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EXECUTIVE SUMMARY

PHILADELPHIA GAS WORKS

MEDIUM-BTU COAL GASIFICATION PROJECT

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1.0 INTRODUCTION

This report is the final item submitted to the United States Department of Energy in fulfillment of the requirements of DOE Grant Number DE-FG01-80 RA50371. The objective of this effort was to conduct a definitive design and cost estimate for a medium-Btu coal gasification facility to supply fuel gas to Philadelphia industry.

Upon the accomplishment of that goal, a commercialization plan was then developed that would enable Philadelphia Gas Works (PGW) to make a decision to proceed with detail design and plant construction.

The final report for this project has been produced in six divisions for the convenience of the reader and for selective distribution to parties with specific areas of interest.

The report divisions are listed as follows:

- Executive Summary,
- Plant Design,
- Capital and Operating Cost Estimate,
- Environmental Assessment,
- Financial/Legal Analysis, and
- Project Implementation

1.1 PROJECT BACKGROUND

The Philadelphia Gas Works (PGW), a municipally owned gas utility, distributes gas for residential, commercial, and industrial uses to 540,000 customers within the limits of the City of Philadelphia.

Philadelphia Gas Works has experienced difficulties in securing a sufficient supply of natural gas to meet the requirements of all who would prefer to use this fuel. Restrictions have had to be placed

on the acceptance of new industrial customers. This inability to project a reliable, sufficient, and moderately priced supply of natural gas for the future contributed to Philadelphia's difficulties in retaining the present industrial base as well as attracting new companies to the area.

A primary driving force behind the development of an acceptable industrial alternative fuel has been the belief in the continuing uncertainty of supply, as well as increasing price escalation in the future for natural gas and fuel oil. As a result of PGW's initial discussions with its identifiable industrial market, PGW was able to verify that industry in general shares in PGW's somewhat bleak assessment of energy economics in the future.

There are several domestic and international factors which appear to support the validity of the increasing "real" price of oil through 1990. Although the current foreign and domestic oil markets are soft, this condition is undoubtedly temporary. One factor placing upward pressure on oil prices domestically is the deregulation of crude prices. Deregulation has served to push the price of domestic crude oil toward parity with the price of the equivalent imported crude. A second factor which effects the foreign oil prices is the value of the U.S. dollar in international markets. Presently, the dollar enjoys a relatively strong position in the international market. If this position should weaken, it would place upward pressure on the price of oil. A third factor contributing to the escalation of the price of oil is the expected revitalization of the U.S. and European economies within the next few years.

In view of the potentially serious impact that the lack of a reliable competitive energy supply will have on the City of Philadelphia, PGW embarked on a search to develop alternate sources of fuel for industry within the city.

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

An assessment of a central coal gasification plant was initiated in November 1979 by PGW under a grant provided by the Department of Energy through NPI RA-21. The objective of that study was to assess the technical and economic feasibility of producing, distributing, selling, and using coal gas for industrial applications in Philadelphia.

The study, which was completed in October 1980, served as the basis for the PGW Coal Gasification Project. It resulted in the identification of: (a) users of the gas, (b) selection of a commercially proven gasification process, (c) a conceptual system design and cost estimate, and (d) a financial analysis. The specific tasks and their results are summarized on Table 1-1.

As a result of the Conceptual Design and Feasibility Study (Phase I), PGW determined that the Coal Gasification Project could serve as a point of industrial growth and stability in Philadelphia. PGW looked upon this project as being capable of making a significant contribution to the energy supply of Philadelphia and entered into Phase II of the project (Definitive Design Stage).

TABLE 1-1

REVIEW OF PHASE 1

o Market Analysis	Contacted 160 users throughout the city. Resulted in design basis concentrating on major users along Delaware River.
o Define Transmission Options	Computer analysis of various distribution systems demonstrated feasibility of isolated systems for transmission of low/medium-Btu gas. A segregated system dedicated to industrial customers will ensure protection from interruption by residential market.
o Site Selection	Reviewed suitability of 16 sites throughout the city. Concluded that three sites on Delaware River are most suitable.
o Process Selection and Conceptual Design	Evaluated six different coal gasification processes. Selected the Koppers-Totzek for conceptuaal design for plant to produce 20 billion Btu per day of medium-Btu gas.
o Retrofit Assessment	Evaluated the feasibility of producing LBG versus MBG. Concluded that LBG is feasible for larger users with some derating, but MGB is most suitable for distribution to variety of users. Customer could take advantage of retrofit tax credits.
o Financial Analysis	Conducted detailed financial analysis for municipal and private ownership scenarios. Concluded that MGB is competive with No. 6 fuel oil.

1.2 PROJECT OBJECTIVES

The specific objectives of this project are as follows:

a. Review of Phase I Conceptual Design by reviewing the perceived market and fuel requirements, the identified site, the availability of suitable coal, and the overall gasification process.

b. Establish a definitive design for the coal gasification facility to a level of detail that major equipment is specified and supporting systems are designed.

c. Prepare a definitive cost estimate for the plant and associated operating costs.

d. Prepare an engineering/construction schedule for the project.

e. Perform a gas cost analysis based upon mid-project economics that will provide a cost of gas to be used in preliminary supply contract discussions with users of the gas.

f. Perform an assessment of the environmental impact resulting from plant construction and operation.

g. Perform a detailed financial/risk analysis to determine the most appropriate ownership/operating scenario for the project; to be used as a basis for the PGW Commercialization Plan.

The project, in addition to providing a definitive design and cost estimate, was aimed at meeting the objectives of the Philadelphia Gas Works. The PGW objectives are listed on Table 1-2.

TABLE 1-2

OBJECTIVES OF THE PHILADELPHIA GAS WORKS

The major objective of the Philadelphia Gas Works is to provide a reliable and competitive energy source in the City of Philadelphia by means of a medium-Btu gas coal gasification production and distibution system that will:

- Be operational in 1985.
- Provide energy for existing companies and maintain existing jobs within the City of Philadelphia.
- Provide energy for new companies and develop new jobs within the City of Philadelphia.
- Use a wide range of eastern bituminous coals.
- Provide a fuel that can subsitute for natural gas, oil, or coal in existing boilers and process equipment.
- Be environmentally acceptable.
- Have wide application leading to use by other gas utility companies throughout the United States.

2.0 DEFINITIVE DESIGN

The primary objective of this work was to develop a definitive design and cost estimate for the gasification system selected for conceptual design. The level of detail in this phase reflects the application of approximately 10 to 15 percent of the engineering for the project.

The objectives of this phase were accomplished by first establishing process criteria for the design. In transition from conceptual to definitive design, process suppliers in areas such as gasification and desulfurization were requested to supply coal- and product gas-specific heat and material balances. The net result was a process description with process flow drawings to be used as the basis for design.

The definitive design entails developing a list of equipment, preparing specifications for the major items, and evaluating the quotations received from vendors in sufficient detail to select the best offerings for estimating purposes. The cost estimate and the design then serves as the basis for the decision to enter into the detail plant design and construction phases.

2.1 REVIEW OF PHASE I

2.1.1 Market and Fuel Use Considerations

The three major energy users that were identified in Phase I were contacted individually to review Phase I and to discuss the competitive position of MBG with alternative fuels.

Each of these companies was given a copy of the Phase I Draft Report and meetings were held with each on separate days during the week of November 17, 1980. The pertinent information discussed at these meetings was a review of the Phase I effort and the resultant

economic analysis. Fuel price comparisons for Philadelphia were developed in current dollars and were compared with the projected costs for MBG. The gas users were advised of the effort involved in Phase II of the Project and that PGW intends to develop a negotiable cost figure for MBG by August 1981. The users were requested to indicate their interest and to provide further information with respect to load characteristics and future requirements.

Results of these meetings are summarized as follows:

- Rohm & Haas - Indicated that they are evaluating several options, one of which is MBG. They are the only company of the three that can economically consider conversion to direct firing of coal. They agreed to maintain interest in the MBG alternative as requested, and would advise immediately if it were removed from consideration.

- Allied Chemical - Indicated that direct firing of coal was still an option but it did not appear viable. Other offerers of fuel gas from coal had been notified by Allied that they were not being considered in deference to PGW. Allied agreed to maintain interest and would provide load information as requested.

- National Sugar - Stated that the results of PGW's coal gasification study would be evaluated in comparison with National's future alternatives. They did not consider direct firing of coal to be an alternate because of the large capital costs. They also agreed to maintain interest and would provide load information as requested.

A further penetration of the MBG market in Philadelphia was conducted by exploring the interest of the following companies and agency:

a. Publicker Industries,
b. Amstar Sugar,
c. Philadelphia Navy Yard, and
d. Newman & Company.

As with the three major users, copies of the Phase I Draft Report were distributed to each and a single meeting was held with each group represented. The results of that meeting indicated that insufficient interest in MBG exists to warrant distribution south of National Sugar. Newman & Company expressed considerable interest and was included as a point of distribution for the project.

Conclusions reached from the user analysis in these Subtasks are:

a. Interest expressed by the three major users and Newman was sufficient for the basis of a distribution system.

b. The total connected load of these users is approximately 20 billion Btu per day.

c. The number of gasifiers required to supply these customers is in excess of one, and considerably less than three. Therefore, the plant design will be based on two GKT gasifiers.

d. Each user will be expected to maintain a dual fuel burner capability, probably using No. 6 fuel oil as the backup.

2.1.2 Site Considerations

The conceptual design of Phase I identified the former gasifier site of PGW as the site for definitive design. This selection was made

after determining the feasibility of locating the plant at various sites within the city and along the Delaware River. Early in Phase II, the PGW site was precluded from consideration as a plant site in view of its potential use for future peak shaving facilities by PGW. It became necessary to identify and evaluate alternate sites for the gasification plant.

The following alternate sites were identified:

Eastern Gas	Not acceptable on the basis that siting would require purchase and demolition of the Philadelphia Coke Works.
Kerr-McGee	No longer available.
Northern Metals	No longer available.
Riverside	This site was the second choice in the conceptual study. At the time of Phase II evaluation, ownership and availability was not clear, which necessitated review of additional sites.
Port Richmond Coal Terminal	Two parcels of land available from Conrail on a long-term basis. Suitability of one parcel was determined.

2.1.2.1 Selection of the Riverside Site

The site is located in the northeast section of Philadelphia, east of Richmond Street and between Dyott and Cumberland Streets. The location has direct Delaware River frontage with a shipping berth on the eastern side of the site.

The site is located adjacent to the Conrail's Port Richmond rail yard. As a result, the site will have easy access to existing rail lines.

Based on the required facility configuration and the area requirements for the major process units, the site appears to be feasible. From a preliminary layout viewpoint, the site allows sufficient area for plant roads, conveyor systems, drainage ditches, pipe racks, and cable trays.

The owners of the Riverside Site were contacted to enter into negotiations for a one year option to purchase the site. In view of the limited availability of alternate sites for this project, the definitive design proceeded under the assumption that the Riverside Site is available.

2.1.3 Process Selection

The process selection criteria for this project was based upon the requirement to use commercially proven processes. The commercial viability of this plant required that the level of technological risk identified with the process be minimal. Therefore, it was imperative that the processes making up the complete system be selected from those which are commercially proven and are guaranteed by a process supplier.

2.1.3.1 Gasification System

The Koppers-Totzek (KT) Entrained Bed gasification process was selected and Gesellschaft for Kohle-Technologie mbH (GKT) of West Germany is supplying process information. Since the start-up of the first KT plant in 1951, more than 50 gasifiers have been delivered to 14 different clients to produce synthesis gas, primarily for ammonia production. The daily ammonia capacity of KT plants in operation is in the range of 4,000 ton per day, which represents more than 90 percent of the world's coal-based ammonia production.

