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Executive Summary
Low/Medium BTU Coal Gasification Assessment Program for Potential Users in New Jersey

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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
Fossil Energy

Patent Status

This technical report is being transmitted in advance of DOE patent clearance and no further dissemination or publication shall be made of the report without prior approval of the DOE Patent Counsel.

EXECUTIVE SUMMARY

LOW/MEDIUM BTU COAL GASIFICATION ASSESSMENT PROGRAM FOR POTENTIAL USERS IN NEW JERSEY FOR THE U.S. DEPARTMENT OF ENERGY

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EXECUTIVE SUMMARY

I. INTRODUCTION

In the last several years since the 1973/74 Arab oil embargo and the natural gas shortages that occurred during the winter of 1976/77, there has been an ever increasing concern about the U.S. future natural gas and oil supplies and dependence on imported oil.

Currently, there is surplus of natural gas due to successful conservation efforts, prior conversions from gas to other fuels, and increased exploration resulting from price deregulation. However, this situation is not expected to continue into the distant future. In the middle 1980's, it is projected that natural gas demand may again exceed available supplies nationwide and therefore threaten the economic stability of the Nation.

With the national commitment to reduce oil imports and the occurrence of recent large oil price increases, there has been considerable incentive to investigate the utilization of other available domestic fuel resources. Coal is the most abundant natural fossil fuel in the United States. Its increased use, in an environmentally acceptable manner, is necessary if this Nation is to achieve energy independence.

In order to evaluate the potential for coal utilization, Burns and Roe Industrial Services Corporation (BRISC) and Public Service Electric and Gas Company (PSE&G), supported by Scientific Design Company (SDC), conducted a preliminary technical and economic assessment of district coal gasification in New Jersey. This evaluation addressed the possibility of installing a coal gasification plant to use a high sulfur eastern coal to produce a medium Btu content gas (MBG) having a heating value of approximately 300 Btu/SCF (vs. 1030 Btu/SCF for natural gas). In addition, the work also appraised the regulatory, environmental and marketing, and financial considerations of such a facility.

Tnree (3) options for use of the MBG produced as a fuel gas were examined:

1. Supplemental boiler fuel in existing oil fired power plant boilers at the site.

2. Industrial fuel for customers, delivered through a dedicated supply transmission and distribution system.

3. Blending with natural gas for distribution to customers through the existing gas distribution network.

In all cases, clean coal derived MBG would displace oil and/or natural gas usage.

The study was conducted on the basis of PSE&G ownership and operation of the gasification plant and any associated gas transmission and distribution facilities. The selected site for the gasification installation is PSE&G's Sewaren Generating Station located in Wood-Bridge, New Jersey.

Although some of the information contained in this report is generally applicable to other sites, the majority of the information is directly applicable only to the selected New Jersey plant location.

II. PROJECT DESCRIPTION

The coal gasification project considered in this study involves the gasification of coal to produce a medium Btu gas (MBG) having a heating value of approximately 300 Btu/ SCF. The MBG will be used in a dedicated supply system as a boiler fuel for an electric/gas utility and/or its industrial gas customers as an alternative to oil and natural gas.

The preferred coal feedstock for the study was determined to be a high sulfur (2.5 - 3.5%) eastern coal from western Pennsylvania and northern West Virginia. Such a coal would result in the lowest feedstock cost for a coal gasification project located in New Jersey.

A screening evaluation of available gasification technologies resulted in the selection of the Texaco process as the preferred study technology. The Texaco process is a pressurized, entrained flow process which can utilize a wide variety of coals, including eastern high sulfur caking coals, and has minimal production of undesirable by-products. The Texaco process offers the best combination of advanced design and readiness for commercial application of the various similar processes. Fixed bed processes, such as Lurgi, are not suitable for using eastern coal because of the caking characteristics of the coal.

A number of PSE&G electric generating stations were considered for the gasification plant site. The Sewaren Generating Station was chosen as the preferred site based on its advantages for integrating the gasification plant with the existing generating plant facilities. Also, coal handling facilities exist at Sewaren and are presently unused. There appears to be adequate space available to locate the gasification plant at Sewaren.

