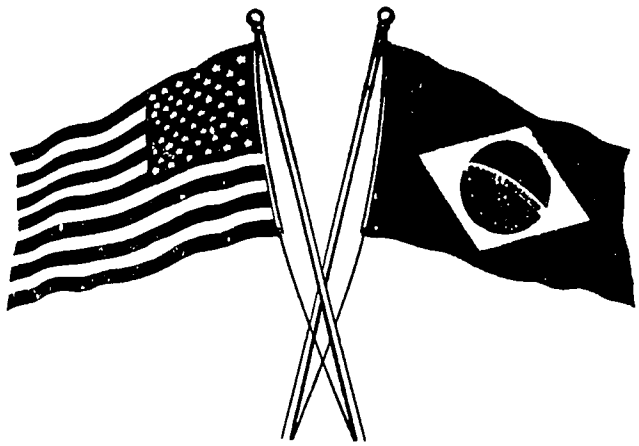
PN-AAL-396



BRAZIL
SOUTHERN CONE ENERGY NETWORK
COAL GASIFICATION FOR SNG PRODUCTION AND PIPELINE SYSTEM

FEASIBILITY STUDY
EXECUTIVE SUMMARY

VOLUME I

UNITED STATES
TRADE AND DEVELOPMENT PROGRAM
AND
AGENCY FOR INTERNATIONAL DEVELOPMENT

CONTRACT PDC-0000-C-00-1106-00

FLUOR ENGINEERS, INC.

CONTRACT 836504
AUGUST 1982

NOTICE

This report was prepared by Fluor Engineers and Constructors, Inc. as an account of work sponsored by the U.S. Agency for International Development, Washington, D.C. Neither Fluor, nor any person acting on its behalf, (a) makes any warranty, guaranty, or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

In arriving at the preliminary estimates contained herein, Fluor may have applied specialized estimating techniques to information, including assumptions and projections, not within Fluor's control. While we believe that the preliminary estimates contained herein will be reliable under the conditions and subject to the qualifications set forth, Fluor does not warrant or guarantee the accuracy of such preliminary estimates or the assumptions or projections on which they are based. Anyone using such estimates and information does so at his own risk, and such use constitutes a release and agreement to defend and indemnify Fluor from and against any liability in connection therewith, whether arising out of Fluor's negligence or otherwise.

TABLE OF CONTENTS

VOLUME I

EXECUTIVE SUMMARY

BRAZIL SOUTHERN CONE ENERGY NETWORK

COAL GASIFICATION FOR SNG PRODUCTION
AND PIPELINE SYSTEM
FEASIBILITY STUDY

ARRANGEMENT OF REPORT DOCUMENT

		VOLUME NUMBER	PART NUMBER
	EXECUTIVE SUMMARY	I	-
	FEASIBILITY STUDY REPORT	II	I and II
	PART I - COAL GASIFICATION FOR SNG PRODUCTION	II	I
Section 1.0	Introduction	II	I
Section 2.0	Gasification Plant	II	I
Section 3.0	Schedule and Implementation Plan	II	I
Section 4.0	Cost Estimate	II	I
Section 5.0	Economic Analysis-Gasification Plant	II	I
Section 6.0	Basis of Study	II	I
Section 7.0	Site Study	II	I
Section 8.0	Coal Resource Study	II	I
Section 9.0	Coal Market	II	I
Section 10.0	Gasification By-Product Market	II	I
Section 11.0	Gas Demand Survey	II	I
	Appendix - Part I	II	I
	PART II - GAS PIPELINE AND DISTRIBUTION SYSTEM	II	II
Section 12.0	Introduction	II	II
Section 13.0	Pipeline and Distribution	II	II
Section 14.0	Schedule and Implementation Plan	II	II
Section 15.0	Cost Estimate	II	II
Section 16.0	Economic Analysis - Pipeline System	II	II
Section 17.0	Basis of Study	II	II
Section 18.0	Route Selection	II	II
Section 19.0	Alternate Transportation Modes	II	II
	Appendix - Part II	II	II

BRAZIL SOUTHERN CONE ENERGY NETWORK

COAL GASIFICATION FOR SNG PRODUCTION
AND PIPELINE SYSTEM
FEASIBILITY STUDY

TABLE OF CONTENTS - EXECUTIVE SUMMARY (VOLUME I)

		PAGE
1.0	Purpose and Scope	1-1
2.0	Discussion	2-1
	2.1 English Test	2-1
	2.2 Texto Portugues	2-10
3.0	Facility Description	3-1
	3.1 Gasification Plant	3-1
	3.2 Pipeline and Distribution Systems	3-4
4.0	Project Schedule	4-1
5.0	Capital and Operating Cost Summary	5-1
	5.1 English Text	5-1
	5.2 Texto Portugues	5-3
6.0	Project Economic Analysis	6-1
	6.1 English Text	6-1
	6.2 Texto Portugues	6-3

TABLE OF CONTENTS - FEASIBILITY STUDY REPORT (VOLUME II)

PART I - COAL GASIFICATION FOR SNG PRODUCTION

		PAGE
1.0	Introduction	1-1
2.0	Gasification Plant	2-1
2.1	Technology Screening	2-1
2.2	Final Technology Selection	2-4
2.3	Process Alternatives - Medium Btu gas versus High Btu gas (SNG)	2-8
2.4	Plant Description - Westinghouse Case	2-9
2.5	Plant Description - Lurgi/Westinghouse Case	2-22
2.5.1	Utility Requirements	
2.5.2	Catalyst and Chemical Requirements	
2.5.3	Operating Manpower Requirements	
2.5.4	Plot Plan	
3.0	Schedule and Implementation Plan	
3.1	Schedule	3-1
3.2	Project Implementation	3-2
3.2.1	Managing Contractor	
3.2.2	Phased Engineering	
3.2.3	Step I Project Scoping and Preliminary Engineering	
3.2.4	Step II Full Scale Design, Procurement, and Construction	
3.2.4.1	Procurement	
3.2.4.2	Construction	
3.2.5	Brazilian Contractors	
3.2.6	Permits	
4.0	Cost Estimate	
4.1	Capital Cost	4-1
4.2	Operating and Maintenance Costs	4-3
4.3	Preoperational Costs	4-6

PAGE

5.0 Economic Analysis - Gasification Plant

5.1 Methodology 5-1
5.2 Summary of Base Case Results 5-2
5.3 Basis of Analysis 5-5
5.4 Sensitivity Analysis 5-8
5.5 Definitions 5-11

6.0 Basis of Study

6.1 Technical Criteria 6-1

6.1.1 Plant Description
6.1.2 Plant Location
6.1.3 Meteorological Data
6.1.4 Raw Water Data
6.1.5 Plant Reliability/Availability
6.1.6 Design Criteria
6.1.7 Environmental
6.1.8 Plant Limit Definition

6.2 Coal Characterization 6-3
6.3 Cost Estimate Basis 6-4

7.0 Site Study

7.1 Site Selection 7-1
7.2 Climatic Conditions 7-3
7.3 Water Availability 7-3
7.4 Rainfall Data 7-4
7.5 Local Labor Availability 7-4
7.6 Local Equipment Availability 7-5

7.6.1 Supply Breakdown for Typical Plant
7.6.2 Equipment Type

7.6.2.1 Mechanical/Piping
7.6.2.2 Electrical
7.6.2.3 Instrumentation

7.6.3 Materials

7.6.3.1 Civil
7.6.3.2 Electrical
7.6.3.3 Instrumentation
7.6.3.4 Equipment and Piping Materials

7.7 Electrical Power 7-7
7.8 Engineering and Construction Codes 7-7

PAGE

7.8.1 Study Basis
7.8.2 Standards Followed During Design and Construction in Brazil

7.9 Permits to be Obtained 7-7
7.10 Transportation Facilities and Limitations 7-8

7.10.1 Transportation Facilities

7.10.1.1 Road Access
7.10.1.2 Railway Access
7.10.1.3 Ports
7.10.1.4 Airport

7.10.2 Transportation Limitations

7.10.2.1 Roads
7.10.2.2 Railway
7.10.2.3 Ports

8.0 Coal Resource Study

8.1 Introduction 8-1
8.2 Assessment Summary 8-1

8.2.1 Conclusions
8.2.2 General Geology
8.2.3 Reserves

8.2.3.1 Rio Grande do Sul
8.2.3.2 Santa Catarina
8.2.3.3 Parana

8.2.4 Mine and Reserve Requirements
8.2.5 Coal Preparation Characteristics

8.2.5.1 Washability
8.2.5.2 Volume Recovery
8.2.5.3 Carbon Recovery

8.3 Resource Description 8-13

8.3.1 Introduction
8.3.2 Present Reserves
8.3.3 Present Production
8.3.4 Types of Coal

8.3.4.1 Santa Catarina
8.3.4.2 Rio Grande do Sul

PAGE

8.3.5 Users
8.3.6 Brazilian Government Expansion Plans
8.3.7 Detailed Implementation Plans, Production

8.3.7.1 Projects Analyzed/Approved
8.3.7.2 Effective Expected Coal Production

8.3.8 Characteristics of Rio Grande do Sul and Santa Catarina Coals

8.3.8.1 Rio Grande do Sul Coals
8.3.8.2 Santa Catarina Coal

8.3.9 Specific Data on Some Deposits and Mines of Rio Grande do Sul and Santa Catarina

8.3.9.1 Candiota Deposits
8.3.9.2 Irui Deposit
8.3.9.3 Leao-Butia Deposit
8.3.9.4 Charqueadas Deposit
8.3.9.5 Morungava Deposit
8.3.9.6 Chico Loma Deposit
8.3.9.7 Deposits in Southern Santa Catarina

8.3.10 Coal Distribution - The Role of CAEEB

9.0 Coal Market

9.1 Types of Coal 9-1
9.2 Evolution of Coal Demand 9-1
9.3 Present Demand 9-2
9.4 Distribution Infrastructure 9-5

9.4.1 Transport

9.4.1.1 Railway
9.4.1.2 Water Transportation

9.4.2 Warehouses

9.5 Coal Demand Projections 9-8

9.5.1 Initial Forecast
9.5.2 Revised Estimates
9.5.3 Future Coal Demand
9.5.4 Coal Versus SNG
9.5.5 Coal Prices

10.0 Gasification By-Product Market

10.1 Introduction 10-1
10.2 Sulfur Market 10-1

PAGE

10.2.1 Sulfur Production Capacity

10.2.1.1 Present Capacity
10.2.1.2 New Plants Planned

10.2.2 Sulfur Demand
10.2.3 Sulfur Uses

10.3 Ammonia Market 10-3

10.3.1 Ammonia Production Capacity

10.3.1.1 Present Capacity
10.3.1.2 New Plants Planned

10.3.2 Anhydrous Ammonia Demand
10.3.3 Ammonia Uses

10.4 Naphtha Market 10-5

10.4.1 Naphtha Produced by Brazilian Refineries
10.4.2 Forecast of Naphtha Demand

11.0 Gas Demand Survey

11.1 Introduction 11-1
11.2 Criteria Adopted 11-1

11.2.1 Units
11.2.2 Forecast of Fuel Demand

11.3 Fuel Gas Demand 11-2
11.4 Fuel Usage, 1979 11-4
11.5 Adjustments to 1979 Fuel Consumption 11-12

11.5.1 Introduction
11.5.2 Fuel Conservation Programs
11.5.3 Fuel Substitution Programs
11.5.4 Production Levels
11.5.5 New Plant Capacity
11.5.6 Refineries
11.5.7 Industrial Market Summary

11.6 Nonindustrial Market 11-19

11.6.1 Introduction
11.6.2 Household Demand
11.6.3 Total Nonindustrial Demand

11.7 Total SNG Demand 11-21
11.8 Consideration of SNG as a Feedstock 11-24

PAGE

11.8.1 Methanol Market
11.8.2 Ammonia Market

Appendix (Part I)

A Abbreviations A-1

B Coal Production and Analysis B-1

C Washability Curves C-1

D Coal Resource Maps D-1

E Jacui River Water Analysis E-1

F Applicable Brazilian Environmental Regulations F-1

G Oil Refining Structure in Brazil G-1

H Pro Forma Financial Statements and Cash Flow Projections H-1

PART II - GAS PIPELINE AND DISTRIBUTION SYSTEM

		PAGE
12.0	Introduction	
12.1	Executive Summary	12-1
12.2	Summary and Conclusions	12-1
12.3	Feasibility Study	12-1
13.0	Pipeline and Distribution	
13.1	General	13-1
13.1.1	Major Components	
13.2	Pipeline System (Hydraulics)	13-2
13.2.1	Pipe Sizes	
13.2.1.1	Main Transmission	
13.2.1.2	Distribution to Sao Paulo	
13.2.1.3	Distribution to Mogi Guacu	
13.2.1.4	Distribution to Pindamonhangaba	
13.2.1.5	Laterals	
13.2.2	Compressor Stations	
13.2.2.1	Intermediate	
13.2.2.2	SNG Plant	
13.2.2.3	Drivers	
13.2.2.4	Instrumentation	
13.2.3	Mainline Taps	
13.2.3.1	Incoming Gas	
13.2.3.2	Distributions	
13.2.4	Incremental Throughput	
13.3	Gas Storage Facilities	13-5
13.3.1	Packing the Pipeline	
13.3.2	Liquefying the Gas	
13.3.3	Using Abandoned Wells	
13.3.4	Sealed Caverns	
13.4	Cathodic Protection	13-7
13.4.1	Internal	
13.4.2	External	
13.4.2.1	Transmission Line	
13.4.2.2	Distribution System	

PAGE

13.5 Supervisory Control, Data Acquisition, Communications 13-8

13.5.1 Command
13.5.2 Data Transmission

13.5.2.1 Telephone
13.5.2.2 Radio (VHF & UHF)
13.5.2.3 Microwave

13.5.3 Central Control

13.5.3.1 Remote Control

13.5.4 Communications
13.5.5 Leak Detection
13.5.6 Electrical Power Requirements
13.5.7 Personnel

13.6 Operations 13-13

13.6.1 Operational Districts

13.6.1.1 Southern
13.6.1.2 Northern

13.6.2 Functions - Operations

13.6.2.1 Measurements
13.6.2.2 Gas Control
13.6.2.3 Communication

13.6.3. Functions - Maintenance

13.6.3.1 Pipeline Programs
13.6.3.2 Building Maintenance
13.6.3.3 Equipment Maintenance

13.6.4 Engineering

13.6.4.1 Corrosion
13.6.4.2 Mechanical
13.6.4.3 Process
13.6.4.4 Civil/Electrical/Instrumentation

13.7 Training 13-16

Design Place
Construction Phase

PAGE

13.7.1 Transmission Pipeline System

Management
Technical Training
Technicians
Operator

13.7.2 Gas Transmission Emergency and Safety Procedures

14.0 Schedule and Implementation Plan

14.1 Basis 14-1

14.1.1 Number of Construction Spreads

14.2 Long Lead Time Items 14-1
14.3 Phases of Work 14-2
14.4 Approvals 14-2
14.5 Bidding 14-2
14.6 Accelerated Schedule 14-3

14.6.1 Phases of Work
14.6.2 Revisions and Approvals
14.6.3 Construction

15.0 Cost Estimate

15.1 Capital Investment 15-1
15.2 Operating 15-1

15.2.1 Pipeline
15.2.2 Compressor Stations
15.2.3 Energy
15.2.4 Summary

15.3 Organization and Training 15-3
15.4 Basis of Estimate 15-3

15.4.1 Objectives
15.4.2 Materials
15.4.3 Subcontractor Costs
15.4.4 Other Costs
15.4.5 Excluded Costs

16.0 Economic Analysis - Pipeline System

16.1 Methodology 16-1
16.2 Summary of Base Case Results 16-2
16.3 Basis of Analysis 16-7
16.4 Sensitivity Analysis 16-10
16.5 Definitions 16-13

PAGE

17.0 Basis of Study

17.1 General 17-1

17.1.1 Energy Consumption Centers
17.1.2 Assumptions
17.1.3 Limitations

17.2 Process Design 17-6

17.2.1 Process Design
17.2.2 Length of Pipeline
17.2.3 Consumers/Delivery Pressures
17.2.4 Composition of Gas
17.2.5 Physical Properties of Gas
17.2.6 Throughputs
17.2.7 System Design Pressures
17.2.8 Delivery Pressures
17.2.9 Terrain
17.2.10 Head Loss Calculations