By experience gained in actual operation, the commercial capability of the KT process has been proven. A range of feedstocks can be gasified, from lignite to anthracite as well as petroleum coke, charcoal, tars, and heavy residues.

Feedstocks of high ash and/or sulfur content, which are not acceptable for conventional processes because of technical or environmental aspects, can be easily utilized by the KT process. Unlike fixed bed and fluidized bed processes, no limitation regarding size distribution exists with the KT process, and the entire mine output can be utilized. In general, critical design considerations with respect to ash or coking properties of the coal are not existent.

2.1.3.2 Desulfurization System

Other processes selected for this plant were also judged on proven commercial background. The most pertinent of these is the desulfurization plant, for which the Stretford process was selected.

The Stretford process uses reliable, rugged, simple technology for almost total removal of H_2S from gas streams. There are 31 successful Stretford units operating around the world. These involve a variety of applications: town-gas, coal gas, SNG, coke-oven gas, and natural processing.

This proprietary process has been developed by W. C. Homes & Co. Ltd., England, a part of Peabody Galion Corporation of New York. This process is now available for wider use in the U.S. with four installations already operating sucessfully in St. Louis, Honolulu, Ontario, and York, Pennsylvania. The sulfur tonnage handled by individual Stretford plants has grown over the past 14 years from 200 pounds per day to a capability of 30 long tons per day in a single-train. PGW also is using the Stretford process for desulfurization of gas produced in its 60 MMCFD synthetic gas plant.

2.1.3.3 Reliability Factors

Reliability and on-stream factors were considered in completion of the plant design. The plant will be operated as a baseload facility with a 50 percent turndown capability on weekends and a two or three week scheduled shutdown per year. It is anticpated that routine maintenance will be scheduled on dual train equipment for weekends. The stream factor of all equipment in this plant is rated above 90 percent. This is either guaranteed by the process supplier or is reflected in the design specifications.

2.2 FEEDSTOCK SUPPLY/BYPRODUCT DISPOSAL

2.2.1 Coal Supply

In Phase I, a typical Pittsburgh No. 8 coal was used as the base coal in conceptual design. The base coal was only generic in that it was not identified with any specific coal suppliers and, as a consequence, some key data such as coal costs, availability, etc. were not firmly established.

In Phase II, a search for a design coal with identifiable coal suppliers was conducted to rectify these uncertainties.

The coal search was initiated by developing a design coal specification, followed by prescreeening of coal companies in the five-state area, including Pennsylvania, West Virginia, Ohio, Kentucky, and Maryland. Letters of solicitation for coal data/information were sent to 15 potential coal suppliers, five of which responded. The coal data, as provided by the coal companies, were than analyzed and compared, and the impacts on the plant performance plant economics evaluated. A detailed description of the coal search and a summary of the evaluation is presented in Appendix A of the Plant Design volume.

The results of the initial evaluation showed that coal supplied by C&K is the preferred design coal in that it has the advantage of yielding relative potential savings compared to an average cost for Pittsburgh No. 8. It also has the advantage of abundant coal reserves and large production rate to meet the PGW gasification plant requirements.

In order to procede with the definitive design in a timely manner, the heat and material balances for the gasification process were based upon the analysis of Pittsburgh No. 8 which is very similar to the analysis of C&K and several other coals under evaluation. The supplier of the gasification process indicated that these similar coals would all produce essentially the same balances at this level of analysis, and that precise performance guarantees could not be determined without full commercial testing of the specific design coal.

2.2.2 Ash Disposal

In Phase I, the conceptual design and economics generally considered ash and sulfur as disposable byproducts. In Phase II, definitive outlets for these items were investigated.

The GKT Gasifier Produces Ash in Two Forms:

a. Fly Ash From the Gas Clean-up Stream - This is in the form of a filter cake containing 50 percent water. The material is non- hazardous by virtue of high temperature oxidation and is suitable for landfill. It also contains 50 percent carbon (dry basis) giving it a heating value equivalent to a low grade coal. Disposal options for this ash would include offsite fuel application such as power plants or incinerators. Fifty percent of this ash will be recycled with the feed coal, thereby increasing carbon conversion efficiency and reducing the volume of ash to be disposed.

b. Fused Ash In The Form Of Quenched Slag - This material has the consistency of coarse, wet sand. It is totally non-leaching and has definite applications for aggregate or for use by highway departments for ice control.

Various methods of disposal of both ash and slag were examined. Both public and private landfill sites were evaluated in addition to the above-considered options.

In view of the uncertainty of alternate options for disposal of ash, the definitive design and economics were based upon contractual hauling of ash to approved landfills. Letters from landfill operators indicating their acceptance of the ash are included in the Environmental Assessment.

2.2.3 Sulfur Disposal

The Stretford Process produces pure sulfur that can be removed in the form of a filter cake or in a pure molten form.

In Phase I, the filter cake option was considered because of the low volume (30 tons per day) and non-hazardous characteristics of the cake made landfill a viable option.

Further discussions in Phase II with Stretford licensors indicated that it is not feasible to dispose of filter cake. The filter cake consists of sulfur and other process chemicals including sodium thiosulfate, sodium thiocyanate, sodium metavanadate, ADA, and sodium carbonate-bicarbonate. Environmental problems could result because the filter cake would probably be designated as a hazardous material and would require the expense of disposal in a licensed hazardous waste disposal area. Because of this, the basis for definitive design was to produce molten sulfur and to use a zero discharge incinerating technique for the purge solutions.

The molten sulfur can then be either sold as a feedstock for sulfuric acid or landfilled. The sulfur disposal plan that was developed is described in detail in Appendix C of the Design Section. It is based upon a viable market for pure sulfur which is currently allowing $125 per ton.

3.0 PLANT DESIGN

3.1 DESIGN BASIS

The underlying philosophy behind the project is to design a coal gasification plant in Philadelphia using state-of-the-art pollution control technology and process equipment for producing a medium-Btu gas which can be both produced by the facility and burned by industrial users in an environmentally acceptable manner. The coal gas will replace 198,388 gpd of No. 6 fuel oil or 20.6 x 10^6 cfd of natural gas which the industries would otherwise use as fuel. Specific features of the project are listed as follows:

Type of Plant: Coal gasification plant producing medium-Btu gas for industrial users.

Plant Site: City of Philadelphia on the Delaware River at the Riverside site located between the Benjamin Franklin and Betsy Ross Bridges.

Plant Size: Two gasifiers with a capacity of producing 20.58 x 10^9 Btu/day of medium-Btu gas.

Coal Feed: 1,128 tpd (329,000 tpy) of western Pennsylvania bituminous coal.

Coal Storage: Live storage; 6,000 tons. Dead storage; 60,000 tons.

Gasification Process: GKT gasification process provided by Krupp/Koppers.

Sulfur Removal and Recovery: Stretford plant designed to remove 90 percent of sulfur from the product gas which contains 2.64 percent sulfur by weight (dry basis) based on burning Pittsburgh No. 8 coal. Twenty-seven and two-tenths tons per day of

99.9 percent pure elemental sulfur will be produced, with recovered sulfur being sold to the highest bidder.

Make-up Water Supply: Potable water (11,000 gpd) is to be supplied from the City of Philadelphia Water Department. Plant water requirements (1,396,000 gpd) are supplied directly from the Delaware River.

Wastewater Disposal: Sanitary wastewater (11,000 gpd) discharged to the City of Philadelphia Sanitary System; cooling water blowdown, water treatment wastes, and treated coal pile runoff (360,000 gpd) discharged into the Delaware River. Twenty-six percent of the water removed from the river will be returned to the river at the facility.

Solid Waste Disposal: Non-hazardous fly ash from gas scrubbing (202 tpd) and slag from gasifier bottoms (48 tpd) picked up at the plant gate by a contracted hauler and transported to a licensed landfill. The volume of solid waste produced will be 347 cubic yards per day.

Health and Safety: A health safety program for worker protection includes monitors and alarms for H_2S, CO, H_2, dust, polynuclear aromatic hydrocarbons, and organic compounds. Almost instantaneous shutdown of the gasifier is possible in the event of an emergency such as loss of the coal feed system or a change in oxygen pressure.

Dust Control: Dust control and filters, sprays, and enclosed structures used to control dust during storage and handling of coal, ash, and slag.

Noise: Enclosed buildings, accoustical shrouding, and insulation specified at major sources of noise such as at the coal unloading area and coal crushers.

3.2 PROCESS DESCRIPTION

A block diagram of the gasification process is shown on Figure 3-1. The plant will process 1,128 tons per day of a high sulfur bituminous coal to produce 20.58 billion Btu per day of fuel gas. The gas will have a higher heating value of 290 Btu per standard cubic foot.

3.2.1 Coal Handling and Storage

Sized coal (2 inches by 0 inches) is delivered by a unit train via an in-plant track to the coal gasification plant. Thaw sheds are provided to prevent freezing of moisture in the incoming coal in the winter. The coal is unloaded via a car shaker to an underground hopper. From the hopper, a belt conveyor conveys the coal via a transfer tower to the storage area which is sized for a 60 day supply of coal, or 66,000 tons. To minimize air pollution because of coal dust, the bulk of the coal is placed in "dead storage," where the coal is held in a compacted and sealed pile. Under this arrangement, coal from "dead storage" is taken only in an emergency when the normal supply of coal is interrupted.

Coal is fed via a variable speed feeder into roller mills where it is dried to two percent moisture by a circulating stream of hot flue gas. Coal dust (90 percent minus 200 mesh) is removed by cyclones and fed to the pulverized coal bunker. The dried pulverized coal is pneumatically conveyed with nitrogen to the service bunkers where it is dropped into feed bins serving the feed screws to the gasifier.

3.2.2 Gasifiers

Pulverized coal is fed by four screw feeders into blowpipes. An oxygen/steam mixture is introduced at the end of the screw feeders and conveys the coal at high velocity through the blowpipes into the gasifier, where the mixture ignites, and the partial oxidation

reaction takes place. The gasifiers operate at slightly above atmospheric pressure. The flame zone temperature is in the region of 3,500°F. However, endothermic reactions between the carbon and steam reduce the gasifier temperature to around 2,700°F. The ash in the coal melts and 50 percent of it flows downward as molten slag into a quench tank. The remaining ash along with the uncoverted carbon (five percent of total carbon) passes up with the gas through a top outlet, where quench water is injected to reduce the temperature to 2,300°F, causing the ash to resolidify. The rapid cooling of the quench tank produces a granule somewhat below one-quarter inch in size.

Gas leaving the gasifier enters a waste heat boiler where saturated high pressure steam is produced for in-plant use. The gas leaving the waste heat boiler at about 350°F passes through a cluster of cyclones to remove heavy particulates. The gas then enters a washer/cooler where the gas temperature is reduced to about 170°F. Subsequent cleaning is accomplished in two Theisen disintegrators arranged in series.

The overflow from the slag quench tank and the cooling water streams from the gas clean-up unit is taken to a clarifier for solids removal. The slurry from the clarifier is vacuum filtered to produce a fly ash cake containing 50 percent water. 50 percent of this cake is recycled with the incoming coal, serving to reduce the volume of ash for disposal and to increase the carbon conversion efficiency of the process.