Preliminary cost estimates were prepared for plant sizes ranging from 1000 to 2500 tons of coal per day (18 to 45 billion Btu of MBG per day). A 2000 tons/day size was chosen as the preferred size for the study recognizing the investment and operational requirements and optimum economy of scale.

The economic viability of coal gasification for the electric power plant application was evaluated by comparing the capital related and operating costs for the gasification plant with PSE&G's electric system production cost savings resulting from the use of MBG in reducing oil consumption as a boiler fuel. The production cost savings were determined by comparing cases with and without MBG fuel in use at the oil fired Sewaren Generating Station.

The use of MBG for industrial boilers was also investigated. A number of large industrial natural gas customers in the nearby PSE&G gas service territory were interviewed to obtain data on

their current use of natural gas and on their ability to substitute it with MBG. Preliminary evaluation indicates that with appropriate customer equipment modifications and adequate reliability of supply, MBG supplied via a dedicated pipeline system could be a suitable substitute for natural gas.

The environmental effect of installing a coal gasification plant at Sewaren Generating Station was evaluated on a preliminary basis. The impact on air emissions by burning MBG in substitution of oil was also identified.

III. SUMMARY AND CONCLUSIONS

The preliminary study evaluation has manifested an overall technical and economic feasibility for producing a medium Btu quality gas (MBG) from coal at PSE&G's Sewaren Generating Station in New Jersey. The production of MBG for use as a fuel gas for on-site power plant boilers or for distribution to industrial customers appears to be economically attractive. The economic attractiveness of MBG is very dependent on the location of sufficient numbers of industrial customers near the gasification facilities and on high utilization of the gasification plant.

A. Gasification Plant

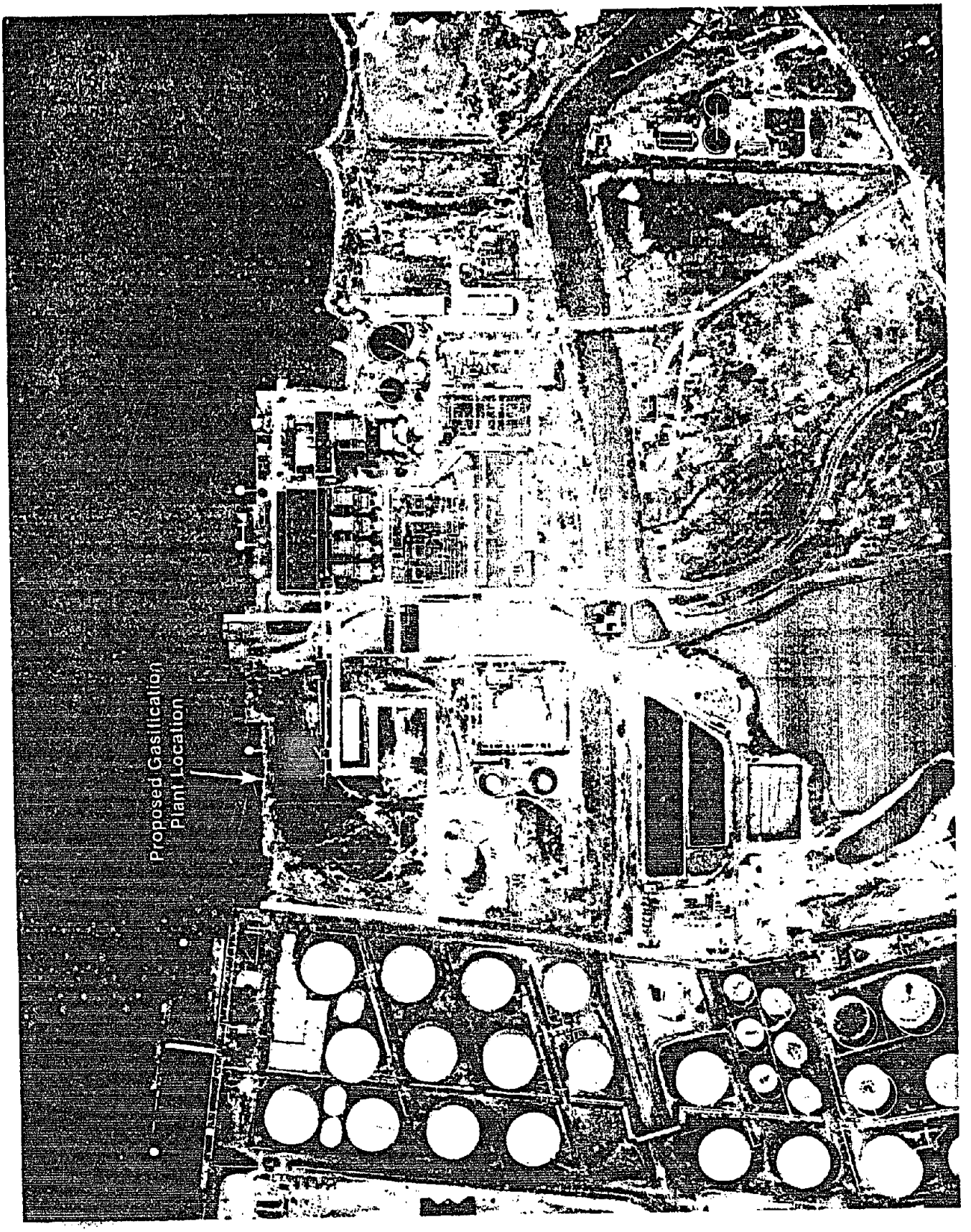
1. The Sewaren Generating Station was identified as potentially the most suitable site for a gasification plant. Selection factors delineated were amendable coal handling equipment, four nominal 100 MW oil fired boilers adaptable to MBG, sufficient available land, and adequate auxiliary provisions such as water, coal receiving, and wastewater treatment. An initial assessment indicates this site is environmentally acceptable and that acquiring all necessary permits may impose no serious problems.

