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AN ECONOMIC SENSITIVITY STUDY OF UCG BASED ON FIELD PERFORMANCE,
THEORY, AND OPERATIONAL EXPERIENCE

By
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Laramie Energy Technology Center
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Thesis at the University of Wyoming

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Boysen, John Eugene; Gunn, Robert D., An Economic Sensitivity Study of UCG Field Performance, Theory, and Operational Experience

This paper provides the results of an economic analysis in which uncertainty has been minimized through the use of the following three types of information: (1) theoretical and experimental correlations of underground coal gasification (UCG) operating parameters; (2) detailed process design based on operational experience; and (3) sensitivity variables.

Design of the process has been carried out in considerable detail and is based on five years of operating experience during the Hanna field tests conducted by the Laramie Energy Technology Center of the U.S. Department of Energy. All equipment described is currently commercially available. A number of sources have been considered for cost information, but in most cases the pricing data used have been obtained directly from the vendors. Essential items which are often neglected such as piping accessories (flanges, flange bolts, fittings), high-temperature positive-seal valves, flow controllers and air and gas-metering equipment, are included in the design and do have impact on the economics.

Independent variables cannot be fixed with certainty--for example, gas heating values are known for short-term field tests but remain uncertain for a long-term commercial operation. Such variables are designated sensitivity variables and are over their entire probable range. Other sensitivity variables are percent gas loss, well spacing, and the volumetric combustion sweep efficiency (VCSE). Depth and thickness of the coal seam are also designated sensitivity variables because they are strictly site-specific. A total of 1,296 cases have been considered in order to cover a full range of all sensitivity variables. Only-dirty gas selling prices are calculated in order to avoid assumptions concerning unproven methods of gas cleanup.

Results show that the seam depth/thickness ratio is the most important variable affecting the economics of UCG. Low BTU gas from a thick coal seam of moderate depth (30 ft. seam at 600 ft.) can compete with current natural gas prices on a BTU basis even under poor operating conditions such as high leakage and low heating value. Well spacing and gas heating value also have notable impacts on the economics of UCG. The gas leakage rate and VCSE affect the economic results to a lesser extent for the range of values considered.

Future research is needed to define optimum well spacing and methods for control of the gas heating value. Research is also needed to provide information in those areas about which little or nothing is known such as gas cleanup and utilization, environmental impact, and subsidence.

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CHAPTER I
INTRODUCTION AND GENERAL INFORMATION ABOUT
UNDERGROUND COAL GASIFICATION

Introduction

In recent years, the United States has been faced with the problem of limited and rapidly dwindling petroleum and natural gas reserves. The problem, termed an energy shortage, is actually a shortage of economic alternatives to petroleum-based fuels. The urgent need to develop economic alternate energy sources has been exposed by the 1973 oil embargo and the ensuing economic turmoil caused by an escalating trade deficit in the United States.

Possible Fuel Alternatives and Their Immediate Potential

One substantial energy source in the United States is coal. Presently, the amount of energy derived from coal is smaller than the amount derived from oil and gas, but the United States possesses about 48% of the world's known coal reserves. (1)¹ Although direct utilization of coal is a viable economic alternative energy source, three factors restrict direct coal utilization from being a complete solution. The factors limiting the magnitude of direct coal utilization are:

1. The equipment demands are large for the coal mining and transportation industries. The increase in the amount of coal utilization has already made heavy demands on the manufacturers of equipment for coal mining. This has resulted in the long lead-times which are required for the acquisition of mining equipment. Also, the major method for transporting coal over long distances is by railroad. If coal production were to increase by an order of magnitude, it would probably necessitate the construction of more railroad tracks, which would require much more time and be a serious economic burden.
2. Many of the nation's industries are not presently designed or equipped to operate using a solid fuel. The conversion to a solid fuel such as coal can be time-consuming and expensive. In view of this fact, the use of an economically

¹Numbers in parentheses refer to citations of references provided at the end of this thesis.

comparable alternate liquid or gaseous fuel is probably preferable.

3. About 12% of the total United States coal resource is termed "economic to recover" by conventional mining techniques. (2) New techniques for coal extraction are needed to increase the amount of coal economically recoverable.

These reasons establish a need for economical, near-term alternative energy sources to be used in conjunction with direct coal utilization. In summary, direct coal utilization is an economically and technically viable alternate energy source, but it is not the entire solution to the energy shortage.

There are a variety of potential alternate sources for liquid or gaseous fuels to fill the energy void created by dwindling petroleum and natural gas reserves. The first group discussed is those surface coal gasification processes technically proven for large scale use. This group includes the Lurgi, Koppers-Totzek, Wellman-Galluscha, and Winkler gasifiers. Although the technical state of these gasifiers is proven, economic factors in the United States make their near term use questionable.

The cost of the gas made by these processes does not compare favorably with the present regulated natural gas prices. Economic studies show a gas selling price well over \$3.00/MM BTU for gas made from the Lurgi or Koppers-Totzek processes. (3,4) Other drawbacks are the large capital equipment demands and long construction times associated with these processes.

Another group of alternatives is the many experimental coal gasification and liquefaction processes currently being tested in the United States. The number of different processes is so large that they will be discussed only collectively. Although data are available for almost all of these processes because of total or partial government funding, the technical state of these processes is such that near-term application is unlikely. Also, preliminary economic studies show high costs similar to those associated with the Lurgi and Koppers-Totzek processes. (4)

The final alternate gaseous fuel source is both a coal gasification process and a unique coal extraction process. This combined process is underground coal gasification (UCG). This paper provides detailed economics for UCG.

Underground Coal Gasification

The basic concept of UCG is a relatively simple one. Boreholes are drilled into the coal seam. The coal is prepared by various methods to

enhance the seam's permeability. The coal in the seam is then ignited and air or oxygen is injected into one or more of the boreholes. The oxygen allows gasification and combustion. The gases thus formed are forced through the coal seam and drawn off through one or more of the production boreholes to be cleaned and possibly upgraded for use.

There are many different methods for UCG, but all of the processes involve two steps:

1. Preparation of the coal seam to increase the seam's permeability.
2. Gasification of the coal. (5)

A Description of the Linked Vertical Well Process for UCG

There are many methods for UCG, such as the longwall generator concept, the borehole process, the explosive fracturing process, and the linked vertical well process (LVW). Most methods for UCG, including those mentioned above, differ primarily in the method used to enhance the permeability of the coal seam. The process to be discussed here is the linked vertical well process as used by the Laramie Energy Technology Center (LETC). This process has been the most successful and more information is available for it than for any other UCG method.

In this particular process for UCG, reverse combustion is used to create a permeable pathway between process operating wells. The steps involved in reverse combustion linking are shown in Figure 1.1 A, B, and C. The wells drilled are completed into the coal seam and the coal at the base of one of the wells is ignited. Air at slightly less than the lithostatic pressure of the seam is injected at the ignition well to sustain combustion. Air injection is then switched to an adjacent well and the injected air percolates through the seam to the ignition well. The small volume of high pressure air draws the combustion zone towards the injection well, i.e., the combustion zone moves in a direction opposite to the direction of air flow. The expression "reverse combustion" comes from this countercurrent motion of the combustion zone and injected air. A localized, highly permeable pathway of carbonized coal is left behind as the combustion zone proceeds towards the injection well. When the combustion front reaches the injection well, the seam will accept at low pressures the high volume of air necessary for efficient gasification. This preparatory step is important because its location within the coal seam, and its successful completion determine the course of gasification. In addition, it is essential to create the needed permeability in the seam.

FIGURE 1.1

THE LINKED VERTICAL WELL PROCESS FOR UCG

Figure 1.1 D, E, and F show schematically the gasification steps upon initiation of high-volume, low-pressure air injection. First, the gasification zone expands around the injection well until it encompasses the full seam thickness. The gasification zone then proceeds back towards the ignition well. Thus, this step is a forward combustion process, i.e., the combustion zone movement and air or gas flow are in the same direction. In this manner, the full seam thickness is gasified between two adjacent wells with high thermal and high sweep efficiencies.

The Historical Development of UCG

The idea of UCG was first suggested by the British scientist Siemens in 1868. Twenty years later, the Russian chemist Mendeleev, independently proposed the idea. Other early workers include an American, Betts, who patented the idea in 1909, and a British researcher, Ramsey, who began experimental work in 1912--but was forced to cease work when World War I broke out. Also, in 1913, Lenin proposed using UCG to reduce the number of workers exposed to the hazards of underground coal mining. (6)

In 1933, the USSR initiated experimental work which was soon expanded to investigate several different methods for UCG. By the 1950's, UCG was being used in the Soviet Union on an industrial scale. In 1965, the Soviets halted development of UCG when large oil and natural gas reserves were discovered in Siberia. The USSR does, however, have two commercial-size UCG plants still in operation. (6)

In the 1940's, 1950's, and 1960's, experimental work was also conducted by Belgium, Italy, Poland, Czechoslovakia, Morocco, Great Britain, and the United States. The British were quite successful, but stopped work on UCG because of excess coal supplies and because of the availability of cheap oil from the Middle East. (6)

U. S. Efforts in UCG

The following pages are devoted to a brief discussion of the major efforts in the United States in UCG. These brief summaries are designed to give the reader some idea of advances in UCG made by United States researchers.