3.2.3 Desulfurization

After being compressed to 4.5 psig, the crude gas enters the hydrogen sulfide (H_2S) absorber where nearly all the H_2S is removed (but all the COS is passed through).

Since nearly all the H_2S in the gas is removed, which accounts for 90 percent of the total sulfur in the crude gas, the final fuel gas would contain 0.04 mole percent sulfur and will meet the environmental standard when burned.

The Stretford process will produce 27 tons per day of pure molten sulfur. This will be marketed for sulfuric acid manufacture.

3.2.4 Air Separation Plant (98 Percent O_2)

The oxygen requirement for the plant is 1,137 tons per day. The oxygen compressors are driven by a combination of electric motor and steam turbine. Sixty-five percent of the compressor power is supplied by steam and the motor is capable of supplying 50 percent of the power requirement.

3.2.5 Gas Compression Unit

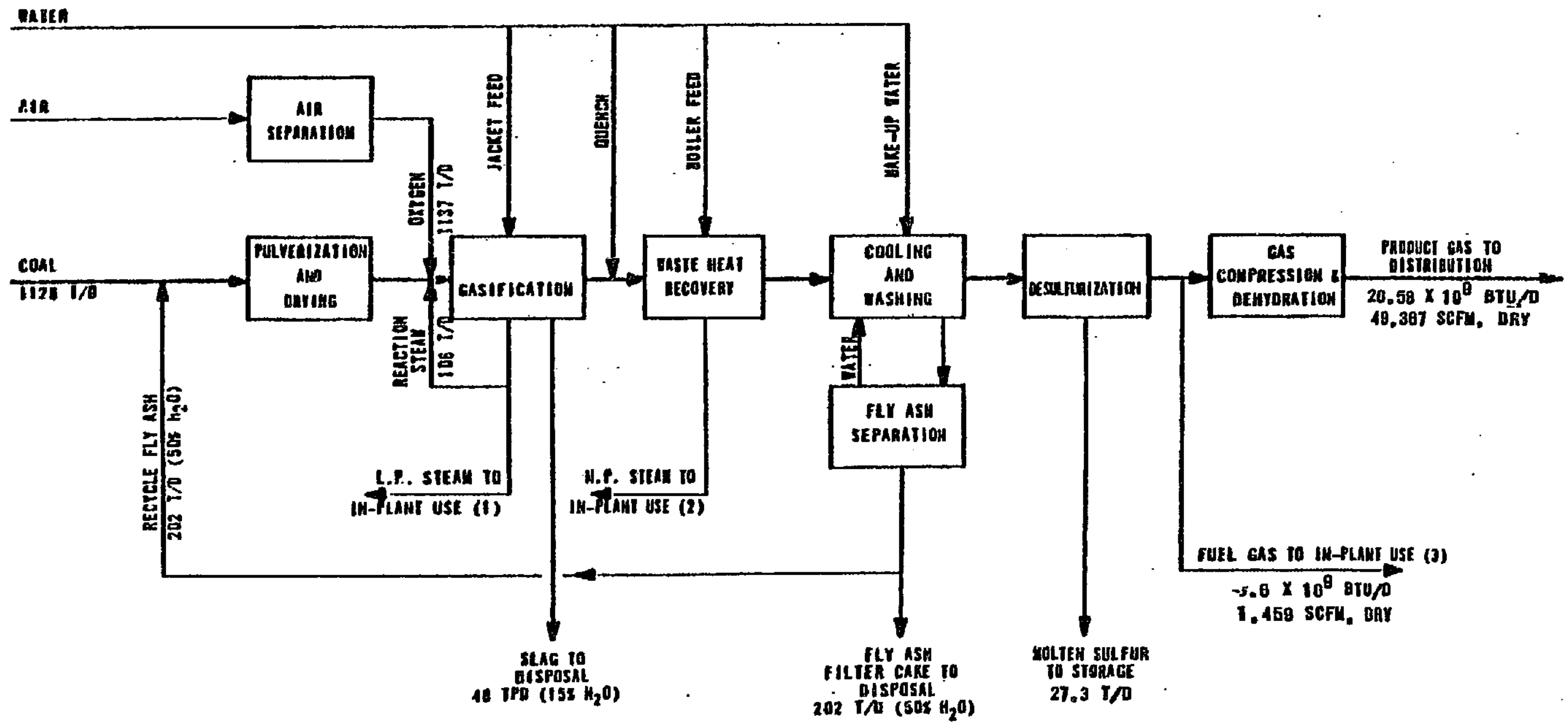
The clean gas will be compressed by using steam-driven compressors. A 50 percent motor-driven compressor is provided as a spare.

The gas will be compressed to 35 psig for distribution to the users. A glycol dehydration unit is provided to reduce the dewpoint of the gas to 20°F.

3.2.6 Distribution System

A distribution system will be constructed for this project that will be dedicated to the exclusive transportation of medium Btu gas. A distribution system has been designed on a definitive scale. The actual street routes were identified and installation will be in accordance with PGW operational procedures. The system design is based upon having gas available at the use sites of 10 psig.

An investigation in Phase I showed that consideration of co-mingling MBG with PGW Natural Gas was not feasible.



NOTES:

1. L.P. STEAM (28.8 PSIG, 272° F) FOR GAS COMPRESSION AND SPACE HEATING, ETC.
2. H.P. STEAM (927 PSIG, 537° F) FOR AIR SEPARATION, DEHYDRATION AND DESULFURIZATION.
3. GAS (FOR FUEL) TO DRYING AND STRETFORD DESULFURIZATION.

PHILADELPHIA GAS WORKS
PHILADELPHIA, PA
PGW COAL GASIFICATION PROJECT
OVERALL BLOCK FLOW DIAGRAM
(FLY ASH RECYCLE CASE)

DRAWING NO. 08 8276SS-
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

Figure 3-1

4.0 COST ESTIMATE

4.1 CAPITAL COST ESTIMATE

The capital cost estimate for the project is the result of an engineering design effort that was conducted on the following level:

a. Detailed process description with heat and material balances;
b. Coal-specific design information from process suppliers;
c. Detailed equipment list;
d. Major equipment specifications;
e. Plot plan and layout and arrangement drawings;
f. Piping flow diagrams;
g. Electrical one-line diagrams, and
h. Site-specific structural design.

Using the definitive design as a basis, capital and operating costs were developed by obtaining quotations for equipment delivered to the site. The air separation plant was specified and quotations were obtained for turnkey construction of the entire plant.

The balance of the plant was estimated by direct take-off for piping, steel, electricals, and instruments. Concrete and foundations were generally bulk take-offs. Construction labor was estimated for all disciplines, using the Philadelphia labor market as a base.

The level of detail used to determine the direct capital costs of the project is indicated on Table 4-1. Adjacent to the cost basis for each area, a level of confidence is indicated which reflects the methodology of estimating. Those areas in which equipment specifications were used to obtain lump sum quotations for systems or equipment have a level of 85 or 90 percent, depending upon the detail submitted in the vendor quotation. Site work and structural

estimates were considered to have lower levels as a result of the lesser detail in their respective designs, but it is noted that the site work confidence level was given a 90 percent since the estimate was based upon a "worst case" design.

By weighing the impact of each cost area with the confidence level, a contingency of 12 percent has been placed on the total direct cost of the project.

For purposes of economic analysis, the cost of detailed engineering for the project has been estimated to be six percent of the total direct cost, and the cost of construction management for the project has been estimated to be three percent of the total direct cost.

Table 4-2 provides a summary of the capital costs estimated for this project in mid-1981 dollars.

4.2 OPERATING COST ESTIMATE

Summarized in Table 4-3 are the labor, raw materials, and utility requirements for the operation of the PGW coal gasification plant. The operating labor requirement is based on the estimates shown in Table 4-4 for each individual unit or area, and Table 4-5 is a summary of the unit costs applied to each operating unit.

Table 4-6 summarizes the operating costs estimated for the project.

TABLE 4-1

SOURCE INFORMATION - CAPITAL COST ESTIMATE

COST AREA	COST BASIS	CONFIDENCE LEVEL
Land	Firm Price	100
Site Work	Site specific quantity take-offs based on plot plan and layouts. Included quantity and material take-offs. Estimate based on current prices.	90
Structures	Basis - Preliminary design of buildings, foundations, and structures. Estimates based on present day prices for steel and concrete. Buildings estimated individually.	75
Electrical	Preliminary design and single-line diagrams based on load study. Sized transformers, breakers, load centers, etc. Vendor quotation for equipment, conduit, tray and cable estimates based on average length per circuit and present rates for installation.	85
Instrumentation	Actual vendor prices based on Instrument List.	85

TABLE 4-1 (Cont'd)

COST AREA	COST BASIS	CONFIDENCE LEVEL
Process Equipment	Specifications for major equipment areas used to obtain vendor quotations. Erection cost based on weight. Engineering take-offs for piping estimates. Labor costs based on Philadelphia rates and productivity.	
- GKT	Lump sum based on specific two gasifier design - includes engineering.	90
- Desulfurization	Lump sum.	90
- Air Separation	Lump sum.	90
- Product Gas Compressor	Lump sum and individual equipment vendor	80
- Wash Water System	(with GKT)	85
- Waste Water System	Individual equipment vendor.	80
- Dehydration	Lump sum.	85
- High/Low Condensate	Individual equipment vendor.	80
- Cooling Water	Individual equipment vendor.	80
- Plant Air System	Individual equipment vendor.	80
- Coal Processing	Lump sum.	85
- Flare System	(with GKT)	90
- Piping & Valves	Design take-off and vendor prices.	90
Coal Handling		
- Car Unloading	Lump sum.	85
- Coal Pile	Individual pricing based on design.	80
- Thaw Shed	Lump sum.	85
- Locomotive	Vendor quotation.	90
- Bulldozer	Vendor quotation.	90
Ash Handling	Lump sum.	85
Miscellaneous	Individual equipment quotations.	85

TABLE 4-2

SUMMARY OF CAPITAL COSTS

(MID-1981 DOLLARS)

100	Land		$ 1,600,000
200	Site Work		5,217,000
210	Structures		15,171,300
300	Electrical Power Equipment		8,891
400	Process Equipment		
	GKT Gasifier	33,036,000	
	Desulfurization	5,776,400	
	Air Separation	27,400,000	
	Gas Compression	5,533,000	
	Waste Water Treatment	561,500	
	Gas Dehydration	600,000	
	High & Low Press. Condensate	620,400	
	Cooling Water	2,434,600	
	Plant Air	248,000	
	Coal Processing	5,437,700	
	Piping	8,190,000	
	Valves	1,547,000	
	Instrumentation	2,620,000	
	Subtotal Process Equipment		$ 94,004,600
410	Coal & Ash Handling		6,017,000
450	Miscellaneous		279,000
500	Distribution System		7,591,600
	Subtotal Direct Costs		$138,771,500
	Engineering		8,362,300
	Construction Services		4,181,100
	Contingency		16,724,600
	Subtotal Indirect Costs		$ 29,268,000
	TOTAL COST		$168,039,500

TABLE 4-3

ANNUAL RAW MATERIALS, UTILITY, LABOR, AND BY-PRODUCT SUMMARY

(PGW Coal Gasification Plant, 20.58 x 10^9 Btu/day)

On-Stream Factor	0.8
Raw Materials	
As Received Coal	329,376 ton/year
Stretford Chemicals	104,420 lb/year
Electricity	136,761 MWhr/year
Water	
City Water	3.212 MW gal/year
River Water Consumed	308.732 MM gal/year
Sanitary Sewer Discharge	3.212 MM gal/year
River Water Used and Returned	132.014 MM gal/year
Steam	None
Operating Labor	14 men/shift, 3 shifts/day plus 3 men/shift, 1 shift/day
By-Products	
Slag	14,016 ton/year
Fly Ash	58,984 ton/year
Molten Sulfur	7,972 ton/year

