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CELANESE
CHEMICAL COMPANY, INC.

COASTAL BEND FEASIBILITY STUDY FINAL REPORT

March 30, 1982

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COASTAL BEND

FEASIBILITY STUDY

FINAL

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COASTAL BEND FEASIBILITY STUDY

FINAL REPORT

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COASTAL BEND FEASIBILITY STUDY

I. INTRODUCTION

Overview

This report presents the results of a study to determine the feasibility of utilizing coal derived synthesis gas to replace natural gas at Bishop. This study sought to answer three key questions generated during presentation of the 1981 Strategic Plan:

- Is coal derived syngas commercially feasible?
- Is coal an economical replacement for gas after deregulation?
- Is Bishop the correct site for the coal/gas plant?

Results

Coal derived syngas for the Bishop plant is commercially feasible.

Coal derived syngas is not an economical replacement for natural gas at Bishop based on current gas price forecasts.

A mine sited coal/gas plant is more favorable economically than a Bishop sited coal/gas plant.

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Chronology

Initial designs and capital cost data for the Coastal Bend study were developed by Stearns-Roger from January 1, 1981 through October 31, 1981.

Refinements to capital costs, development of operating costs and all economic evaluations were conducted by the Coal Program Team in the Dallas office from November 1, 1981 through March 31, 1982.

Although the engineering house effort was terminated early, it is felt that the design and cost elements presented here are adequate for the future evaluation of coal gasification opportunities.

This Executive Summary represents the highlights of data developed during the study. Those interested in further details are referred to the full report including the Reference Manuals produced by Stearns-Roger.

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II. OBJECTIVE

The objective of the Coastal Bend Project study was to determine the technical and economical viability of developing syngas for methanol and other chemicals from either a high Btu coal or Texas lignite. The intent was to replace the consumption of natural gas at Bishop. The syngas would be used to produce electric power and process steam and as raw material for the existing Bishop methanol plant.

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III. CONCLUSIONS

The following conclusions were reached as a result of this study:

1. Coal based syngas as a raw material for methanol and combined cycle electricity generation is technically feasible.

2. No environmental, transportation, raw material availability, or water availability problems were found for either the Bishop site or mine site.

3. The most economical approach to replace natural gas at Bishop is to gasify lignite at a site in East Texas and pipeline the syngas to Bishop.

4. Using current Celanese economics standards and natural gas price forecasts, a coal gasification plant to retrofit the Bishop plant is not economically attractive.

5. Coal based syngas will only compete economically at this time with natural gas under a utility type or other unusual financing arrangements. Various design and raw material alternates were developed. The results of which are shown in the following summary table:

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BISHOP SITE

Process	Raw Material	Feed Rate TPD	Capital Cost, $MM (1981)	Annual Operating Cost, $MM (1981)	% DCF
Lurgi	Lignite	9,954	720	146	10.3
Texaco	Raton Coal	4,385	782	146	10.2
Westinghouse	Lignite	10,872	783	157	10.9
Lurgi/Texaco	Lignite	9,730	848	146	10.4

MINE SITE
ROBERTSON COUNTY, TEXAS

Lurgi	Lignite	11,057	875	106	13.4

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IV. RECOMMENDATIONS

Based on the conclusions reached, the following is recommended:

1. Celanese should not pursue a coal gasification project further at this time for Bishop.

2. Celanese should explore innovative financing options for a large scale syngas production facility.

3. Management attention to developments in the gasification area should be maintained.

4. It is recommended that the data accumulated during this study be retained in usable form and updated for future studies, as required.

V. PLANT DESIGNS

A. Background

1. March, 1979 Joint Study

In late 1978 and early 1979 Celanese participated in a joint study[1] to assess lignite or coal as a fuel or feedstock in its existing Texas Gulf Coast plants.

The study was conducted at the Radian Corporation, Austin, Texas and participants besides Celanese were:

- The Almunimum Co. of America
- E.I. Dupont DeNemours & Co.
- Houston Lighting & Power Company
- Panhandle Eastern Pipeline Company
- Conoco Energy Development Company
- Texas Eastern Transmission Corp.

Answers sought were:

- Commercial readiness of coal to medium Btu gas processes.
- True cost of medium Btu gas to users for energy and chemical manufacturing.

The combined expertise, used to develop costs for mining, transportation, gasification, and product gas distribution, was a key feature of this study.

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1. March, 1979 Joint Study (cont'd.)

The input data and cost analysis by sponsoring company representatives kept results on a "real life" basis.

Evaluations included:

- Three processes
- Two different plant sites
- Two different feedstocks

Economic analysis included both utility financing methods and standard 100% equity discount cash flow methods.

Conclusions reached were:

- No apparent technological, environmental, or regulatory barriers would prevent the construction of a gasification plant in Texas.
- The levelized cost of medium Btu gas in 1978$ was estimated to be Btu utilizing utility financing methods, and Btu utilizing the DCF method.

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1. March, 1979 Joint Study (cont'd.)

For the gasification systems evaluated, medium Btu gas costs exhibit little dependence on the type of processing technology. It was also determined that the use of Texas lignite was more attractive then the use of a non-Texas coal.

1 "Feasibility of Medium Btu Gas Production From Coal For Use in Texas Gulf Industries", March 1979, Radian Corporation (Library KD 16a & b).

2. 1980 Methanol Strategy

Long term availability of natural gas as an economical feedstock for methanol was a key question during development of the 1980 Methanol Strategy[2]. Long range economic evaluations by Celanese Planning, confirmed that, coal could become the preferred source of syngas for methanol manufacture.

Concurrent with Celanese Planning, the United States Department of Energy began soliciting for feasibility studies to explore production of "alternate fuels". Methanol emerged as a leading alternate fuel candidate. Methanol blended into gasoline, by even a small percentage, would more than double the methanol market.

Although this potential market (methanol for motor fuel) was recognized, Celanese Planning analyzed only the projected growth in our traditional markets for chemical grade methanol.

From the economics performed at that time, it was concluded that a coal based methanol expansion or a methanol expansion in Canada would yield comparable economic returns.

2. 1980 Methanol Strategy (cont'd.)

As a result of this projection, Celanese Chemical Company decided to perform a feasibility study to generate coal syngas for Bishop and to retrofit the Bishop MS Plant to utilize coal based syngas. A proposal was also prepared for presentation to the DOE.

2 "Methanol Strategy, 1980 CCC" (Library VII.E.9)

3. DOE Proposal - April 1980

Preparation of a proposal to the DOE was begun in March, 1980. Morrison-Knudsen was employed to prepare this proposal. The DOE proposal presented a plan to study the technical and economical viability of developing syngas for methanol and other chemicals from either a high Btu coal or Texas lignite. The syngas would be used to produce electric power and retrofit the existing Bishop methanol plant, and produce process steam.

As part of the proposal a work plan was developed which was designed to develop sufficient knowledge of the state of the art on coal gasification to allow selection of the most economical process, feedstock, and site for such a facility.