Initial work on UCG in the United States was begun in 1946 by the Bureau of Mines in Gorgas, Alabama. This test lasted until 1959 and resulted in failure. (6)

In 1968, a UCG experiment was conducted by the Gulf Research and Development Company. This test was significant because it was conducted in a swelling bituminous coal. Extensive pressure, 30% above the overburden pressure, was used and a gas heating value of 270 BTU/scf was attained. The techniques used by Gulf were similar to those used in

petroleum combustion recovery processes. After the test, the affected coal was excavated and definite rubble, coke, and coal interfaces were found. (6)

Since 1973, the Lawrence Livermore Laboratory (LLL) has been investigating UCG. Their field test site is located at Hoe Creek, in northeastern Wyoming. In their first test, explosive fracturing was used to enhance the coal permeability between two wells spaced 30 feet apart. On October 15, 1976, the coal was ignited to begin the actual testing of the explosive fracturing UCG process. The experiment lasted 11 days, during which 130 tons of an estimated 1000 tons of fractured coal were gasified. The initial gas heating value was 150 BTU/scf and this value steadily dropped to 0 BTU/scf at which time the test terminated. The average gas heating value was 90-100 BTU/scf. LLL observed gas channeling and excessive water influx promoted by the fracturing. (5) LLL's current plans are to use the LVW process as developed by LETC. In the second half of 1977, LLL conducted a UCG test using the LVW process at the Hoe Creek location. During gasification using air, the product gas heating value averaged 108 BTU/scf and 2436 tons of coal were gasified. Oxygen was also injected for two days and the product gas heating value ranged from 250 to 300 BTU/scf during this period.

The Morgantown Energy Technology Center (METC) has also been investigating UCG since 1973. METC has considered testing a process called the longwall generator process. Briefly, this process involves the directional drilling of two or more parallel deviated boreholes. The deviated wells are drilled from the surface to enter the seam and to run along it horizontally. The area between the boreholes in the coal is gasified. METC has completed one deviated well extending 500 feet into the coal seam. Because of the great cost of this well, METC has changed its plans, and intends to test the LVW process in eastern bituminous coal. (5)

The Laramie Energy Technology Center has conducted five field tests since 1973. The tests have been conducted in the Hanna #1 coal seam at a site located near Hanna, Wyoming. The first test, Hanna I, lasted 12 months during which various methods for preparing the coal seam to increase its permeability were tested and the LVW process was developed. In this test, 4000 tons of coal were gasified and the average gas heating value was 126 BTU/scf. (7,5)

Hanna II consisted of three separate experiments and was designed to improve gas quality and coal recovery, and to increase gas production rates. The Phase 1 test lasted from June 3 to July 11, 1975. One thousand five hundred tons of coal were gasified with an average gas heating value of 152 BTU/scf. (8,5)

Phases 2 and 3 were completed in August, 1976. The well pattern consisted of four wells located at the corners of a 60-foot square. The two wells on the southern edge of the square were linked by reverse combustion in December, 1975, then the fire was intentionally quenched. During April and May, 1976, the two northern-most wells were linked, and the coal was gasified in May of 1976. Gasification between the northern wells, #5, and #6, was the objective of the Phase 2 experiment. Over the 27-day gasification period, 2500 tons of coal were gasified with an average heating value of 172 BTU/scf. (8,5) The actual well pattern described above for the Phase 2 and Phase 3 experiments is shown in Appendix B along with the pattern for the wells of the Phase 1 experiment.

The Phase 3 experiment consisted of the gasification of coal between the southern wells, #7 and #8, using the link created in December of 1975. The gasification lasted 36 days (from June 24 to July 30, 1976) and 4100 tons of coal were gasified with an average gas heating value of 138 BTU/scf. (8,5)

Hanna II was successful from both a practical and technical viewpoint. Some of the accomplishments are:

1. Highest sustained product gas heating value ever reported.
2. Highest thermal efficiencies ever reported.
3. Highest gas production rate from any UCG plant in the Free World.
4. Highest overall sweep efficiency ever reported.
5. The most thoroughly instrumented UCG test ever conducted.

The reader is directed to the references cited for a more complete description of the Hanna II test.

Hanna III is an environmental test designed to provide the first accurate data on the effect of UCG on the ground water quality. The well pattern consisted of two process wells with a 60-foot spacing and 12 additional wells to monitor water quality in the coal seam and in an overlying aquifer. The gasification lasted 38 days and 2850 tons of coal were gasified with an average gas heating value of 138 BTU/scf. LETC personnel are presently waiting for the cavity created by the gasification to fill with ground water, at which time sampling and analysis of this water will begin. The well pattern for Hanna III is shown in Appendix B.

Hanna IV started in the late fall of 1978 to investigate the LVW process with greater well spacings, 100 feet and 150 feet. This test is

in operation at this time. Hanna V is presently being planned to demonstrate UCG operation on a pilot plant scale.

The results of the United States tests have provided answers to many of the important questions associated with UCG. However, six questions about UCG remain without answers:

1. Can a constant gas heating value be maintained?
2. What are the effects of subsidence on the process and the environment?
3. Can excessive water influx be prevented or controlled?
4. What is the maximum well spacing that can be used?
5. Will the process work on ranks of coal other than subbituminous?
6. Are there important difficulties associated with product gas cleanup and usage?

These uncertainties have important economic implications.

In spite of the uncertainties, the gasification of coal underground has many advantages over the gasification of coal on the surface. The advantages are:

1. UCG expands the amount of coal reserves that are economically recoverable.
2. UCG requires no mining of the coal.
3. UCG minimizes the surface disturbance and need for waste disposal.
4. UCG consumes less water than surface gasifiers.
5. UCG reduces the socioeconomic impact.
6. UCG requires less capital investment than surface gasifiers.
7. UCG has a higher thermal efficiency than surface gasifiers.
8. UCG generates less atmospheric pollution.

A major disadvantage of UCG is related to gas usage. The economics of piping gases dictate that low BTU content gas cannot be economically

transported more than a few miles. The use of the low BTU gas is limited to on-site or near-site usage for this reason.

The Goal of this Study

The history and advantages of UCG confirm the process' potential as a near-term energy source at least from a technical viewpoint. If UCG's economics are stable and competitive with natural gas, then UCG can be an important energy source. The goal of this study is to present accurate and realistic data on the commercial economics of UCG. Accuracy in the economic data is obtained by integrating into the calculations these features:

1. Operating data from LETC's Hanna tests.
2. Theory of UCG provided by a numerical process model with proven reliability. (9)
3. Detailed information concerning process operation and equipment and labor needs based on five years of field testing experience.

With this information, it is possible to make a more accurate evaluation of the sensitivity of the economics to changes in process operating variables whose values are presently uncertain. The economic data and sensitivity are the tools for evaluating the current commercial potential of UCG. In addition, the important different areas of future research can be determined.

CHAPTER II

LITERATURE REVIEW

Underground coal gasification is not new, and many technical papers have been written on various aspects of the process. Several of these papers have dealt with the current economics of UCG for the linked vertical well process. This review discusses those current papers whose results can be compared to the results of this study. The discussion here involves only the methods and assumptions used in other studies. A comparison of results follows later in the paper.

Jennings carried out the first investigation outside the USSR of UCG economics based on linked vertical well operating data. (10) The only LVW process data available at the time (1975) were very limited results from part of the Hanna I test. Since that time, knowledge of UCG and the linked vertical well process has increased greatly, due largely to the enormous increase in operating data and to the development of an accurate numerical theory of UCG. (9) Jennings investigated the sensitivity of process economics to variations in the following variables:

1. Seam depth.
2. The energy produced per volume of air injected.
3. Gas heating value.
4. The dry gas production rate per well.
5. Well spacing.
6. Seam thickness.
7. Coal recovered per well.

The paper by Jennings was important because it was the first to show the considerable economic potential of UCG in subbituminous coal. This work, however, is now outdated due to the great increase in available data and in understanding of the process. For example, it is now known that variables 2, 3, and 4, which are listed above, are interrelated and cannot be chosen independently.

Three recent economic studies of UCG have been prepared by Bechtel Corporation. The first paper is a preliminary order-of-magnitude estimate for one set of operating conditions. (11) Hanna data, in part, was used in this investigation. The second paper, presented by Buder, et al., at the Second Annual Underground Coal Gasification Symposium

(1976), estimates the costs of producing synthetic natural gas from UCG operation with oxygen injection. (12) It also considers the generation of electrical power from low-BTU gas derived from an air injection process. Two types of processes are considered: the longwall generator concept applied to eastern bituminous coal and the LVW process applied to western subbituminous coal. The cost of producing low-BTU gas from the LVW process is presented for one fixed set of operating variables.

The most recent paper by Buder and Terichow compares the economics of UCG of horizontal and steeply-dipping coal beds. (13) Data from the results of the Hanna II, Phase 2, test were used to define the process variables. Results are presented for seam depths ranging from 200 to 1000 feet and seam thicknesses of 20 and 30 feet, but the process variables are held constant.

Gulf Research and Development Company has presented several economic studies of UCG. Economic sensitivity is considered in some detail. A variety of sources of process data ranging from a Lurgi gasifier to Soviet literature are used as the basis for the calculations. The paper by Garon and Swartz is the most recent and probably the most accurate. (14) This paper encompasses UCG cost sensitivity for three product gas options: synthetic natural gas, medium BTU gas, and low BTU gas. The authors of this paper are the first to comment on the importance of the interdependence among many of the process variables.