TABLE 4-4

OPERATING LABOR REQUIREMENTS

(PGW Coal Gasification Plant, 20.58×10^9 Btu/day)

	Men/Shift	Shifts/Day
Coal Handling	3	1
Coal Preparation	1	3
GKT Gasification	5	3
Oxygen Plant	2	3
Stretford & Nittetu Incineration	1	3
Gas Compression & Dehydration	1	3
Water Treatment	1	3
Utilities	1	3
Auxiliary Boiler	1	3
Offsite - ash & slag handling	1	3

TABLE 4-5

BASIS OF OPERATING COST ESTIMATE

(1981 $'s)

(PGW Coal Gasification Plant, 20.588 x 10^9 Btu/day)

On-Stream Factor	0.80(1)
Operating Units Costs	
Coal	$45/ton
Stretford Chemicals	$6.45/lb
Operating Labor	$13/man-hr
Supervision & Administration	30% of total operating labor
Electricity	$0.05/kWh
Water	$0.097/1,000 gallons(2)
Maintenance (Labor & Material)	2% of TPI(3)
By-Product Disposal	
Flyash	$6/ton
Slag	$6/ton
By-Product Credit	
Sulfur	$110/ton

---

(1) Based on an assumed operation of 5 days at 100% capacity and 2 days (weekends) at 50% capacity. Plant availability factor assumed is 93%. On-stream factor = 0.93 (5/7 x 1.0) + (2/7 x 0.5) = 0.80

(2) Water unit cost represent the following water costs:

- o City of Philadelphia water
- o Delaware River water used
- o Sanitary sewer and drain discharge
- o Delaware River water used and returned

(3) TPI = Total Plant Investment

TABLE 4-6

ANNUAL OPERATING COSTS (SUMMARY)

(Mid 1981 $'s)

Raw Materials	$ 15,978,000
Utilities	6,892,000
Operating Labor	1,708,000
Administration & Supervision	512,000
Maintenance	3,373,000
Management Fee	368,000
Waste Disposal	438,000
Byproduct Credit (Sulfur)	(877,000)
Net Operating Cost	$ 28,392,000

5.0 ENVIRONMENTAL IMPACTS

The overall environmental impact of the project is a positive one. The facility will have the capacity to produce 20.58 x 10^9 Btu per day of clean burning medium-Btu gas (HHV = 290 Btu per cu ft). This will replace 198,388 gpd of No. 6 fuel oil which the industries would otherwise use as fuel. The project will have a stimulatory impact on the economy. During the construction period, an estimated 500 construction jobs created by the project will have a positive effect on the Philadelphia economy. The operating facility is projected to provide 105 full time jobs. The increased demand on the Pennsylvania coal industry to supply 329,376 tpy of coal will benefit that industry by an increase of approximately 20 jobs. Philadelphia industries which are presently operating on fuel oil or interruptable natural gas would potentially close down or move away from the city if their conventional sources of energy were to become unavailable or too expensive. This trend could severely impact the city's economy at a time when there is an active program to attract new industry to Philadelphia. The facility will provide a reliable source of fuel to these industries.

The coal gasification plant will occupy a 43-acre site, known as the Riverside Site, which is located along the Delaware River next to Port Richmond between the Betsy Ross and Benjamin Franklin Bridges. The cleared site was previously used for industrial purposes and has a G-2 industrial zoning.

Adverse impacts during the construction phase of the project are not expected to be significantly different than those occurring during any major industrial construction project. Adverse impacts will be avoided or minimized whenever possible through the use of good engineering practices.

During operation of the coal gasification facility, specific mitigative measures have been designed into the facility to avoid

adverse environmental impacts wherever possible. In addition to these extensive engineering safeguards, elaborate monitoring and control instrumentation shall be used.

The GKT entrained bed, oxygen-blown gasification process provided by Krupp/Koppers was selected because it is a commercially proven system and because of its positive environmental characteristics such as its ability to gasify many coal types and the fact that it does not necessitate disposal of tars, phenols, or ammonia. During gasification of the coal, pollutants such as heavy metals in the coal are concentrated into non-leaching slag and ash. None of these pollutants are found in the product gas.

The facility will produce 250 tpd of non-hazardous slag and fly ash. The proportion of this which is fly ash will be reduced to a minimum by returning 50 percent of the fly ash which is produced to the gasifier. The combined slag and fly ash will occupy 347 cubic yards per day of landfill volume. Available haulers and landfills have been identified. Other methods for solid waste disposal, including returning the solid waste to the mines from which the coal came, are being explored.

Process water requirements (1,396,000 gpd) will be supplied directly from the Delaware River. This is a very small percentage of the total flow of the river. Cooling water blowdown, water treatment wastes, and treated coal pile runoff (360,000 gpd) will be returned to the river. Twenty-five percent of the water removed from the river will be returned to the river. The total quantity of Delaware River water consumed because of evaporation and process utilization will be 1,057,300 gpd. City of Philadelphia water will be used at the rate of 11,000 gpd for potable, sanitary, and miscellaneous uses and then returned to the city sanitary system.

The K-T gasifier has an uninterrupted history of safe operation. In an emergency such as loss of the coal feed system or a change in

oxygen pressure the gasifiers can be shut down almost instantaneously.

A sophisticated health and safety program will be required by the operator of the facility. This will include appropriate monitoring instruments for CO, H_2, H_2S, polynuclear aromatic hydrocarbons, organic compounds, and coal dust.

Air emissions from operation of the coal gasification plant are not considered significant. During start-up, product gas will be flared. Overall air impacts of the facility have been examined by comparing air emissions which would result if the four industries were to burn medium-Btu gas and No. 6 fuel oil (0.5 percent S). Sulfur dioxide emissions resulting from burning low sulfur oil and medium-Btu gas will be approximately the same; and, less than 70 percent of the maximum permitted by city air quality standards for burning the quantity of fuel which will be produced. None of the proposed industrial users of the medium-Btu gas is in a non-attainment area for SO_2.

Conversion to burning of the medium-Btu gas from fuel oil by the four industrial users should cause a decrease of 283 tons per year of total suspended particulate emissions and a decrease of 1,001 tons per year of nitrogen dioxide emissions.

Dust control systems have been designed into the facility to minimize fugitive dust emissions so that they comply with the City of Philadelphia air regulations for fugitive and nuisance dusting. Water and polymer sprays shall be utilized to control dust at the coal piles. A wind, time-activated spray system shall be used on the reserve coal pile. At other points where coal dust could be generated, such as at the delumpers, silos, and pneumatic conveyors, highly efficient fabric filters shall be used to prevent coal dust particles larger than 0.04 microns from entering the atmosphere. All coal conveyors will be shrouded. Slag and ash shall be stored

in covered hoppers and a spray system shall be used to minimize dusting when the material is transferred to covered trucks.

Noise from operating the gasification facility will be minimized by using acoustical insulation and noise is not expected to be discernible among the background of industrial and highway noises already heard at the residential areas near the site.

Rail traffic through Port Richmond will increase by one 70-car train per week which will unload during a two or three day period. Thirteen 23-ton truck loads of slag/ash will leave the facility five days per week. The train traffic resulting from supplying coal to the gasification facility is less than three percent of the traffic which will be generated from the scheduled expansion of adjacent Port Richmond so that it can serve as a major coal exporting yard.

5.1 AGENCIES AND COMPANIES CONTACTED

The following agencies or companies have been contacted concerning the project and have been made cognizant of the project status and PGW's intent.

Delaware River Basin Commission,
Pennsylvania Department of Environmental Resources,
Philadelphia Department of Licenses and Inspection,
Philadelphia Air Management Services,
Philadelphia Water Department,
Philadelphia Port Corporation,
Philadelphia Industrial Development Corporation,
Philadelphia Planning Commission,
United States Environmental Protection Agency,
U.S. Army Corps of Engineers,
U.S. Energy Management Agency,
Conrail,
Danella Bros., Inc.,
Lanchester Corporation,
Arco Chemical Co., and
Essex Chemical Corporation

6.0 ENGINEERING CONSTRUCTION SCHEDULE

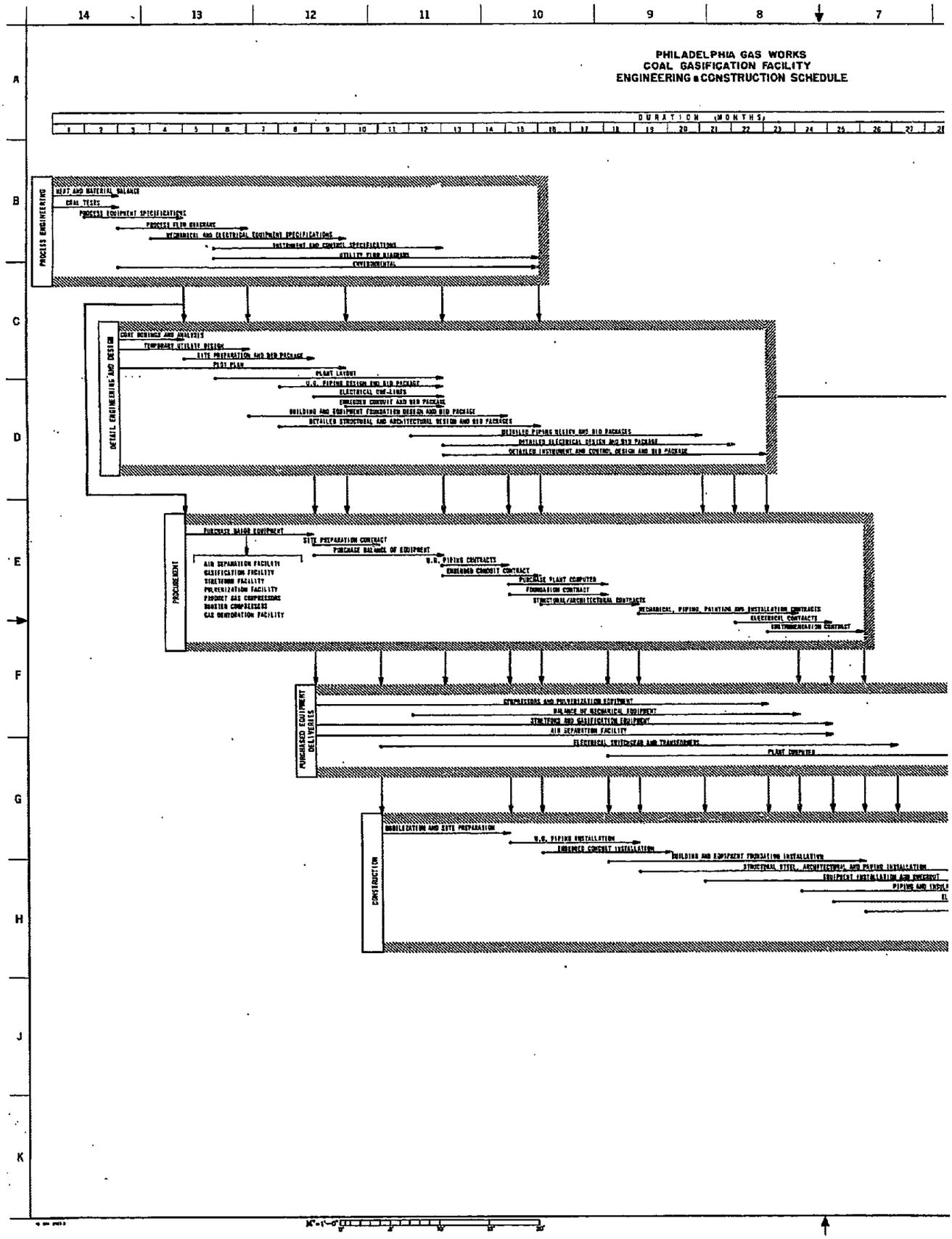
An engineering construction schedule for the project was prepared by establishing the level of activity required to design and construct the facility. Particular attention was given to advance order requirements for major equipment and other areas of major schedule impact. The schedule of engineering, procurement, construction, and start-up is presented on Figure 6-1.