   In addition, potentially receptive industrial customers are located within the PSE&G gas service territory only five miles away. Figure 1 is a photo of the proposed plant site.

2. The Texaco Coal Gasification Process (TCGP) was selected as the gasifier type due to a combination of efficiency and pilot plant experience. Further, it has the advantage of being a pressurized process, capable of supplying the gas without downstream compression which is required if the gas is to be transported to industrial consumers. The TCGP can handle the high sulfur eastern coals chosen as a feedstock. All equipment downstream of the gasifier is commercially proven. For maximum efficiency and flexibility, it would be desirable to consider the integration of the gasification process with a methanol synthesis plant, consuming up to 25% of the MBG produced. Such a combination scheme would allow storage of MBG when its demand is low and thereby increasing the gasifier capacity factor and minimizing its turndown requirements. The overall economic advantages of this scheme, however, have not been fully explored in this study.

   It is projected that a nominal 2000 tons-per-day coal gasification plant used to supply supplemental

FIGURE I



Aerial Photograph of Sewaren Plant with Proposed Site

utility boiler fuel would operate at roughly 80% capacity factor, 70% overall efficiency, and be self-sufficient in plant energy usage via generation of both high and low pressure steam and 1800 kW of internal electrical power.

Besides fuel-grade methanol, the process produces by-product solid sulfur and ammonia from the gas purification steps and unwanted slag/ash to be disposed of offsite. Figure II is a block diagram of the proposed plant.

Preliminary evaluation indicates such an integrated plant could be designed and installed to meet air, water, and solid waste environmental constraints.

