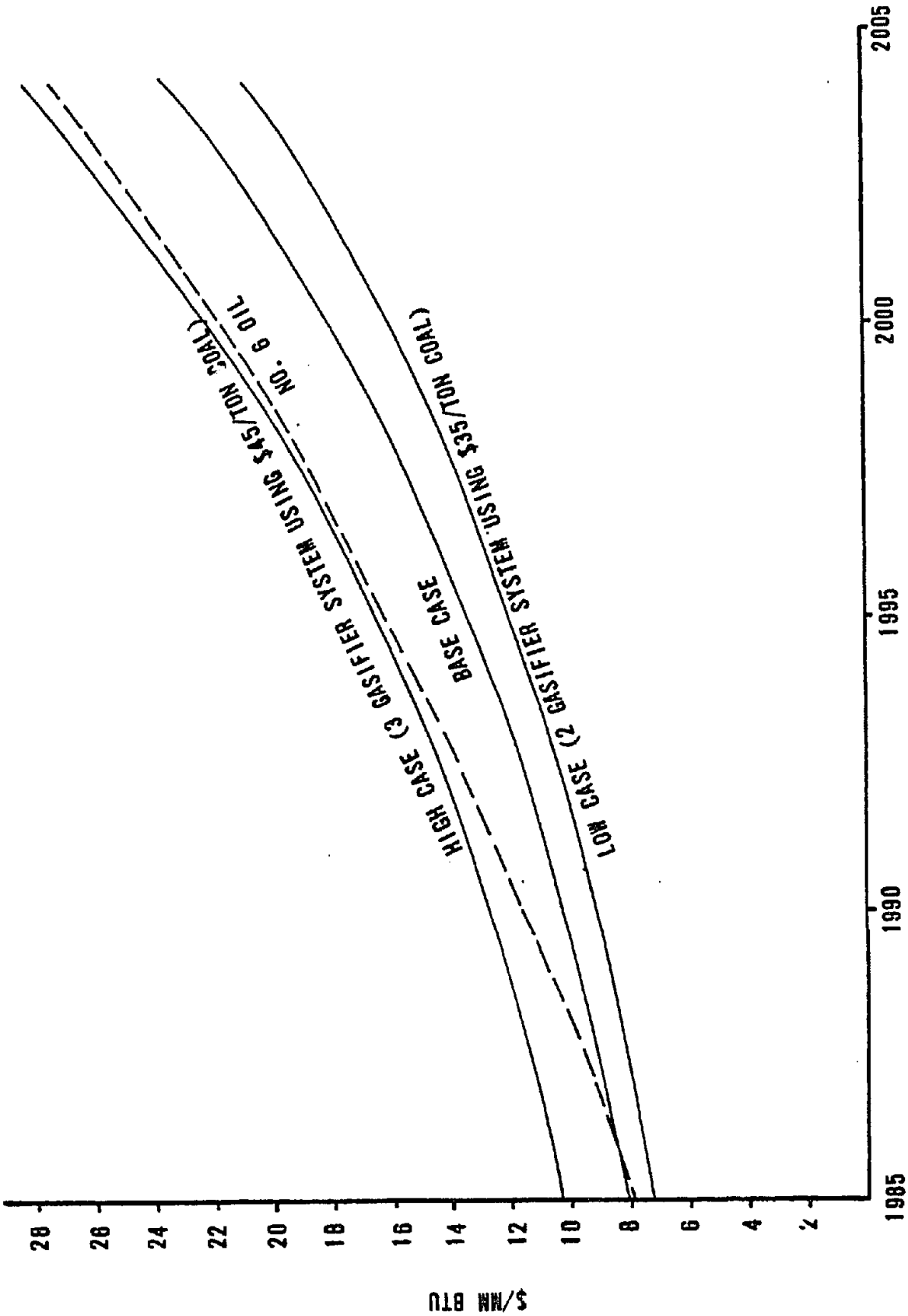

FIGURE 1
RANGE OF GAS COSTS COMPARED TO NO. 6 OIL

TABLE II

FINANCIAL SUMMARY - MUNICIPAL OWNERSHIP

(000 $)

	Base Case	Low Case	Conceptual Design Case
Total Capital Expenditures (Current Dollars)	151,964.9	139,367.3	188,347.2
Total Operating Cost (Current Dollars - 20 year life)	1,401,267.9	1,237,876.0	1,515,574.5
Total Costs (Current Dollars - 20 year life)	1,858,295.9	1,655,276.0	2,080,914.5
Total Annual Debt Service W/1.25 coverage	22,851.4	20,870.0	28,267.0
Total Levelized Annual Cost	79,946.5	71,312.4	90,018.9
Levelized Cost/$/MMBtu	12.11	10.80	13.64
First Year Cost/$/MMBtu	8.10	7.26	9.30

TABLE III

FINANCIAL SUMMARY - PRIVATE OWNERSHIP

(000 $)

	Base Case	Low Case	Conceptual Design Case
55-10 35 Ownership Option (12.1% Return)			
Total Costs (Current Dollars - 20 year life	1,860,013	1,658,434	2,085,314
Total Levelized Annual Cost	80,520	72,006	91,501
Levelized Cost $/MMBtu	12.20	10.91	13.86
First Year Cost $/MMBtu	11.24	10.15	13.21
75-25 Ownership Option (13.25% Return)			
Total Costs (Current Dollars - 20 year life)	1,900,145	1,695,423	2,134,553
Total Levelized Annual Cost	76,758	68,640	87,060
Levelized Cost $/MMBtu	11.63	10.40	13.19
First Year Cost $/MMBtu	6.68	5.96	7.59