17.3 Pipeline Design 17-9

17.3.1 Design Criteria
17.3.2 Design Conditions
17.3.3 Road Crossings
17.3.4 River and Stream Crossing
17.3.5 Stress Analysis

17.4 Corrosion Control 17-11

17.4.1 External Protection
17.4.2 Internal Protection
17.4.3 Right of Way
17.4.4 Terrain and Crossing Summary

17.5 Supervisory Control System (SCADA), Communications 17-13
17.6 Training/Operations 17-13

17.6.1 Transmission System Training
17.6.2 Functions-Operations

18.0 Route Selection

18.1 Pipeline Route Selection 18-1
18.2 Topography and Soil Conditions 18-4

18.2.1 Topography
18.2.2 Soil Conditions

18.3 Main Transmission Pipeline 18-4

PAGE

18.3.1 State of Rio Grande do Sul
18.3.2 State of Santa Catarina
18.3.3 State of Parana
18.3.4 State of Sao Paulo

18.4 Distribution System 18-7

18.4.1 Sao Paulo Line (City)
18.4.2 Mogi Guacu Line (Northwest)
18.4.3 Pindamonhangaba Line (Northwest)

18.5 Field Trip Report 18-10

18.5.1 Confidence Levels
18.5.2 Rock
18.5.3 Straightening the Pipeline
18.5.4 River Crossings
18.5.5 Stream Crossings
18.5.6 Road Crossings
18.5.7 Railroad Crossings
18.5.8 High Tension Lines
18.5.9 Pipeline Burial
18.5.10 Kilometer Readings
18.5.11 Fill

19.0 Alternate Transportation Modes

19.1 Relative Merits (Summary) 19-3

19.1.1 Quantitative Evaluation
19.1.2 Qualitative Evaluation

19.2 Basis of Study 19-7
19.3 Logistics of Barge Transport 19-9
19.4 Description of Coal Handling System 19-10
19.5 Capital Investments and Operating Cost 19-11

19.5.1 Case I-A - Gas Pipeline System

19.5.1.1 Capital Investment
19.5.1.2 Operating Costs

19.5.2 Case I-B - Liquefied Gas Transportation
19.5.3 Case II-A - Barge Haul

19.5.3.1 Capital Investment
19.5.3.2 Operating Costs

19.5.4 Case II-B - Coal Slurry Pipeline

19.5.4.1 Capital Investment
19.5.4.2 Operating Costs

PAGE

19.5.5 Case II-C - Railroad Haul

19.5.5.1 Capital Investment
19.5.5.2 Operating Costs

Appendix (Part II)

I Pro Forma Financial Statements and Cash Flow Projections I-1

J Definitions and Conversion Factors J-1

K Reference Documents K-1

VOLUME I EXECUTIVE SUMMARY

LIST OF TABLES

TABLE NO.	DESCRIPTION	PAGE
2-1	Projected Gas Consumption - Brazil and Sao Paulo	2-3
3-1	Evaluation of Alternative Transportation Modes - Quantitative	3-8
3-2	Evaluation of Alternative Transportation Modes - Qualitative	3-9
3-3	Relative Merits of Transportation Systems	3-10
5-1	Estimate Summary	5-2
6-1	Summary of Base Case Results	6-2

VOLUME I EXECUTIVE SUMMARY

LIST OF ILLUSTRATIONS

FIGURE NO.	DESCRIPTION	PAGE
1-1	Map of South America	1-3
1-2	Map of Southern Brazil	1-4
2-1	Map of Distribution Areas	2-4
2-2	Pipeline Flow Diagram	2-5
4-1	Master Schedule	4-2
836504-00-4-0001	Overall Block Flow Diagram Lurgi/Westinghouse Hybrid Case	3-3
836504-00-5-050	Overall Plot Plan	3-5

1.0 PURPOSE AND SCOPE

This Executive Summary document summarizes the study report on the economic and technical feasibility of gasifying coal to produce a substitute natural gas (SNG) for distribution to the industrial areas of southern Brazil. The report includes data surveys, technology assessments, process evaluations, and conceptual designs and analyses. This study has been accomplished under sponsorship of the United States Agency for International Development (Contract PDC-0000-C-00-1106-00). The work has been carried out with guidance from the Trade and Development Program of the International Development Cooperation Agency (IDCA) and from the Secretaria da Industria, Comercio, Ciencia e Tecnologia (SICCT), Sao Paulo, and representatives of the Ministry of Mines and Energy. The study contributes to the Brazilian Government efforts to investigate feasible crude oil substitution programs that will meet the nation's energy needs by utilizing domestic resources, thereby reducing the severe negative impact of foreign crude oil importation on Brazil's balance of payments.

This Executive Summary of the Feasibility Study comprises Volume I of the report; the detailed report on the Study is issued as a separate Volume II, and is itself composed of two major parts. Part I describes the SNG Plant, together with related material on coal gasification processes and Brazil's coal resources. Part II describes the Gas Pipeline and Distribution System, including pipeline and route data. Also included in Part II is an alternative energy transportation study which evaluates the feasibility of locating the gasification plant 1000 kilometers farther north near Santos (the area of major gas usage) and transporting the coal from the mines to the SNG Plant.

The primary goals for the study were to make the necessary preliminary investigations and then develop a feasible plan to produce, transport, and distribute SNG, utilizing Brazilian coal as feedstock. The gas produced will be used to supplement the energy needs of Brazil through 1990 and beyond.

The Advanced Technology Division of Fluor Engineers and Constructors, Inc., Irvine, California, in association with Jaakko Poyry Engenharia Ltda. of Sao Paulo has carried out this study. The pipeline system portion of the study was supported by Fluor Ocean Services, Houston. Fluor Mining and Metals, Redwood City, California provided an overview of the coal resource assessment. Jaakko Poyry provided information on Brazilian coal, gas demand, product markets, site, pipeline route, costs, economics, and general local data.

The SNG Plant location is proposed for the southern coal-producing area of Brazil near Minas do Leao. The map in Figure 1-1 shows the southern states of Brazil, and Figure 1-2 depicts the pipeline system proposed to carry gas from the SNG plant to the State of Sao Paulo.

Fluor compiled and analyzed available data on coal resources and potential gas demand, then used this data to select the gas plant site, assess coal reserve areas, define coal characteristics, and set a

philosophy of design for the pipeline system that will serve the principal areas with a potential for industrial gas consumption.

After determining the coal characteristics, Fluor screened various gasification technologies with respect to their abilities to gasify the high-ash subbituminous Brazilian coal. Then process engineers prepared a conceptual process design for the gasification plant, based on the technology selected by the screening study. Capacity-factored capital and operating cost estimates were prepared for the plant. Using this data, together with coal feed costs, by-product revenues and economic data provided by Jaakko Poyry and Brazilian Government authorities, Fluor developed a discounted cash flow analysis to show the required plant gate price for the SNG produced.

The pipeline system was conceptually designed to distribute SNG and imported natural gas to the industrial centers of southern Brazil. The route was selected based on a macroscopic assessment of the route. Order-of-magnitude capital and operating cost estimates were prepared, and then used to generate a discounted cash flow economic analysis showing the transportation cost of the gas from the plant gate to the proposed areas of industrial consumption.

Various cases were analyzed to illustrate the sensitivity of the economic viability of the plant and pipeline to changes or uncertainties in selected key economic variables.

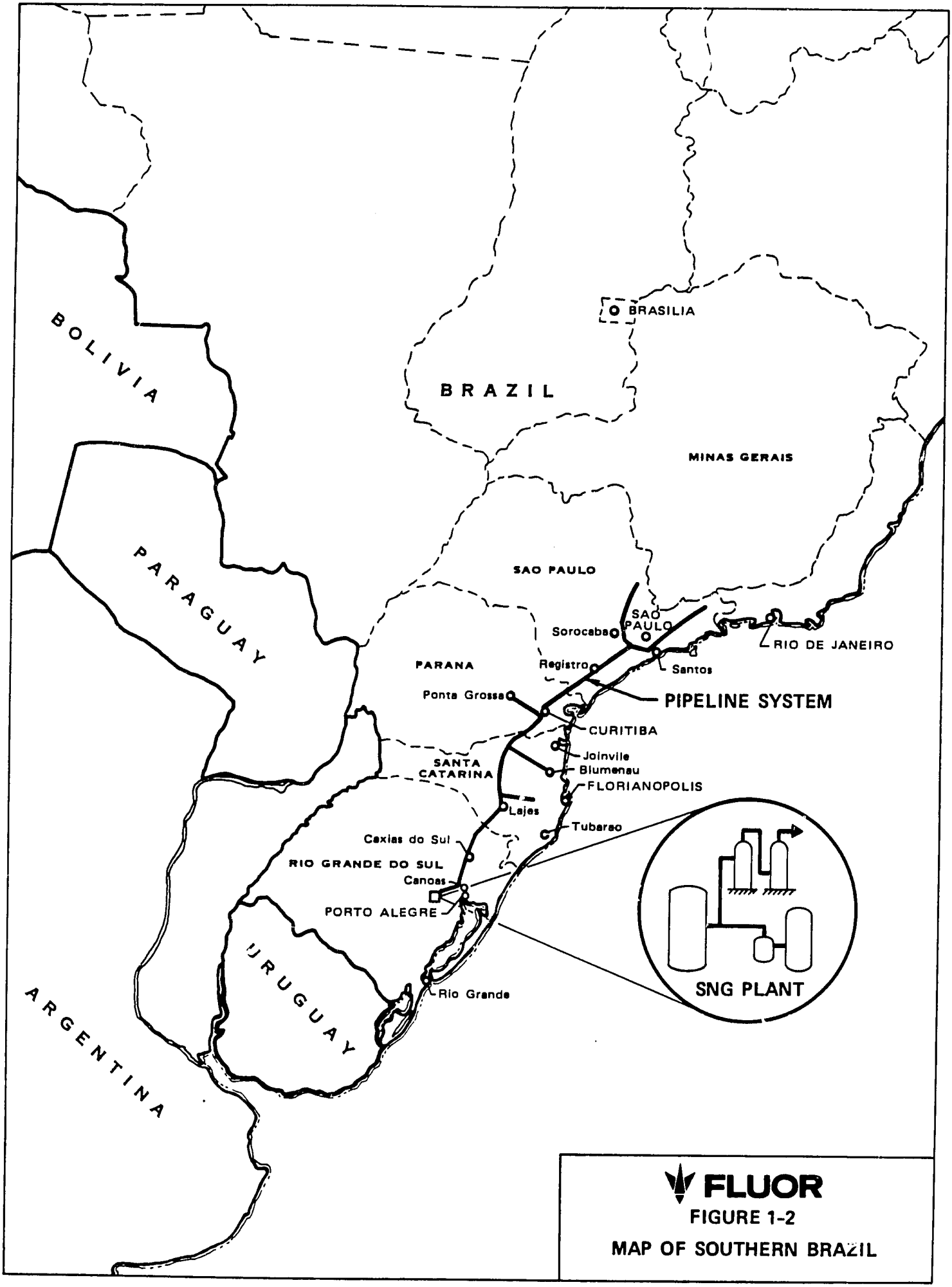
The economic analyses for the coal gasification plant and the gas pipeline are presented in Volume II, Parts I and II, respectively. A combined economic analysis for the plant and pipeline is shown in Section 6.0 of this Executive Summary.

Project schedules have been developed assuming an initial project release date of January 1, 1983. Plans of implementation for the SNG plant and the pipeline are separately discussed in Volume II, Parts I and II, and an overall project schedule is presented in Section 4.0 of this Executive Summary.

FLUOR

FIGURE 1-1

MAP OF SOUTH AMERICA



FLUOR

FIGURE 1-2

MAP OF SOUTHERN BRAZIL

2.0 DISCUSSION

2.1 ENGLISH TEXT

2.1.1 Objective of Study

The objective of this study is to assess the technical and economic feasibility of building and operating a coal gasification plant to produce and distribute substitute natural gas (SNG). For the purposes of this study, a "base case" arrangement was considered which assumed the gasification plant to be located near the mine mouth and in the general area of Minas do Leao in the state of Rio Grande do Sul (Figure 2-1). The gas produced by the SNG plant would be transported northward approximately 1000 kilometers by pipeline, and the bulk of the gas distributed to the industrial centers in the Sao Paulo region. Figure 2-2 shows the proposed location of the pipeline.

Fluor has developed technical and economic evaluations in sufficient detail to provide the basis for a capacity-factored cost estimate for the gasification plant and an order-of-magnitude estimate for the pipeline system. Cost estimates are stated in terms of January 1982 U.S. dollars.

The report also addresses the social and economic effects that may result from the construction and operation of the mines, gasification plant and pipeline.

2.1.2 Gasification Plant

The proposed gasification plant will gasify 14 283 metric tons per day of coal to produce 3.61 million (3.61×10^6) normal cubic meters per stream day of SNG. This is equivalent to a higher heating value of 33 000 million (33×10^9) kilocalories per day.

A major consideration in the selection of suitable gasification technologies is the high ash content and highly friable nature of the Brazilian coal. Some gasifiers are not suitable for high-ash coals, and some cannot handle coals with a high percentage of fines. By using a combined Lurgi/ Westinghouse process it is possible to conceptually design the plant to handle virtually all of the coal feed as received. The coarse fraction of the coal (6.35 mm and above) will be gasified in the Lurgi units, and the fines (below 6.35 mm) will go to the Westinghouse units. The plant design is based on 35 percent ash (dry basis) coal from the Leao mines.

Lurgi technology is commercially proven; Lurgi gasifiers having processed other coals similar to the Brazilian coal. The Westinghouse technology, while not commercially proven, appears likely to have a commercial size plant operating in 1984. This is well within the schedule for this project, allowing time for the process to be evaluated before final commitment to the Westinghouse gasifiers. This is considered suitable for the purposes of this study.

The SNG plant will be self-sufficient during normal operation. Raw water will be obtained from the Jacui River. Ash and sludge will be disposed of on-site. In addition to SNG, the plant will also produce 45.2 tons per day of ammonia, 226.2 tons per day of sulfur and 109 600 litres per day of naphta, all of which are saleable.

2.1.3 Priority Gas Demand Versus Pipeline Throughput

The present and projected needs for natural gas for Brazil's priority industries substantially exceed the presently considered SNG output of the coal gasification plant. Table 2-1 shows the projected gas consumption for priority industries in the years 1985 and 1990 for all of Brazil and for the State of Sao Paulo alone.

TABLE 2-1

PROJECTED GAS CONSUMPTION

BRAZIL AND STATE OF SAO PAULO

	Brazil		State of Sao Paulo	
YEAR	1985	1990	1985	1990
Oil per yr (TOE)* (mT/y)x10^6	4.65	5.5	4.0	4.7
Equivalent Gas $Nm^3/Dx10^6$	14.0	16.5	12.0	14.1
SCFDx10^6	525	621	452	531

*TOE: Tons of oil equivalent (@ 10400 kcal/kg oil HHV)

Nm^3/D: normal cubic meters/day (@ 0°C, 760 mm Hg), based on 365 days/year

SCFD: standard cubic feet/day (@ 60°F, 14.696 psia), based on 365 days/year

The output of SNG from the gasification plant is 3.61 x 10^6 Nm^3/D, while the anticipated gas requirements for priority industries in Sao Paulo alone are 12.0 and 14.1 x 10^6 Nm^3/D, respectively, for 1985 and 1990. Hence additional sources of gas are required to meet these projected needs. It is anticipated that additional sources of natural gas will be made available, both domestic and foreign. For the purposes of this study it is assumed that 10.0 x 10.0^6 Nm^3/D of natural gas will be imported, added to the SNG from the gasification plant, and the combined gases will flow northward in the pipeline. Hence, the pipeline is initially designed to handle the output of the SNG plant, but is expandable to accommodate the combined flow by the addition of intermediate compressor stations.