The proposal was presented to the DOE in order to register Celanese as a potential participant in the syn-fuels industry. No funds were requested with this proposal. It was felt that the temporary loan of funds would involve governmental controls which would seriously hamper our efforts. This turned out to be a proper concern, based on the experience of others who requested funds.

As a result of the effort involved in preparing this proposal, an RFA was prepared for approval of funds to employ an outside engineering firm to perform the feasibility study.

4. RFA 040-034

RFA 040-0345 was presented to company management and approved by the management committee, in July 1980. The object of this RFA was: "Develop a detailed technical and financial analysis for a medium Btu coal gasification system at Bishop to provide feed for the methanol plant, other syn-gas consumers and to generate electrical power and steam".

This report, and the data base to support it, are the results of this RFA. Although the project was terminated early, at the request of management, a large data bank has been developed. The technical and financial analysis performed are adequate for management direction. Specific opportunities however will require further work before management decisions can be made.

After this RFA was approved (along with a companion RFA for a similar study for the Clear Lake plant), company management decided to establish a Coal Program group. During the mobilization of this group it became apparent that only limited manpower could be made available to staff the study projects. A "Core Group" was established to supply support in the resource development, technical, operation, and financial areas.

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4. RFA 040-034 (cont'd.)

After extensive analysis of the capabilities and costs of various engineering houses, Stearns-Roger Engineering Corporation of Denver was selected as the prime contractor for the basic feasibility study.

A program manager was available to direct the study activities of Stearns-Roger in Denver. This was not adequate staffing to provide complete supervision over this complex study; therefore a management contractor was employed. Extensive effort was devoted to locating a firm with adequately qualified personnel to support our efforts. Voss International was selected as the project management contractor.

Voss supplied a project engineer to augment the Celanese effort. After a short period, however, a former Celanese employee was hired as the project manager to coordinate Stearns-Roger activities and use of the Voss engineer was terminated.

B. Program Design

The Coastal Bend Project was set up to be conducted over an 18 month period beginning January 1, 1981. Stearns-Roger of Denver was selected to perform the main process study and Radian Corp. of Austin was selected to complete the environmental assessment.

The 18 month study was divided into 4 phases;

Phase I - Select a third process to be included in the remaining evaluation together with the two preselected processes, Texaco and Lurgi.

Phase II - Design plant systems for a Bishop site utilizing the most favorable raw materials for each of the three processes.

Phase III - Prepare capital costs and operating costs for all the above designs.

Phase IV - Conduct financial analysis of all designs and other possible scenarios based on directional indications.

B. Program Design (cont'd.)

Termination of the Stearns-Roger work on October 31, 1981 required that we complete the balance of Phase III and all of Phase IV in the Dallas office.

The following pages of this section on plant designs describe more fully the methodology used to select the third process. In addition, sections D and E discuss the plant design configurations, with block diagrams to show major components. Section F discusses the commercial viability of these designs.

C. Process Selection

Selection of three coal gasification technologies for the Coastal Bend project was the result of joint efforts by Celanese and Stearns-Roger.

Celanese asked Stearns-Roger to explore the fixed bed Lurgi process and the entrained bed Texaco process.

The third technology was selected by Stearns-Roger via a qualitative ranking technique. This technique addressed such major parameters as:

- Process Maturity
- Technical Complexity
- Conversion/Thermal Efficiency
- Reliability
- Process Safety
- Government Development Funding
- Byproduct Waste Generation

Approximately 100 candidate processes were compiled and screened via the above technique. Survivors from the first round for further consideration were:

C. Process Selection (cont'd.)

Shell Koppers

Saarberg/Otto

Westinghouse

Babcock and Wilcox

High Temperature Winkler

British Gas/Lurgi

The Westinghouse gasifier was selected as #3 after an in depth review of specific details furnished by each of the above gasification process vendors.

Inclusion of the Westinghouse gasifier into the study provided the advantage of assessing a fluidized bed gasification technology.

Results of fuel resource work provided combinations of Texas lignite (Wilcox), New Mexico coal (Raton), and Illinois #6 coal for each gasifier. Fuel acceptability for each gasifier was reviewed in depth. The resulting technologies and fuel combinations determined viable for the project study were:

Lurgi - Texas lignite (Wilcox)

Texaco - New Mexico coal (Raton)

Westinghouse - Texas lignite (Wilcox)

C. Process Selection (cont'd.)

As the investigation work and vendor information proceeded, a combined process, featuring some Lurgi and some Texaco gasifiers fed with lignite, was included in the study. This combination appeared attractive because the Texaco gasifier can utilize the lignite fines which are generated in handling and preparing the sized feed required for the Lurgi gasifier.

This report presents the completed feasibility study work for the above gasification technologies and fuels.

The fully described selection procedure, contained in the project files, is documented in the Stearns-Roger report titled "Gasification Process Selction Report" (April 1981) and "Addendum No. 1" (May 1981).

D. Base Case Designs

INTRODUCTION

Stearns-Roger developed four designs as the base case for coal gasification facilities located at the Bishop plant:

- Lurgi using Wilcox lignite
- Texaco using Raton coal,
- Westinghouse using Wilcox lignite, and
- Lurgi/Texaco combination using Wilcox lignite.

Each plant was sized to provide sufficient syngas to retrofit Bishop's methanol (MS) unit, butyraldehyde (Oxo) unit, and hydrogenation (H_2) facilities. Furthermore, sufficient steam and power were produced to meet both the gasification plant and the Bishop plant needs. Also excess power was generated for sale to a utility company.

A general process description and simplified block flow sheet follows for each case. These process descriptions will differ somewhat from Stearns-Roger work since there were some "loose ends" requiring finalizing by Celanese after the curtailment of Stearns-Roger's activities. These changes are listed after each process description. Details of the original four cases are documented by Stearns-Roger in their Design Report and, for the most part, apply to the revised cases.

1. Process Description (Lurgi-Lignite)

A process description of a Lurgi coal gasification plant located at Bishop and using Texas lignite (Wilcox seam) follows. Figure I shows a simplified block flowsheet while Table I summarizes some process information.

Sized lignite (7000 TPD), high pressure steam (480 M PPh), and oxygen (1250 TPD) are fed to 7 Lurgi gasifiers. These units produce 128 MM SCFD of hydrogen (H_2) and carbon monoxide (CO) which is sufficient syngas to retrofit Bishop's MS, Oxo, and H_2 facilities. In addition significant amounts of methane and liquid hydrocarbon byproducts are produced from the gasifiers. Also a significant amount of coal fines is produced during coal handling that is unacceptable as feed for the gasifiers. Ash from the gasifiers is conveyed as a slurry, dewatered, and landfilled.

Heat, particulate, and condensables are removed from the syngas during cooling and gas-liquor separation. Liquid byproducts including tars, oils, phenols, naphthas, and ammonia are separated from the condensables using Lurgi's design for gas-liquor separation, phenol recovery (Phenosolvan), and ammonia recovery (CLL). The remaining wastewater is treated and reused.