The Stanford Research Institute (SRI) has contributed two papers on the economics of the LVW process for UCG using Hanna data. The first paper investigates the sensitivity of the cleaned gas selling price to plant size, overrun in the estimate capital investment, and resource recovery. (15) In the second paper (16) some assumptions are modified, and major emphasis is on the comparison of the selling price of electrical power generated respectively from mined coal and from low heating value gas produced by UCG.

The final two papers to be considered involve UCG of Texas lignite. The first paper (17), a Master's thesis by Oztiregen, incorporates some very optimistic assumptions. In a later paper, some of these optimistic assumptions are revised. (18) Both papers are concerned with the sensitivity of the clean gas selling price to seam depth and thickness. The cost of electric power generation and transmission is also investigated.

CHAPTER III

EVALUATION OF THE PROCESS DYNAMICS

The development of an economic analysis of a technical process requires information in four distinct categories:

1. Process dynamics.
2. Equipment design.
3. Pricing of equipment, facilities, services, and labor.
4. Economic method.

Knowledge of process dynamics is essential for an accurate economic study and is the topic of this chapter. Items 2, 3, and 4 are discussed in succeeding chapters.

The process dynamics determine the response of the UCG process to changes in the operating variables such as the air injection rate. Process dynamics also establish the existence of interrelationships among various production parameters. For example, a decline in the heating value of the production gas is symptomatic of a simultaneous decline in process thermal efficiency.

The process dynamics are the criteria on which the equipment design, subsequent costing of equipment, and resulting economics for the process are based. Two tools are used to determine process dynamics: field operating data and mathematical models. The following is a discussion of these tools and the role of each in understanding the process dynamics.

The Hanna field tests are the major source of operating data for this study. These data are extensive and cover a wide range of process operating conditions, but there are also some limitations. All of it is from isolated field tests of moderate duration. No data are presently available in the United States for the commercial scale operation of multi-well patterns, or for the continuous operation of interacting systems. However, there is limited information available on commercial UCG operation in the USSR. (19) This information is useful as it provides some understanding of the uncertainties generated when scaling the Hanna data. One important concern is the uncertainty that arises when the product gas heating value data are scaled. Discussion of how this particular uncertainty is dealt with in this analysis follows in a later section of this chapter.

Two numerical models are used in this study. The first performs material and energy balance calculations on the Hanna data. The results of these calculations show that dependencies exist among important process operating variables. The method for the material and energy balance calculations, as well as results of these calculations, are discussed in detail in the following section. The second model that is used in this study is the process model developed by Gunn, et al. (9, 20, 21). The model is chosen for this study because of its accessibility and demonstrated agreement with field data. A theoretical interpretation of field test behavior is provided by this model. This information supports the dependencies among process variables determined by the material and energy balance calculations. The theoretical explanations for these dependencies lend generality and confidence in the experimental data correlations and, thus, enhance the reliability of the economic analysis.

The next section discusses the material and energy balance calculations for UCG, the empirical relationships among process variables as determined from the material and energy balances and the Hanna field test data, and the theoretical reasons for these relationships.

Relationships Among the UCG Process Variables

The first step in the evaluation of the UCG process dynamics is to perform material and energy balance calculations with field test data.

Material and Energy Balances

A method of calculating the material balance for UCG has been previously developed by Elder, et. al. (22). This method is based on the assumption that gasification occurs in two separate modes: carbonization of the coal, and gasification of the remaining coal. The method uses atomic balances for oxygen, hydrogen, and carbon to obtain a solution. Although this method is correct in its assumption, the solution is very sensitive to the input data.

Elder defines the temperature at which the coal is charred as the one assumption required in this method and the reason for the strong sensitivity is related to the temperature of charring the coal. Application of this method to the results of the LETC field tests yields, in many cases, erroneous results. Examples of the erroneous results are negative amounts of water consumed and large amounts of coal carbonized while small or negative amounts of char are gasified. For these reasons, a new method for the material balance for UCG was developed.

The simplifying assumption in this new method is that all of the coal affected by UCG operation is completely consumed; i.e., the coal is carbonized, and subsequently the remaining char is gasified completely.

The justification for this assumption is that the amount of coal carbonized and not gasified by UCG operation is small compared to the coal that is completely consumed. Support for this assumption is found in the results of the coring of the Hanna tests, the process model by Gunn, et al. (9), and the laboratory scale, two-dimensional physical UCG simulator developed and tested at LETC, (20). Following is a discussion of this method for the UCG material and energy balances.

Input data to the material balance are the wet gas production rate, dry gas composition, and the air injection rate. Atomic balances for nitrogen, hydrogen, and carbon are used to solve for unknowns such as the mole percent water vapor in the gas, the amount of coal consumed, and the quantity of aquifer water used in the process.

The material balance calculation consists of the following steps:

1. A nitrogen balance yields the dry gas production rate:

$$W_{DG} = (Y_{NA}/Y_{NDG}) W_A \quad (3.1)$$

Where: W_{DG} = The dry gas flowrate.

Y_{NA} = The mole % elemental nitrogen in air.

W_A = The air injection rate.

Y_{NDG} = The mole % elemental nitrogen in the dry product gas.

The difference in the calculated dry gas production rate and the measured wet gas production rate is the volume of water vapor in the gas:

$$Y_{WWG} = (W_{WG} - W_{DG})/W_{WG} \times 100 \quad (3.2)$$

Where: Y_{WWG} = The volume percent H_2O in the wet product gas.

W_{WG} = The volumetric wet gas flowrate.

It is necessary to calculate the volume of water vapor in the product gas because continuous measurement of this quantity has not been recorded in the field as yet. The amount of water vapor in the gas does vary during the life of a test, and knowledge of the amount of water vapor in the product is critical to understanding and evaluating the process operation.

* Variables or unknown quantities are presented on the left side of the equation. Known or measured quantities are on the right.

2. A carbon balance gives the amount of coal consumed by the operation. (It should be noted that coal liquids produced are included in the calculations).

$$M_C = (X_{CDG} M_{DG} + X_{CT} M_T) / X_{CC} \quad (3.3)$$

Where: M_C = The amount of coal consumed.

X_{CDG} = The weight % carbon in the dry gas.

X_{CT} = The weight % carbon in the produced coal liquid.

M_T = The production rate of coal liquids.

X_{CC} = The weight % carbon in the coal.

M_{DG} = The production rate of dry gas.

3. A hydrogen balance then yields the aquifer water involved in the gasification:

$$M_{WR} = (X_{HDG} M_{DG} - X_{HC} M_C) / X_{HW} \quad (3.4)$$

Where: M_{WR} = The amount of aquifer water consumed by reaction.

X_{HDG} = The weight % elemental hydrogen in the dry product gas.

X_{HC} = The weight % elemental hydrogen in the coal.

X_{HW} = The weight % elemental hydrogen in water = 2/18.

4. An oxygen balance provides a fourth equation that allows the results from the above method to be independently checked for consistency.

$$X_{OWG} M_{WG} = X_{OA} M_A + X_{OC} M_C + X_{OW} M_{WR} \quad (3.5)$$

Where: X_{OWG} = The weight % elemental oxygen in the wet product gas.

X_{OA} = The weight % elemental oxygen in the air.

X_{OC} = The weight % elemental oxygen in the coal.

X_{OW} = The weight % elemental oxygen in water = 16/18.

M_{WG} = The wet gas production rate in lb./hr.

M_A = The air injection rate in lb./hr.

The energy balance calculation consists of the following steps:

1. The gross heating value of the coal consumed is calculated directly from the amount of coal consumed and the coal heating value. The coal heating value is determined from core samples.

$$Q_C = M_C H_C \quad (3.6)$$

Where: Q_C = The gross heat content of the coal consumed.

H_C = The analytically determined coal heating value.

2. The total heating value of the dry product gas produced is calculated from the dry gas composition and flowrate:

$$Q_{DG} = W_{DG} H_{DG} \quad (3.7)$$

Where: Q_{DG} = The total heat content of the dry gas.

H_{DG} = The dry gas higher heating value.

3. The wet product gas sensible and latent heats are calculated from the wet gas flowrate and composition, wellhead temperature, and a reference temperature of 77°F (25°C). Temperature dependent heat capacities for each component are also used.
4. The total heat content of the liquid products or tars is calculated directly from the analytically determined HHV and measured production rate.

$$Q_T = M_T H_T \quad (3.8)$$

Where: Q_T = The total heat content in the coal liquids produced.

H_T = The coal liquids higher heating value.

5. The estimated heat losses are found by subtracting the sum of items 2, 3, and 4 from item 1. The losses include heat lost to the ash and surrounding rock strata and heat lost in raising the temperature of the seam and seam water from the ambient seam temperature to the reference temperature.

The reader is directed to the paper by Fischer, et al., (23) for additional information regarding the material and energy balances.

Results of Material and Energy Balances

The results of the material and energy balances show interdependence among the following variables:

1. The produced gas higher heating value (HHV).
2. The % thermal efficiency (η_{TE}) of the process².
3. The ratio of dry gas produced to air injected.
4. The ratio of dry gas produced to coal consumed.
5. The molecular weight of the dry gas.