The ultimate design throughput of the pipeline system is set at 13.61 x 10^6 Nm^3/D of gas (508 x 10^6 SCFD), established as follows:

	Normal Cubic Meters/Day
Gasification Plant SNG:	3.61 x 10^6
Natural Gas (assumed imported):	10.00 x 10^6
Pipeline Design Throughput	13.61 x 10^6

Most of the gas (86%) is needed in the Sao Paulo metropolitan area.

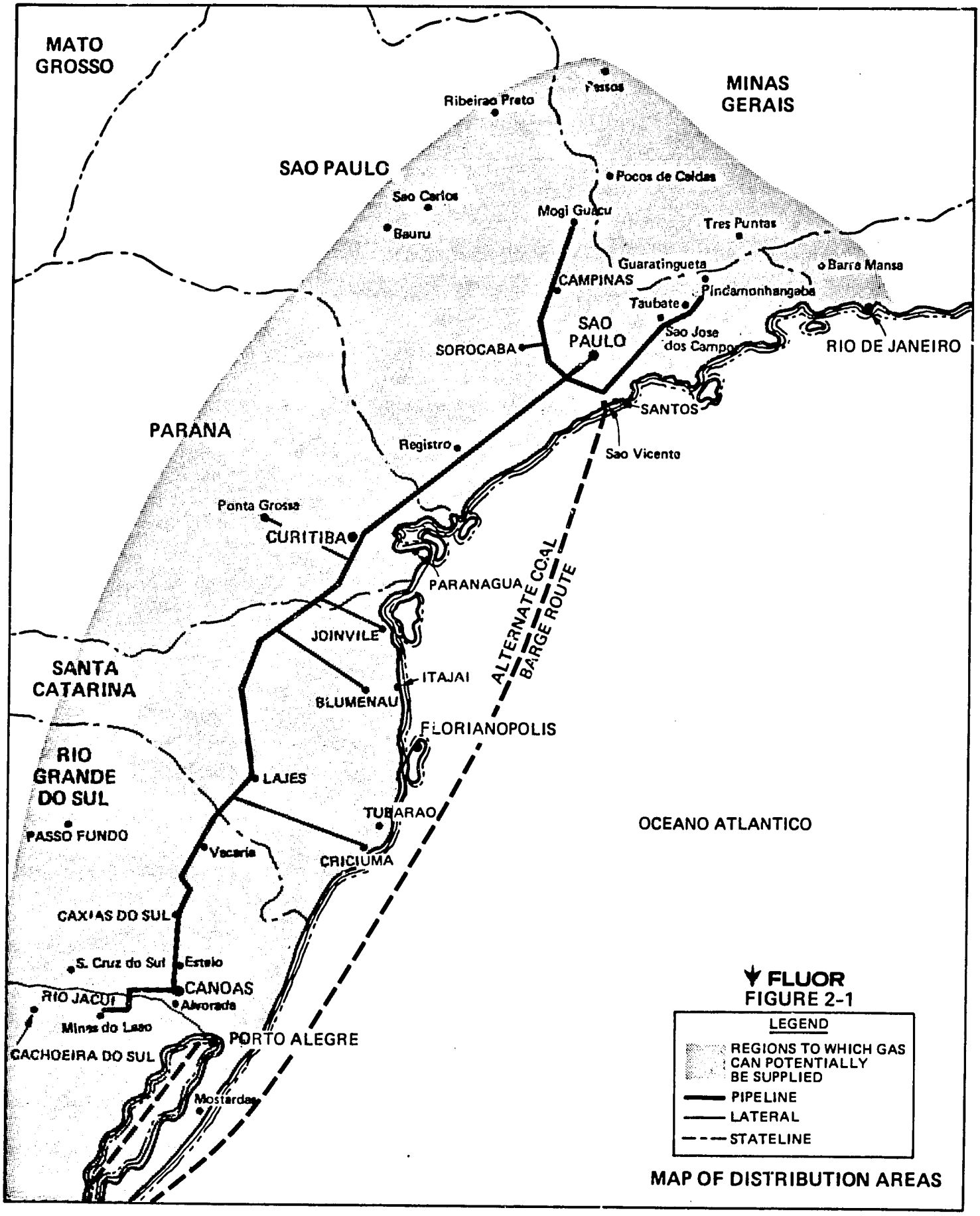
2.1.4 Viability

The distribution of 13.61 x 10^6 Nm^3/D (508 x 10^6 SCFD) of SNG and natural gas through the main transmission pipeline and the associated distribution system is technically viable and, of the alternates studied, is the most economical system of transferring energy from the coal mines in the south of Brazil to the consumers in the targeted industrial areas.

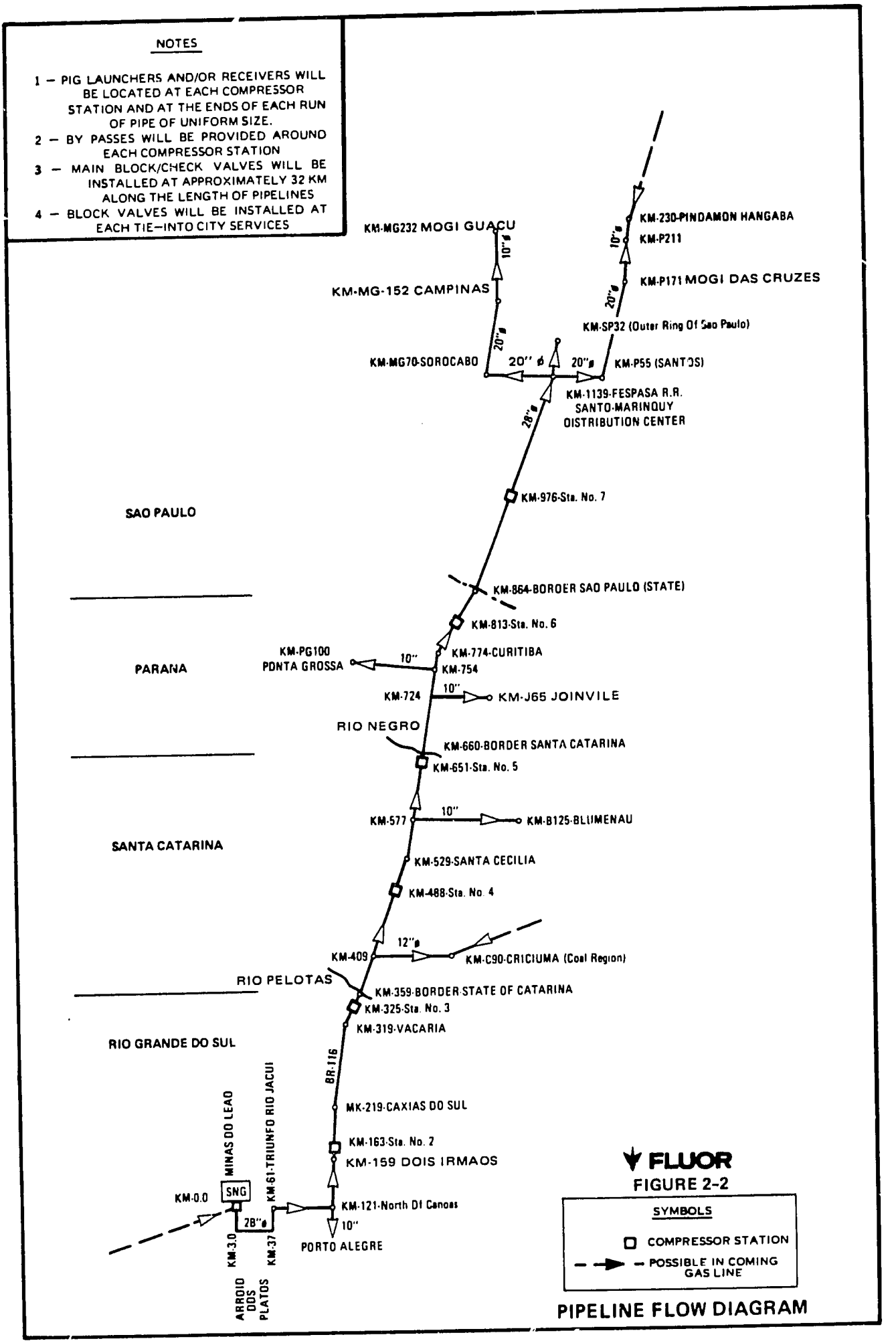
This pipeline system will be beneficial to the country as a whole, because of multiple benefits that will be derived from development of the subbituminous coal reserves to produce SNG. It will provide energy needed to expand the economy of the nation, and the pipeline will provide a base system that can be expanded to collect new sources of gas and to distribute this energy throughout Brazil.

2.1.5 Operating Energy Source

The energy required for pipeline operations will be primarily electricity. Because of its availability and low cost (power lines already exist along the pipeline right of way) electric power is selected to drive the intermediate pipeline compressors. Furthermore, none of the much-needed gas will be used to drive compressors. However, an economic analysis must be made during the engineering design phase of the pipeline to confirm the selection of electric motors over gas turbine drivers, for this service.



MAP OF DISTRIBUTION AREAS


NOTES
1 – PIG LAUNCHERS AND/OR RECEIVERS WILL BE LOCATED AT EACH COMPRESSOR STATION AND AT THE ENDS OF EACH RUN OF PIPE OF UNIFORM SIZE.
2 – BY PASSES WILL BE PROVIDED AROUND EACH COMPRESSOR STATION
3 – MAIN BLOCK/CHECK VALVES WILL BE INSTALLED AT APPROXIMATELY 32 KM ALONG THE LENGTH OF PIPELINES
4 – BLOCK VALVES WILL BE INSTALLED AT EACH TIE–INTO CITY SERVICES
KM-MG232 MOGI GUACU
10"ø
KM-MG-152 CAMPINAS
20"ø
KM-MG70-SOROCABO
20" ø
20"ø
KM-P55 (SANTOS)
KM-230-PINDAMON HANGABA
10"ø
KM-P211
KM-P171 MOGI DAS CRUZES
20"ø
KM-SP32 (Outer Ring Of Sao Paulo)
KM-1139-FESPASA R.R.
SANTO-MARINQUY
DISTRIBUTION CENTER
28"ø
KM-976-Sta. No. 7
SAO PAULO
KM-864-BORDER SAO PAULO (STATE)
KM-813-Sta. No. 6
KM-774-CURITIBA
KM-PG100
PONTA GROSSA
10"
KM-754
PARANA
KM-724
10"
KM-J65 JOINVILE
RIO NEGRO
KM-660-BORDER SANTA CATARINA
KM-651-Sta. No. 5
KM-577
10"
KM-B125-BLUMENAU
SANTA CATARINA
KM-529-SANTA CECILIA
KM-488-Sta. No. 4
KM-409
12"ø
KM-C90-CRICIUMA (Coal Region)
RIO PELOTAS
KM-359-BORDER STATE OF CATARINA
KM-325-Sta. No. 3
KM-319-VACARIA
RIO GRANDE DO SUL
BR-116
MK-219-CAXIAS DO SUL
KM-163-Sta. No. 2
KM-159 DOIS IRMAOS
MINAS DO LEAO
KM-61-TRIUNFO RIO JACUI
KM-0.0
SNG
28"ø
KM-121-North Of Canoas
10"
PORTO ALEGRE
KM-3.0
KM-37
ARROIO DOS PLATOS
FLUOR
FIGURE 2-2
SYMBOLS
COMPRESSOR STATION
POSSIBLE IN COMING GAS LINE
PIPELINE FLOW DIAGRAM

2.1.6 Cost and Economics

The estimated capital, operating, and maintenance costs of the SNG plant and gas pipeline system are summarized in Section 5 of this Executive Summary. This cost information, together with the project schedule (estimated to cover a period of 5.5 years from project initiation through mechanical completion) and economic criteria established during the course of the study, were used to perform the discounted cash flow analysis for the project summarized in Section 6.

Economic analyses were performed separately for the SNG plant (to show an SNG cost at the plant gate), and for the pipeline system (to show the gas transportation cost). For the purpose of economic analysis the gasification plant was assumed to operate 330 days per year (or approximately a 90 percent on-stream factor). The pipeline is assumed to carry this quantity of SNG plus 10 million normal cubic meters per day of natural gas. The natural gas is assumed to have the same calorific value as the SNG produced, and to be available 365 days per year (100 percent on-stream factor).

The results of our economic analysis showed a plant gate price for SNG of U.S. $31.22 per gigacalorie, plus U.S. $2.62 per gigacalorie transportation cost (pipeline), giving a required a total price of U.S. $33.84 per gigacalorie for gas delivered to the Distribution Center near Sao Paulo, to meet the base case financial criteria.

Sensitivity studies were performed to illustrate the impact of changes in various key variables such as coal price, plant life, inflation rate, capital cost etc., on the gas price. The results of these studies are included in the feasibility study report (Volume II).

For comparison purposes, prices quoted for some fuels presently used in Brazil, effective January 1982, are as follows:

LPG:	U.S. $23.21 per gigacalorie
Fuel Oil:	U.S. $15.87 per gigacalorie
Town Gas:	U.S. $37.78 per gigacalorie

All three fuels are government-subsidized.

2.1.7 Benefits to Brazil

Major benefits to the Brazilian economy and citizens would be derived from the gasification of Brazilian coal to produce SNG, and the distribution of the gas by the pipeline system. Some of these benefits are discussed below.

2.1.7.1 Balance of Payments The goal of the Brazilian government is to displace imported oil with energy derived from domestic resources.

It is understood that the federal government's 1985 target is to replace 500 000 barrels per day of oil by domestic energy sources. Implementation of this coal gasification project would reduce Brazil's dependency on Middle East oil, which is politically volatile and an unstable source of supply. Using coal as a diversified source of energy means a higher degree of survival capability in the event of an energy crisis.

This proposed coal gasification plant can reduce oil import costs by U.S. $233 million, based on 1.042 million tons of oil equivalent per year as the plant output, which is about 6.85 million barrels of oil per year at a world market value of a barrel of oil as U.S. $34.

The savings from reduced oil imports will free investment capital in Brazil, where capital needs are enormous. Money used to pay for imported oil is, in effect, loaned back to Brazil by foreign banks at prevailing interest rates, causing an ever-increasing debt.

2.1.7.2 Social. Completion of this project will have considerable socioeconomic benefits for the country in general. It will contribute toward greater employment and development of labor skills, improve the environment, develop industry, and increase technology in Brazil.

The availability of energy will allow the dispersement of industry to areas that are presently depressed and will provide new economic vigor where it is needed.

The present polarized trend toward increasing population in the Sao Paulo metropolitan area may be reversed as gas becomes available in the corridor between the SNG plant and Sao Paulo.

2.1.7.3 Energy Corridor. A potential 160 km x 1140 km energy corridor, as shown in Figure 2-1, will be created along the main transmission pipeline able to supply gas to present and future consumers. This energy corridor will stimulate industrial development through the whole area. The corridor will extend through the states of Rio Grande do Sul, Santa Catarina, Parana, and Sao Paulo. In addition, the distribution system will create a potential energy corridor north of Sao Paulo covering an area of 255 km (E&W) by 300 km (N&S). The direction of flow can be reversed in any of the laterals in the distribution system, should additional gasification plants be built in the future or should gas be discovered in the southern States.

2.1.7.4 Existing Wells and Future Development. Gas or associated gas from the wells being drilled offshore north of Rio de Janeiro can be fed into this base pipeline system. Natural gas is compatible with SNG. Hence, sweet gas produced from new discoveries would reach the marketplace faster and cheaper with this base pipeline system installed and operational. Furthermore, the existence of such a gas distribution network, able to accommodate new gas production, as well as allow reduction of imported gas flow, will stimulate field exploration and development.

2.1.7.5 Environment. We expect the net environmental impact of the SNG plant and gas pipeline to be minimal.

Discharges into the water and air from the SNG plant will be strictly controlled within acceptable limits.

The pipeline will be buried throughout its length, except for a few situations where local conditions require the line to be aboveground. However, there will in general be no aboveground structures except at compressor stations and block valves. A 15-meter pipeline right-of-way will be required to lay and bury the pipeline; this will parallel the existing power line right-of-way in most places. The pipeline right-of-way will be temporarily disturbed during the construction period, but would then be restored to its natural condition. Operation of the pipeline will produce no discharge to the atmosphere, since the compressors will be driven by electric motors.