The acid gasses (CO_2 and H_2S) are removed from the syngas using the Rectisol process. The acid gas stream containing all of the H_2S and most of the CO_2 is fed to a Stretford sulfur recovery unit. A sulfur-free CO_2 stream is also produced which is injected into the MS unit feed to achieve the desired CO_2 concentration. A portion of the MS purge gas is recycled to the Rectisol unit for purification and recovery of the CO and H_2.

The syngas leaving the Rectisol unit is fed to a cryogenic unit and separated into five streams (methane, hydrogen product, crude hydrogen, carbon monoxide, and flash gases) which are recombined into the following four streams:

- MS unit feed,
- butyraldehyde (Oxo) unit feed,
- hydrogenation feed, and
- methane byproduct

The MS, Oxo, and H_2 streams are fed to guard beds to remove contaminates (e.g. sulfur) and then to their process units. Compression (if necessary) is provided.

The methane, liquid hydrocarbons, and coal fines byproducts are fed to a high pressure steam boiler. Steam in excess of the process needs and the existing Bishop plant needs is fed to a condensing turbine generator. Power primarily produced here meets the needs of the gasification plant and the existing Bishop plant plus provides 79 MW power for export sales.

CHANGES TO STEARNS-ROGER'S DESIGN

The following changes were made to Stearns-Roger design.

1. The syngas requirements for a gas turbine-generator-heat recovery system were eliminated since the excess steam produced by byproducts incineration produced sufficient electricity for the export market.

2. The MS purge gas was recycled to the gasification plant to recover CO and H_2 thereby reducing operating costs.

3. The Bishop plant steam requirement was reduced to 300 M PPH from 500 M PPH to reflect future energy conservation projects.

TABLE I

PROCESS INFORMATION

LURGI-LIGNITE

Gasifier Information

7000 TPD Sized Lignite
480 M PPH Steam
1250 TPD Oxygen
450 PSI Pressure

Syngas Uses

MS		MM SCFD CO & H_2
Oxo		MM SCFD CO & H_2
H_2		MM SCFD H_2
Boiler	32	M PPH Liquids
	26	MM SCFD CH_4
	3000	TPD Coal Fines

Gasifier Production

128 MM SCFD CO & H_2
32 M PPH Liquid Byproducts
26 MM SCFD CH_4
3000 TPD Coal Fines

High Pressure Steam Generation (M PPH)*

By-Product Boiler 2,300

Power Generation (MW)

Condensing Turbine	145
Misc. Drivers	19
	164

High Pressure Steam Use (M PPH)*

Process Consumers	480
Process Drivers	310
Bishop Plant	300
Condensing Turbine	1,210
	2,300

Power Use (MW)

Gasification Plant	38
Bishop Plant	47
Export Sales	79
	164

* Low pressure steam requirements are met by Lurgi steam generation.

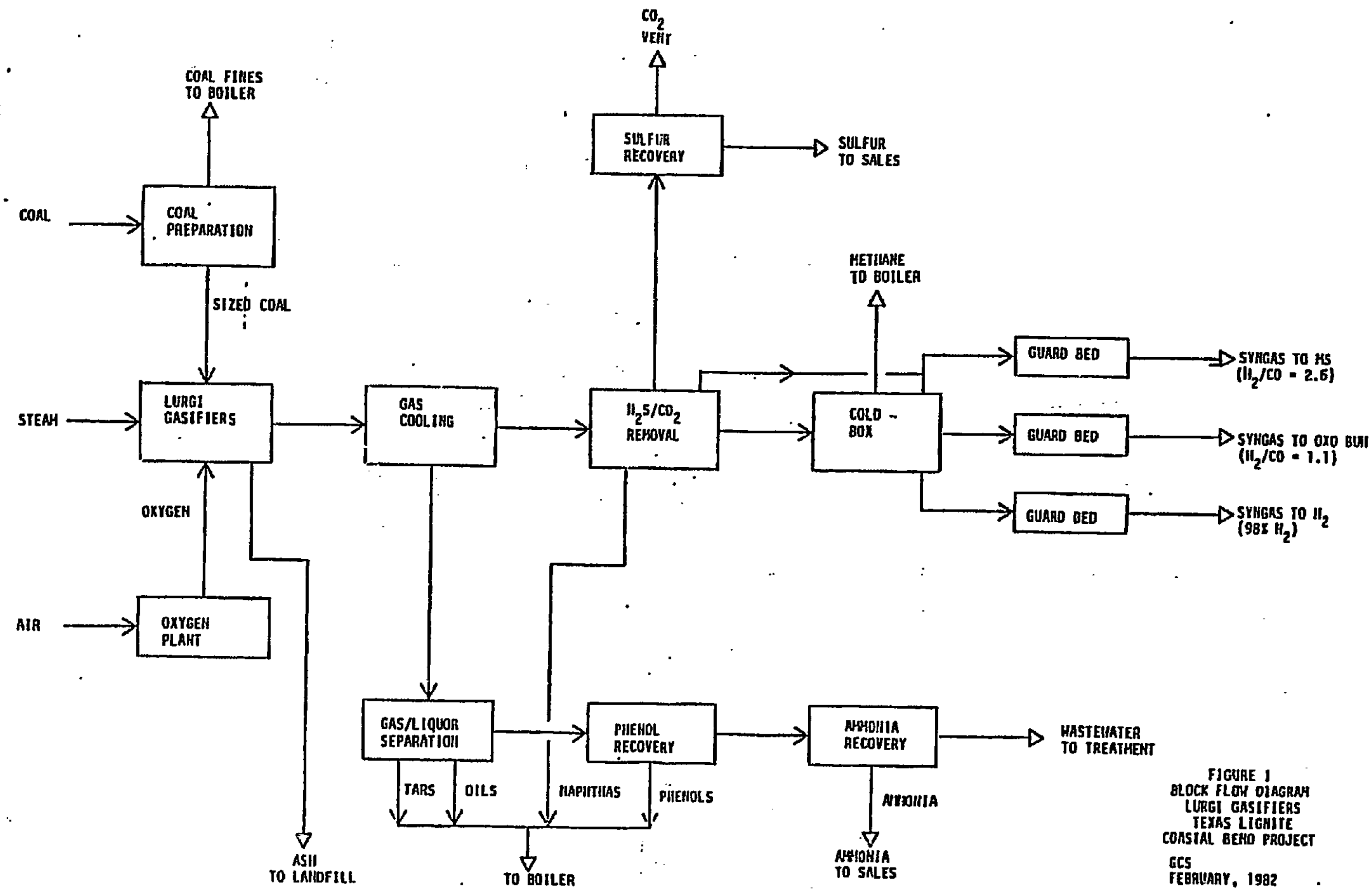

FIGURE 1
BLOCK FLOW DIAGRAM
LURGI GASIFIERS
TEXAS LIGNITE
COASTAL BEND PROJECT

GCS
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2. Process Description (Texaco-Raton)

A process description of the Texaco gasification plant at Bishop using New Mexico Raton bituminous coal follows. Figure II shows a simplified block flowsheet while Table II summarizes some process information.