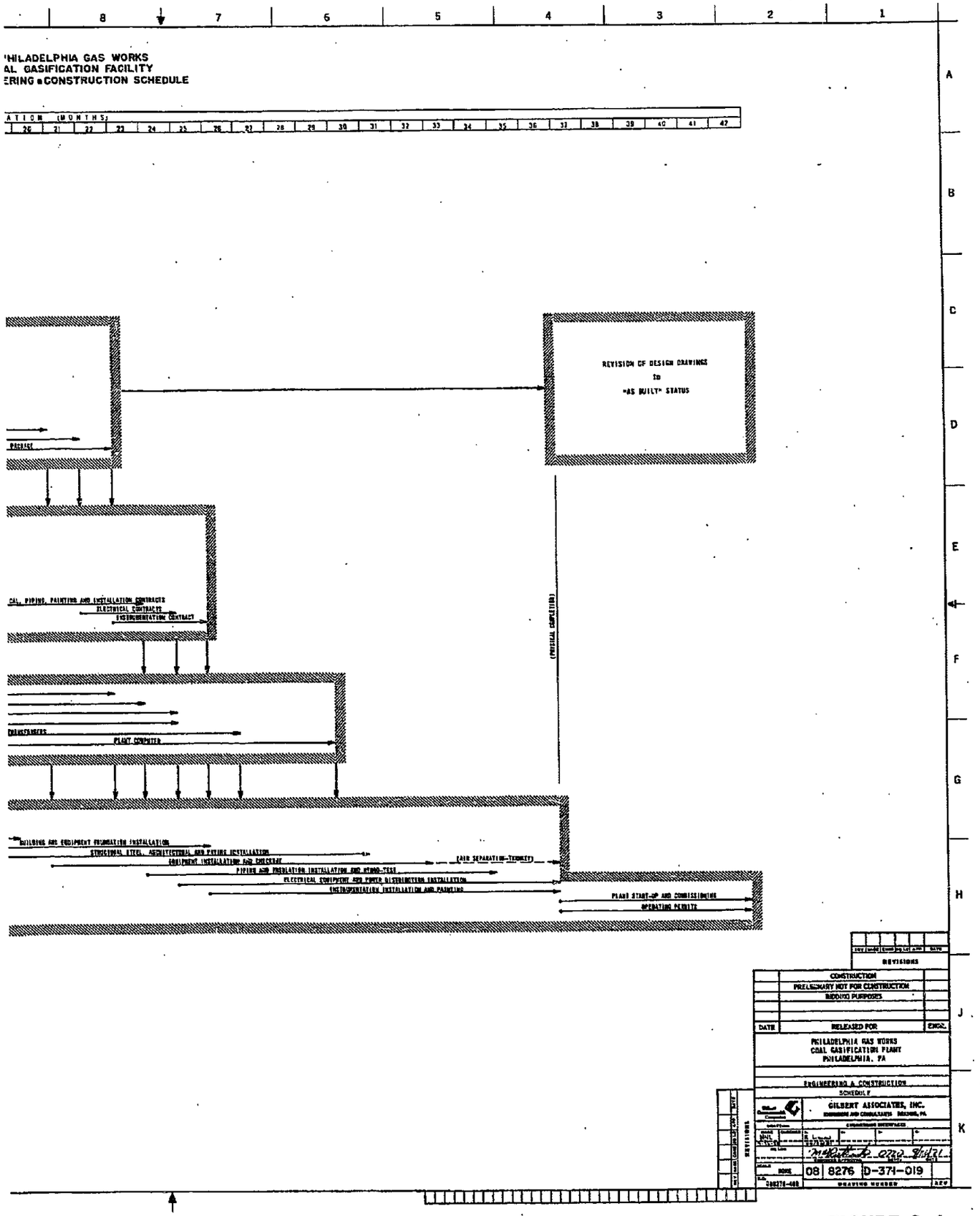
Upon establishing the schedule for engineering and construction, a time frame was established for obtaining the necessary permits and licenses for construction and plant commercialization. Table 6-1 is a list of permits and licenses to be obtained, and Figure 6-2 is a schedule that indicates the time frame in which they will be pursued.

TABLE 6-1

PERMITS REQUIRED FOR PGW COAL GASIFICATION PLANT

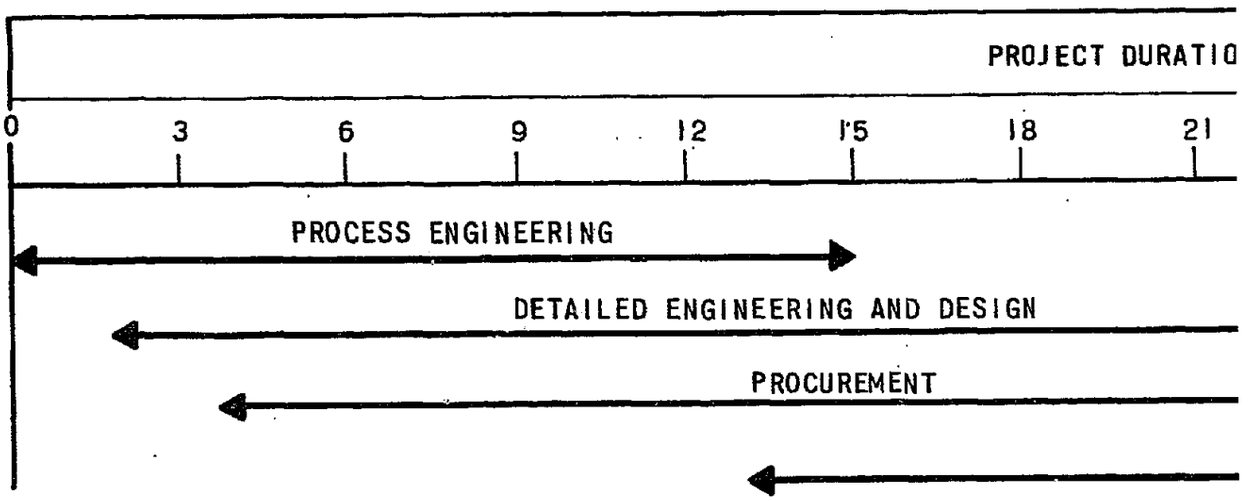
No.	Permit	Permitting Time	Permit Needed During: Design	Construc.	Operation	Other Related Permits Which Must Proceed It	Agency/Contact
1	Construction Permit Phil. Dept. of Licenses and Inspection	3 wks.	X				Henry Herling/686-1776
	Air Pollution						
2	Installation Permit Phila. Dept. of Licenses and Inspections	8 wks.	X				Henry Herling/686-1776
3	Operating License Phila. Air Management Services	8 wks.			X		Tom Elliot/686-7894
	Water						
	- Encroachment						
4	PA DER	6-9 wks.	X			7	Dan Lengo/717-787-6826
5	U.S. Corps	11 wks.	X			7,4	John Olsen/215-597-4722
6	DRBC	4 wks.	X			4,5,7	Dave Everett/609-883-9500
7	Phil. Dept. of Commerce	4 wks.	X			Before 4,5,6	
	- Wastewater Discharge -- To Delaware River						
8	PA DER	17-26 wks.	X			Before 9	George Kohut/215-631-2411
9	DRBC	4 wks.	X			8	Dave Everett/609-883-9500
	-- To Municple System						
10	Phil. Industrial Sewage Permit	8 wks.	X				Thomas Kulesza/686-1776
	- Water Consumed -- From Delaware River						
11	DRBC Water Consumption Permit	4 wks.	X				Dave Everett/609-883-9500
12	-- From Phil. Water System Phil. Water Permit	8 wks.	X				George Bey/686-3891
	Solid Waste						
13	PA Solid Waste Module Permit PA DER	8 wks.	X				Wayne Lynn/631-2420
14	Environmental Assessment DOE	6 mos.	X				
15	Storage of Hazardous Chemicals Phila. Dept. of Licenses and Inspections	6 mos.			X		Henry Herling/686-1776


PHILADELPHIA GAS WORKS
COAL GASIFICATION FACILITY
ENGINEERING & CONSTRUCTION SCHEDULE
DURATION (MONTHS)
PROCESS ENGINEERING
HEAT AND MATERIAL BALANCE
COAL TESTS
PROCESS EQUIPMENT SPECIFICATIONS
PROCESS FLOW DIAGRAMS
MECHANICAL AND ELECTRICAL EQUIPMENT SPECIFICATIONS
INSTRUMENT AND CONTROL SPECIFICATIONS
UTILITY FLOW DIAGRAMS
ENVIRONMENTAL
DETAIL ENGINEERING AND DESIGN
COST MONITOR AND ANALYSIS
TEMPORARY UTILITY DESIGN
SITE PREPARATION AND BID PACKAGE
PLOT PLAN
PLANT LAYOUT
U.G. PIPING DESIGN AND BID PACKAGE
ELECTRICAL CHF-LINES
EMBEDDED CONDUIT AND BID PACKAGE
BUILDING AND EQUIPMENT FOUNDATION DESIGN AND BID PACKAGE
DETAILED STRUCTURAL AND ARCHITECTURAL DESIGN AND BID PACKAGES
DETAILED PIPING DESIGN AND BID PACKAGES
DETAILED ELECTRICAL DESIGN AND BID PACKAGE
DETAILED INSTRUMENT AND CONTROL DESIGN AND BID PACKAGE
PROCUREMENT
PURCHASE MAJOR EQUIPMENT
SITE PREPARATION CONTRACT
PURCHASE BALANCE OF EQUIPMENT
U.G. PIPING CONTRACTS
EMBEDDED CONDUIT CONTRACT
PURCHASE PLANT COMPUTER
FOUNDATION CONTRACT
STRUCTURAL/ARCHITECTURAL CONTRACTS
MECHANICAL, PIPING, PAINTING AND INSULATION CONTRACTS
ELECTRICAL CONTRACTS
INSTRUMENTATION CONTRACT
AIR SEPARATION FACILITY
GASIFICATION FACILITY
STRETFORD FACILITY
PULVERIZATION FACILITY
PRODUCT GAS COMPRESSORS
BOOSTER COMPRESSORS
GAS DEHYDRATION FACILITY
PURCHASED EQUIPMENT DELIVERIES
COMPRESSORS AND PULVERIZATION EQUIPMENT
BALANCE OF MECHANICAL EQUIPMENT
STRETFORD GASIFICATION EQUIPMENT
AIR SEPARATION FACILITY
ELECTRICAL SWITCHGEAR AND TRANSFORMERS
PLANT COMPUTER
CONSTRUCTION
MOBILIZATION AND SITE PREPARATION
U.G. PIPING INSTALLATION
EMBEDMENT CONDUIT INSTALLATION
BUILDING AND EQUIPMENT FOUNDATIONS INSTALLATION
STRUCTURAL STEEL, ARCHITECTURAL AND PIPING INSTALLATION
EQUIPMENT INSTALLATION AND INSCHOUT
PIPING AND INSUL
EL