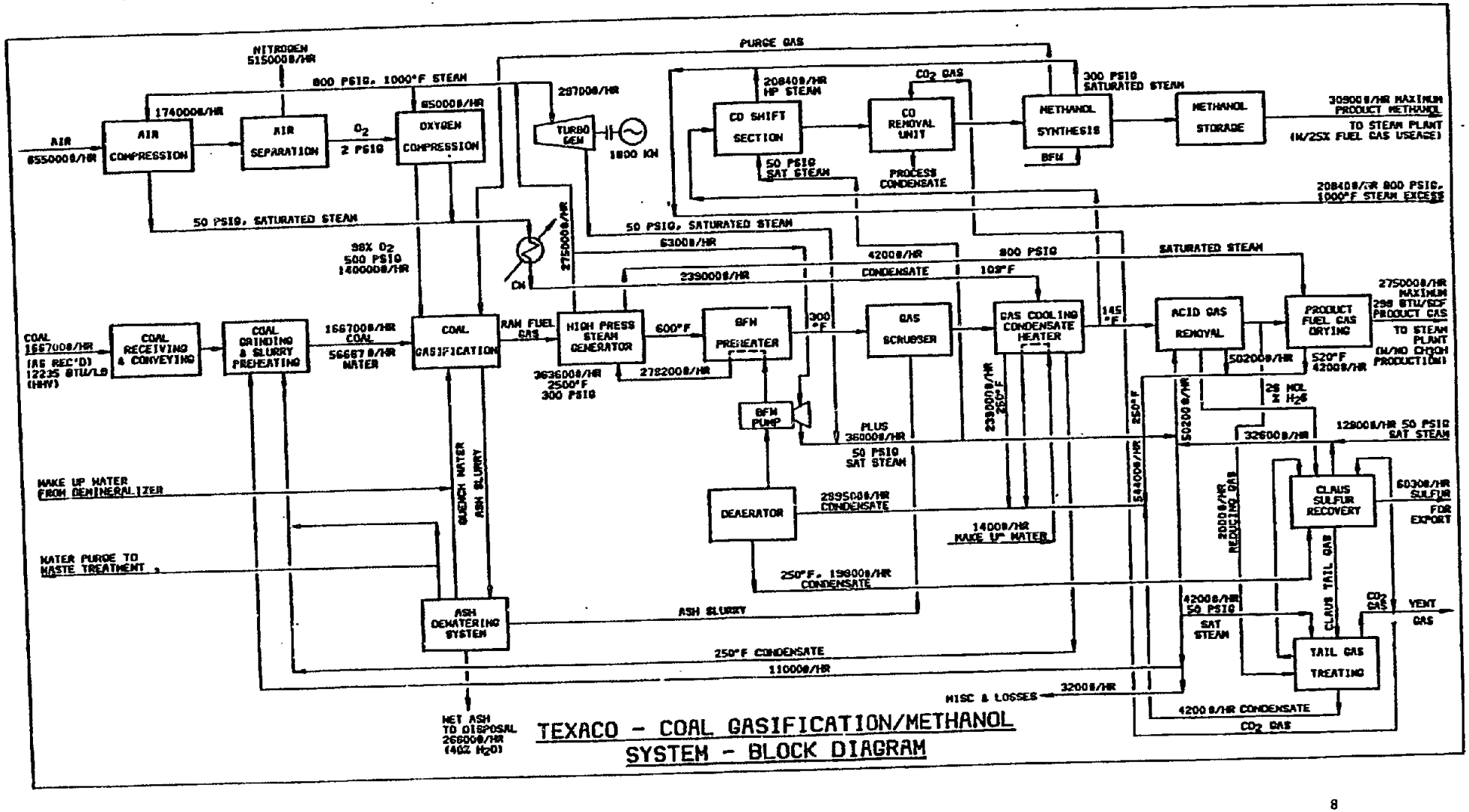
B. MBG Utilization

1. Supplemental Utility Boiler Fuel - Conversion of the four nominal 100-MW oil fired Sewaren boilers to burn a combination of 300 Btu/SCF MBG at 35 psig and fuel oil appears to be feasible. However, no detailed studies were conducted to determine whether and to what extent any boiler derating would occur. A 2000 tons/day coal gasification plant used to supply fuel to the Sewaren boilers would displace approximately 1,260,000 barrels of fuel oil per year.

   In addition to the economic advantages of coal gasification, certain environmental advantages were identified in this study. The SO2 emissions from burning MBG are expected to be considerably less than from burning either coal or oil. Particulate emissions from burning MBG are also less than those from burning coal directly.

2. Natural Gas Substitute - Large potential industrial consumers were identified within the proximity of Sewaren Generating Station inside the PSE&G gas service territory. Some of these customers were interviewed and indicated that MBG would be considered as an alternative fuel providing it was economically justified. The MBG would have to be transmitted and distributed in a dedicated pipeline system to the customers.