Industrial use of the SNG to replace fuel oil will improve the environment in the industrial area, since the clean-burning gas will eliminate the sulfur, particulates, and other pollutants produced by burning fuel oil. Further, the anticipated dispersal of industry from its present concentration around Sao Paul will have a diluting effect on the air and water pollution produced by industry.

2.1.7.6 Industrial Development. The presence of the energy corridors will potentially attract industry to the southern States and areas to the north of the Sao Paulo metropolitan area.

During construction of the plant and pipeline system, unskilled workers will gain various construction skills from working along with skilled craftsmen and engineers. The operation of the plant will provide permanent employment for about 500 engineers, operators, and other workers. Additional jobs will be created in the related service industries - coal mining, for example. This must be an important consideration, since Brazil needs 1.6 million new jobs per year to support the natural growth of the present Brazilian population of 120 million people.

The SNG plant and pipeline will contribute to the development of the following sectors of coal-related industry in Brazil:

- Mining industry and technology
- Synthetic fuel industry and technology
- Coal handling and transportation industry
- Gas handling industry, such as compressor stations and specialized instrumentation and controls

- Industrial heat generation based on coal
- Waste management

This project could be the beginning of a viable synthetic fuels industry in Brazil, providing substantial opportunities for technology transfer.

2.0 DISCUSSAO

2.2 TEXTO EM PORTUGUES

2.2.1 Objetivo do Estudo

O objetivo dêste estudo é evaliar a viabilidade técnica e econômica da onstrução e operação de uma usina de gaseificação de carvão para produção e distribuição de gás natural sintético (SNG). Com este propósito em vista, um "caso de referência" foi considerado para o qual foi suposta a localização da usina de gaseificação junto à boca de mina de carvão mineral, situada na área de Minas do Leão, no Estado do Rio Grande so sul (Figura 2.1). O gás produzido pela usina de SNG seria transportado por um gasoduto em direção norte, com comprimento aproximado de 1 000 km, e em sua maior parte seria distribuido aos centros industriais na região da cidade de São Paulo.

A figura 2.2 mostra o traçado proposta para o gasoduto.

A firma Fluor realizou os estudos de avaliaçao técnica e econômica com suficiente detalhe para o cálculo estimativo dos custos para a usina de gaseificação e de uma ordem de grandeza dos custos para o sistema de gasodutos. As estimativas dos custos estão estabelecidas em termos do valor do dólar de janeiro 1982.

O relatório tambem trata dos efeitos sociais e econômicos que poderão advir da construção e operação das minas de carvão, usina de gaseificação e dos gasodutos.

2.2.2. Usina de Gaseificação

A usina de gaseificação gaseificará 14 283 toneladas métricas de carvão por dia para produzir 3,61 milhões ($3,61 \times 10^6$) metros cúbicos normais por dia de SNG. Isto é equivalente em valor calorífico superior a 33 000 milhões (33×10^9) de kilocalorias por dia.

Um fator especialmente considerado na seleção das tecnologias de gaseificação foi a natureza do carvão brasileiro, que é caracterizado por possuir alto conteúdo de cinzas e ser muito friável. Alguns gaseificadores não são apropriados para carvões com grande percentagem de cinzas e outros não podem lidar com carvões com alta porcentagem de finos. Utilizando-se de um processo combinado LURGI/WESTINGHOUSE é possível projetar-se conceitualmente uma usina capaz de lidar virtualmente com todos os tipos de carvões. A fraçao grossa do carvão (com granulometria superior a 6,35 mm) seria gaseificada em unidades LURGI, e os finos (menos de 6,35 mm) iriam para as unidades WESTINGHOUSE. O projeto da usina foi baseado em carvão com 35% de cinzas (em base sêca) das minas de Leão.

A tecnologia LURGI está comprovada comercialmente; gaseificadores LURGI já processaram outros carvões similares ao carvão brasileiro. A tecnologia da WESTINGHOUSE, apesar de não estar comprovada comercialmente, terá com grande probabilidade unidade comercial operando em 1984. Esta data é compatível com o cronograma deste projeto, podendo-se avaliar este processo ainda em tempo, antes de uma decisão final sobre os gaseificadores da WESTINGHOUSE. Isto foi considerado adequado para os propósitos deste estudo.

A usina de SNG operará de modo auto-suficiente. A fonte de água para a usina seria o Rio Jacuí. As cinzas e lamas seriam descartadas no próprio local apropiadamente. Além do SNG, a usina produzirá 45,2 toneladas diarias de amonia, 226,2 toneladas diarias de enxôfre e 109 600 litros/dia de nafta, todos eles perfeitamente passíveis de venda no mercado.

2.2.3. Demanda Prioritária do Gás versus Capacidade do Gasoduto

As necessidades, atual e futura, de gás natural das indústrias brasileiras consideradas prioritárias excedem a capacidade de produção projetada para usina de SNG. A tabela 2.1 mostra o consumo previsto de gás para as indústrias prioritárias nos anos 1985 e 1990 para todo o Brasil e para o Estado de São Paulo.

TABELA 2-1
PREVISAO DO CONSUMO DE GAS PARA O BRASIL E O ESTADO DE SAO PAULO

	Brasil		Estado deo São Paulo	
ANO	1985	1990	1985	1990
Tonelada de óleo equivalente, ton/ano 10^6*	4,65	5,5	4,0	4,7
Gás equivalente, $Nm^3/d \times 10^6$	14,0	16,5	12,0	14,1
Pés cubicos/dia, (SCFD) x 10^6	525	621	452	531

* = tonelada de óleo equivalente (óleo com PCS de 10 400 kcal/kg)

Nm^3/d= metro cúbico normal/dia (a ^oC, 760 mm/Hg), baseado em 365 baseado em 365 dias/ano.

SCFD: "standard cubic feet/day" (60° F, 14,696 psia) baseado em 365 dias/ano.

A produção de SNG será de 3.61 x 10^6 Nm^3/dia, ao passo que as necessidades de gás previstas para o atendimento somente das indústrias prioritárias em São Paulo saõ 12.0 e 14.1 x 10^6 Nm^3/dia, respectivamente em 1985 1990. Fontes adicionais de gás são portanto necessárias para o atendimento desta demanda. Considera-se que a demanda venha a ser atendida tanto a partir de fontes nacionais quanto de importadas. Foi assumido no estudo que 10.0 x 10.0^6 Nm^3/dia de gás natural serão importados, adicionados ao SNG produzido na usina de gaseificação, e que os gases misturados serão despachados em direção norte pelo gasoduto. O gasoduto foi, portanto, conceituado para atender no início somente à produção de SNG da usina, mas podendo depois atender à vazão dos gases combinados com a adição de estações compressoras intermediárias.

A vazão final de projeto adotada para o sistema do gasoduto foi fixada em 13.61 x 10^6 Nm^3/dia de gás (508 x 10^6 SCFD) conforme discriminado abaixo:

	Metros cúbicos normais/dia
SNG da usina de gaseificação	3.61 x 10^6
Gás natural (assumido como importado)	10.00 x 10^6
Vazão de projeto do gasoduto	13.61 x 10^6

A maior parte do gás (86%) seria utilizada na região metropolitana de São Paulo.

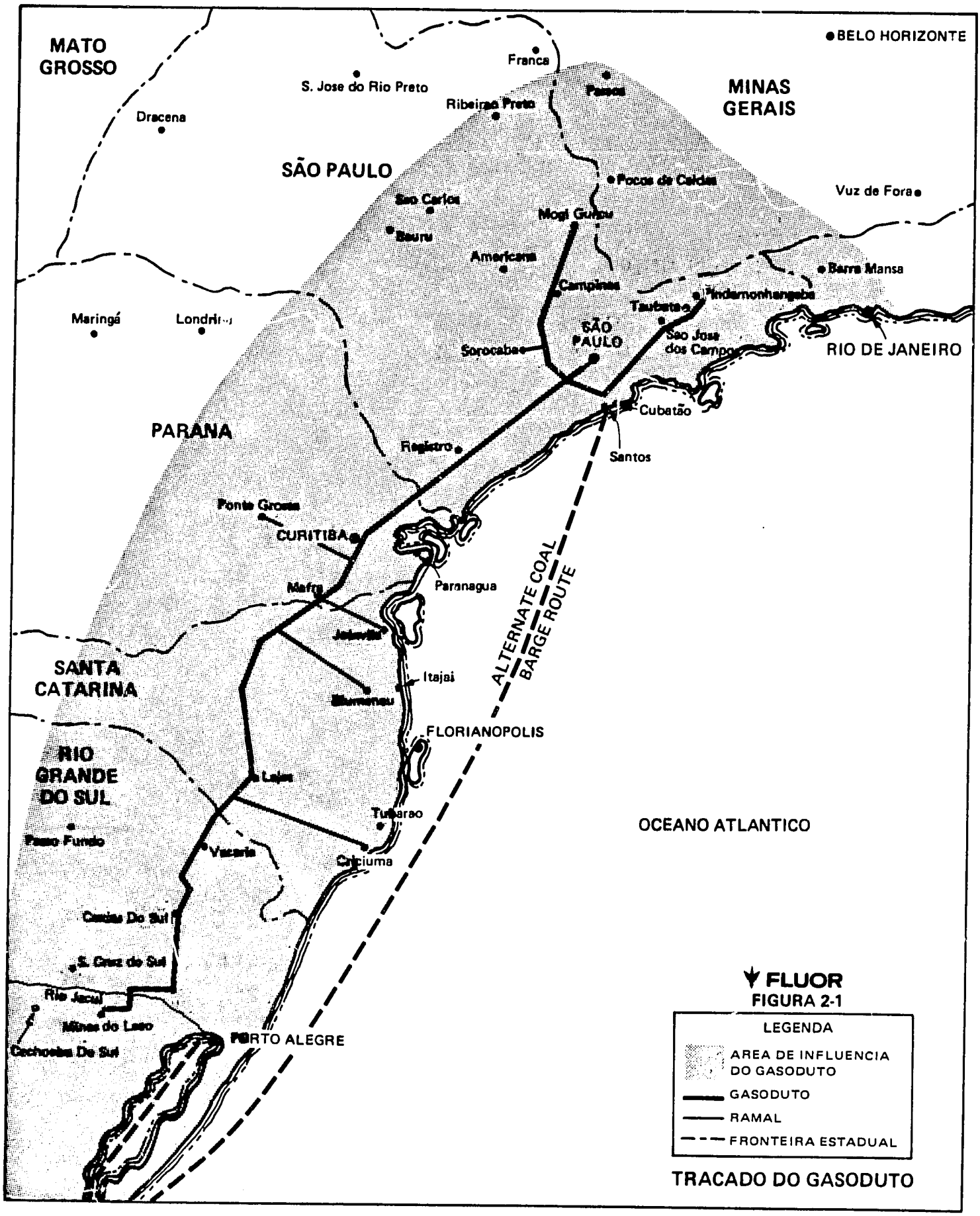
2.2.4 Viabilidade

A distribuição de 13.1 x 10^6 Nm^3/dia de SNG e gás natural pelo gasoduto principal e sistema de distribuição associado é técnicamente viável e, dentre as alternativas estudadas, é a maneira mais econômica de transferir energia das minas de carvão do sul do Brasil aos consumidores na região industrial considerada.

Este sistema de gasodutos beneficiará o país como um todo devido às multiplas vantagens a serem obtidas com o aproveitamento das reservas de carvão do sul na produção de SNG. O sistema proporcionará a energia alternativa necessária à expansão da economia nacional, e consistir-se à num sistema inicial que poder ser expandido para coletar novas fontes de gás e para distribuir essa energia a outras regiões do Brasil.

2.2.5 Origem da Energia para Operação

A energia necessária á operação do gasoduto será basicamente a eletricidade. Devido á sua disponibilidade e baixo custo (já existindo linhas de de força ao longo do traçado considerado), a energia elétrica foi escolhida para acionamento dos compressores das estações intermediárias. Dessa forma, nenhuma parcela do gás a ser transportado seria desperdiçada no acionamento dos compressores. Quando do projeto de engenharia do gasoduto, porém, uma comparação economica deve ser feita para confirmar a escolha de motores elétricos e não de turbinas a gás para esta função.


MATO GROSSO
BELO HORIZONTE
Franca
S. Jose do Rio Preto
Passos
MINAS GERAIS
Dracena
Ribeirao Preto
SÃO PAULO
Pocos de Caldas
Vuz de Fora
Sao Carlos
Mogi Guaçu
Bauru
Americana
Barra Mansa
Campinas
Taubate
Indaiatuba
Maringá
Londrina
SÃO PAULO
Sao Jose dos Campos
RIO DE JANEIRO
Sorocaba
Cubatão
PARANA
Registro
Santos
Ponta Grossa
CURITIBA
Paranagua
Mafra
ALTERNATE COAL BARGE ROUTE
Joinville
SANTA CATARINA
Itajai
Blumenau
FLORIANOPOLIS
RIO GRANDE DO SUL
Lajes
Tubarao
OCEANO ATLANTICO
Passo Fundo
Vacaria
Criciuma
Caxias Do Sul
S. Cruz do Sul
Rio Jacui
Minas do Leao
Cachoeira Do Sul
PORTO ALEGRE
FLUOR
FIGURA 2-1
LEGENDA
AREA DE INFLUENCIA DO GASODUTO
GASODUTO
RAMAL
FRONTEIRA ESTADUAL
TRACADO DO GASODUTO

NOTAS

1. Instalacoes para lancamento e chegada de "pigs" serao locadas em cada estacao compressora e no fim de trechos com bitola uniforme.
2. Serao previstos by-passes em cada estacao compressora.
3. Valvulas de bloqueio o retencao serao locadas a cada 32 km.
4. Valvulas de bloqueio serao instaladas em cada conexao com as redes municipais de distribuicao.

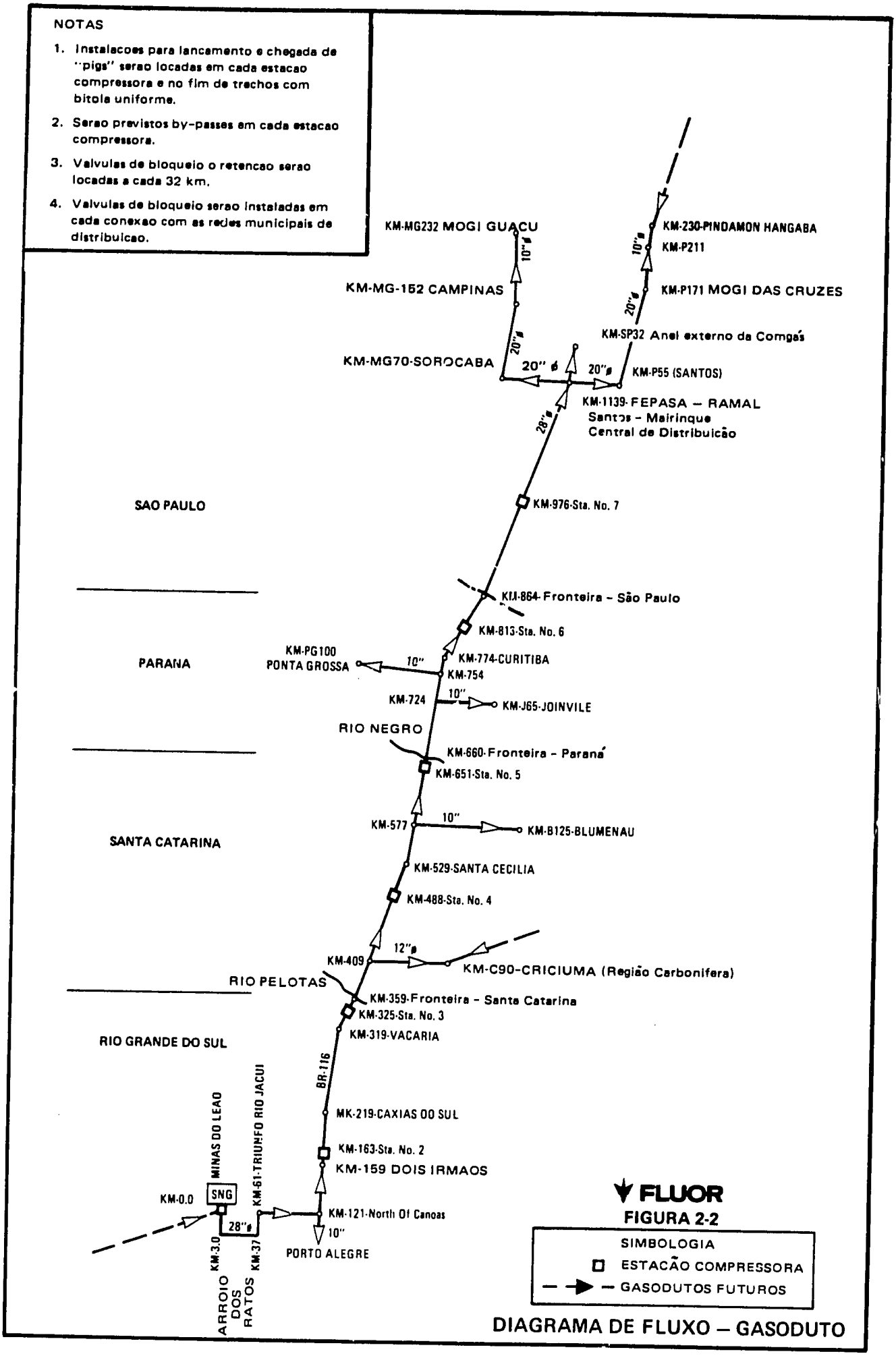


DIAGRAMA DE FLUXO – GASODUTO

2.2.6 Custo e Economicidade

As estimativas dos custos de capital, operação e manutenção da usina de SNG e do sistema de gasodutos está resumidas na seção 5 dêste resumo. Estas informações sobre custos, em conjunto com o cronograma do projeto (estimado para cobrir um período de 5,5 anos desde início do projeto até o término da construção) e os critérios econômicos estabelecidos ao longo do estudo, foram utilizados na análise econômica do fluxo de caixa do empreendimento, resumido na seção 6.