Daily averaged field data from Hanna II, Phases 2 and 3, and the Hanna III tests are used to find the relationship for the interdependence of each of the process variables mentioned above to the produced gas HHV. A total of 43 operating days are used in the calculations. Table C-I in Appendix C lists the experimental data used. Two key relationships are plotted vs. the gas HHV on the following page. The precise form of the correlations is dependent on the coal properties. The coal properties assumed in this study are those of the Hanna #1 coal used in the LETC field experiments; they are listed in Appendix D. Although these data apply to a specific coal, the data can be assumed to apply to similar coals without much difficulty. However, application of the economic method to coals differing greatly from the subbituminous Hanna coal is possible through the use of a model such as that developed by Gunn, et al. (9).

The process model of Gunn, et al., aids in the determination of the interdependences and also provides theoretical support of the empirical relationships.

The dashed line in Figure 3.1 is the correlation used in the economic study. The solid line is the theoretical relationship obtained from the process model. The average deviation between the two correlations is less than 2 percent. The theoretical correlation, however, has a consistent conservative bias -- that is, the predicted thermal efficiencies follow the locus of lowest experimental efficiencies.

Figure 3.1 clearly shows that heating value and thermal efficiency cannot be chosen independently and that a nearly linear relationship exists between the two variables. A close examination of the interior calculations of the process model (24) provides insight into the reasons

$$^2\eta_{TE} = (Q_{DG} + Q_T)Q_C \times 100$$

FIGURE 3.1
PLOT OF THERMAL EFFICIENCY VS. PRODUCT GAS HHV

for this relationship. The following two reactions are major contributors to the gas heating value:

Both reactions are highly endothermic, and, if the product gas is to have a high heating value, the largest possible fraction of thermal energy generated by the combustion of coal must be consumed by these reactions. A lower thermal efficiency occurs when heat losses exist. In a thin coal seam, heat is lost by conduction into the surrounding rock strata. In the Hanna field tests, the coal seam is 30 feet thick, and little heat is lost in this way. Excessive water influx has been a major cause for low thermal efficiencies during parts of the Hanna tests. In this case, a substantial fraction of energy produced is used to vaporize large quantities of water. Heat losses, regardless of the exact cause, use up energy that otherwise promotes the gasification reactions, and the gas heating value is adversely affected. Thermal efficiency is a quantitative measure of the amount of heat loss. These effects have been described in greater detail elsewhere. (24, 25)

Theoretical models are especially helpful in determining parameter interdependencies which might otherwise go undetected. An unexpected relationship is the dependence of the gas/air ratio on heating value. This is an important correlation because it determines the air injection rate needed to sustain a fixed gas production rate. Figure 3.2 shows a plot of the gas/air ratio vs. heating value based on the same field test data used in Figure 3.1. The average deviation between the theoretical and experimental correlation is 3 percent. Once again, the process model provides a theoretical explanation for the dependence of the gas/air ratio on the heating value. A low thermal efficiency leads to both a low heating value and to a low gas/air ratio. Quite simply, at low thermal efficiencies less energy enters into the gasification reactions and less gas is produced.

In summary, process model calculations are valuable in conducting an economic study in the following ways:

1. Indicating process variable relationships which are not apparent otherwise.
2. Lending validity and generality to experimental correlations by providing theoretical explanations for the shape of empirical curves.
3. Providing correlations development capability of the type shown in Figures 3.2 and 3.3 with very limited field test data or with none at all.

FIGURE 3.2

PLOT OF DRY GAS PRODUCTION RATE TO AIR INJECTION RATE VS. PRODUCT GAS HHV

Sensitivity Variables Used to Determine the UCG Process Dynamics

In preparing an economic study, the analyst cannot fix certain variables with any degree of confidence with the current level of knowledge concerning UCG. No definitive cost study can be made under these conditions; nevertheless, much useful information can be obtained from an economic analysis through a sensitivity study -- that is, through an analysis of how the range of uncertainty in particular variables affects the required selling price of the product gas.

Six of the parameters, defined here as sensitivity variables, are used in this work. It is necessary that the number of these variables be reduced to an absolute minimum. Otherwise the economic analysis will have little value because it contains too many degrees of uncertainty. Each of the sensitivity variables used and the selected range of variation is discussed below:

1. Depth of the Top of the Coal Seam -- 300, 600, and 1000 feet.
2. Seam Thickness -- 10, 30, and 50 feet. Fifty feet is chosen as the maximum because of the very limited number of seams of greater thickness.
3. Well Spacing -- 60, 100, 150, and 200 feet. Sixty feet is chosen as the minimum based on LETC's repeated success with reverse combustion linking and forward gasification over this distance.
4. Dry Gas HHV -- 100, 125, 150 and 175 BTU/scf. The maximum is equal to the results of the Hanna II, Phase 2 test. The Phase 2 test achieved the highest average gas HHV for an entire UCG test ever recorded. Heating values of 100 to 125 BTU/scf have been achieved by the Soviets over extended periods and during commercial operations. (19)
5. Volumetric Combustion Sweep Efficiency (η_{CS})³ -- 50, 65 and 80%. Sweep efficiencies of greater than 80% for small tests have been reported in Great Britain and the Soviet Union. (19) A similar value is reported for Hanna II, Phases 2 and 3. (8) The 50% value allows for coal barriers between large individual gasification patterns and for the occasional loss of a two-well module due to such eventualities as well damage, gravity override, or coal seam anomalies.

³Volumetric combustion sweep efficiency is defined as the fraction of the total volume of coal within a module contacted by the gasification zone.

6. Leakage Rate -- 0, 10, and 20%. Gas leakage is a potential problem for large patterns experiencing extensive subsidence. Field test experience in the current United States UCG program has provided little information concerning this problem. Well patterns used for Hanna field tests have been small, and subsidence has never been detected at the surface. Gas leakage in these tests has been negligible. The Soviet literature, however, reports that leakage has been limited to 10 to 20% in successful large-scale operations. (19)

All possible combinations of selected values for the sensitivity variables result in 1296 different cases to be calculated. Results of these calculations are discussed in later chapters and presented in tabular form in Appendix G.

Application of this Method to Other Sites

A discussion of site characterization prior to initiating economic studies is beyond the scope of this paper, but the subject is discussed elsewhere. (27) An accurate economic study requires correlations of the types shown in Figures 3.1 and 3.2. For coals similar to the Hanna 1 seam product, Figures 3.1 and 3.2 can be used with reasonable accuracy.

These figures are not valid for coal with substantial differences in the ultimate and proximate analyses, in the carbonization analyses, or in physical properties. Experimental field test data sufficient to establish the desired correlations are not initially available; therefore, model calculations and laboratory simulation experiments are used to establish the needed correlations.

Process Calculations

Module Concept

The starting point of the process calculation is the definition of the basic UCG process unit hereafter referred to as a module. A process module is defined as that volume of coal confined within the square area having dimensions equal to the well spacing. Each module has two wells passing through the outer edges of the volume at the midpoints of the width as shown in Figure 3.3 and Figure 3.4.

When modules are placed end to end, each module shares its wells with two neighboring modules. Therefore, after the initial module, only one well is necessary for the construction of each additional adjacent module. The module concept is important, and many of the calculations discussed in this study are performed on the basis of one module.

EACH SQUARE REPRESENTS ONE MODULE

FIGURE 3.3

TWO-DIMENSIONAL REPRESENTATION OF MODULES IN A NINE-WELL ARRAY

FIGURE 3.4

THREE DIMENSIONAL REPRESENTATION OF ONE MODULE

Prior to discussion of the calculations, a brief description of the field layout and the commercial UCG operation are presented. This description is to provide clarification of the physical concept of a module as it relates to both the plant operation and the calculations performed in the analysis.

Commercial Operation

A commercial operation involves the gasification simultaneously of many modules in different stages of development. Continuous UCG operation is achieved by relaying the gasification down parallel lines of wells. Figure 3.5 is presented to clarify this concept and also to clarify how the necessary movement of process piping proceeds during continuous operation.

Figure 3.5 represents the field layout at the time of plant start-up. The duplicate surface piping system is needed to achieve relaying of the gasification and linking activities from one row of wells to another. Prior to the plant start up, reverse combustion links are created between neighboring wells in rows 1 and 2, 2 and 3, and 3 and 4. These rows of wells are thus prepared for gasification. The start-up of modules in a row is staggered in time so that at the end of the start-up period modules are being gasified in all stages of development. This is a technique used successfully in commercial UCG operation in the USSR (19) to produce a constant quality gas. Gasification of the modules involves air injection into the wells of row 1 with gas production through the wells of row 2. The lines indicated are used for transporting the product gas from the well to the plant facilities. Linking of wells is performed continuously during the plant operation. Relaying the gasification pattern down the rows of wells is achieved by switching the wellhead piping when necessary.

The following pages provide a discussion of the calculations involving the modules and the field layout.

The Module Consumption Rate

The tonnage of coal in the module is calculated from the module dimensions and the coal density (coal properties are in Appendix D).

$$M_{CM} = b(d_{WS})^2 \rho_C \quad (3.15)$$

Where: M_{CM} = The mass of coal in one module.

b = The seam thickness.

FIGURE 3.5

INITIAL WELL FIELD LAYOUT

d_{WS} = The well spacing.

ρ_C = The coal density.