FIGURE II


NITROGEN 5150008/HR
800 PSIG, 1000°F STEAM
1740008/HR
AIR 8550008/HR
AIR COMPRESSION
AIR SEPARATION
O2 2 PSIG
650008/HR
OXYGEN COMPRESSION
297008/HR
TURBO GEN
1800 KW
PURGE GAS
208408/HR HP STEAM
CO SHIFT SECTION
50 PSIG SAT STEAM
CO2 GAS
CO REMOVAL UNIT
PROCESS CONDENSATE
300 PSIG SATURATED STEAM
METHANOL SYNTHESIS
BFW
METHANOL STORAGE
309008/HR MAXIMUM PRODUCT METHANOL
TO STEAM PLANT (W/25% FUEL GAS USEAGE)
208408/HR 800 PSIG, 1000°F STEAM EXCESS
50 PSIG, SATURATED STEAM
98% O2 500 PSIG 1400008/HR
2750008/HR
CW
50 PSIG, SATURATED STEAM
63008/HR
42008/HR
800 PSIG
SATURATED STEAM
2390008/HR
CONDENSATE
109°F
2750008/HR MAXIMUM 298 BTU/SCF PRODUCT GAS
TO STEAM PLANT (W/NO OXYGEN PRODUCTION)
COAL 1667008/HR (AS REC'D) 12235 BTU/LB (HHV)
COAL RECEIVING & CONVEYING
COAL GRINDING & SLURRY PREHEATING
1667008/HR COAL
566878/HR WATER
COAL GASIFICATION
RAW FUEL GAS
HIGH PRESS STEAM GENERATOR
3636008/HR 2500°F 300 PSIG
600°F
2782008/HR
BFW PREHEATER
300 °F
GAS SCRUBBER
GAS COOLING CONDENSATE HEATER
145 °F
ACID GAS REMOVAL
PRODUCT FUEL GAS DRYING
502008/HR
520°F 42008/HR
2% MOL % H2S
BFW PUMP
PLUS 380008/HR 50 PSIG SAT STEAM
2390008/HR 250°F
850°F
544008/HR
1280008/HR 50 PSIG SAT STEAM
326008/HR
MAKE UP WATER FROM DEMINERALIZER
QUENCH WATER
ASH SLURRY
DEAERATOR
2895008/HR CONDENSATE
14008/HR MAKE UP WATER
2008/HR REDUCING GAS
CLAUS SULFUR RECOVERY
60308/HR SULFUR FOR EXPORT
WATER PURGE TO WASTE TREATMENT
250°F, 198008/HR CONDENSATE
CLAUS TAIL GAS
42008/HR 50 PSIG SAT STEAM
CO2 GAS
VENT GAS
ASH DEWATERING SYSTEM
ASH SLURRY
TAIL GAS TREATING
250°F CONDENSATE
11008/HR
MISC & LOSSES
3208/HR
4200 8/HR CONDENSATE
CO2 GAS
WET ASH TO DISPOSAL 268008/HR (40% H2O)
TEXACO - COAL GASIFICATION/METHANOL SYSTEM - BLOCK DIAGRAM

3. Natural Gas Blending - Mixing of MBG into the existing natural gas system would be limited to less than 2% based on tariff restrictions which limit the heating content of natural gas to be no less than 1020 Btu/SCF. If the heating value limit were lowered to 980 Btu/SCF, based on the ability of end use equipment to use MBG without modifications, then approximately 6-7% of gasifier output could be mixed with natural gas. Due to such low utilization percentage, the mixing option was not further considered in this project.

C. Economics - MBG As Supplemental Boiler Fuel

The economic viability of a coal gasification plant installed to provide electric utility boiler fuel was judged by a comparison of the total PSE&G electric system production cost savings with a gasification plant to supply supplemental fuel for Sewaren generating units against the capital investment and the operating costs for the gasification plant. Electric system production cost savings were determined, using PSE&G's production cost simulation program, by comparing two simulations: one in which the Sewaren units use only oil fuel, and the other in which the Sewaren units use a combination of MBG and oil fuels. The resulting Sewaren electric output is different in these two cases because of cost differentials between oil and the manufactured MBG. The difference in total system production costs between the two simulations represents the savings attributable to the less expensive MBG/oil fuel mix versus all oil fuel at Sewaren.

The 1980 capital cost estimates for a 2000 ton/day and a 1000 ton/day gasification plant along with support facilities, such as new coal conveyers, existing coal handling rehabilitation, piping, piles, access road, electrical feeders, ash storage bins and demineralizer system are as follows:

Cost Elements	Plant Size Tons/Day	
	2000	1000
	$x1000	$x1000
Gasification Plant	96,000	60,000
Support Facilities	4,530	4,130
Contingency @ 15%	15,070	9,600
	115,600	73,730
1987 Cost to Build	174,000	111,000

A capital cost estimate of approximately $10/kW of electric capacity, based on published industry information, was used for the boiler retrofit cost at Sewaren. This represents a 1987 investment of $4,000,000 which was included in the economic analysis.