A análise econômica foi feita separadamente para usina de SNG (para mostrar os custos de SNG na saída da usina), e para o gasoduto (para mostrar o custo de transporte). Para efeito de análise econômica foi assumido que a usina de gaseificação operasse 330 dias por ano (ou aproximadamente com fator de carga de 90%). Foi também assumido que o gasoduto transportasse, além do SNG, 10 milhões de metros cúbicos normais por dia de gás natural. Adotou-se que o gás natural tenha um poder calorífico igual ao do SNG produzido, e que esteja disponível 365 dias por ano (100% de fator de carga.).

O resultado de nossa análise econômica indica um preço básico para SNG, na usina, é de US$31,22 dólares por gigacaloria, mais US$2,62 dólares por gigacaloria para o custo de transporte por gasoduto, resultando num preço total de US$33,84 dólares por gigacaloria para o gás no Centro de Distribução nas proximidades de São Paulo, para que sejam satisfeitos os critérios financeiros adotados como base para o estudo.

Estudos de sensibilidade foram realizados para ilustrar o impacto das mudanças em vários parâmetros-chaves, tais como preço do carvão, vida útil da usina, taxa de inflação, custo de capital etc., sobre o preço do gás gerado. Os resultados destes estudos estão incluidos no relatório do estudo de viabilidade (Volume II).

Para afeito de comparação, os preços estabelecidos para alguns combustíveis presentemente utilizados no Brasil, efetivos em janeiro de 1982, sãos seguintes:

GPL:	US$ 23,21 por gigacaloria
Oleo combustível	US$ 15,87 por gigacaloria
Gás de rua	US$ 37,78 por gigacaloria

Todos os três combustíveis estão sendo subsidiados pelo Governo.

2.2.7 Benefícios para o Brasil

A gaseificação do carvão mineral brasileiro para produção de SNG e a distribuição do gás através de um sistema de gasodutos resultará em benefícios de monta para a economia e para a população brasileiras.

Alguns desses benefícios são discutidos a seguir:

2.2.7.1 Balança de Pagamentos

Um dos objetivos do Governo Brasileiro é o de substituir petróleo importado por fontes alternativas nacionais de energia. O Governo Federal tem por meta a substituição de 500.000 barrís por dia de petróleo importado por fontes de energia nacionais em 1985. A implementação desse projeto de gaseificação de carvão reduziria a dependência brasileira do petróleo proveniente do Oriente Médio e de suas incertezas políticas, aumentando-se assim o poder de sobrevivência econômica na eventualidade de outras crises energéticas.

Esta usina de gaseificacão reduziria os custos de importação de petróleo em US$ 233 milhões anuais, baseado na produção de 1,042 milhões de toneladas equivalentes de petróleo por ano pela usina, que equivalem a 6,85 milhões de barrís de petróleo por ano a um preço de US$34.00 por barril prevalentes no mercado internacional.

A economia resultante da redução da importação de petróleo liberará capital para novos investimentos no Brasil, onde as necessidades de capital são enormes. De outra forma, o capital utilizado pelo País no pagamento da conta de petróleo é emprestado de volta ao Brasil por bancos estrangeiros com altas taxas de juro, provocando o aumento contínuo da dívida externa.

2.2.7.2 Benefícios Sociais

Substanciais benefícios de ordem socio-econômica poderão advir da execução desse projeto. Ele contribuirá para o aumento do emprego no País e treinamento de pessoal em novas técnicas, importará em melhoria do meio ambiente, no desenvolvimento de novas indústrias, tanto no setor de bens de capital como da utilização do gás e outros insumos produzidos pela usina, e na oportunidade de absorver e desenvolver novas tecnologias.

A disponibilidade de energia permitirá a implantação de industrias em novas regiões, o que resultará em desconcentração do crescimento industrial.

A atual tendência de crescimento populacional concentrado em São Paulo poderá ser invertida permitindo-se o crescimento em direção ao longo do corredor de SNG.

2.2.7.3 Corredor de Energia

Um corredor energético potencial de 160 km de largura por 1 140 km de extensão, como mostra a Figura 2.1, seria criado ao longo da principal linha de transmissão (gasoduto principal) capaz de suprir gás para os consumidores atuais e futuros. Este corredor se energia estimulará o desenvolvimento industrial de toda esta área colocando em disponibilidade uma fonte de energia limpa e confiável.

Este corredor se extenderia desde São Paulo até o Rio Grande do Sul, passando por Paraná e Santa Catarina. Além disso, o sistema de distribuição (ramais secundários) poderá criar um outro corredor energético ao

norte de São Paulo, de 255 km de extensão (no sentido leste-oeste) por 300 km de largura (no sentido norte-sul). O sentido de fluxo de gás poderá ser invertido em qualquer ramal no sistema de distribuição caso novas fontes de gás se tornen disponíveis ou novas usinas de gaseificação sejam construídas no futuro.

2.2.7.4 Fontes Atuais de Gás e Desenvolvimentos Futuros

Gás natural proveniente das reservas de Campos, no norte no Estado do Rio de Janeiro, poderão ser injetados no sistema de distribuição de gás aquí proposto. Gás natural é perfeitamente compatível com SNG. Assim, novas descobertas de gás poderão ter sua utilização acelerada pela existência desse sistema de distribuição já construído, representando um mínimo de custos adicionais. Estas possibilidades estimularão a procura e o desenvolvimento de novas fontes de suprimentos de gás.

2.2.7.5 Meio Ambiente.

Os efeitos ecológicos provocados pela usina de gaseificação e pelos gasodutos serão mínimos. Emissões para água e ar provocadas pela usina de SNG serão submetidas a controles rígidos e sua liberação será feita dentro das regras aceitas nos países mais industrializados.

Os gasodutos serão subterrâneos em toda su extensão, exceto em alguns locais que requeiram sua disposição fora da terra. Contudo, em geral, não haverá estruturas acima da terra exceto nos locais onde se encontrarão as estações de bombeamento e válvulas de bloqueio. Uma faixa de terra de 15 m de largura será requerida para construção de vala e colocação dos dutos. Esta faixa de terra, na maioria dos casos, correrá em paralelo com as faixas reservadas às linhas de transmissão elétrica. O terreno ao longo do gasoduto será temporariamente pertubado durante o período de construção, que è extremamente rápido (100 km por mês, tipicamente), após o que será restaurado às suas condições naturais. A operação do gasoduto não implicará em qualquer descarga para a atmosfera, pois os compressores serão acionados por motores elétricos.

A utilização industrial do SNG como substituto do óleo combustível melhorará sensivelmente o meio ambiente local, pois a sua queima è praticamente livre de resíduos poluidores eliminando-se, assim, compostos de enxofre, particulados e outros poluentes produzidos na queima do óleo combustível.

Além disso, a esperada desconcentração do crescimento industrial, decorrente da existência do gasoduto no interior, diminuirá a poluição do ar e água produzido pelas indústrias locais onde essas indústrias encontram-se já instaladas.

2.2.7.6 Desenvolvimento Industrial.

A existência do corredor de energia atrairá indústrias para a região sul do Brasil e para áreas ao norte e a leste da região metropolitana de São Paulo.

Durante a construção da usina e do sistema de gasodutos, trabalhadores seriam treinados nas técnicas especializadas de construção de gasodutos. A operação da usina necessitará de cerca de 500 pessoas dentre engenheiros, operadores e outros empregados. Novos empregos resultarão das necessidades de mineração de carvão e nas industrias que se instalarão ao longo do corredor. Este desencadeamento do desenvolvimento econômico resultante da implementação desse projeto constituir-se-á em importante fator social considerando-se a necessidade de criação de 1,6 milhões de novos emprêgos por ano, no Brasil, decorrente do crescimento populacional natural do País.

A usina de SNG e os gasodutos contribuirão para o desenvolvimento dos dos seguintes setores industriais no Brasil:

- Indústria a tecnologia de mineração;
- Indústria e tecnologia de combustíveis sintéticos;
- Indústria de transporte e manuseio de carvão;
- Indústria de manuseio de gás combustível, tais como estações compressoras, e os sistemas de controle e instrumentação especializados;
- Indústria de geração térmica baseada no carvão;
- Administração de resíduos.

Este projeto poderá significar o advento da indústria maciça de combustíveis sintéticos no Brasil, abrindo uma oportunidade ímpar de transferência, absorção e desenvolvimento de sua tecnologia.

3.0 FACILITY DESCRIPTION

3.1 GASIFICATION PLANT

3.1.1 Location

Site selection was based primarily on the indication of a coal resource adequate to support the gasification plant, together with water availability and transportation access. Based on these criteria, the study considers a gasification plant located in the general area of Minas do Leao, south of the Jacui River and approximately 100 kilometers from Porto Alegre.

3.1.2 Coal Resource

Coal feed is assumed to be from the Leao mines. Coal resource and characterization data were reviewed and, after consultation with gasification process licensors, it was concluded that Leao coal, washed to reduce the ash content to 35 weight percent ash (dry basis), should be used as the "reference" coal for the conceptual design.

3.1.3 Gasification Process Screening

Candidate gasification processes were evaluated in relation to their present or potential commercial application experience, and their ability to handle high-ash Brazilian coal. This resulted in the selection of a combined Lurgi/Westinghouse gasification process, allowing the gasification of virtually all coal from the wash plant. Because Brazilian coal is easily broken, we expect a high percentage of fines in the coal from the washing operation.

3.1.4 Plant Description

The proposed plant will gasify 14 283 tons per stream day of washed coal (containing 35 percent ash on a dry basis), and will daily produce substitute natural gas (SNG) with a higher heating value of 33 000 million kilocalories (33 000 gigacalories). This corresponds to 1.042 million Tons of Oil Equivalent (TOE) per year.

Coal will be mined from one or more new or existing mines, washed to the required ash specifications, and delivered to the gasification plant. The mines and washing facilities are outside the scope of this study, but we have allowed in the cost estimate for 15 kilometers of conveyors to deliver the washed coal to the gasification plant.

Washed coal received at the plant is separated into coarse and fine fractions, the coarse fraction going to the Lurgi gasifiers. Approximately 70 percent of the fines will be consumed in the Westinghouse gasifiers, with the remainder being fired in the plant boilers for the generation of steam and power.

Oxygen required for the coal gasification will be produced in an air separation plant.

The raw gas produced will be quenched and cooled (after heat recovery in the case of Westinghouse gasifiers) to condense the tar, oil, phenols, ammonia, and water from the gas stream. These components will comprise the gas liquor stream, which is treated separately.

The gas is then shifted in catalytic reactors to produce the correct ratio of hydrogen to carbon monoxide for methanation-about 3.6 to 1. Carbon monoxide is reacted with steam to produce the additional hydrogen required.

The shifted gas is further processed by a low temperature methanol wash in the Rectisol Unit. In this unit, all naphtha, essentially all sulfur and a portion of the carbon dioxide are removed to prepare the gas for methanation. The Rectisol off-gases are scrubbed in a Stretford Unit, producing elemental sulfur for sale, while the Stretford off-gases are incinerated in the boilers to avoid emitting residual hydrocarbons and undesirable sulfur compounds. The recovered naphtha from the Rectisol Unit is stabilized to produce a by-product for sale.

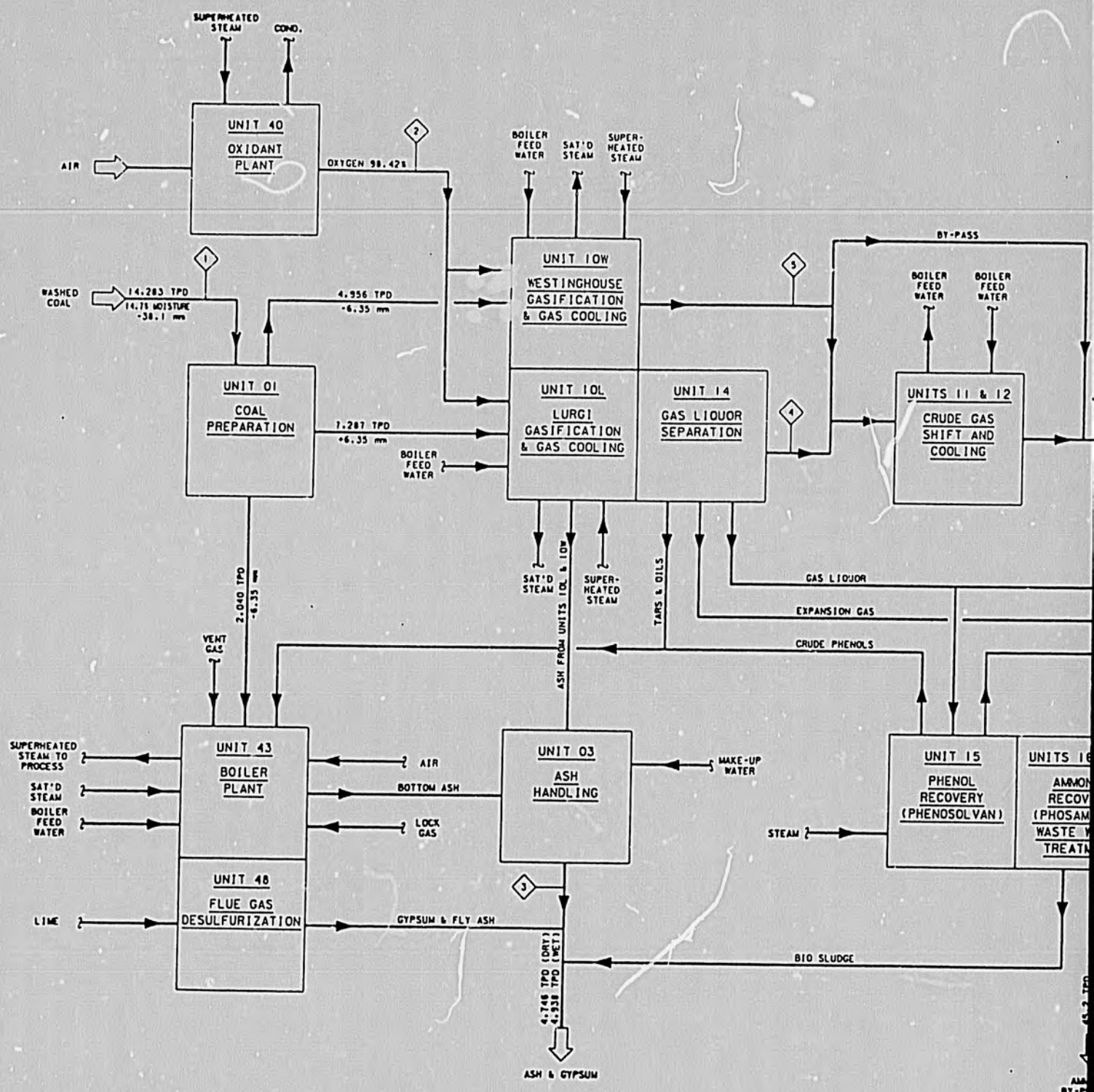
The clean synthesis gas, after preheating and dilution with recycled gas, is passed through parallel catalyst beds where carbon oxides react with hydrogen to form methane. A final cleanup reactor reduces remaining concentrations of the hydrogen and carbon monoxide and ensures a higher BTU-product gas. The gas will be cooled and compressed and the bulk of the remaining carbon dioxide removed in the Rectisol Unit. The SNG thus produced is further compressed to 68.6 kg/cm^2 (abs) and delivered to the pipeline at battery limits.