The energy produced to the surface from one module in a usable form is found next. A usable form of energy is considered to be only energy in the form of the dry gas HHV or liquid product HHV. Heat produced to the surface in the form of sensible and latent heat in the product gas is not considered.

$$Q_M = M_{CM} H_{C\eta CS} (1 - X_L) \eta_{TE} \quad (3.16)$$

Where: Q_M = The heat recovered to the surface from one module in a usable form.

H_C = The HHV of the coal.

η_{CS} = The volumetric combustion sweep efficiency.

X_L = The leakage rate.

η_{TE} = The process thermal efficiency.

At this point, an iterative procedure for calculating the total energy production rate (Q_P) is required because the quantity of energy to be supplied to the consumer is fixed, but the energy required to run the UCG facility is initially unknown.

$$Q_P = Q_D + Q_R \quad (3.17)$$

Where: Q_D = The energy for sale (100 megawatts electrical energy).

Q_R = The energy required to operate the UCG facility.

The module consumption rate (R_M) is then calculated from the total energy production rate (Q_P) and the usable energy produced from one module (Q_M).

$$R_M = Q_P / Q_M \quad (3.18)$$

The Number of Modules or Wells in Production

The operation of the UCG facility requires that several modules must be in operation at one time (Figure 3.5). The calculation of the number of modules in operation (P_M) requires that a basis be selected for the amount of time required to gasify a module. Forty days is selected as the time to gasify one module having the following characteristics:

1. Sixty-foot well spacing (d_{WS}).
2. Fifty percent VCSE (η_{CS}).

The material energy balances and the process model of Gunn, et. al. (9) provide information needed to scale this time value. The value for the time required is scaled linearly with well spacing according to the process model. The material and energy balances also show that linear scaling of the time value with respect to item 2 is consistent. The equation for the amount of time required to gasify one module is:

$$T_M = 40 (d_{WS}/60) (\eta_{CS}/.50) \quad (3.19)$$

Where: T_M = The time required to gasify one module.

The selection of 40 days being required to gasify a module with a 60 foot well spacing and 50% sweep efficiency is based upon the results of LETC's field tests. Field tests have shown that from 25 to 38 days are required to gasify such a module. Forty days is selected to be conservative. The conservative bias creates flexibility in the UCG operation by designing into the air injection schedule the capability of increased injection should increased production be necessary.

The number of operating modules required is determined by the amount of time required to gasify a module and by the module consumption rate.

$$P_M = 24 R_M T_M \quad (3.20)$$

Air Requirements

For Forward Gasification

The sensitivity variables and corresponding dependent variables yield the total volume of gas produced from gasification of one module.

$$V_{DG} = \frac{Q_M (X_{QDG}/100)}{H_{DG}} \quad (3.21)$$

Where: V_{DG} = The total volume of dry gas produced from one module.

X_{QDG} = The percent of total energy produced that is in the form of dry gas HHV.

The total volume of air required for forward gasification is:

$$W_{GA} = V_{DG} R_M / [(1 - X_L)(Z_{G/A})] \quad (3.22)$$

Where: W_{GA} = The total air flowrate required for forward gasification.

$Z_{G/A}$ = The ratio of the volume of dry gas produced per volume of air injected.

For Reverse Combustion Linking

The total volume of air required for linking (W_{LA}) is:

$$W_{LA} = 1000 W_L d_{WS} R_M (1 + C_L) / 1440 \quad (3.23)$$

Where: W_L = MSCF of air required per foot of link. (Values found in Appendix E).

C_L = Contingency for linkage air requirements. (This study assumes $C_L = .50$).

Required Compressor Discharge Pressures

For Forward Gasification

The compressors providing low-pressure air for forward gasification are designed to deliver the air at a pressure equal to the hydrostatic head of the coal seam. The calculation of the hydrostatic head of the Hanna 1 seam at various depths is based on the piezometric surface which is 150 ft. below the ground level.

The pressure drop in the surface lines and process wells must also be calculated. These calculations require that the maximum air injection rate in a process well be determined. The maximum air injection rate in a process well is 4500 scf/min., based on a 60 ft. well spacing and a 30 ft. coal seam.

This number is consistent with the Hanna experiments. Higher air injection rates may be possible, but as yet, higher rates have not been demonstrated. Investigation of the process model and laboratory experiments yield information regarding scaling this number. This value is also scaled linearly with respect to well spacing and seam thickness.

$$W_{MA} = 4500 (d_{WS}/60) (b/30) \quad (3.24)$$

Where: W_{MA} = The maximum air injection rate in a process well.

The equations for calculating the pressure gradient in the piping system are found in the literature (equation 187 and equation 214 in reference 28). The required compressor discharge pressure is:

$$P_{CD} = P_L + P_H + P_A \quad (3.25)$$

Where: P_L = The total pressure drop in the injection piping and wells.

P_H = The hydrostatic seam pressure in psig.

P_{CD} = The required compressor discharge pressure.

P_A = The atmospheric pressure.

The reason for designing injection at the hydrostatic head is to control water influx into the gasification region. If there is an excess of water present, injection at a pressure slightly greater than the hydrostatic head will impede the influx of seam water. If a shortage of water exists, the pressure may be relaxed to aid water influx.

For Reverse Combustion Linking

The compressors providing the high-pressure air for linking are sized to a discharge pressure equal to the lithostatic pressure on the coal seam. The lithostatic pressure is about 1 psi per foot of overburden. The pressure in the process wells during linking is calculated based on an air injection rate of 100 scf/min. This value may be conservative but has been demonstrated in the field. The pressure calculations and the calculations of the required discharge pressure for linking are identical to the methods discussed for forward gasification.

Determination of the Compressor Capacity Required

For Forward Gasification

The compressors are sized by assuming polytropic compression in the calculation of the required horsepower. The inlet air conditions are assumed to be 60°F and 11.3 psi. The compressor efficiencies were provided by the compressor manufacturer and are discussed in the next chapter. The required horsepower is:

$$B_L = \frac{.0643 T_I \gamma (W_{LA} + W_{GA}) N_S [(Z_C)^{1-1/\gamma-1}]}{520 (\gamma-1) \eta_{LP}} \quad (3.26)$$

Where: B_L = The compression horsepower required for low pressure air requirements.

T_I = The inlet air temperature.

γ = Ratio of specific heats = 1.4 for air.

η_{LP} = The compressor efficiency.

Z_C = The compression ratio per compression stage.

N_S = The number of stages of compression.

For Reverse Combustion Linking

The sizing of the compressors required to provide linkage air uses an equation similar to equation 3.26. Linkage air is taken from the forward gasification air line and boosted to the required pressure.

The compressors are to be driven by steam turbines with steam generated from a boiler fired with product gas. Since the boiler fuel is low BTU gas, the boiler will require special design considerations. The product gas used to fire the boilers will require cleanup and is discussed in the next chapter.

The combined efficiency of the components of the steam generating system is 31%. The energy requirements for the plant operation are now calculated:

$$Q_R = B_T / \eta_S \times 2545 \quad (3.27)$$

Where: B_T = The total compression horsepower.

η_S = The steam-cycle efficiency.

Q_R is substituted into equation 3.17 and the succeeding calculations are repeated until convergence is achieved. That is, when the plant produces an amount of energy equal to the sum of the energy delivered to the consumer and the energy required for process operation.

Upon convergence, the process requirements are determined and the process equipment can be sized. The major items determined in this section are:

1. The total plant heat load.

2. The rate at which modules are consumed.
3. The coal consumption rate (directly from 2).
4. The number of wells or modules in production.
5. The initial drilling requirements (directly from 4).
6. The requirements for drilling replacement wells (directly from 2).
7. The process air requirements.
8. The compressor size.
9. The size of the steam cycle required to drive the compressors.

CHAPTER IV

EQUIPMENT DESIGN

In addition to the process dynamics, the design of a commercial-scale UCG facility is critical for accurate process economics. The purpose of this chapter is four-fold:

1. To discuss the specific equipment required by the UCG operation.
2. To discuss the function of each type of equipment as it relates to the process operation.
3. To clarify the determination of the size and/or amount of each equipment item required.
4. To present the design criteria.

The general topics covered in this chapter are presented in the following order:

1. Commercial UCG operation.
2. Discussion of each of the equipment requirements.

Commercial UCG Operation

The economic results presented in Chapter VII apply to an UCG operation using the linked vertical well (LVW) process. Figure 4.1 depicts the general plant layout. The UCG facility consists of two general items: surface facilities and the well field. The surface facilities include all of the compression equipment, buildings, machinery, and data acquisition and monitoring equipment.

The compression equipment is required to provide air for the gasification and linking activities. The compression equipment includes:

1. Compressors providing the large volumes of low-pressure air for forward gasification.
2. Compressors providing small volumes of high-pressure air for reverse combustion linking.
3. Steam turbines to drive both types of compressors.

FIGURE 4.1
PLANT LAYOUT

4. Low-BTU gas fired boilers for the generation of process steam.
5. Gas cleanup equipment to clean the product gas required to fire the boilers.

Each of the above items is discussed in detail later in the chapter.

The buildings, machinery, and data acquisition and monitoring equipment are also individually discussed later in this chapter.