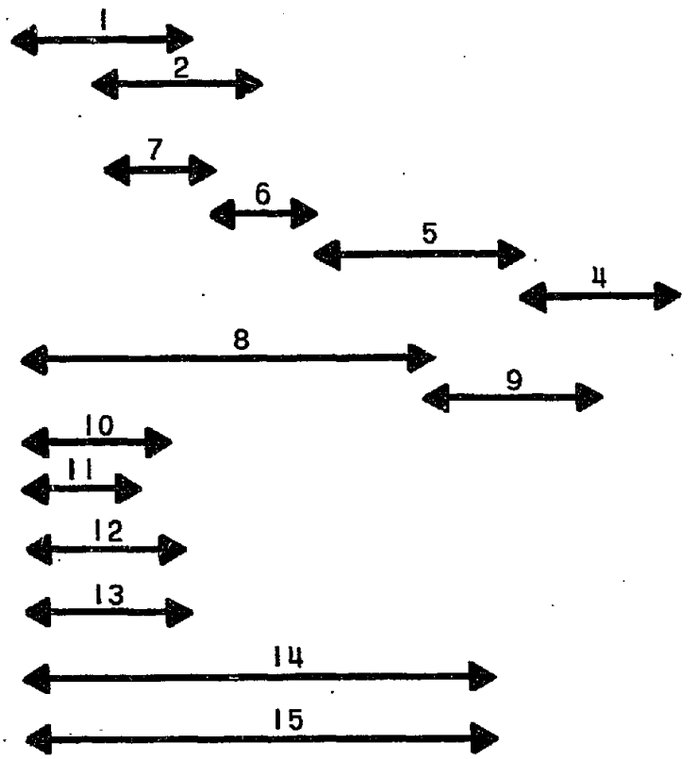

'HILADELPHIA GAS WORKS
AL GASIFICATION FACILITY
ERING & CONSTRUCTION SCHEDULE
A T I O N (M O N T H S)
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
REVISION OF DESIGN DRAWINGS
TO
"AS BUILT" STATUS
PACKAGE
CAL, PIPING, PAINTING AND INSTALLATION CONTRACTS
ELECTRICAL CONTRACTS
INSTRUMENTATION CONTRACT
CRANES/CABLES
PLANT COMPUTER
(PHYSICAL COMPLETION)
BUILDING AND EQUIPMENT FOUNDATION INSTALLATION
STRUCTURAL STEEL, ARCHITECTURAL AND PIPING INSTALLATION
EQUIPMENT INSTALLATION AND CHECKOUT
(AIR SEPARATION-TECHNIP)
PIPING AND INSULATION INSTALLATION AND HYDRO-TEST
ELECTRICAL EQUIPMENT AND POWER DISTRIBUTION INSTALLATION
INSTRUMENTATION INSTALLATION AND PAINTING
PLANT START-UP AND COMMISSIONING
OPERATING PERMITS
REVISIONS
CONSTRUCTION
PRELIMINARY NOT FOR CONSTRUCTION
BIDDING PURPOSES
DATE
RELEASED FOR
ENGR.
PHILADELPHIA GAS WORKS
COAL GASIFICATION PLANT
PHILADELPHIA, PA
ENGINEERING & CONSTRUCTION
SCHEDULE
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS READING, PA
08 8276 D-371-019
DRAWING NUMBER

6-3

FIGURE 6-1



No.	Permit
1	Construction Permit Phil. Dept. of Licenses and Inspection
	Air Pollution
2	Installation Permit Phila. Dept. of Licenses and Inspections
3	Operating License Phila. Air Management Services
	Water
	- Encroachment
4	PA DER
5	U.S. Corps
6	DRBC
7	Phil. Dept. of Commerce
	- Wastewater Discharge — To Delaware River
8	PA DER
9	DRBC
	-- To Municple System
10	Phil. Industrial Sewage Permit
	- Water Consumed -- From Delaware River
11	DRBC Water Consumption Permit
12	-- From Phil. Water System Phil. Water Permit
	Solid Waste
13	PA Solid Waste Module Permit PA DER
14	Environmental Assessment DOE
15	Storage of Hazardous Chemicals Phila. Dept. of Licenses and Inspections



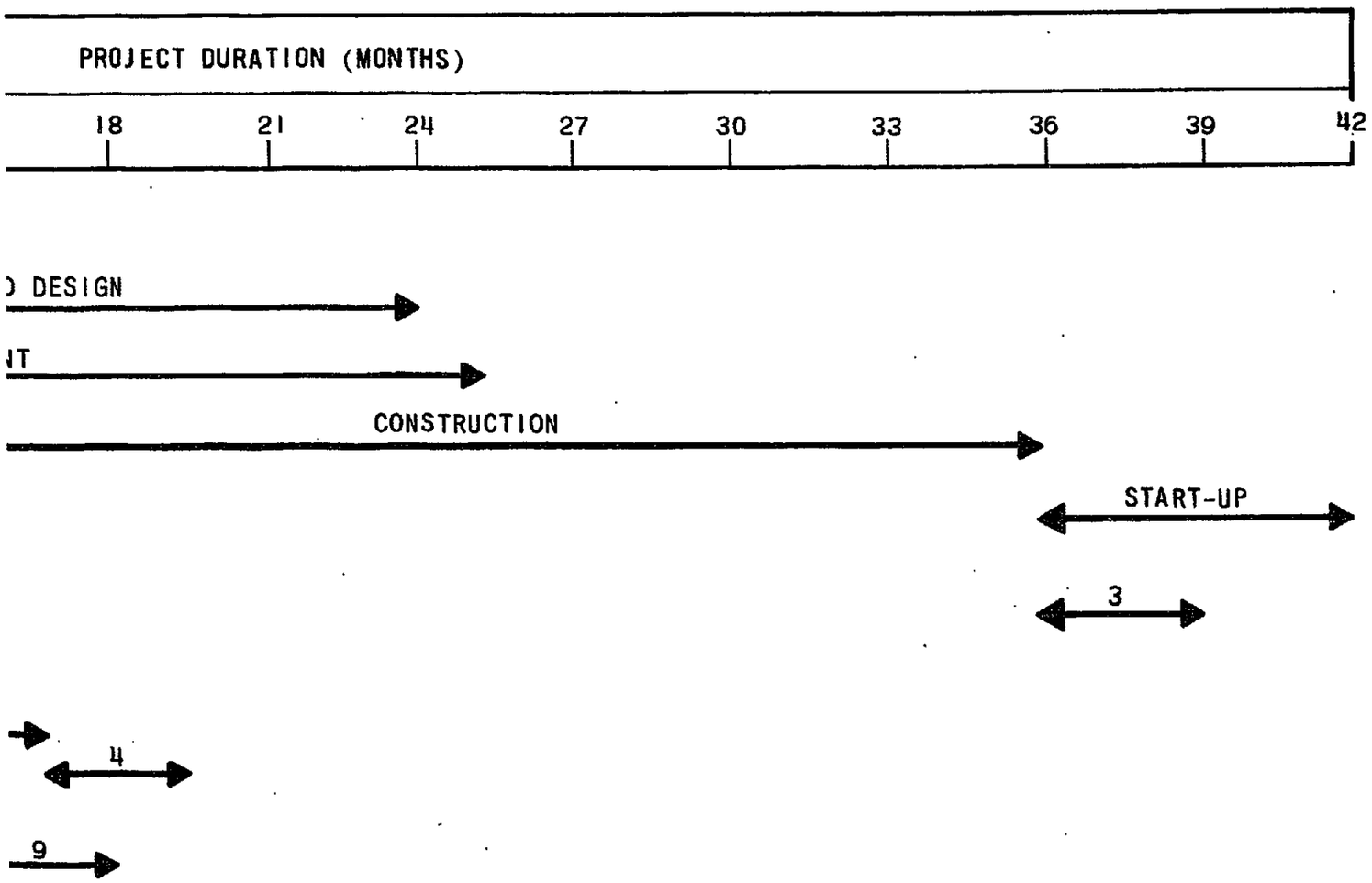


FIGURE 6-2

PERMIT AND LICENSING SCHEDULE

7.0 FINANCIAL/LEGAL ANALYSIS

7.1 METHODOLOGY OF ANALYSIS

In the course of its Phase I Feasibility Study of a medium-Btu coal-gas facility, PGW identified the financing mechanism as having significant impact on gas cost from the project. Consequently, PGW formed a "Financial/Legal Task Force" composed of legal, financial, and project analysis specialists to study various ownership/ management options for the coal gasification project. The objective of the Task Force, and, in fact, of PGW, was to achieve a feasible financing structure at the lowest possible cost per Btu for future gas purchasers.

In seeking an acceptable ownership, management, and financing arrangement, certain ownership forms were initially identified and classified. These forms consisted of several public ownership, private ownership, and third party ownership options for the coal-gas plant. The ownership and financing forms were classified as two base alternatives for the PGW Project tax-exempt and taxable financing arrangements:

a. Tax Exempt Financing - available mainly to municipalities and other governmental subdivisions. The alternatives identified as ownership options using tax-exempt financing were:

   1. City of Philadelphia General Obligation Bond Financing, and

   2. Philadelphia Facilities Management Corporation (PFMC) subsidiary or Authority Revenue Bond Financing.

b. Taxable Financing - this would consist of private ownership of the PGW Project and encompasses a wide variety of loan configurations. The alternatives identified as ownership options using taxable financing are:

1. Third Party ownership by one or more of the following:

   - o Sole owner other than PGW
   - o Separate Facilities Ownership of Coal-Handling and Oxygen Plant
   - o State Participation, and
   - o Separate distribution company

2. Private ownership in the form of a partnership structure or a leveraged lease arrangement, with PGW as a potential project operator and/or partner.

PGW identified governmental loan guarantees which might alleviate investor resistance to the coal gas project and reduce risk. The major source of guarantees identified was the Synthetic Fuels Corporation (SFC). The SFC will offer to a limited group of synthetic fuel project sponsors loan guarantees or price supports. Reference to the SFC and an approach to seek loan guarantees or price supports was made in the analysis.

Once the various ownership options were identified and developed, the Task Force examined legal and tax implications that would impact PGW depending on the ownership option chosen, especially if a private ownership structure was determined to be the most feasible.

Addressing the Task Force's major objective, lowest gas costs, and taking into consideration various ownership constraints, such as legal requirements, IRS regulations, and acceptable credit criteria,

five financing alternatives were developed for detailed analyses. These consist of three public tax-exempt options and two private taxable options. These are described below:

a. Public Option I - Assumed ownership by the City of Philadelphia of a 20 billion Btu per day medium-Btu coal gasification facility and methanation plant financed by three concurrent bond issues guaranteed by the SFC.

b. Public Option II - Assumed ownership by the City of Philadelphia of a 20 billion Btu per day medium-Btu coal gasification facility and no methanation plant financed by two concurrent bond issues guaranteed by the SFC.

c. Public Option III - Assumed ownership by PGW or an affiliate of a 20 billion Btu per day medium-Btu coal gasification facility financed by PGW revenue bonds.

d. Private Option I - Assumed ownership of a 20 billion Btu per day medium-Btu coal gasification facility by a partnership. PGW would be the general partner and operator and the limited partners are corporations still to be identified. Corporate bonds would be guaranteed by the SFC.

e. Private Option II - Assumed ownership of a 20 billion per day medium-Btu coal gasification facility where PGW would be the general partner and operator and the limited partners would be corporations rated a minimum of A by Standard and Poors.