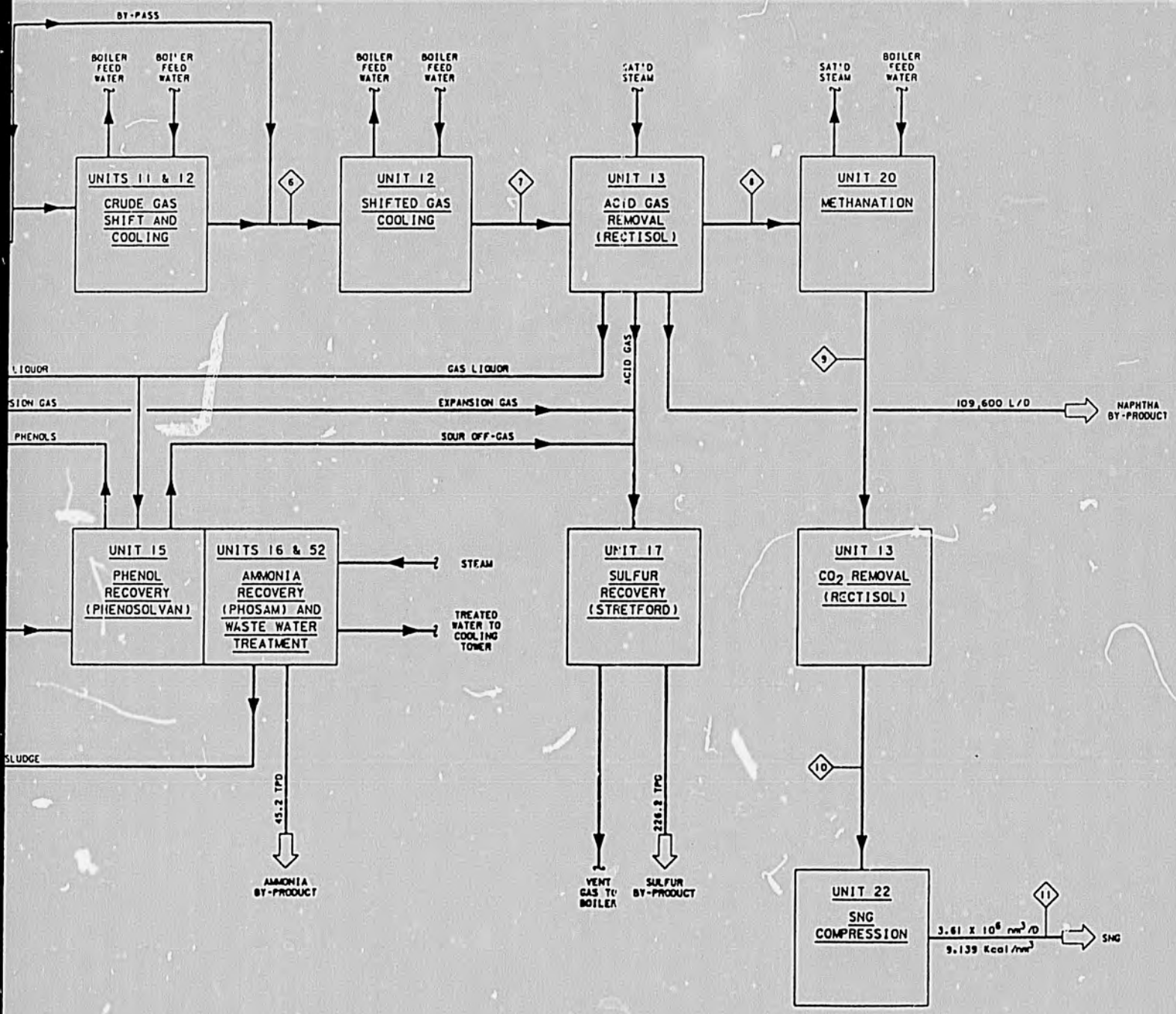
The gas liquor removed from the raw gas is passed through three stages of gravity separation to remove the tar and oil. The phenols are then extracted with di-isopropyl ether. The dephenolized water is stripped in a Phosam-W still to remove ammonia and acid gases, and after treatment is used as makeup in the cooling towers. Anhydrous ammonia is produced for sale and the tar, oil, and phenols are used to fuel the plant boilers and superheaters.

Raw water requirements of the plant, estimated at 1092 cubic meters per hour, will be met by water pumped from the Jacui River. The plant will be self-sufficient with respect to electrical power requirements during normal operation.

In addition to the 3.61 million cubic meters per stream day of SNG, the plant will produce 226.2 tons per day of sulfur, 45.2 tons per day of ammonia, and 109 600 liters per day of naphtha. Sulfur will be produced in the form of solid blocks, and ammonia and naphtha, as liquids, will be dispatched from the plant by truck to the nearest rail connection at Ramiz Galvao.

The only waste materials rejected from the plant are coal ash and gypsum. These are conveyed to the on-site ash pile for disposal.


SUPERHEATED STEAM
COND.
UNIT 40
OXIDANT PLANT
AIR
OXYGEN 98.42%
2
BOILER FEED WATER
SAT'D STEAM
SUPER-HEATED STEAM
UNIT 10W
WESTINGHOUSE GASIFICATION & GAS COOLING
BY-PASS
3
BOILER FEED WATER
BOILER FEED WATER
WASHED COAL
14,283 TPD
14.7% MOISTURE
-38.1 mm
1
4,956 TPD
-6.35 mm
UNIT 01
COAL PREPARATION
7,287 TPD
+6.35 mm
BOILER FEED WATER
UNIT 10L
LURGI GASIFICATION & GAS COOLING
UNIT 14
GAS LIQUOR SEPARATION
4
UNITS 11 & 12
CRUDE GAS SHIFT AND COOLING
SAT'D STEAM
SUPER-HEATED STEAM
TARS & OILS
GAS LIQUOR
EXPANSION GAS
CRUDE PHENOLS
2,040 TPD
-6.35 mm
VENT GAS
ASH FROM UNITS 10L & 10W
SUPERHEATED STEAM TO PROCESS
SAT'D STEAM
BOILER FEED WATER
UNIT 43
BOILER PLANT
AIR
BOTTOM ASH
LOCK GAS
UNIT 03
ASH HANDLING
MAKE-UP WATER
UNIT 15
PHENOL RECOVERY (PHENOSOLVAN)
STEAM
UNIT 48
FLUE GAS DESULFURIZATION
LIME
GYPSUM & FLY ASH
3
BIO SLUDGE
4,746 TPD (DRY)
4,938 TPD (WET)
ASH & GYPSUM



NOTES:

1. FLOWRATES ARE PER STREAM DAY.

FLUOR

D.P. HALVERSON
C.C. ABATAY
G.O. BOWD
A. RAD

OVERALL BLOCK FLOW DIAGRAM
LURGI/WESTINGHOUSE HYBRID CASE
SNG FROM COAL
U.S. A.I.D./BRAZIL

NONE | 836504-00-4-0001 | 0

001 36500001

The overall process configuration for the Lurgi/Westinghouse study design case is shown in the attached Block Flow Diagram, Drawing No. 836504-00-4-0001. The plant, including the ash disposal area, will require a plot space of approximately 1900 meters x 1280 meters, as illustrated by the attached Plot Plan, Drawing No. 836504-00-5-050.

3.2 PIPELINE AND DISTRIBUTION SYSTEMS

3.2.1 General Description

The 960-psi pipeline and distribution system is shown on Figures 2-1 and 2-2.

The 28-inch main transmission pipeline begins at Minas do Leao in the state of Rio Grande do Sul and parallels Route BR 116 to the main line distribution center located south of the city of Sao Paulo near the FEPASA railroad (Santo-Marinquy). The lateral distribution lines vary from 10 inches to 12 inches in diameter, as shown on Figure 2-2. These laterals, along the length of the transmission pipeline, supply gas to Blumenau, Joinvile, Ponta Grossa, Criciuma, and Curitiba in the states of Santa Catarina and Parana.

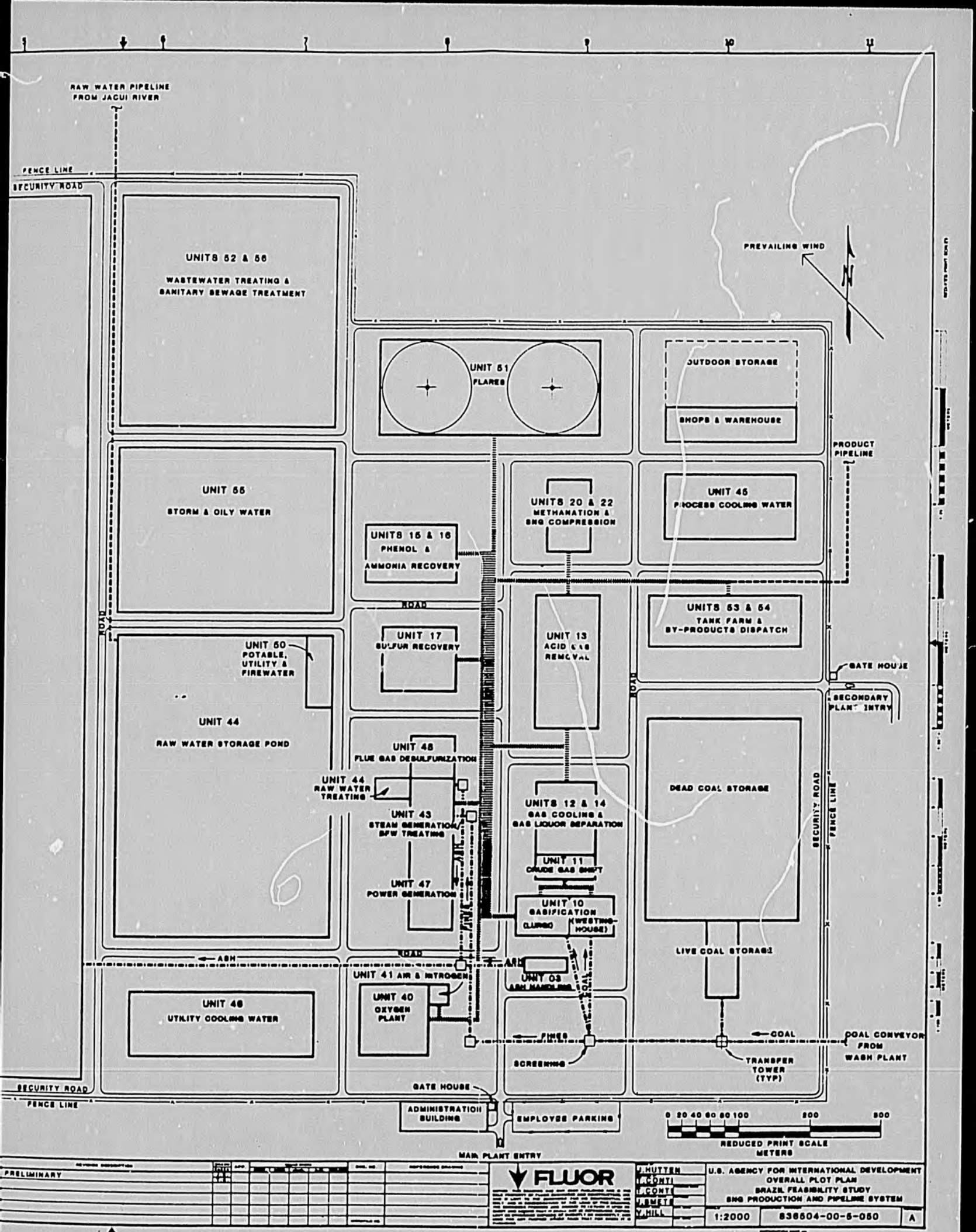
The distribution system includes:

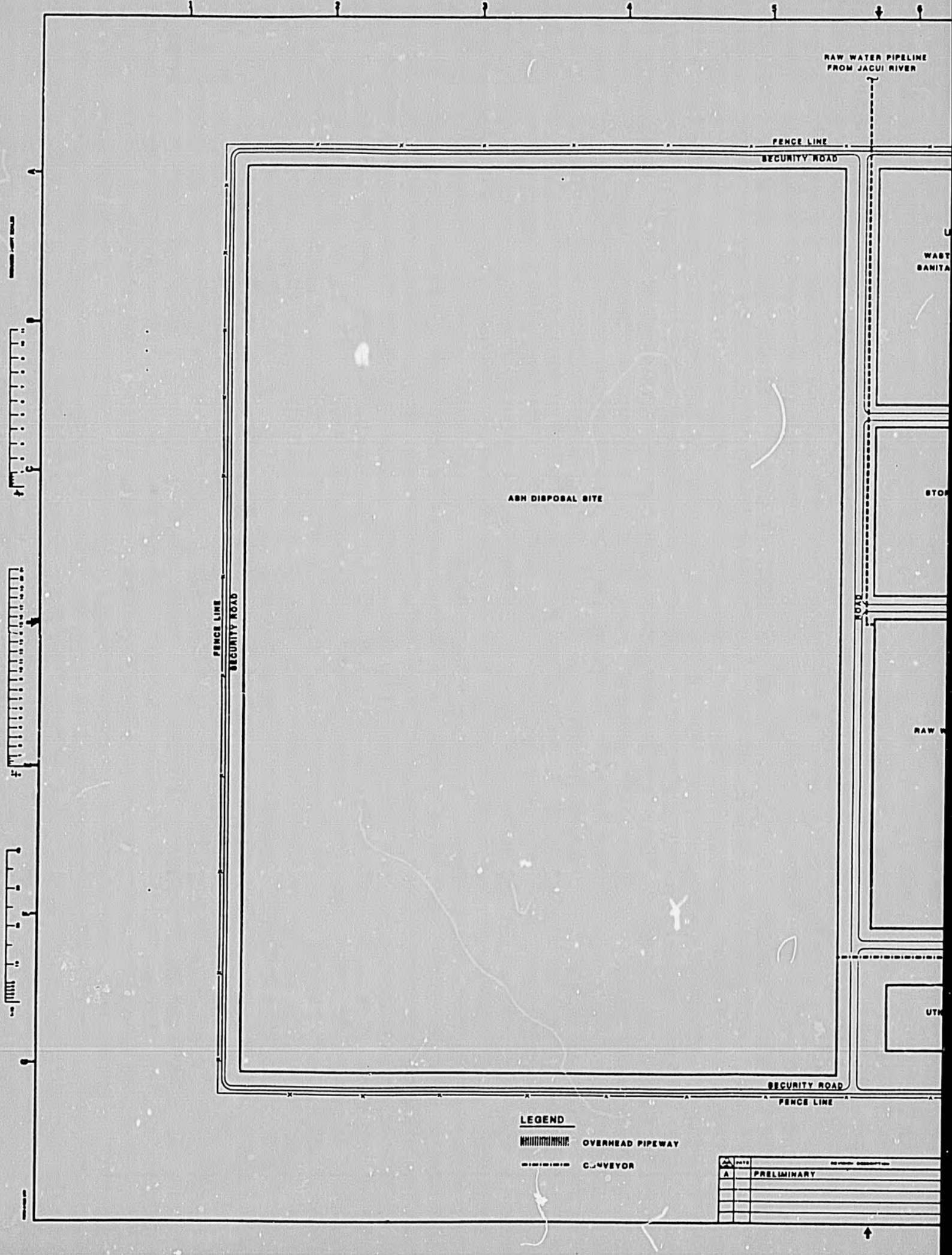
- Connection to high pressure system of the city of Sao Paulo
- The eastern leg to Cubato/Santos, S. Jose Dos Campos, Taubate, and Pindamonhangaba
- The western leg to Sorocaba, Campinas/Aulina, and Mogi Guacu.