The well field is divided into five areas:

1. Depleted area -- This region consists of the area over the coal that has been gasified. The only activities performed here are observation of subsidence, periodic analysis of water percolating through this region, and eventual abandonment of wells.
2. Gasification area -- The forward gasification of coal is performed in this region. Process wells, wellhead piping, surface piping for low pressure air distribution, and product gas gathering piping are required equipment. Work here consists of monitoring and control of the air, product gas flows, and periodic movement of the wellhead and surface piping.
3. Linking area -- Reverse combustion linking is performed here. Process wells, piping for the high-pressure air injection, and product gas gathering piping are used. Work is similar to that in the gasification region. The purpose of the reverse combustion linking is to prepare the coal seam for forward gasification by enhancing the permeability of the coal along the linkage path.
4. Drilling area -- The process wells required for UCG operation are drilled in this region. Well drilling and well completion activities are performed here. The equipment used includes drilling rigs, well completion equipment and wellheads. In addition to the well drilling and completion activities, a preliminary evaluation of the coal seam properties is performed. Draw-down tests, build-up tests, air injectivity tests, and coring are used to acquire the data necessary to evaluate the seam properties.
5. Future expansion area -- Work required to prepare the topography for the drilling of additional process wells is performed here. This work includes the surveying of well locations, preparation of roads, and other necessary earthwork.

Figure 4.2 illustrates the wellfield as it appears at the time of plant start-up. Initially, there is no depleted area. The gasification area is between well rows 1 and 2. The area between well rows 2 and 4 is ready to be gasified because the necessary linkages in the coal seam is completed prior to plant start-up. The linking activity is essentially continuous and at start-up reverse combustion is underway between wells in rows 4 and 5. Also, drilling continues beyond well row 7.

As stated in Chapter III, the gasification of the modules in a well row is staggered in time to maintain a constant product-gas quality as well as a constant energy production rate. Staggering the gasification patterns requires careful design and, preferably, dual sets of surface piping systems. For clarification, the movement of the surface piping system is discussed next in considerable detail. Figure 4.3 is provided to illustrate the pipe movement necessary for continuous operation of a UCG plant using this type of module development. Diagram A in the figure illustrates two modules in a row. Module A is near completion of gasification and module B is midway through the gasification. Air is injected through wells 1 and 2 and the low-BTU gas is produced through wells 3 and 4. The diagram also shows the air injection header not in use and the gas production header not in use. These lines are beyond wells 3 and 4 and the need for these lines will be apparent with further discussion of Figure 4.3.

Diagram B illustrates the relaying of the gasification zone from module A to module A'. This is done by moving the wellhead injection piping from well 1 to well 3 and correspondingly the production well head piping is moved from well 3 to 5 as indicated.

Diagram C shows the relaying of the gasification from module B to module B' as the gasification of module B is completed. Wellhead injection piping is switched from well 2 to well 4 and wellhead production piping is switched from well 4 to well 6.

Diagram D illustrates the relaying of the gasification from module A' to module A''. This is performed by closing the valve on the wellhead piping which connects well 3 to the first injection header and also closing the valve on the wellhead piping which connects well 5 to the first production header. The valve on the wellhead piping connecting well 5 to the second injection header is opened, and the valve connecting the wellhead piping on well 7 to the second production header is opened. Duplicate sets of injection and production headers allow this relay of the gasification process to proceed without disrupting the operation.

Diagram E illustrates the relaying of the gasification from module B' to module B''. This relay is achieved by switching the injection wellhead piping from well 4 to well 6 and switching the production well-

FIGURE 4.2
INITIAL WELL FIELD LAYOUT

FIGURE 4.3

PIPE MOVEMENT REQUIRED TO RELAY GASIFICATION

head piping from well 6 to well 8. The injection header between the first two well rows is not in use and the production header between the second and third well rows is also not in use. These two headers are then moved into position for further use as the gasification proceeds. The new locations of these headers is indicated by the dashed lines in diagram E. The duplication of these headers allows time for the pipe to be moved without disrupting gasification. Surface lines are flanged to facilitate the necessary movement.

Further relaying of the gasification proceeds by repeating the steps illustrated in Figure 4.3. Additional discussion of the piping is provided later in this chapter.

In summary, the general items required in the UCG operation are:

1. Process wells.
2. Surface piping and piping accessories.
3. Compressors and related items.
4. Site facilities.
5. Plant personnel.

Each of these items is individually discussed in the following sections.

Equipment Requirements and Specifications

Drilling and Completion of Wells

In this section the following topics are discussed:

1. The function of the wells.
2. Determination of the number of wells required for plant start-up and the number of wells that must be drilled annually.
3. Sizing of the process wells.
4. Criteria for casing selection.
5. Drilling and completion techniques.

The process wells in a UCG operation serve several functions. Each process well is used as a source for air injection into the coal seam and is later used to collect the low-BTU gas. The process wells are

also used in the initial evaluation of the coal seam properties and in reverse combustion linking.

The process wells required for the plant start-up are considered as capital investment. A sufficient distance between the gasification, linking and drilling activities is required for each operation to proceed without difficulty. The number of wells used for plant start-up is equal to five times the number of wells in production. The method for determining the number of wells or modules in production has been discussed in Chapter III. During the prestart-up linking of wells in rows 1, 2, 3 and 4, the sixth and seventh rows of wells are drilled but are considered as an operating expense. The separation distances between the drilling, linking, and gasification activities are illustrated in Figure 4.2.

The number of wells that must be drilled annually is equal to the annual module consumption rate. The module consumption rate is also discussed in Chapter III. Common practice has shown that the drilling and completion of wells can be performed in five to eleven days time in southeastern Wyoming. Because the gasification of a module takes from 40 to 213 days, ample time is available for the drilling of new wells. It should be noted, however, that in some cases considered (thin seams and small well spacings) a large number of modules are gasified each year. Several drilling rigs are necessary to meet the drilling requirements in these cases.

The process wells are designed to be the economic optimum size. Pressure losses in the surface lines and process wells are major factors controlling this optimization. Various inside diameters for the process wells are considered for each case and the specific diameter resulting in the minimum gas selling price is selected. To determine pressure losses in the wellhead piping and process wells, maximum air injection and maximum gas production rates in the wells are selected based on field test data. The determination of these maximum rates is as follows:

A maximum air injection rate of 4500 scf/min., for a 60-ft. well spacing and a 30-ft. thick seam, is used based on the data from the LETC field experiments. To insure air flux rates within the ranges of the rates achieved in the LETC field tests, changes in the well spacing and seam thickness must be accounted for in the calculations. Equation 4.1 is used to determine the maximum air injection rate for design purposes. The maximum air injection rate as a function of the well spacing and seam thickness is:

$$W_{MA} = 4500 (d_{WS}/60)(b/30) \quad (4.1)$$

Where: W_{MA} = The maximum air injection rate in scf/min.

This air flux rate is based on the area of the combustion zone. The above correction for the seam thickness is used because the area of the combustion zone is directly proportional to the seam thickness. The correction used for the well spacing is arrived at through examination of the geometry of the combustion zone in UCG. The geometry of the combustion is discussed in detail in reference 20.

The value selected for the maximum ratio of the volumes of wet gas to air injected is equal to 2.0. This value is also determined from the field data. Using this ratio, the maximum wet gas production rate is directly calculated from the maximum air injection rate.

Selecting the wall thickness required for the line pipe casing the process wells and selecting the flanges for surface wellhead piping require a temperature and pressure criteria for design. The following design criteria are selected for this study based upon the results of the LETC field tests.

Table IV-I

Design Criteria for Selecting
Pipe Schedules and Flange Classes.

Location	Maximum Temperature (°F)	Maximum Pressure (PSIA)
Process well used for low pressure air injection	400	Hydrostatic Pressure + 20
Process well used for gas production	1000	Hydrostatic Pressure
Process well used for high pressure air injection	400	Lithostatic Pressure + 20

The process wells in the UCG operation described in this study are used to serve three different functions. The wells are used to inject high pressure air for linking, to inject low-pressure air for gasification, and to draw off the low-BTU gas produced underground. The three uses of each well require three different sets of temperature and pressure criteria for design. The three sets of temperature and pressure criteria are presented in Table IV.1. The calculation of the required wall thickness is outlined in reference 31. Calculations using each of the three criteria show that conditions are most severe

when a well is used for gas production. Selection of the wall thickness of the line pipe in a process well meet the most severe conditions. Thus the wells are cased with line pipe conforming to the specifications required for gas production. Only standard pipe sizes are considered for reasons of availability.

The drilling and stringing of the casing are performed on a contract basis. Each well is cased to within five feet of the bottom of the coal seam. The bottom five feet is an open hole completion with a 25-foot rathole continuing beyond. The well completion is contracted also. Completion techniques are discussed in reference 32. Additional information concerning the completion and related costs is presented in Chapter V.

Process Piping

The surface piping is divided into four categories:

1. Wellhead piping -- Included in this category are the pipe and related items that are necessary to connect each process well to the distribution or collection headers. Items necessary for flow control and metering at each well are also included. A detailed discussion of each of these items follows later in this chapter.
2. Distribution lines for low pressure air for gasification -- The function of this system is simply that of transporting the low-pressure air from the compressors to the well field where the air is then transported to the process wells via the wellhead plumbing.
3. Distribution lines for high pressure air for reverse combustion linking -- The function of this piping system is analogous to that of the distribution line for low pressure air delivery.
4. Gas gathering system -- The function of this piping system is to collect the gas produced at the individual process wells and then to transport it to the plant boundary.