An estimate of the manpower requirements for a 1000 ton/day plant is 73 personnel and for a 2000 ton/day plant is 81 personnel. This estimate was based on 24 hours, 7 days, and 365 days per year operation.

Coal gasification appears to be a viable economic alternative to oil as a fuel source for electric generation. Table I shows the base case economics for both a 1000 ton/day and a 2000 ton/day facility to be installed in 1987 and retired by 2000 when it is expected that the Sewaren boilers will be retired. The table shows that there are significant cost savings attainable if MBG from coal is used to supplement the oil presently used to fuel the Sewaren 1-4 generating units.

D. Sensitivity Analysis - MBG As Supplemental Boiler Fuel

A number of scenarios were analyzed to investigate the sensitivity of the economic results to key coal gasification parameters. The parameters investigated were:

- o must-run operation of Sewaren generating units
- o coal cost escalation rate
- o gasifier efficiency
- o gasifier availability
- o gasifier capital cost
- o boiler derating when burning MBG
- o extended life of Sewaren generating units

These sensitivity cases were based on a 2000 ton/day coal gasification plant, since the base cases showed this to be the more economical plant size. A summary of

Table I

District Coal Gasification Study
Texaco Gasifier at Sewaren Generating Station
1987-2000 Levelized Annual Costs
Present Worthed to 1980

Base Cases

Gasifier Size	1000 Ton/day	2000 Ton/day
Number of Gasification Trains	1-1000 TPD	3-1000 TPD
Net Plant Availability	90%	98.5%
Net Plant Efficiency	70%	70%
Capital Costs - $1000		
Gasification Plant		
Installed Cost - 1987	111,000	174,000
Construction Compound Interest Factor	1.165	1.165
Carrying Charge Rate	.152	.152
Present Worth Factor	.4499	.4499
Annual Cost - 1980	8,840	13,860
Sewaren Boiler Retrofit		
Installed Cost - 1987	4,000	4,000
Construction Compound Interest Factor	1.080	1.080
Carrying Charge Rate	.187	.187
Present Worth Factor	.4499	.4499
Annual Cost - 1980	360	360
Total Annualized Capital Cost	9,200	14,220
Gasification Plant Operating Cost - $1,000		
Fuel	11,390	25,170
Labor	2,360	3,200
Material	1,430	2,240
Total Annual Operating Cost	15,180	30,610
Total Annual Project Cost - $1000	24,380	44,830
Project Credits - $1000		
Electric System Production Cost Savings	25,250	59,160
By-product Sulfur Credit	0	0
By-product Ammonia Credit	0	0
Total Annual Credits	25,250	59,160
Net Annual Project Savings - $1000	870	14,330

the results, indicating the impact on the net levelized projected savings, is shown in Table II.

Economy-of-scale is the most important factor affecting the economic viability of coal gasification as indicated in Table I. Other factors that significantly affect economic attractiveness of MBG are the relative escalation of coal and oil prices, the impact of using MBG on the boiler rating and the useful life of the gasification plant.

E. Economics - MBG For District Supplies

The economic viability of a coal gasification plant installed to produce MBG for distribution to industrial customers in a nearby district was evaluated by comparing the costs to PSE&G to produce and deliver coal derived MBG to customers versus the projected costs to PSE&G of conventional natural gas supplies. In order to deliver MBG in a dedicated pipeline system, it is estimated, very roughly and conservatively, that a 1987 cost of $30,000,000 would be required for new transmission and distribution facilities.

A market analysis of large volume gas customers identified two clusters of potential MBG users in the Sewaren area. One cluster, in Edison, has a combined peak load of 200 x 10^6 Btu/hour. The other cluster, in New Brunswick, has a combined peak load of 285 x 10^6 Btu/hour. These peak loads are based on cumulative demands of the customers and are not adjusted for any load diversity which may exist among them. The peak output of a 2000 ton/day gasifier, using 13,000 Btu/ton coal and having a 70% net conversion efficiency, is approximately 1500 x 10^6 Btu/hour of MBG. Although the market survey did not identify sufficient customers to utilize the full output of a 2000 ton/day gasifier, a more detailed evaluation could potentially identify such additional customers. This analysis assumes that sufficient customers could be identified to utilize the full output of the gasifier if the entire MBG is to be used for industrial boilers only.