Pulverized slurried Raton coal (4380 TPD) and oxygen (4020 TPD) are fed to 3 Texaco gasifiers. An additional gasifier is provided for a spare. These gasifiers produce 237 MM SCFD of CO and H_2. The raw syngas is cooled using radiant and convective waste heat boilers which produce saturated high pressure steam. Particulates are removed from the cooled syngas in a water scrubber system. Residual dust and chlorine are then removed in fixed catalyst beds.

Ash removed from the gasifiers and water scrubbing systems is transported as a slurry, dewatered, and landfilled. Wastewater is treated and reused in the gasification plant.

The syngas divides into two streams here. One stream after further processing will provide syngas for the gas turbines and steam superheater. The other stream will ultimately provide syngas for the MS, Oxo, and H_2 facilities.

The portion of the syngas for the process units is separated into three streams for MS, Oxo, and H_2. The CO and H_2 concentrations are adjusted using sulfur tolerant shift catalyst. Acid gases are removed from each stream using selective Selexol technology. Carbonyl sulfide (COS) hydrolysis reactors are upstream of the H_2S Selexol scrubbers on the MS and Oxo streams. Regeneration of the Selexol rich solvents is provided in a common offgas regeneration unit. The H_2S rich offgas feeds a combination Claus-Super SCOT sulfur recovery unit and then an incinerator prior to atmospheric discharge. The CO_2 offgas vents to the atmosphere.

These MS, Oxo, and H_2 streams are then fed to guard beds to remove residual contaminants (e.g. sulfur) and then to their process units. Methanation of the H_2 stream is also required to reduce CO concentration to acceptable levels.

The portion of the syngas production that feeds the gas turbines and steam superheater is fed to a Selexol unit to remove H_2S and then to a power recovery unit where expansion of the high pressure syngas through a turbine will generate electricity. The rich Selexol solvent feeds the common regeneration facilities discussed earlier. Syngas containing 70 MM SCFD CO and H_2 is fed to a gas turbine combined cycle system where power and high pressure steam is generated. The remaining portion of this syngas containing 25 MM SCFD CO & H_2 is fed to the steam superheater.

High pressure steam generated by the gasifiers and the gas turbines feeds the superheater which is fired by syngas and the MS purge gas. This steam meets the needs of the gasification plant and the existing Bishop plant. Excess high pressure steam feeds a condensing turbine to generate power.

Power is generated primarily by the gas turbines, syngas expansion turbine, and the steam condensing turbine. The quantity of power is sufficient to meet the needs of the gasification plant and the existing plant plus to provide 79 MW power for export sales.

CHANGES TO STEARNS-ROGER'S DESIGN

1. The saturated steam generated by the Texaco gasifier was not fully used in the Stearns-Roger's work. Thus a steam superheater and a condensing turbine generator were added to produce power. Power generated here was sufficient to reduce the syngas requirements for the gas turbines.

2. The Bishop plant steam requirement was reduced to 300 M PPH to reflect future energy conservation projects.

TABLE II

PROCESS INFORMATION

TEXACO-RATON

Gasifier Information

4380 TPD Coal
0 Steam
4020 TPD Oxygen
950 PSI

Syngas Uses

MS		MM SCFD H_2 & CO
Oxo		MM SCFD H_2 & CO
H_2		MM SCFD H_2
Superheater	25	MM SCFD H_2 & CO
Gas Turbines	70	MM SCFD H_2 & CO

Gasifier Production

237 MM SCFD CO & H_2
0 Liquid Byproducts
0.6 MM SCFD CH_4

High

Generation (M PPH)

Gasifiers	1,050
Gas Turbine	330
	1,380

MW)

Gas Turbine	89
Syngas Expansion	11
Condensing Turbine	45
Misc. Drivers	16
	161

High Pressure Steam Use (M PPH)

Process Consumers	140
Process Drivers	560
Bishop Plant	300
Condensing Turbine	380
	1,380

Power Use (MW)

Gasification Plant	29
Bishop Plant	47
Export Sales	85
	161

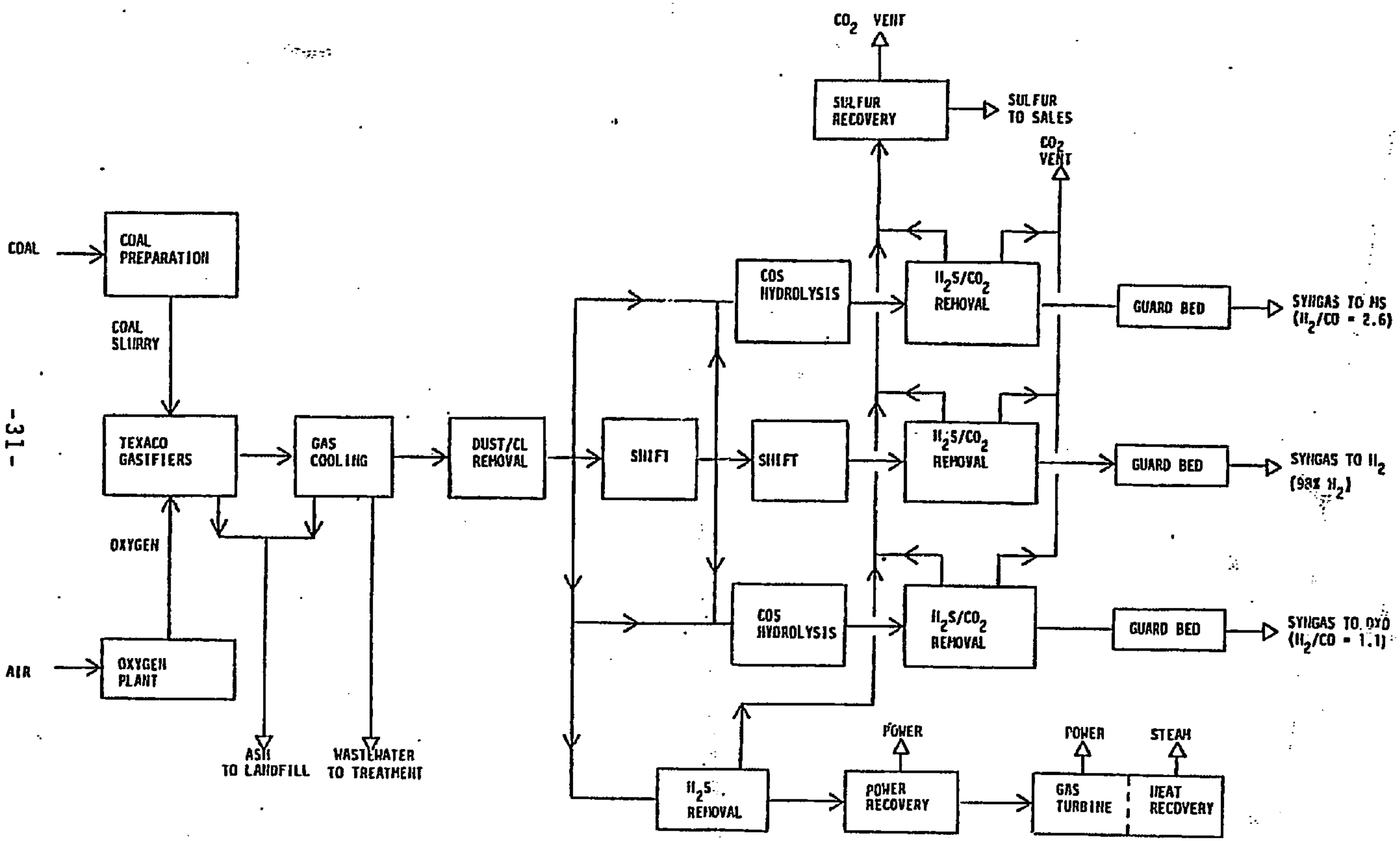

FIGURE II
SIMPLIFIED BLOCK DIAGRAM
TEXACO GASIFIERS
RATON COAL
COASTAL BEND PROJECT
GCS
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3. Process Description (Westinghouse-Lignite)