Items 2, 3, and 4 above are collectively discussed in the following pages. A discussion of the wellhead piping directly follows the sections dealing with the distribution and collection systems.

The bulk of the surface air distribution and gas collection lines is purchased as capital investment. The initial purchase for these lines is sufficient to set up the UCG operation and also sufficient to provide for expansion over the first year of operation. Figure 4.2 illustrates the initial set up of the air distribution and gas collec-

tion systems. All surface pipe within the well field is flanged. Also, 750 feet of pipe is included to extend each surface piping system from the well field to the plant. This number is based on the assumption that the plant is 500 feet from the well field so that it is unaffected by subsidence and other field operating problems. The following equations represent the initial length of pipe purchased for each of these surface systems.

$$l_{CS} = l_I + l_E \quad (4.2)$$

Where: l_{CS} = The length of pipe required for one of the surface systems.

l_I = The length of pipe required for start-up.

l_E = The length of pipe required for first year's well field expansion.

Figure 4.2 illustrates the initial set up. Accounting for the pipe in this figure yields:

$$l_I = 2d_{PW} + 750 + 2d_{WS} \quad (4.3)$$

Where: d_{PW} = The width of the well field.

$$= P_M d_{WS}$$

The length of pipe required for the first year's expansion is determined from the number of operating modules and the module consumption rate (R_M).

$$l_E = \frac{(2)(24)(365)\eta_P R_M d_{WS}}{P_M} \quad (4.4)$$

Where: η_P = the plant load factor.

A 10% excess of pipe is purchased and stock piled. Also, two valves for each system and one orifice set up for the gas gathering line are purchased in 10% excess. As previously stated, the surface pipe within the well field is flanged to facilitate movement of these lines. The flanged joints of pipe are equal in length to the well spacing. Flange bolts and pipe fittings such as crosses, tees, elbows, etc., are counted and purchased with 10% excess. Annual purchases of pipe and pipe accessories are required to extend the surface systems to the gasification region as it moves down the well field. The amount of each item required annually is equal to the distance the well field expands (l_E). Again, 10% excess pipe and pipe accessories are pur-

chased. Pipe diameters for the air distribution lines for linking and gasification are the economic optimum size as mentioned in a previous section.

The diameter of the gas gathering system is calculated assuming that the product gas is at 30 psig pressure at the plant boundary when the well field is at its maximum extension. This pressure is selected to insure that the product gas has sufficient pressure to fire boilers in the electric power plant. Calculations of pipe diameter, given the length of pipe and the pressure drop, are provided in reference 28.

The criteria for selecting pipe schedules and flange classes are provided in Table IV - II.

Table IV - II
Design Criteria for Selecting
Pipe Schedules and Flange Classes.

Location	Maximum Temperature (°F)	Maximum Pressure (PSIA)
Low-Pressure Air Distribution System	400*	Hydrostatic Head + 20
High-Pressure Air Distribution System	400*	Lithostatic Pressure
Injection Wellhead Piping	400*	Hydrostatic Head + 20
Gas-Gathering System	800	Hydrostatic Head
Production Wellhead Piping	1000	Hydrostatic Head
Linking Wellhead	400*	Lithostatic Pressure + 20

*The selection of the maximum temperature on the air distribution systems is based on the maximum allowable air discharge temperature from the compressors of 400° F.

The wellhead piping is divided into three groups: wellhead piping for the high-pressure reverse combustion linking system, wellhead piping for the low pressure gasification air system, and wellhead piping for gas production. Each type consists of similar equipment which includes:

1. Two positive seal fullbore valves.
2. One flow controller and required accessories.
3. One flow metering device and required accessories.
4. Pipe and piping accessories.

Expensive high-temperature positive seal valves are necessary to insure the safety of the operators when they are changing orifice plates or moving pipe. Metering and control at each wellhead are critical items because accurate flow measurement is required to evaluate the process operation. If the operating modules intersect, the air flow through modules can become unbalanced. Air flowing across modules can result in underground combustion of the product gas and also result in low sweep efficiencies. Accurate flow measurements at each well provide information for the calculation of material and energy balances for each operating module. The results of these calculations are used to detect flow across modules, and control at each well is necessary to correct this situation. This technique for control of intersecting gasification systems has been successfully demonstrated by the British in the Newman Spinney UCG field test (29). In this test, four intersecting gasification systems were successfully gasified simultaneously. As a note in passing, the piping accessories (i.e., flanges, elbows, tees, etc.), valves and metering and control equipment represent the bulk of the cost of the wellhead piping.

Figure 4.4 depicts the pipe and related items on each injection wellhead. The wellhead piping used in linking is identical to the injection wellhead piping except that the cross is replaced by an elbow. Figure 4.5 depicts the production wellhead.

Table IV - III provides an inventory of wellhead piping needs. The number of complete sets of wellhead piping required for plant operation is equal to twice the number of operating modules. While only one set of wellhead piping is needed for each well in use, the duplication of the surface piping systems requires that additional sets of this piping be purchased. Annual purchases of wellhead piping are for replacement parts only. This piping is the same diameter and same schedule as the line pipe used to case the process wells.

FIGURE 4.4
PROCESS PIPING FOR THE INJECTION WELLHEAD

FIGURE 4.5
PROCESS PIPING FOR THE PRODUCTION WELLHEAD

Table IV - III
Inventory of Equipment on Each Wellhead.

Item	Amount Required for Injection Wellhead	Amount Required for Production Wellhead	Amount Required for Linking Wellhead
Pipe	Case Specific	Case Specific	Case Specific
R.F. slip on Flanges	15	16	15
Bolts	Case Specific	Case Specific	Case Specific
Orifice Set ups	1	1	1
Elbows	1	0	2
Tees	0	1*	0
Crosses	1*	1*	0
Blind Flanges	2	3	0
Valves	2	2	2
Control Valves	1	1	1

* Crosses and tees are used on the wellheads to reduce particulate erosion at bends in the pipe and also to facilitate the switching of wellhead piping.

Air Compression

This section provides a discussion of all items included in the air compression system. Items included in this section are:

1. Compressors required for providing the high-pressure air for reverse combustion linking.
2. Compressors required for providing the low-pressure air for forward gasification.
3. Steam turbines selected as drivers for both types of compressors.
4. Boilers designed to be fired by cleaned low-BTU gas. The boilers are for the generation of process steam required by the turbines.
5. Cleanup equipment to clean the low-BTU gas used as boiler fuel.

Linkage air is provided by reciprocating booster compressors. The system is designed to compress the low-pressure air discharged from the gasification compressor. The exact discharge pressure for this system is case specific. The calculations required to determine the discharge pressure and compressor size are discussed in Chapter III. The cost of the booster compressors is a capital investment item. Sufficient compression horsepower is purchased to provide the needed flow rate when the compressors operate at 90% of their maximum capacity. The reasons for this are the reduced compressor maintenance and the flexibility provided by the 10% excess capacity. The mechanical efficiency of the reciprocating compressor is 95% according to the manufacturer.

The air for forward gasification is provided by axial-flow compressors. This type of equipment is especially well suited to the need for very large volumes of compressed air. The axial-flow compressor differs greatly from the centrifugal compressor in its aerodynamic properties. The axial machine eliminates changes in air direction through the compressor and thereby realizes increased efficiency. Axial compressors use rotating-turbine-type blades in series to obtain a smooth pressure increase. This design yields high reliability, reduced maintenance, and high efficiency. The axial design is more expensive on a horsepower basis than the centrifugal, but the increased efficiency results in a lower total cost of operation for the cases considered in this study. The cost of these compressors is also a capital investment item. Sufficient compression horsepower is purchased to meet the low-pressure air requirements when the compressors operate at 90% of their maximum capacity. The efficiency of the axial compressor is 85% according to the manufacturer.

Both the axial-flow and reciprocating compressors are driven by steam turbines. The process steam required to run the turbines is generated in boilers designed to burn clean low-BTU gas. The boiler-turbine cycle resembles a conventional Rankine cycle with an efficiency of 31%.

The items in the steam cycle include:

1. Boilers.
2. Steam turbines.
3. Water treatment facilities.
4. Condensers.
5. Heat exchangers.
6. Water storage vessels.
7. Controls and instrumentation.
8. Pipe and accessories.
9. Flue gas stack.

The low-BTU gas serving as the boiler fuel is taken from the product gas stream. This gas must be cleaned first because it contains water vapor, coal liquids, oxides of sulfur, and nitrogen compounds. Presently there is disagreement regarding equipment required and the subsequent cost for gas cleanup. To be conservative, extensive cleanup of the gas is planned. However, the British P-5 experiment with UCG demonstrated that boilers are operable using low-BTU gas cleaned only by a cyclone separator (29).

The first step in the gas cleanup involves a series of heat exchangers that are designed to cool the product gas, and to condense water vapor and coal liquids. The cooled gas is washed in a baffle-tray particulate scrubber to remove particulates. A tray type absorption tower then removes ammonia from the gas stream. Finally, the H_2S content in the gas stream is removed by a Selexol Process. This design for the gas cleanup system is also discussed in the literature (3). The gas leaving the Selexol Process is used to fire the boilers. The sulfur content of this gas is reduced sufficiently to meet all current state and federal SO_2 emission standards.

Site Needs

The site needs are grouped into three categories: buildings, heavy equipment, and major electrical equipment. Each of these items is discussed in detail in this section.