The levelized cost of MBG (1987-2009) ranged from a $4.81/$10^6$ Btu for a gasifier capacity of 80% to $8.00/$10^6$ Btu for a gasifier capacity factor of 30% as shown in Figure III.

TABLE II

District Coal Gasification Study
2000 TPD Texaco Gasifier at Sewaren Generating Station
1987 - End of Life Levelized Annual Costs
Present Worthed to 1980

Summary of Sensitivity Analysis

Scenario	Base Case	Sensitivity Cases						
Sensitivity Parameter Values		1	2	3	4	5	6	7
1. Generating Unit Dispatch	Unrestricted Economic	Must-Run	Unrestricted Economic	Unrestricted Economic	Unrestricted Economic	Unrestricted Economic	Unrestricted Economic	Unrestricted Economic
2. Coal Price Escalation - High Sulfur	5.6%/Year	5.6%/Year	7.3%/Year	5.6%/Year	5.6%/Year	5.6%/Year	5.6%/Year	5.6%/Year
Low Sulfur	5.3%/Year	5.3%/Year	7.0%/Year	5.3%/Year	5.3%/Year	5.3%/Year	5.3%/Year	5.3%/Year
3. Gasifier Efficiency	70%	70%	70%	75%	70%	70%	70%	70%
4. Gasifier Availability	98.5%	98.5%	98.5%	98.5%	90%	98.5%	98.5%	98.5%
5. Gasifier Capital Cost - 1987 $1000	174,000	174,000	174,000	174,000	174,000	217,500	174,000	174,000
6. Boiler Derating	0%	0%	0%	0%	0%	0%	15%	0%
7. Generating Unit Retirement Date	2000	2000	2000	2000	2000	2000	2000	2009
Annualized Capital Costs - $1000	14,220	14,220	14,220	14,220	14,220	17,680	14,220	12,400
Gasification Plant Annual Operating Costs - $1000	30,610	33,110	45,620	30,610	28,470	31,170	30,610	34,740
Total Annual Project Costs - $1000	44,830	47,330	59,840	44,830	42,690	48,850	44,830	47,140
Total Annual Project Credits - $1000	59,160	60,380	61,140	63,970	54,120	59,160	48,860	69,610
Net Annual Project Savings (Penalty) - $1000	14,330	13,050	1,300	19,140	11,430	10,310	4,030	22,470

FIGURE III

Economic Analysis of Coal Gasification
For Industrial Sales
2000 TPD Gasifier At Sewaren Generating Station
Levelized Annual 1987-2009 Costs
Present Worthed to 1980