A conceptual design of the system was developed to meet the projected needs of priority industrial centers for the years 1985 and 1990 and beyond to 2000. It does not include allowance for nonpriority commercial or residential users. The proposed system is readily expandable. Incremental expansions can be made to accept and distribute additional gas as the supply of gas is increased to meet the overall consumer demand. The additional high-BTU gas may come from new gas wells, additional coal gasification plants, associated gas from oil wells or from neighboring countries.

3.2.2 System Capacity

The initial pipeline system throughput design capacity is $13.61 \times 10^6 Nm^3/D$ (508×10^6 SCFD). The SNG Plant will produce $3.61 \times 10^6 Nm^3/D$ (135×10^6 SCFD) and the balance of $10 \times 10^6 Nm^3/D$ (373×10^6 SCFD) will be supplied from other sources. A conservative design has been proposed by assuming that the gas from other sources will be injected into the end of the pipeline at the SNG Plant and that all of the gas will be delivered through the main transmission pipeline. Six intermediate compressors are required to deliver the design capacity flow to the distribution center south of Sao Paulo.


RAW WATER PIPELINE FROM JACUI RIVER
FENCE LINE
SECURITY ROAD
UNITS 52 & 56
WASTEWATER TREATING & SANITARY SEWAGE TREATMENT
PREVAILING WIND
UNIT 51
FLARES
OUTDOOR STORAGE
SHOPS & WAREHOUSE
PRODUCT PIPELINE
UNIT 55
STORM & OILY WATER
UNITS 20 & 22
METHANATION & SNG COMPRESSION
UNIT 45
PROCESS COOLING WATER
UNITS 15 & 16
PHENOL & AMMONIA RECOVERY
ROAD
UNIT 17
SULFUR RECOVERY
UNIT 13
ACID GAS REMOVAL
UNITS 53 & 54
TANK FARM & BY-PRODUCTS DISPATCH
UNIT 50
POTABLE, UTILITY & FIREWATER
GATE HOUSE
SECONDARY PLANT ENTRY
UNIT 44
RAW WATER STORAGE POND
UNIT 48
FLUE GAS DESULFURIZATION
UNIT 44
RAW WATER TREATING
UNIT 43
STEAM GENERATION BFW TREATING
UNITS 12 & 14
GAS COOLING & GAS LIQUOR SEPARATION
DEAD COAL STORAGE
UNIT 11
CRUDE GAS SHIFT
UNIT 47
POWER GENERATION
UNIT 10
GASIFICATION
(LURGI)
(WESTING-HOUSE)
LIVE COAL STORAGE
ASH
UNIT 41 AIR & NITROGEN
UNIT 03
ASH HANDLING
UNIT 46
UTILITY COOLING WATER
UNIT 40
OXYGEN PLANT
FINES
COAL
COAL CONVEYOR FROM WASH PLANT
SCREENING
TRANSFER TOWER (TYP)
GATE HOUSE
ADMINISTRATION BUILDING
EMPLOYEE PARKING
MAIN PLANT ENTRY
0 20 40 60 80 100 200 300
REDUCED PRINT SCALE METERS
PRELIMINARY
FLUOR
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
OVERALL PLOT PLAN
BRAZIL FEASIBILITY STUDY
SNG PRODUCTION AND PIPELINE SYSTEM
1:2000
836504-00-5-050
A


RAW WATER PIPELINE
FROM JACUI RIVER
FENCE LINE
SECURITY ROAD
ASH DISPOSAL SITE
FENCE LINE
SECURITY ROAD
ROAD
SECURITY ROAD
FENCE LINE
LEGEND
OVERHEAD PIPEWAY
CONVEYOR
A
PRELIMINARY

The gas will free flow from the distribution center to each of the three distribution legs. Conservatively estimated, the design flow of gas will exceed 2.7 x $10^6 Nm^3/D$ (101 x 10^6 SCFD) in the Mogi Guacu leg and 2.4 x $10^6 Nm^3/D$ (89 x 10^6 SCFD) in the Pindamonhangaba leg.

The pipeline system can be modified for increased throughput by adding more compressors, looping parts or all of the lines, or by a combination of each.

3.2.3 Gas Storage

Gas storage is considered in two categories, namely, that required for seasonal and that for daily variations in gas demand. The gas industry frequently handles seasonal variations by injecting gas into abandoned wells for storage, and daily fluctuations by packing the pipeline, using storage tanks, or by liquefying the gas and then storing the cryogenic liquid in tanks.

The present and future priority demands for gas energy in Brazil will exceed both SNG production and projected supply from other sources. In addition, the current gas supply is allocated to industrial users who require a relatively constant supply of gas and whose demand is not materially affected by seasonal temperature variations. Hence, long term storage will not be required until, and if, the gas is supplied to nonpriority commercial and residential users. This contingency lies beyond the scope of this study.

Gas demand for an individual industrial user will usually be on a constant basis, for 330 days/year (minimum) or 365 days/year (maximum). The variations in demand are anticipated on a day-to-day basis. The pipeline system is designed to store in excess of a day's gas demand by packing the line, which will more than adequately handle variations, even if the demand in some plants is on an 8-or 12-hour-per-day basis. Further studies during Phase 2 of the future pipeline project will be required to evaluate the need for additional storage facilities, after fluctuation statistics become available.

3.2.4 Supervisory Control (SCADA), Communications

The entire pipeline system can be fully operated from a remote central control system located at Minal do Leao. This will be accomplished through a microwave system which will send and receive signals to control and monitor the system.

3.2.5 Pipeline vs. Barges

The scope of work for this report includes a study to compare the relative merits of two methods of energy transport: (1) building the coal gasification plant near the coal mines and shipping the SNG by pipeline to the Santos area; and (2) building the gasification plant near Santos and barging the coal from the mines to the gasification

plant. For this comparative study, the pipeline was sized as it would be to transport only the SNG from the gasification plant, eliminating "other source" gas as a variable in the comparisons. The study was further expanded to include consideration of other modes of transporting energy from Leao to consumers in the Sao Paulo metropolitan area.

A summary of quantitative and qualitative evaluations that were made is shown on Tables 3-1 and 3-2, respectively.

The comparison showed that the initially selected pipeline system was the least costly with respect to both capital investment and operating costs. In addition, of the systems evaluated, it provided the most advantages with respect to regional growth, national growth, social, economic, technological, ecological, and political effects, national security, utilization of natural resources, safety, and manpower utilization aspects.

Table 3-3 provides a brief summary of the relative merits of the Base Case pipeline system and those of barging coal to an SNG plant near the area of gas usage.

TABLE 3-1

EVALUATION OF ALTERNATIVE TRANSPORTATION MODES

QUANTITATIVE

CASE DEFINITION		INVESTMENT ($1000)	RANK	ANNUAL ENERGY COST ($1000)	RANK
1. Case I-A	Gas Pipeline System (Base Case)	322 440	1	1 934	1
2. Case I-B	Liquefied Gas Transportation	NOT DETERMINED	-	NOT DETERMINED	-
3. Case II-A	Coal Barge Haul to Santos	373 658	3	64 576	3
4. Case II-B	Coal Slurry Pipeline to Santos	521 740	2	6 453	2
5. Case II-C	Railroad Haul to Santos	994 400	4	134 758	4

TABLE 3-2

EVALUATION OF ALTERNATIVE TRANSPORTATION MODES

QUALITATIVE

SPECIFIC FACTORS	CASE I-A GAS PIPELINE SYSTEM	CASE I-B LNG TRANSPORTS	CASE II-A BARGE HAUL AND PIPELINE	CASE II-B COAL SLURRY PIPELINE	CASE II-C RAILROAD COAL HAUL
1. Economic	1	-	3	2	4
2. Social Homogeneity	1	5	4	2	3
3. Technology	1	5	4	2	3
4. Ecological	1	3	4	2	5
5. Political	1	4	3	2	5
6. National Security	1	5	4	2	3
7. Utilization of Natural Resources	1	4	3	2	5
8. Manpower	1	4	3	2	5
9. Safety	2	5	3	1	4
10. Master Plan Objectives	1	4	3	2	5

TABLE 3-3

RELATIVE MERITS OF TRANSPORTATION SYSTEMS

ITEM	PIPELINE SNG	BARGING COAL
National Interest	o More jobs available, resulting in added tax revenues in the southern states (long term) o Improve upon the existing telephone communications network o Reduces the drain on the balance of payments to foreign countries o Less maintenance and operating problems o Less intensive use of skilled labor	o More jobs in Porto Alegre and Santos (short term) o High diesel consumption, negating some of the gains from use of coal o A large operating organization would have to be created o More intensive use of general labor
Natural Resource Utilization	o Makes use of the vast supply of subbituminous coal from the southern states	o The land required to install the berthing facilities in heavily-congested areas of Porto Alegre and Santos could be utilized to better economic and social advantages
Technological	o More efficient use of natural resources (Brazilian) o Training will uplift the quality of manpower in Brazil	o About 10% of the coal will be lost during transport, creating pollution problems
Social	o Makes gas available throughout the south-eastern part of country; hence, the effect will be to decentralize industry and population centers	o Polarizes industry and population growth in the state of Sao Paulo, in the metropolitan area of the city of Sao Paulo o More jobs will be created, but return on capital investment may not be attractive

TABLE 3-3 (Continued)

RELATIVE MERITS OF TRANSPORTATION SYSTEMS

ITEM	PIPELINE SNG	BARGING COAL
Economic Effects	o Lower capital investment o Lower operating costs o Lower investment in spare parts o Lower routine maintenance costs o Less sensitive to inflation effects o Less infrastructure	
Environmental	o Air pollution levels in industry areas would decrease. The SNG plant will be located in an area where the pollution levels would not be materially increased o There is a sufficient water supply to run the plant	o Air pollution levels in Santos would increase with the installation of the SNG Plant o Water from the Santos Metro area would be required to run the plant
National Security	o Monitoring and security control of buried overland distribution system easier to manage than comparable sea routes	

4.0 PROJECT SCHEDULE

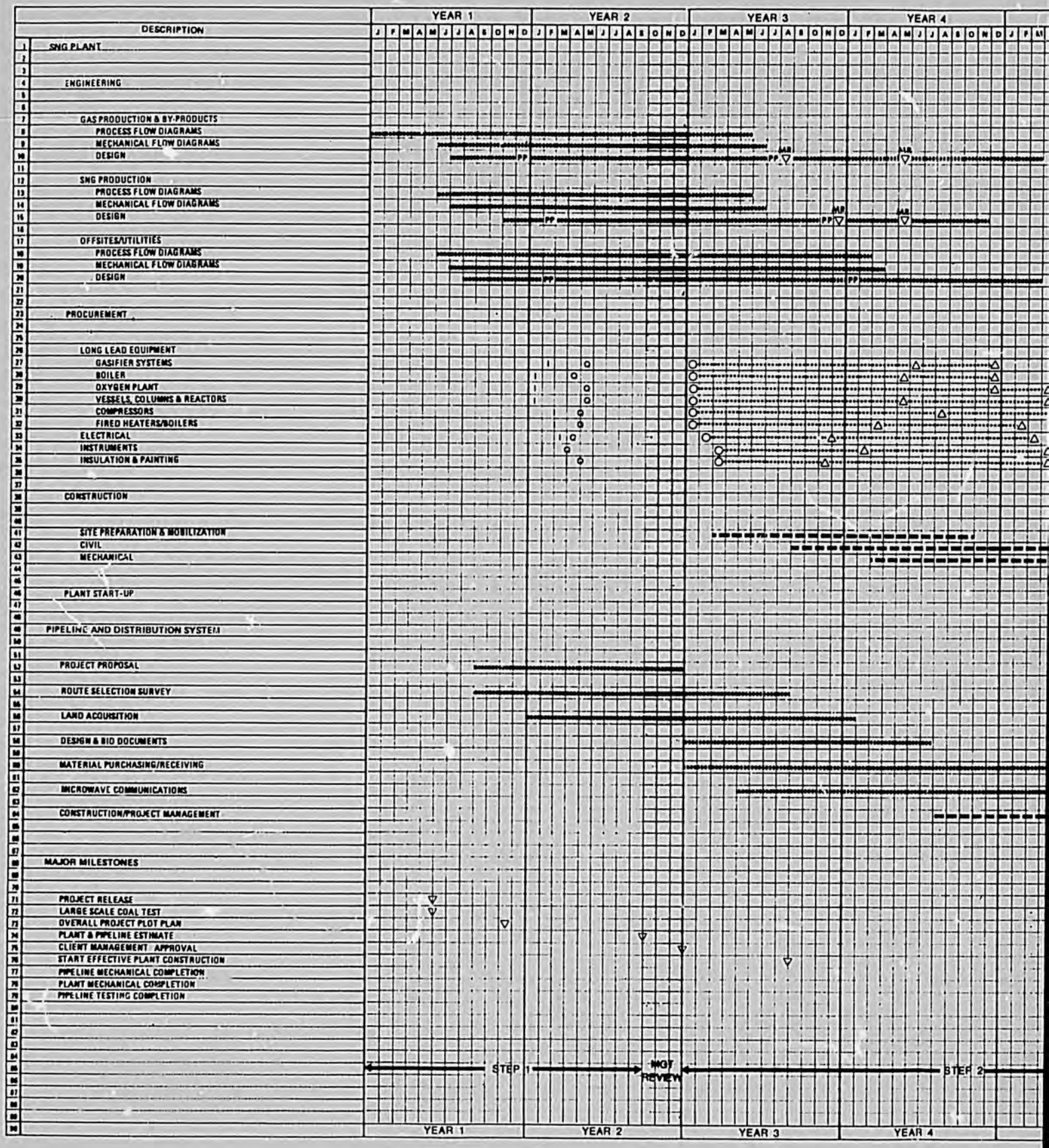
The Master Schedule (Figure 4-1) displays the time relationship for the engineering, procurement, and construction tasks for the coal gasification plant and pipeline system developed in this study.

The schedule provides for a management review of the project, during which preliminary design and a detailed estimate form the basis of the review and decision to proceed. Activities prior to this review are shown on the schedule in the Step 1 period. The first major activity is a large-scale coal test to provide basic design data. At the conclusion of this test, the project is released for Step 1 design and procurement activities. During this period, the progress in engineering is directed to supporting the development of the detailed estimate of both the plant and the pipeline. Inquiries are issued for equipment during Step 1 but actual commitment of the orders is deferred until after the management review.

Mechanical completion is defined as the point when the plant/pipeline have been turned over to the owner for precommissioning activities.

Start-up proceeds as units are completed and precommissioning activities are accomplished by the owner.

The schedule assumes there are no delays due to complying with governmental regulations and the obtaining of environmental permits.