A process description of a Westinghouse coal gasification plant located at Bishop and using Texas lignite (Wilcox seam) follows. Figure III shows a simplified block flowsheet of the process while Table III summarizes some process information.

Sized undried lignite (10,870 TPD), high pressure steam (270 M PPh), and oxygen (5170 TPD) are fed to eight Westinghouse gasifiers which produces 383 MM SCFD (dry basis) of raw syngas. This flow does not include the syngas that is recycled to the gasifiers for feeding coal and gasifier control. Ash from the gasifiers is transported dry to landfill.

Particulates in the raw syngas are separated in dry cyclones and recycled to the gasifiers. Heat is then removed from the syngas in a series of waste heat boilers that generate high pressure superheated steam. The gas is cooled further in a water scrubber system which also removes particulates that are ultimately landfilled. The wastewater produced here is treated and reused.

Next the raw syngas flows to fixed catalyst beds for residual dust and chlorine removal, then to the carbonyl sulfide (COS) hydrolysis reactors, and finally to a selective Selexol scrubber for H_2S removal. The H_2S rich offgas from the regeneration of the rich Selexol solvent flows to a Claus-Super SCOT sulfur recovery unit and then to an incinerator before atmospheric discharge.

After H_2S removal, about 44% of the syngas feeds the gas turbines for power and steam generation.

The remaining syngas is further processed to obtain feed streams for the MS, Oxo, and H_2 facilities. This steam is first fed to a sulfur guard bed. Then it is fed with steam and oxygen to an autothermal reformer that reduces the methane concentration form 4.4% to 0.2%. A portion of the syngas is used to fire the reformer.

The reformer product divides into three streams. One stream is compressed and fed to the Oxo unit after CO_2 removal. The other two streams for the MS and H_2 units require shifting to adjust the CO and H_2 concentrations. Then each stream is compressed and fed to its unit after CO_2 removal. Methanation is also required on the H_2 feed to reduce the CO concentration. Selexol technology is used to remove the excess CO_2 in these three streams. The CO_2 offgas is discharged to the atmosphere.

Most of the high pressure steam is generated by the gasifiers, the autothermal reformer, and the gas turbine waste heat boilers. Excess steam is fed to a condensing turbine for power generation. A superheater fired by MS purge gas is required to add superheat to the steam from the reformer and to the gas turbine waste heat boilers.

Most of the power is generated by the gas turbines and the steam condensing turbine. This power provides electricity for the gasification plant, for the existing Bishop plant, and for export sales (109 MW).

CHANGES TO STEARNS-ROGER'S DESIGN

1. A steam and electrical balance was estimated for the case since Stearns-Roger did not prepare one.

TABLE III

PROCESS INFORMATION

WESTINGHOUSE-LIGNITE

Gasifier Information

10,870 TPD Coal
5,170 TPD O_2
270 M PPH Steam
340 PSI

Syngas Uses

MS	MM SCFD H_2 & CO
Oxo	MM SCFD H_2 & CO
H_2	..MM SCFD H_2
Gas Turbines	104 MM SCFD H_2 & CO & 6.4 MM SCFD CH_4

Gasifier Production

383 MM SCFD Raw Gas (Dry Basis)
259 MM SCFD CO & H_2
16 MM SCFD CH_4
0 Liquid Byproducts
0 TPD Coal Fines

High Pressure Steam Generation (M PPH)

Gasifiers	880
Reformer	240
Gas Turbine	690
	1,810

Power Generation (MW)

Gas Turbine	157
Condensing Turbine	29
Misc. Drivers	13
	199

High Pressure Steam Use (M PPH)

Process Consumers	500
Process Drivers	720
Bishop Plant	300
Condensing Turbine	290
	1,810

Power Use (MW)