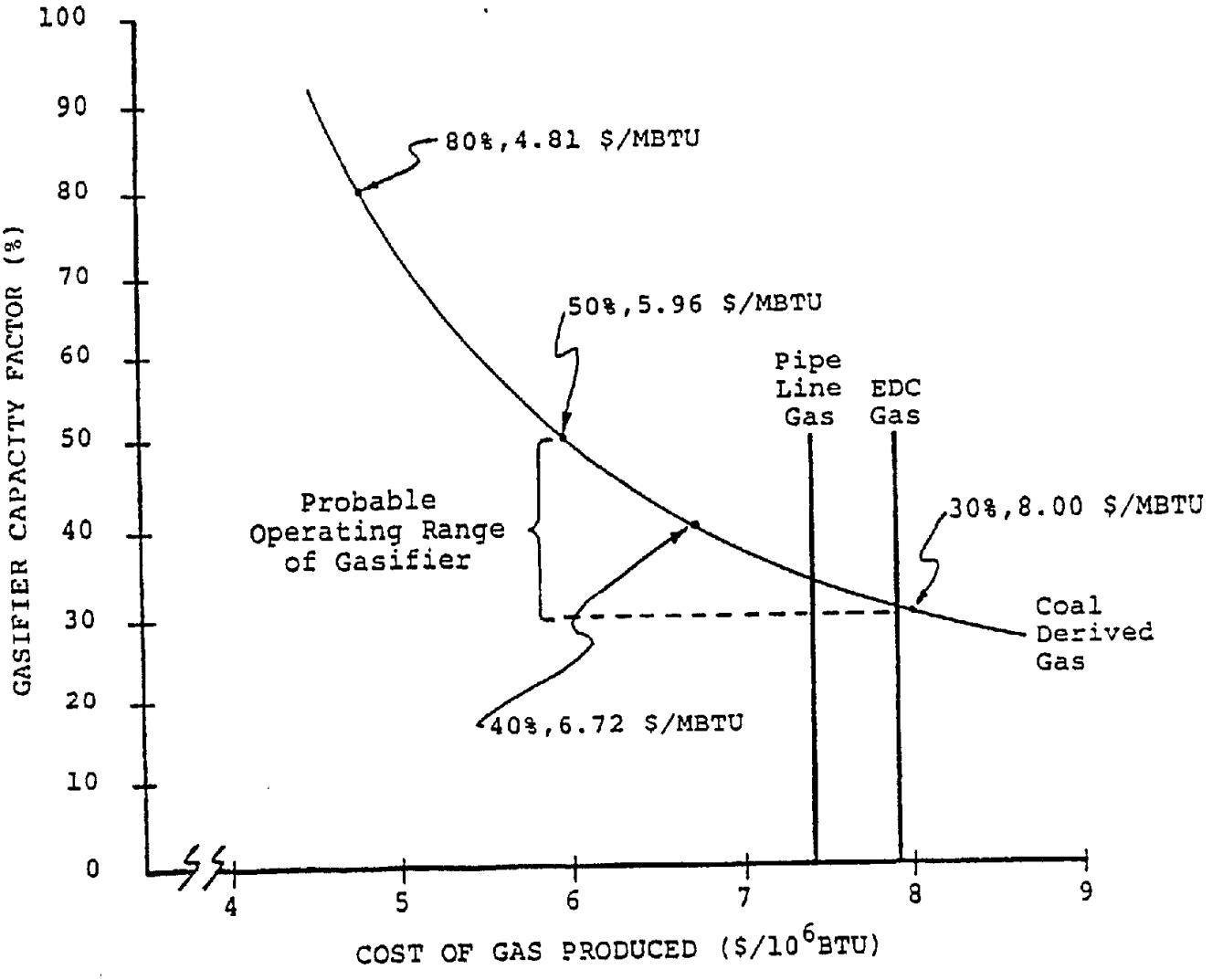


Figure III also indicates the projected costs of existing pipeline companies' supplies and new natural gas supplies developed by PSE&G's Energy Development Corporation subsidiary. The figure shows that MBG is competitive with existing pipeline gas at gasifier capacity factors above 35%. MBG is competitive with gas from new supplies at gasifier capacity factors above 30%.

In this analysis, the cost of customer equipment conversions to adapt to MBG is not included. However, at the higher capacity factors, there appears to be sufficient levelized differential between the calculated cost of MBG and the projected cost of future natural gas supplies to accommodate any reasonable customer modification costs. Although a detailed analysis of customer load factors was not done for this study, a brief review of customer gas billing records shows that a typical industrial customer load factor may be between 35 to 50%.

Since the levelized cost of MBG is expected to be competitive with that of natural gas supplies, the establishment of an MBG rate structure compatible with natural gas tariff does not apear to be a major problem.

IV. FUTURE DIRECTION

With the national emphasis on converting oil fueled electric generating stations to utilize coal, the installation of a medium-Btu coal gasifier at such generating plants to provide a supplemental fuel supply to replace oil represents one viable approach of utilizing coal. Preliminary evaluation indicates that the MBG concept to provide coal-derived fuel is economically competitive and environmentally acceptable. A gasifier also possesses the unique advantage of its "standing alone" feature and can be decoupled with any existing power plant boilers and reconnected to a new power plant, either of single cycle or combined cycle, in the future if so required. Further in-depth assessment appears justified to ascertain the technical feasibility and economic viability of installing a medium-Btu gasification plant at Sewaren Generation Station to provide supplemental boiler fuel. If successful, such applications can be adopted by many utility systems.

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