The computer models used in this analysis were developed specifically for the purpose of investigating alternative coal gasification plant ownership scenarios. Whether financing is handled through a debt based or an equity based scheme, the use of

three interrelated computer models were necessary. Individual models served the following functions:

a. Development of Cash Flow During the Construction Period,
b. Debt Service Schedule,
c. Forecasted Financial Results of Operations,
d. Income Statements,
e. Balance Sheets, and
f. Net Working Capital.

The assessment of feasibility rested on the development and comparison of revenue requirements for each alternative. This is a standard analysis technique to minimize product cost.

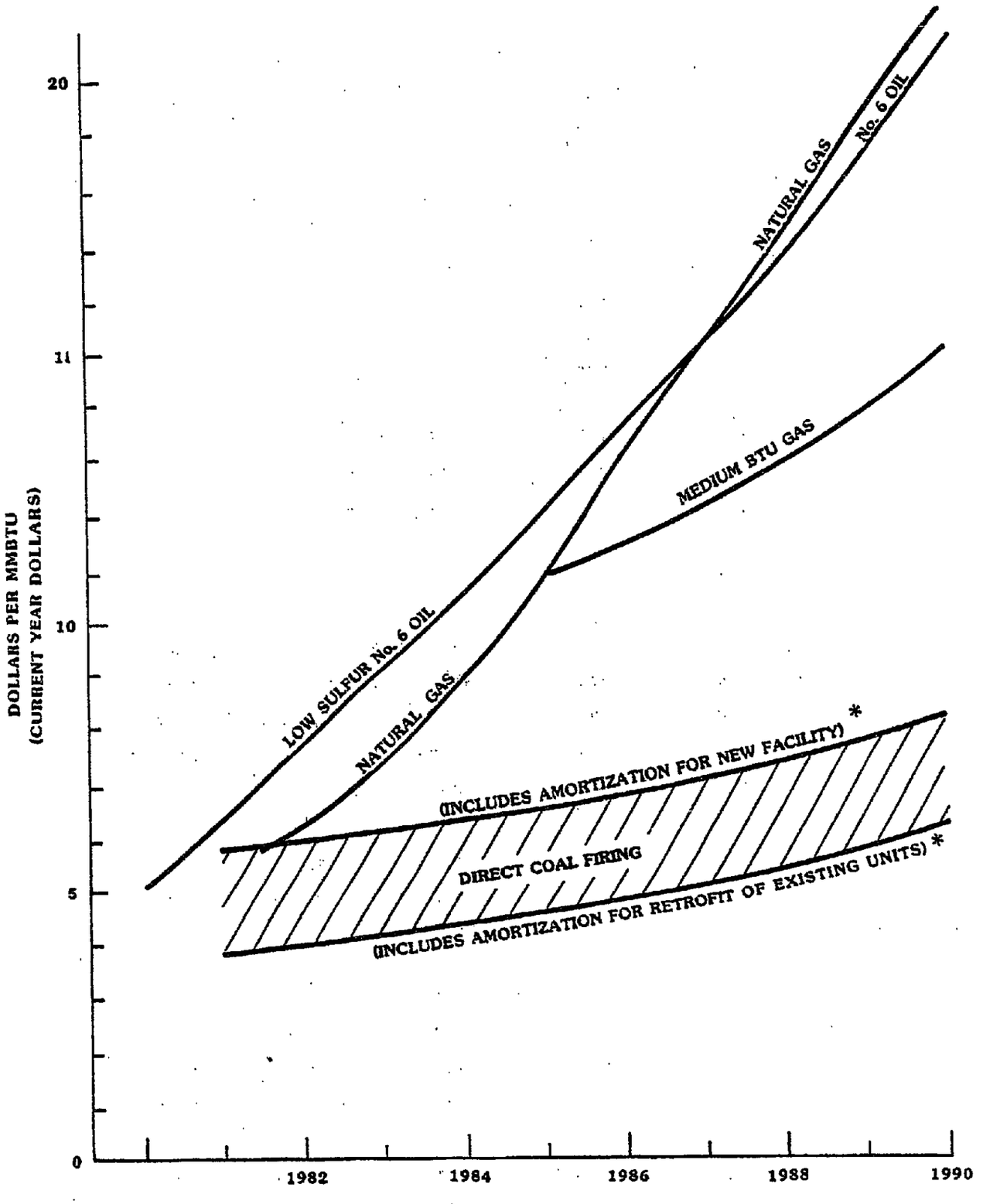
7.2 CONCLUSIONS

Comprehensive review and study by the PGW Financial/Legal Task Force identified an attractive ownership form that was considered economically and financially feasible. Projections of project revenues, expenses, and capital needs based upon pertinent financial criteria yielded the following conclusions:

a. The ownership structure that minimizes gas costs and can be implemented given legal and financing restraints is a partnership/joint venture with PGW as operator.

b. Based on a 40 percent equity, 60 percent debt capitalization structure and an SFC guaranteed bond with a 12 percent coupon rate, 1985 gas costs were projected to be $10.95 per MMBtu escalating at 6.5 percent per year.

c. Fuel price comparisons for the City of Philadelphia demonstrate that the project is competitive and can displace natural gas and No. 6 oil based on price and supply considerations (see Figure 7-1).



* PRICE PROJECTION DOES NOT INCLUDE FUNDS TO SATISFY SITE SPECIFIC ENVIRONMENTAL REGULATIONS

Figure 7-1
FUEL PRICE PROJECTIONS
FOR CITY OF PHILADELPHIA
(CURRENT YEAR DOLLARS)

d. Funding requirements for the project for the partnership ownership form were determined to be:

Equity	$100,000,000
Long Term Debt	
Pollution Control Bonds	22,600,000
Conventional Bonds*	$127,000,000
Total	$249,600,000

* SFC Guaranteed

e. Firm customer agreements with four identified industrial firms, guaranteed debt, and favorable economics will support the economic and financial feasibility of the project.

f. Sensitivity studies demonstrate the following variations in 1985 gas costs of $10.95 per MMBtu:

Increase in Coal Cost of $1.00 per ton	Add $0.08/MMBtu
Increase in Escalation of Coal Costs (Increment of one percent)	Add $0.13/MMBtu
Capital Cost Decrease of ten percent	Deduct $0.60/MMBtu
Increase in Long Term Interest Cost of two percent	Add $0.47/MMBtu

g. The project offers equity participants a DCF rate of return of 33 percent. This is considered to be attractive but will require further examination by an investment banking firm and will heavily depend upon the SFC guarantee for debt.

8.0 PGW ASSESSMENT

8.1 INTRODUCTION

Over the past 12 months PGW, with the assistance of its various advisers, has been in the process of reviewing and analyzing the results generated from the Definitive Design Study. Upon the final review of the cumulative results a decision was to be made as to whether to construct the proposed facility. During the study many critical areas of uncertainty were addressed which would seriously impact the decision to proceed to the next stage of development, that of approaching the financial community for the necessary funding with the commitment to construct the facility.

PWG's assessment of the results generated from the Definitive Design is based on acceptable answers to three critical questions. These questions include:

a. Does a demand exist for an alternative fuel supply and if so, what characteristics must the alternative have to satisfy this demand?

b. Will medium-Btu coal gas satisfy the long-term future fuel demand of industry?

c. Can a medium-Btu coal gas plant be constructed and economically meet the requirements of industry in Philadelphia?

Therefore, it is essential that these questions be thoroughly investigated from every known perspective that could impact the validity of the results presented. To accomplish the overall objective of determining the advisability of constructing this plant, PGW made an assessment by considering five functional areas.

a. Engineering Design,
b. Environmental Impact,
c. Feedstock Availability,
d. Marketing,
e. Ownership and Management, and
f. Finance and Economics.

8.2 SUMMARY

As a result of the objectives accomplished during the completion of the Definitive Design Study, it is PGW's belief that medium-Btu coal gas can be produced in an environmentally acceptable manner and represent a preferred economically attractive energy alternative for industry in Philadelphia or for any other urban based industry. However, before anyone could commit the necessary resources to implement this project with reasonable assurance of success, at least two critical questions must be addressed.

a. Securing Long-Term Purchase Agreements: PGW is well aware of the necessity for ensuring a secure market for the gas production of the facility, but is also cognizant of the difficulty in today's constantly changing business environment of obtaining "take or pay" contracts from customers. Given this condition, PGW, in its discussions with potential customers, has stressed the need for the establishment of relationships which will meet customers needs, but also secure sufficient assured revenues to meet the fixed cost of the facility. While the form of the contract between the plant and its customers may vary, certain critical elements of the contract will be deemed necessary by the financial community. These elements include a mechanism for ensuring sales of a minimum output from the facility and a pricing structure which will allow for economic operation of the plant under all load conditions.

Without the securing of the necessary long-term purchase agreements from potential customers, PGW has concluded the facility should not be constructed.

b. Availability of SFC Incentives: PGW, throughout the investigation of this project, has taken a conservative approach to insure a minimization of risk. This adopted approach has dictated the selection of a commercially available gasification process, as well as the sizing of the facility to meet already existing industrial customer needs. However, perceived risk will undoubtedly still exist within the investment community, primarily related to the technical and marketing segments of the project. These preconceived notions within the financial community are based on two actual facts. Presently, there are no operational medium-Btu coal gasification facilities in the United States. Also, there is a continued uncertainty about alternative fuel cost projections for the future. Thus, it is very important that the SFC act to bridge this gap of perceived risk by insuring the financeability of the project in the private sector through the incentives of the SFC's disposal.

With the continuing uncertainty of alternative industrial fuel price projections in the future as well as the necessity to secure long-term purchase agreements, price guarantees will be required to minimize the risk to the medium-Btu industrial gas market. In addition, with the large capital investment required and the existence of uncertainty being demonstrated by the financial investment community with regard to the technical viability of the process, loan guarantee support may also be necessary if sufficient capital funds are to be generated.

With these two critical areas successfully addressed, PGW believes that the necessary equity investors can be secured, the partnership finalized, and the required customer contracts executed so that the project can proceed to successful completion.

8.3 ENGINEERING DESIGN

With the selection of the Koppers-Totzek (K-T) gasifier, a commercially proven process, the technological risks associated with the facility are no greater than any other coal burning facility. In fact, all of the equipment included in the proposed design is commercially available. The Stretford desulfurization unit, probably the most complicated system, is similar to the system presently operated by PGW at its SNG facility. Coal handling equipment and the air separation facility, the other major components of the design, are being operated satisfactorily throughout the United States.

The only technical area where gasifier operating experience is lacking from PGW's point of view, is in operation under varying load conditions. PGW does not anticipate any major difficulty in developing the appropriate operating procedures.

PGW believes that the major risk associated with the engineering of the proposed facility is the possibility of improperly estimating the actual cost to build and operate the facility. There is no question that medium-Btu coal gas can be produced with the GKT technology; it is being done now in other parts of the world. The question is how much will it cost to produce it.

Based on the level and quality of engineering design and analysis performed during this study, PGW believes that the capital and operating cost estimates developed reflect the best engineering and cost information available at this time. Contingencies incorporated within the cost estimate are sufficient to cover the level of

confidence of the individual major component price estimates. However, the uncertainties in the overall economic conditions world-wide can have a severe impact on the validity of the final capital and operating estimates. Thus, these estimates as well as the overall viability of the project are susceptible to changes such as inflation and interest rates based on future economic conditions.