Bishop Plant	47
Export Sales	109
	199

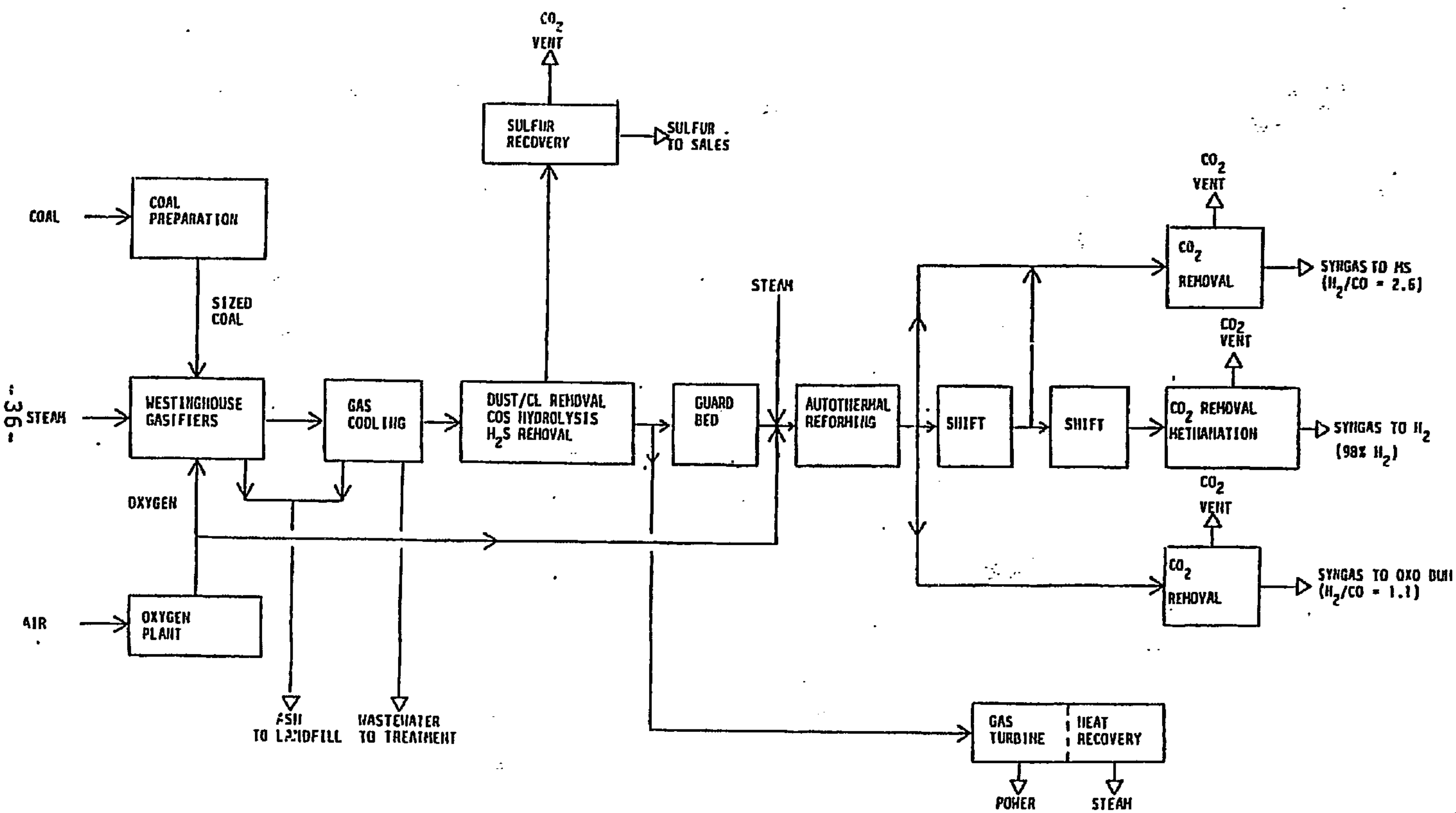

FIGURE III
SIMPLIFIED BLOCK DIAGRAM
WESTINGHOUSE GASIFIERS
TEXAS LIGNITE
COASTAL BEND PROJECT
GCS
FEBRUARY, 1982

4. Process Description (Lurgi/Texaco-Lignite)

A process description of a coal gasification plant that uses both the Lurgi and Texaco gasifiers for Texas lignite follows. Figure IV shows a simplified block flowsheet while Table IV summarizes some process information.

Texas lignite (9730 TPD) is prepared so that 4740 TPD of sized coal are fed with oxygen (850 TPD) and steam (320 M PPH) to 4 Lurgi gasifiers. The remaining 4990 TPD of coal fines are slurried and fed with oxygen (3000 TPD) to 2 Texaco gasifiers. An additional Lurgi gasifier and Texaco gasifier are available as spares. Ash leaving the gasifiers is transferred as a slurry, dewatered, and landfilled.

Approximately 164 MM SCFD (dry basis) of raw syngas is produced by the Lurgi gasifiers. This syngas ultimately provides the feed to the MS, Oxo, and H_2 facilities. Heat, particulates, and condensables are removed from the syngas using cooling and gas-liquor separators. Liquid byproducts including tars, oils, phenols, naphthas, and ammonia are separated from the condensables using Lurgi's designs for gas liquor separation, phenol recovery (Phenosolvan), and ammonia recovery (CLL). The remaining wastewater is concentrated and recycled as make-up to the Texaco coal slurry.

The acid gases (CO_2 and H_2S) are removed from the Lurgi syngas using the Rectisol process. The acid gas stream containing all the H_2S and most of the CO_2 is fed to a Stretford sulfur recovery unit before venting to the atmosphere. A sulfur-free CO_2 stream is also produced.

The syngas leaving the Rectisol unit is fed to a cryogenic unit and separated into five streams (methane, hydrogen product, crude hydrogen, carbon monoxide, and flash gases) which are recombined into the following four streams:

- MS unit feed,
- butyraldehyde unit feed
- hydrogenation feed,
- methane byproduct.

The methane byproduct is fed to a steam reformer to produce syngas. The reformer is fired by MS purge gas and Texaco syngas. This reformer product is combined with the MS unit feed stream leaving the cryogenic unit and the sulfur-free CO_2 stream leaving Rectisol to produce the final MS feed stream. The final MS feed stream and the Oxo and H_2 feed streams are each fed to a guard bed and then to their process units. Compression if necessary is provided.

The Texaco gasifiers produce 134 MM SCFD of CO and H_2. The H_2S is removed by the Selexol process. The H_2S offgas from the Selexol process will combine with the offgas from

Lurgi's Rectisol unit and feed the Stretford sulfur recovery unit before venting. Wastewater from the Texaco gasifiers is treated and reused.

Power is then generated by expanding the 134 MM SCFD to a lower pressure. This stream then splits providing:

- 112 MM SCFD for gas turbines
- 16 MM SCFD for reformer firing, and
- 6 MM SCFD for steam superheater firing.

High pressure steam is generated by the Texaco gasifiers, gas turbines, and the reformer. A superheater fired by Lurgi liquid byproducts (e.g. tars, oils, etc.) and Texaco syngas is required to superheat the saturated steam produced by the Texaco gasifiers. Low pressure steam is also generated by the Lurgi gasifiers. All these steam generators provide steam for the gasification plant and the existing Bishop plant. Any excess high pressure steam is fed to a condensing turbine to produce power.

Electricity, mainly produced by the gas turbine, syngas expander, and condensing steam turbine, provides power for the gasification plant and the existing Bishop plant plus 107 MW excess power for export sales.

CHANGES TO STEARNS-ROGER'S DESIGN

1. A steam and electrical balance was estimated for this case since Stearns-Roger did not prepare one.

TABLE IV

PROCESS INFORMATION

LURGI/TEXACO-LIGNITE

Lurgi Gasifier

4740 TPD Lignite
850 TPD Oxygen
320 M PPH Steam
450 PSIG

Texaco Gasifier

4990 TPD Lignite
3000 TPD Oxygen
950 PSIG

Lurgi Gasifier Production

164 MM SCFD (Dry) Raw Gas
92 MM SCFD CO and H_2
15 MM SCFD CH_4
22 M PPH Liquid Byproducts

Texaco Gasifier Production

134 MM SCFD H_2 and CO

Steam Generation (M PPH)

Texaco Gasifier	960
Gas Turbine	600
Reformer	180
Lurgi Gasifier	320
	2,060

Syngas Uses (MM SCFD CO & H_2)

MS	
Oxo	
H_2	
Gas Turbines	112
Reformer Firing	16
Superheater Firing	6
	276

Power Generation (MW)

Gas Turbine	142
Syngas Expander	16
Condensing Turbine	11
Misc.	25
	194

Power Use (MW)

Gasification Plant	40
Bishop Plant	47
Export Sales	107
	194

Steam Use (MPPH)

Process Drivers	670
Condensing Turbine	90
Bishop Plant	300
Process Consumers	1,000
	2,060