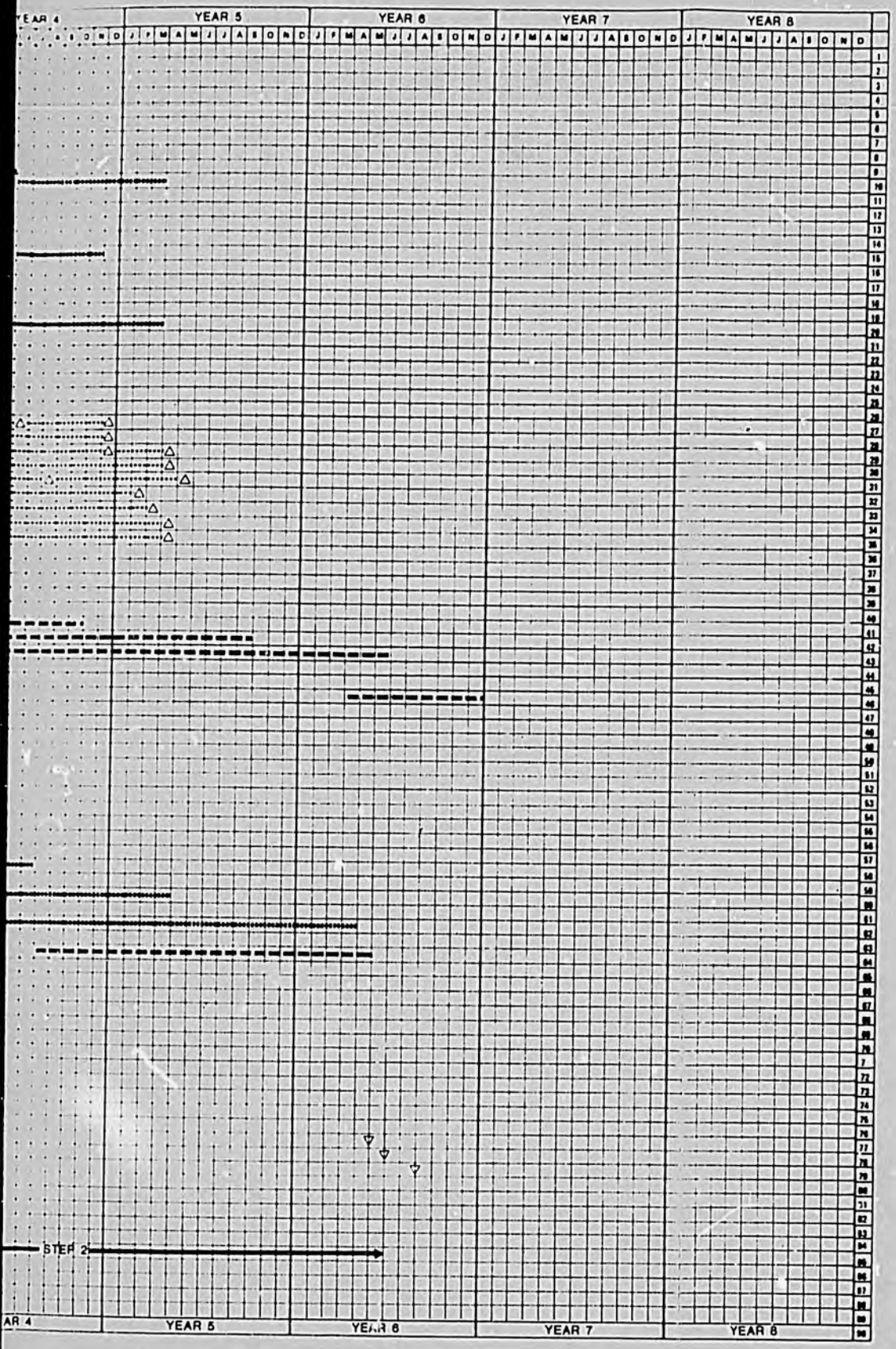


LEGEND

EQUIP. SPECIFICATION	SP	PURCHASE ORDER	○	PLANNED HOME OFFICE ACTIVITY	•••••••••
INQUIRY	I	VENDOR DRAWING	□	PLANNED CONSTRUCTION ACTIVITY	▬ ▬ ▬
RECEIVED QUOTATION	Q	JOBSITE DELIVERY	△	TIME RANGE	•••••••••
MODEL REVIEW	MR	MILESTONE	▽		
PLOT PLAN	PP				
APPROVED FOR CONSTRUCTION	AFC				

	DATE	REVISION DESCRIPTION	DRAWN / CHECK	APP	DWG NO

MICROFILM



NOTES:

1. THE SCHEDULE ASSUMES THAT ALL ENVIRONMENTAL PERMITS AND GOVERNMENT REGULATIONS HAVE BEEN SATISFIED.
2. PROCESS & MECHANICAL FLOW DIAGRAMS WILL BE APPROVED FOR DESIGN DURING STEP 1.
3. EQUIPMENT SPECIFICATION WILL BE APPROVED FOR DESIGN AND PROCUREMENT DURING STEP 1.
4. THE INQUIRY AND RECEIVE QUOTATION DESIGNATIONS (I AND Q) REFLECT THE FIRST INQUIRIES AND THE FIRST VENDOR QUOTATIONS RECEIVED.
5. THE FIRST PLOT PLANS ISSUED WILL BE CONSIDERED PRELIMINARY AND WILL BE USED AS THE BASIS FOR THE ESTIMATE. THE SECOND PLOT PLANS ISSUED WILL BE APPROVED FOR CONSTRUCTION.
6. ENG/DESIGN WORK WILL CONTINUE DURING THE MANAGEMENT APPROVAL PERIOD BUT AT A REDUCED RATE.
7. BOTH THE PLANT AND THE PIPELINE ESTIMATES WILL BE REVIEWED DURING MANAGEMENT APPROVAL PERIOD.
8. IT IS ASSUMED THAT NO COMMITMENTS TO VENDORS WILL BE MADE UNTIL AFTER THE MANAGEMENT APPROVAL PERIOD AND THAT SOME VENDOR QUOTES MAY HAVE TO BE RENEGOTIATED.

	APP	DWG NO	REFERENCE DRAWING
		MICROFILM NO	

FLUOR

NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED AND IS THE SOLE PROPERTY OF FLUOR ENGINEERS AND CONSTRUCTORS INC. AND IS LENT TO THE BORROWER FOR HIS CONFIDENTIAL USE ONLY, AND IN CONSIDERATION OF THE LOAN OF THIS DRAWING THE BORROWER PROMISES AND AGREES TO RETURN IT UPON REQUEST AND AGREES THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR OTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS FURNISHED.

DRAWN BY A. YESSAIAN

CHECKED BY

SUPERVISOR | RELEASE DATE

SUPERVISOR ENGR | INITIALS

PROJECT ENGR | APP DATE

CLIENT | DATE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

MASTER SCHEDULE
BRAZIL FEASIBILITY STUDY
SNG PRODUCTION AND PIPELINE SYSTEM

FIGURE 4-1

REVISION 00

DISTRIBUTION CODE NO

5.0 CAPITAL AND OPERATING COST SUMMARY

5.1 ENGLISH TEXT

The costs Fluor developed for the coal gasification plant and the gas transport pipeline, expressed in instantaneous January 1982 U.S. dollars and for the Brazilian location, are summarized in Table 5-1.

For the purposes of this estimate, a contingency allowance corresponding to a fifty percent probability of underrun in cost is used throughout the project. For more information on contingency, refer to Section 4 of the Feasibility Study Report (Volume I, Part I).

Preoperating costs represent costs not customarily handled by the contractor. Items included are:

- Initial catalysts and chemicals
- Warehouse spare parts
- Mobile equipment
- Building furniture, shop equipment, and laboratory equipment
- Royalties and license fees
- Owner's costs

Operating costs include the following:

- Catalysts, chemicals, and coal
- Operating and maintenance labor
- Maintenance material
- Overhead

Initial working capital and the cost of coal are discussed in the Project Economic Analysis (Volume II, Section 6.0).

TABLE 5-1

ESTIMATE SUMMARY
INSTANTANEOUS JANUARY 1982
U.S. DOLLARS (Millions)

	Gasification Plant	Pipeline System	Total
Direct Field Costs	760.1	611.0	1 371.0
Indirect Field Costs	196.4	71.3	267.7
Office Costs	133.1	18.7	151.8
Camp Costs	40.0	13.5	53.5
Contingency	196.4	124.5	320.9
Subtotal Project	1 326.0	839.0	2 165.0
Preoperating Costs	146.5	30.0	176.5
TOTAL	1 472.5	869.0	2 341.5
Annual Operating Costs (Including Coal)	39.1	17.8	56.9

5.0 RESUMO DOS INVESTIMENTOS E CUSTOS DE OPERACAO

5.2 Texto em Português

Os custos calculados pela Fluor para a usina de gaseificação e para o gasoduto, apresentados em US dólares instantâneos de janeiro de 1982 estão resumidos na Tabela 5-1.

Neste orçamento foi adotada uma reserva de contingências correspondentes a 50 porcento da probabilidade de subestimação de custos. Para maiores detalhes sobre esta reserva, ver capítulo 4 do Volume II. Custos pré-operaçionais são custos geralmente não administrados pelo contratante principal. Por ejemplo:

- Carga inicial de catalizadores;
- Estoque de peças sôbressalentes;
- Equipamentos móveis de transporte interno;
- Móveis, equipamentos de oficina e de laboratório;
- Pagamentos de patentes e liçencas;
- Custos internos do propietário.

Custos operacionais incluem:

- Catalizadores, produtos químicos e carvão;
- Mão de obra de operação e manutenção;
- Materiais de manutenção;
- Despesas gerais

O capital de giro inicial e o custo do carvão são examinados no capítulo 6. do Volume II.

TABELA 5-1

RESUMO DOS CUSTOS
(Dólares instantâneos de janeiro de 1982)

	Usina de Gaseificação	Gasoduto	Total
Custos diretos de construção	760.1	611.0	1 371.0
Custos indiretos de construção	196.4	71.3	267.7
Custos de escritório	133.1	18.7	151.8
Custos de alojamento	40.0	13.5	53.5
Contingências	196.4	124.5	320.9
Subtotal	1 326.0	839.0	2 165.0
	146.5	30.0	176.5
TOTAL	1 472.5	869.0	2 341.5
Custos de operação anuais, incluindo carvão	39.1	17.8	56.9

6.0 PROJECT ECONOMIC ANALYSIS

6.1 ENGLISH TEXT

Using the base case cost data developed in the study, Fluor performed separate economic analyses on the coal gasification plant and on the pipeline system. The gasification plant analysis was based on the plant operating 330 D/yr and producing 3.61 x 10^6 Nm^3/D of SNG (33 000 gigacalories/D) while operating. This basis determined what SNG price would be required at the plant gate. The pipeline analysis was based on pipeline throughput of the SNG from the gasification plant plus an additional 10.0 x $10^6 Nm^3$/D of imported gas for 365 D/yr. This basis determined the incremental SNG price required to cover distribution costs. Combining the plant gate price and pipeline distribution cost results in a delivered product price.

As shown in Table 6-1, the study indicated that a January 1982 plant gate price of U.S. $31.22 per gigacalorie ($7.87 per million BTU) and delivered price of $33.84 per gigacalorie ($8.53 per million BTU) would be needed for the SNG produced by the gasification plant to meet the target return on investment goal, based on the following principal assumptions:

- Ten percent general inflation (on U.S. dollars)
- Three percent real escalation on materials and product price, and five percent real escalation on labor
- Eight percent real internal rate of return (post-tax return on investment)
- Twenty-year plant operation lifetime.

Sensitivity studies were performed to illustrate the impact of changes in key variables, such as coal price, plant lifetime, inflation rate, capital costs, etc., on the SNG price. The results of these studies are detailed in the tables and curves presented in Sections 5 and 16 of the Feasibility Study (Volume II).

TABLE 6-1

SUMMARY OF ECONOMIC ANALYSIS

BASE CASE COAL GASIFICATION PLANT AND PIPELINE

	Million U.S. $ (January 1982)		
	Gasification Plant	Pipeline System	Total
CAPITAL COSTS			
Plant and Equipment	1 326.0	839.0	2 165.0
Preoperational Costs	90.0	--	90.0
Owner's Costs during Construction	56.5	30.0	86.5
Initial Working Capital	15.3	1.5	16.8
Total	1 487.8	870.5	2 358.3
ANNUAL OPERATING COSTS			
Coal (at $32.90/ton)	155.1	--	155.1
Other	39.1	17.8	56.9
Total	194.2	17.8	212.0
BY-PRODUCT REVENUES			
Sulfur (at $140/ton)	10.5	--	10.5
Ammonia (at $177/ton)	2.6	--	2.6
Naphtha (at $0.161/liter)	5.8	--	5.8
Total	18.9	--	18.9

	U.S. $ (January 1982)			
	$/Gcal	$/Million BTU	$/1000 Nm^3	$/1000 SCF
SNG PRICE				
At Plant Gate	31.22	7.87	285.30	7.64
Distribution Cost	2.62	0.66	23.92	0.64
Delivered Price	33.84	8.53	309.22	8.28

	Gasification Plant	Pipeline System
REAL RATES OF RETURN		
ROE	12.5%	12.8%
Pretax ROI	10.1	10.4
Post-Tax ROI	8.0	8.0

6.0 ANALISE ECONOMICA DO EMPREEDIMENTO

6.2 Texto em Português

Foram executados pela Fluor, a partir dos custos estimados para o caso base, duas análises econômicas separadas, uma para a usina de gaseificação e outra para o sistema de gasodutos. A análise para a usina de gaseificação baseou-se na usina operando 330 dias por ano e produzindo 3.61 x 10^6 Nm^3 de SNG por dia de operaçao (33 000 gigacalorias por dia). A análise determinou então o preço a ser pago pelo gás na boca da usina. A análise do gasoduto baseou-se em uma vazão do gasoduto igual à produção de SNG da usina mais 10.0 x 10^6 Nm^3 por dia adicionais de gás importado, durante 365 dias/ano. Foi então calculado o preço adicional a ser pago para cobrir os custos de transporte. O preço final do gás é a soma do preço na boca da mina, mais o preço do transporte.

O estudo mostra, como apresentado na Tabela 6.1, que um preço na boca da usina (dólares de janeiro de 1982) de US$ 31,22 por gigacaloria (ou US$ 7,87 por milhao de BTU), e um preço final do gás de US$ 33,84 por gigacaloria (US$8,53 por milhão de BTU), são necessários para consequir-se o retorno pré-estabelecido sobre o investimento, baseando-se nas seguintes premissas:

- Taxa geral de inflação (em dólares) de 10% ao ano;
- Aumento real de custos de materiais primas e materiais, e de preços de venda, de 3% ao ano, e de 5% para mão de obra;
- Taxa de retôrno real sobre investimento (após impôstos) de 8% ao ano;
- Vida útil de 20 anos para as instalações.

O impacto nos preços de venda de mudanças em variáveis críticas, tais como custo do carvão, vida útil, taxa de inflação, investimentos, etc., foi estudado por meio de análises de sensibilidade. Os resultados das análises são apresentados em detalhes nas tabelas e gráficos dos capítulos 5 e 16 do Volume II.

TABELA 6-1

RESUMO DA ANALISE ECONOMICA CASO BASE
USINA DE GASEIFICACAO E GASODUTO

	Milhões de US $,(Janeiro 1982		
	Usina de Gaseificação	Sistema de Gasoduto	Total
INVESTIMENTO			
Equipamentos e instalaçoes	1 326.0	839.0	2 165.0
Custos pré-operacionais	90.0	--	90.0
Custos internos do propietário durante a construção	56.5	30.0	86.5
Capital de giro inicial	15.3	1.5	16.8
TOTAL	1 487.8	870.5	2 358.3
Despesas Operacionais (anuais)			
Custo de carvão a US$32.90 por tonelada métrica	155.1	--	155.1
Outros	39.1	17.8	56.9
TOTAL	194.2	17.8	212.0
RECEITAS COM SUB-PRODUTOS			
Enxôfre a US$140 por tonelada métrica	10.5	--	10.5
Amonia a US $177 por tonelada métrica	2.6	--	2.6
Nafta a US $ 0.161 por litro	5.8		5.8
TOTAL	18.9	--	18.9

	U.S.$ (Janeiro 1982)			
PRECO DO SNG	$/GigaCal	$/Milhão de BTU	$/1000 m^3n	$/1000 SCF
Na boca da usina	31.22	7.87	285.30	7.64
Custos de transporte	2.62.	0.66	23.92	0.64
Preço final do gás	33.84	8.53	309.22	8.28

TAXAS REAIS DE RETORNO	Usina de Gaseificação	Sistema de Gasodutos
Retôrno sôbre o capital própio(ROE)	12.5%	12.8%
Retôrno sôbre o investimento, antes de impôstos	10.1%	10.4%
Retôrno sôbre o investimento, (ROI), depois de impôstos	8.0%	8.0%