8.4 ENVIRONMENTAL IMPACT

PGW firmly believes that with the application of accepted engineering and design practices the proposed coal gasification facility can be constructed and operated in an environmentally acceptable manner to ensure the well-being of the surrounding environment. With the proposed site located in a highly industrialized area, separated from residential areas by a heavily travelled interstate highway, adverse impacts to the immediate area will be negligible. Overall, with the facility displacing approximately one million barrels of No. 6 fuel oil per year with medium-Btu coal gas, a significant positive impact will be realized with a lowering of nitrogen dioxide and particulate content of the customer's boiler stack gases.

Positive impacts will also be realized by the Philadelphia economy from the temporary employment of up to 500 jobs during the construction period and the permanent employment of approximately 70 others to operate the facility. To the city, these jobs are a clear economic benefit. In addition, they do not represent any adverse socioeconomic impact on the area. They are a relatively small percentage of the present city construction labor force and can be easily absorbed by the area with the present high unemployment picture.

To ensure the securing of the necessary permits in a fashion to allow the timely construction of the facility, it is imperative that the appropriate regulatory agencies be kept informed regularly of

the progress of the project. The framework for this communication link has already been established by PGW with initial and follow-up contacts with representatives of the Environmental Protection Agency (EPA), Pennsylvania Department of Environmental Resources (DER), and Philadelphia Air Management Services (AMS). Philadelphia Gas Works believes it is critical that an on-going relationship be established with these regulatory agencies in order to prevent unnecessary delays at a later date resulting from a lack of communications with the project developers. With the establishment of this relationship the project will be in a position to anticipate any concerns raised by the regulatory agencies and be able to take prudent corrective action where warranted before actual construction begins.

Another necessary and important part of the communication process cited above is the establishment of relationships with the local community, a step already initiated by PGW. Lengthy delays can be avoided when the community is informed and have had the opportunity to discuss the merits of the projects as well as having their concerns addressed.

8.5 FEEDSTOCK AVAILABILITY

During the study, one of the critical areas that had to be assessed was the obtaining of a coal supply. As a result of the information generated from the Definitive Study, it appears certain that the availability of a suitable coal supply represents little concern to the project. Since the K-T process can use most types of coal, the most important aspect of coal selection in this case is cost. In addition, the selection of the K-T process affords PGW the opportunity not only to use coals of various characteristics but also when convenient to the operation to investigate their economic impact on process performance. In short, the plant need not confine its feedstock selection to one particular coal.

A major factor to be considered in the coal selection process is the impact of a recently announced coal exporting terminal to be located adjacent to the coal gas facility. Initial discussions with the coal terminal operators indicated an interest in delivering the PGW coal supply through the proposed terminal, as well as an interest in storing the 60,000 ton dead coal pile on the terminal site. The coal gasification facility would then be able to receive its required coal supply via an "over the fences" conveyor system to be constructed between the two facilities. The effect of such an arrangement would be to eliminate over $15 million of capital investment for coal handling equipment at the expense of constructing a conveyor system and paying a yet to be determined coal terminalling charge. In addition, it might be possible to arrange a coal delivery contract advantageous to the coal gasification plant with a coal supplier who has contracted to export coal through the terminal. The coal demands of the coal gasification project represent only an incremental cost to the coal suppliers and PGW believes such delivery arrangements can be made.

8.6 MARKETING

A major objective of PGW's involvement in this project has been to help satisfy the real and identifiable energy needs of industry in Philadelphia. With this goal in mind, the proposed facility has been sized on the basis of existing need rather than projected demand in the future. Thus, with an existing market already established, the risks associated with market demand are minimized.

Risk minimization has also been considered in securing customers whose operating characteristics will permit the facility to be essentially a baseload operation. Therefore, PGW has placed empnasis on securing customers whose operations are five or seven days per week, 24 hours per day, thus allowing the fixed cost portion of the unit gas cost to be minimized.

To help ensure an economically attractive product that can be competitively marketed to Philadelphia industry, PGW has selected as the basis of design, a two gasifier system without an extra gasifier serving as back-up for the plant's operation. This adopted design basis allows the project to avoid additional capital expenditures for a back-up gasifier and the associated increase in gas cost characteristic of a utility type concept of 100 percent deliverability. This two gasifier approach was adopted with the understanding that potential customers would be expected to retain their alternative fuel capability for use in the event of unforeseen as well as scheduled plant shutdowns. During initial discussions with potential customers this approach was agreeable since dual fuel capability already existed in all cases, and assurance of uninterruptible supply of energy is paramount from the viewpoint of the customer.

The ability to obtain long-term purchase agreements for MBG from industry in Philadelphia is predicated on industry's belief in the future energy projections and what their particular alternative fuel prospects may be. As previously presented in Figure 7-1 and acknowledged by potential customers as being similar to their estimates are the future costs for alternative fuels in Philadelphia. As viewed in these projections, direct coal firing is the only alternative which is more economical than MBG. However, direct coal firing has other characteristics which make it less attractive. It requires:

a. Major capital expenditures:

   1. for new coal burning facility or retrofit of existing facility, and

   2. site specific environmental protection expense.

b. Community considerations.

Therefore, PGW believes that even where site considerations would permit conversion, few industries would convert to direct coal firing because of the existance of these factors. They look upon MBG favorably when considering the points cited above.

Discussed below is a synopsis of the prospective customers the project proposes to serve with MBG:

a. Allied Corporation located approximately two miles north of the Riverside coal gasification site is a seven day per week, 24 hour per day operation. The energy requirements are presently met with No. 6 fuel oil, coke oven gas, process residue, and natural gas supplied by PGW on an interruptible basis. The load pattern is basically flat with little variation on an hourly or seasonal basis.

   The total annual demand of Allied is approximately 2,400,000 MMBtu per year which does not include the process residue internally generated by Allied. Based on a 365 day a year operation this usage equates to approximately 6.5 billion Btu per day.

   In PGW's discussions with Allied they have indicated that while their boilers are candidates for conversion to direct coal firing, there would be logistic problems with available space for the location of necessary equipment. Although Allied has not ruled out the conversion to coal it is not looked upon by them as a favorable alternative.

b. Publicker Industries located approximately five miles south of the Riverside site is a seven day per week, 24 hour per day operation. Their energy requirements are presently met with No. 6 fuel oil and natural gas supplied by PGW on an interruptible basis. The load pattern is basically flat with little variation on an hourly or seasonal basis.

The total annual demand is approximately 1,650,000 MMBtu per year. Calculated on a 365 day per year operation the daily demand would be approximately 4.5 billion Btu per day.

Publicker officials indicated that their earlier plans included direct coal firing. Recently, however, they have indicated that they will in good faith persue contractual arrangements with PGW for the purchase of medium-Btu gas if the project's economies develop as presented.

c. Newman and Company located approximately two and a half miles north of the Riverside site is a five days per week, 24 hours per day operation. Their energy requirements were met with No. 6 fuel oil, however, they recently added the ability to purchase natural gas from PGW on an interruptible basis.

The total annual demand of Newman is approximately 540,000 MMBtu per year. Based on a 240 days per year operation this is approximately 2.2 billion Btu per day.

Discussions with Newman indicate that although direct coal firing is an alternative, they would prefer to utilize the limited space available for expansion in other business ventures rather than for a coal facility.

d. Schmidt Brewing Company located approximately two and a half miles from the Riverside site is a five days per week, 24 hours per day operation. Their energy needs are met with No. 6 fuel oil and natural gas supplied by PGW on an interruptible basis. Their load pattern shows little seasonal variation, however, hourly demands vary significantly.

The total annual demand of Schmidt's is approximately 425,000 MMBtu per year. Based on a 250 days per year operation, daily demand would be approximately 1.7 billion Btu per day.

Initial conversations with Schmidts indicate that direct coal firing is not a feasible alternative and their future energy alternatives are either oil or natural gas.

In addition to the above mentioned markets, PGW has discussed the medium-Btu coal gasification plant with three other large industrial customers whose load characteristics would represent excellent candidates for medium-Btu gas. In PGW's initial discussions with these potential customers, they indicated that they were not in a position to commit themselves to this project until they had an opportunity to evaluate their future energy options, particularly direct coal firing. However, at this time, two of these customers have indicated an interest in further discussing the medium-Btu option with PGW, while the third customer has said they will pursue burning coal directly. These three customers and their associated loads are:

a.	Amstar Sugar	(5.5 Billion Btu per Day)
b.	National Sugar*	(8.0 Billion Btu per Day)
c.	Rohm and Haas	(3.90 Billion Btu per Day)

* Has filed under Chapter II of the Bankrupcy Act for reorganization.

8.7 OWNERSHIP AND MANAGEMENT

As a result of the work performed during the Definitive Design Study, the most economical form of ownership for the proposed facility is a joint venture partnership instead of public ownership by the City of Philadelphia through PGW. In addition to a lower gas

cost produced by the private ownership, legal issues which must be addressed to implement a public ownership option for the proposed facility would be very complicated and the project would be susceptible to delay while these issues were being addressed. Of particular concern in a public option is the issuance of tax-exempt bonds to finance a project which may or may not qualify for "public use."

Furthermore, our investigations have lead PGW to the conclusion that within a joint venture partnership structure the role of PGW as a direct participant is very limited. In most likelihood PGW's involvement could be through an arrangement whereby PGW would either manage the plant under an operating agreement or would purchase the MBG "over the fence" and distribute it to the prospective customers.

Upon the completion of this Definitive Study, PGW's role will be one of project advocate. This role is justifiable by the fact that PGW, as an operating organization closely associated with the city, believes that this project would further enhance the well-being of the industrial sector of the City of Philadelphia. In this role PGW would manage the project with the objective of formulating the joint venture which would finance and own the project. In addition, PGW's post study activities will include the preparation and submittal of a proposal to the Synthetic Fuels Corporation for loan guarantees and price guarantees to insure the timely implementation of the project.

In order to contribute to the creditability of the project, PGW has initiated procedures for the purchase of the Riverside property. The company's Board of Directors has approved the purchase of this site and authorization to purchase it is being sought from the Philadelphia Gas Commission, the agency regulating PGW. Assuming this authorization is obtained, PGW will seek the necessary ordinance from the Philadelphia City Council. The process would be completed with the Mayor signing the ordinance. The land would

represent a small equity participation on the part of PGW/City of Philadelphia in the project.

8.8 FINANCE AND ECONOMICS

PGW, with the assistance of various financial and legal advisers has concluded that the private, taxable ownership option represents the most economical and financeable alternative available to fund the proposed project. The modified base case financial analysis as developed during the Definitive Study with updated assumptions is a realistic presentation of the projected costs of MBG as of this time.

As a result of the information generated during the Definitive Study, it is apparent that one of the most volatile factors to impact the cost of MBG is the interest on debt and the rate of inflation. The impact of interest rates make it imperative that the timing for obtaining of necessary debt capital be such as to minimize the interest portion of the revenue requirement. Thus, it is critical that interest rates and their future projections be continuously updated to insure the validity of the base case MBG cost. The effect of inflation can be minimized through the securing of long term coal contracts and the negotiating of fixed price contracts where possible.

While the uncertainties related to world wide economics are many, it is apparent that any substantial delay in meeting the schedule as set forth within this report will severely impact the capital funds required to construct the facility. However, as of this date, PGW will use the base case gas cost in presentation to customers and the SFC for their evaluation.

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