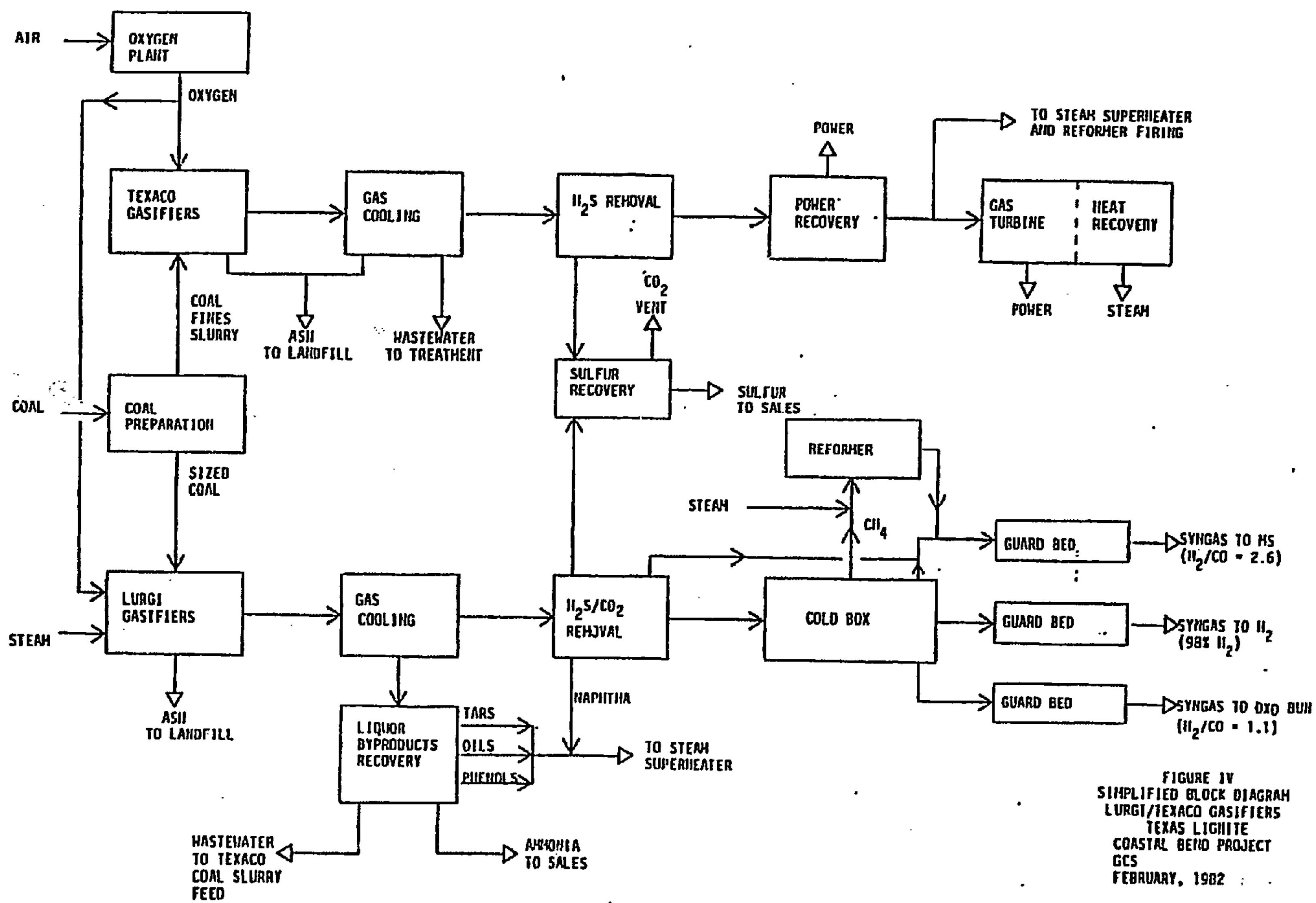

FIGURE IV
SIMPLIFIED BLOCK DIAGRAM
LURGI/TEXACO GASIFIERS
TEXAS LIGNITE
COASTAL BEND PROJECT
GCS
FEBRUARY, 1982

E. Alternative Case Designs

INTRODUCTION

The four base cases discussed earlier had coal gasification located at the Bishop plant with coal transported there by railroad. An alternate case to this approach is to build the coal gasification plant at the mine site and transport the syngas via pipeline. This approach eliminates coal freight at the expense of building a pipeline.

The Lurgi process was chosen as the gasification technology for this case since Texas lignite (Wilcox) is a good feedstock and since the capital and costs for this process were well defined by Stearns-Roger for a Bishop location. Figure V shows a simplified block flowsheet while Table V summarizes some process information. A process description follows.

PROCESS DESCRIPTION
(LURGI-LIGNITE-MINEMOUTH)

About 142 MM SCFD CO and H_2 is produced at the minemouth gasification plant. Production and processing of the raw syngas is very similar to the Lurgi-lignite case described in the section on Base Case Designs. Liquid byproducts are removed via syngas cooling and subsequent processing of the condensables. Acid gases are removed via Rectisol technology. Methane is removed using cryogenic separation. The resulting syngas is mixed with sulfur-free CO_2 from the Rectisol unit, compressed, and delivered to the pipeline for transfer to Bishop. The composition of this stream is suitable for feed to the MS unit.

The offgas from the Rectisol unit is fed to a Stretford sulfur recovery unit prior to venting to the atmosphere.

Ash from the gasifier is transferred as a slurry, dewatered and landfilled. Wastewater from the gasification plant is treated and reused.

The coal fines from coal handling and the liquid and methane byproducts are fed to a high pressure boiler which provides steam for the gasification plant. Excess steam is fed to condensing turbine generators. Power generated mainly by the condensing turbines will provide electricity for the gasification plant plus 167 MW for export sales.

The syngas is delivered to the Bishop plant at 850 PSI where 131 MM SCFD of CO and H_2 is fed directly to the MS unit. The remaining 11 MM SCFD of CO and H_2 is fed to a cryogenic unit after CO_2 removal where 7 MM SCFD of CO and H_2 is separated for the Oxo unit and 4 MM SCFD of H_2 is provided for H_2 facilities. Steam for the Bishop plant will be generated by incinerating MS purge gas and other plant vents in the existing boilers. Bishop will continue to purchase electricity.

TABLE V

PROCESS INFORMATION

LURGI/TEXACO-LIGNITE

MINEMOUTH LOCATION

Gasifier Information

7740 TPD Sized Lignite
30 M PPH Steam
1380 TPD Oxygen
450 PSI Pressure

Syngas Uses

MS	MM SCFD CO & H_2
Oxo	MM SCFD CO & H_2
H_2	MM SCFD H_2
Boiler	36 M PPH Liquids
	27 MM SCFD CH_4
	3320 TPD Coal Fines

Gasifier Production

142 MM SCFD CO & H_2
36 M PPH Liquid Byproducts
29 MM SCFD CH_4
3320 TPD Coal Fines

High Pressure Steam Generation*

By-Product Boiler	2,500

Power Generation (MW)

Condensing Turbine	194
Misc. Drivers	13
	207

High Pressure Steam Use (M PPH)*

Process Consumers	530
Process Drivers	340
Condensing Turbine	1,630
	2,500

Power Generation (MW)

Gasification Plant	40
Export Sales	167
	207

* Low pressure steam requirements are met by Lurgi steam generation.

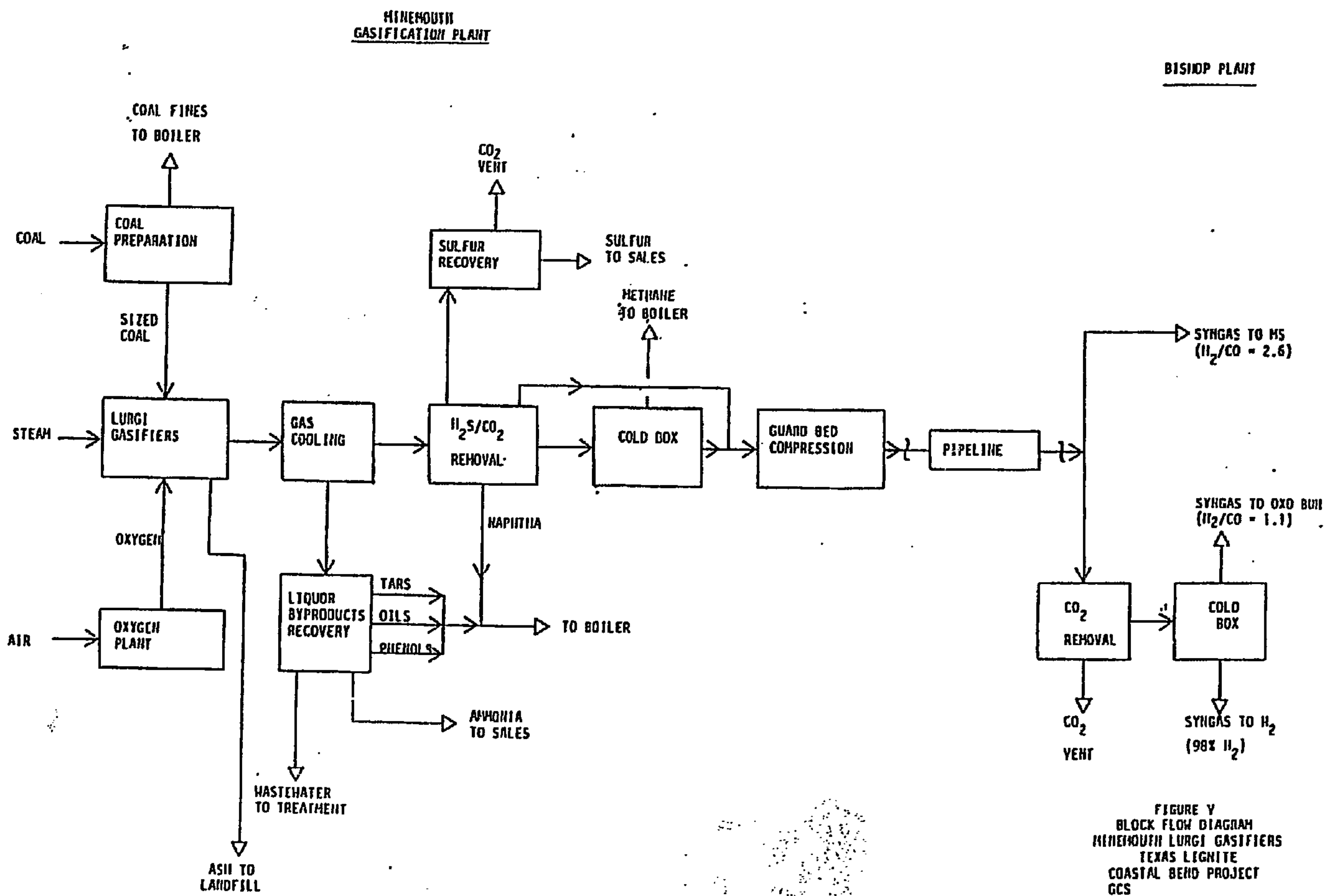

FIGURE Y
BLOCK FLOW DIAGRAM
MINEMOUTH LURGI GASIFIERS
TEXAS LIGNITE
COASTAL BEND PROJECT
GCS
FEBRUARY, 1982

F. Commercial Viability

The anticipated start-up of the Coastal Bend Project in 1989 probably assures that all the technologies will have been demonstrated on a commercial scale on other projects. The Lurgi gasification technology is proven. Two commercial size Texaco gasification plants should start-up in 1983 at Kingsport, Tennessee and in 1984 at Coolwater, California. The Westinghouse gasification process should be operated in commercial size equipment at Sasol, South Africa in 1984. A combination Lurgi/Texaco process will probably not be proven in the 1980's but the separate processes will. The support units for the gasification processes are proven or will be proven in time to insure no first-of-a-kind process for the Coastal Bend Project.

VI. ECONOMIC EVALUATIONS

A. Basis

1. Capital Costs

Stearns-Roger developed the basic capital cost estimates for the Coastal Bend Project. This work consisted of developing factored estimates for four plant designs sited at Bishop. A fifth design with the gasification complex located near the mine connected to the plant via a high pressure gas pipeline was developed by adding pipeline costs to the Stearns-Roger estimates. Since the project was curtailed suddenly, it became necessary to develop cost estimates for very preliminary plant designs. Although the cost estimates were sufficiently accurate for the study, the plant designs themselves were not optimized. Time only permitted one pass at a material and energy balance. Lack of process optimization resulted in a surplus of high pressure steam from the Texaco design, excess electricity with the Lurgi design, and no electricity or steam balance for the Westinghouse design. Four cases were identified for economic evaluation. They were:

- Case I Lurgi Process with Lignite
- Case II Texaco Process with Raton Coal
- Case III Westinghouse Process with Lignite
- Case IV Texaco/Lurgi Processes with Lignite

The plant designs for Case I through IV were modified in order to have comparable quantities of syngas, electricity, and steam production. Concurrently, the items and areas not covered by the Stearns-Roger estimate were identified and added to the estimates. Further review with A.G. Custer resulted in minor modifications to the cost numbers. After initial economic evaluation, it was realized that the capital cost included amounts for land purchase as well as sales tax. These costs were subtracted from the total capital costs, yielding the numbers utilized in the final economic evaluation.

Case V utilized the Lurgi technology at the minemouth, with the pipeline costs based on the work of Stearns-Roger and Ford, Bacon & Davis.

The capital expenditure spread was calculated assuming a 56-month project with a spending profile based upon past Celanese experience. The expenditures and other pertinent cost data are given in the revised data sheets for the Coastal Bend Project included in the Appendix.

2. Operating Costs

All operating and maintenance costs were completed in the Dallas office using coal price data as assembled during the resource analysis study. Labor and maintenance material costs were ratioed from historical data, and chemical costs were obtained from Stearns-Roger experience and from our own history.

3. Natural Gas Savings

All financial analysis work was performed using natural gas price forecasts from the March 1981 planning data.

4. Electricity Sales Credit

Pricing for export electricity on all Coastal Bend cases was based on 90% of "avoided utility costs" for a fuel mix forecast for South Texas utilities from 1989 thru 2000.

B. Bishop Site

The following pages of computer print out summarize the results of economic evaluations for four cases at the Bishop site.