Three buildings are required for operation of the UCG plant. The first building provides:

1. Offices for professional staff.
2. Control room for process, compressors, drivers, and cleanup.
3. Labs for hydrology work, environmental studies, and gas analysis.
4. Electronics workshop.
5. Computer facilities.

The second building will house:

1. Offices for foremen.
2. Facilities for crews.
3. Supply room.
4. Shop.

The third building will house the compression equipment. The first and second buildings are each about 4800 sq. ft. in size. The size of the third building is case specific and its size depends upon the compression requirements.

The heavy equipment is required for well site preparation, earth work, pipe movement and reconstruction, transportation, and general or shop work. One truck-mounted hydraulic pulling rig is required for the hydrology work.

The earth work is necessary to prepare locations for drilling, roads, and pipe installation. The equipment needed to meet these demands includes:

1. A scraper.

2. A caterpillar D-9.
3. A ten-yard payloader.

The repeated movement of the pipe draws on the availability of the heavy equipment. Also, equipment is needed to move the large headers system and relay the wellhead piping. This requires:

1. Two 30-ton cherry pickers.
2. A two-ton truck.
3. Two medium-sized forklifts.
4. Caterpillar D-9 (same machine as above used in both capacities).
5. Two trailer-mounted arcwelders.

The transportation needs are met by five 3/4-ton pickup trucks. These are necessary for workers traveling to the location during the course of their jobs. They are also capable of moving tools and light equipment.

Shop equipment includes:

1. All tools and accessories.
2. Ten-inch metal lathe.
3. An arcwelder.

The major electrical equipment for the process is a computer system, three gas chromatographs (GC), and controls and instrumentation for the compression train and the process.

The computer facility is necessary for process monitoring and control. The monitoring of equipment and process operation are performed along with the metering of the gas flows. The operation of the gas chromatographs is also computer operated. A system similar to the HP-21 - MXE is chosen for the operation. The unit has 518 K of CPU memory. This is sufficient for storage and operation of all control and data reduction programs, as well as the recording of the operating data. Included in this design are all the accessories needed for this unit: memory boards, magnetic tape units for data backup, a multiplatter disc drive for data and program storage, CRT terminals, interface cards for process equipment, line printer for hard copies of operating data, a data plotter, and some purchased software. The real-time application

of this system has been demonstrated by LETC to provide instant process control and monitoring. This results in improved operation, accurate data acquisition and storage, and reduced demands on labor and administrative personnel. The UCG process requires constant monitoring especially during linking and burn completion.

The gas chromatographs used are HP-2640's. These machines analyze for the thirteen major components of the UCG dry product gas. The HP GC's are compatible with and can be calibrated and operated by the computer. Three GC's are required for the process operation. One samples the collected product gas only. The machine is programmed to inject the gas sample when ready, run the sample, store the analysis, and ready itself for another sample automatically. The time frame to run one sample should be about 30 minutes. Thus, the gas going to the consumer is analyzed every 30 minutes. The remaining two GC's are used to run samples from each of the operating modules and the gas cleanup system. Should the GC analyzing the gas to the consumer breakdown, one of the remaining units can be used for back-up until needed repairs are made.

Additional information about the site facilities is presented in Chapter V.

Personnel Requirements

The personnel needs are divided into four groups: professional staff, supervisory staff, skilled labor, and operators. The plant organizational structure is diagrammed on the following page and, for additional clarification, the job responsibilities are briefly discussed.

Professional Staff

The professional staff consists of five people. A brief list of titles and job descriptions is provided below:

1. Plant manager.
2. Field engineers (geological or petroleum engineer) -- Two field engineers are required for plant operation. These people oversee the drilling operations, and evaluate and direct well field expansion. This includes locating the position of wells to be drilled, well completion testing, evaluation of seam hydrology, analysis of the various coal samples, and directing the installation and movement of process piping. Additional responsibilities include anticipating operating problems caused by well completion or seam characteristics, and taking part in decisions regarding operating problems.

PLANT ORGANIZATION STRUCTURE

FIGURE 4.6

3. Controls engineer (electrical engineer) -- This person is responsible for maintenance of major electrical equipment and the hardware for the control and instrumentation. This person supervises two technicians.
4. Process engineer -- This person is responsible for the process operation, including performing calculations necessary to evaluate the process operation, and finding solutions to operating problems that occur.

Supervisory Personnel

The supervisory personnel consists of all the crew foremen:

1. Shift foreman -- Five men are required for 24 hours a day, seven days a week coverage. These people should be familiar with all the operator positions. They are responsible for overseeing process operations and should notify the process engineer immediately of problems in the operation or the equipment. The shift foreman supervises four operators.
2. Maintenance foreman -- This person is responsible for the prompt execution of equipment maintenance and servicing and supervises the maintenance crew.
3. Fabrication foreman -- This person is responsible for relaying of wellhead piping and header movement according to a set time schedule. This foreman supervises the fabrication crews.

Skilled Labor

The needs and responsibilities of the skilled labor are:

1. Secretary -- This person is responsible for all the secretarial needs of the professional staff including payroll, correspondence, and information distribution.
2. Welder -- Three men are required to prepare pipe for installation and to assist with moving surface piping.
3. Heavy equipment operator -- Three men are also needed here for site preparation and pipe movement.
4. Shift maintenance man -- Five men are required for full-time coverage of the operation. Duties are to begin immediate work on maintenance problems, notify the professional staff of problems requiring assistance, and to service process equipment.

5. Compressor service man -- This person is responsible for the compression train maintenance and servicing.
6. Mechanic -- The mechanic is responsible for the maintenance and service of the heavy equipment and vehicles.

Operators

1. Field technicians -- Three men are required to survey for well locations, do hydrology and completion testing, and perform coal analyses.
2. Electrical technicians -- Two men are required to assist the controls engineer in the wiring of control and instrumentation equipment for both the initial plant fabrication and for rewiring due to the repeated movement of wellhead piping.
3. Process operators -- Three men per shift are required, which is a total of 15 men for full-time coverage. One man is needed to perform the gas analysis, and two others to collect the samples, check on the process equipment, and monitor the operation.
4. Day technician -- This man assists the technicians and operators wherever needed.
5. Laborers -- Four men are required to assist wherever needed in the fabrication and maintenance groups.

Details on the cost of personnel are provided in Chapter V.

CHAPTER V

PRICING OF EQUIPMENT, FACILITIES AND LABOR

This chapter contains information pertaining to the cost of items required for the proposed UCG operation. The cost basis and range of the cost data for each individual item are presented along with the source of the cost data and the data itself. The individual items discussed in this chapter are:

1. Process wells.
2. Process piping and pipe related items.
3. Compression facilities including gas cleanup.
4. Site needs.
5. Personnel.
6. Coal royalties.
7. Contingencies.

Process Wells

Drilling and completion of wells is a major cost item in UCG. Included in the cost of a process well is:

1. Drilling.
2. Pipe for casing.
3. Well completion.

The costs are presented here and placed on a common basis. All well costs are reduced to a \$/ft. basis.

The cost to drill the wells and string the casing is obtained from a local drilling contractor. The costs represented by Figure 5.1 are based on actual drilling contracts in the Hanna basin.

Only standard sizes for the line pipe used as casing are considered. The costs for the drilling represent the standard size of the casing in the well. The costs in Figure 5.1 do not reflect the diameter of the hole drilled. For example, the cost of a well cased with line pipe of a 14-inch nominal size is \$21 00/ft. However, for a well to be cased with 14-inch pipe a 17.5-inch diameter hole is required.

FIGURE 5.1

DRILLING COSTS AS A FUNCTION OF WELL CASING INSIDE DIAMETER

* All costs presented in this paper are in 1978 dollars.

Table V - I
Specifications and Costs of the Line Pipe
for Casing Process Wells

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost \$/ft.
2	300	ST (40)	.154	3.653	1.53
	600	XS (80)	.218	5.022	2.10
	1000	160	.343	7.445	3.11
3	300	ST (40)	.216	7.58	3.05
	600	XS (80)	.300	10.25	4.12
	1000	160	.438	14.33	5.76
4	300	ST (40)	.237	10.79	4.16
	600	XS (80)	.337	14.99	5.78
	1000	120	.438	19.00	7.32
5	300	ST (40)	.258	14.62	5.40
	600	XS (80)	.375	20.78	7.67
	1000	160	.625	32.97	12.17
6	300	ST (40)	.280	18.98	6.38
	600	XS (80)	.432	28.58	9.61
	1000	160	.718	45.30	15.23
8	300	ST (40)	.322	28.56	9.13
	600	XS (80)	.500	43.4	13.87
	1000	140	.812	67.8	21.68
10	300	ST (40)	.365	40.5	12.84
	600	80	.593	64.3	20.38
	1000	140	1.000	104.1	32.99
12	300	ST (30)	.375	49.6	15.58
	600	80	.687	88.5	27.80
	1000	140	1.125	139.7	43.88
14	300	ST (30)	.375	54.6	17.00
	600	80	.750	106.1	33.03
	1000	140	1.250	170.2	52.98
16	300	ST (30)	.375	62.6	19.31
	600	80	.843	136.5	42.10
	1000	140	1.500	223.7	68.99
18	300	ST (20)	.375	70.6	21.58
	600	80	.937	170.8	52.20
	1000	140	1.562	274.3	83.83
20	300	XS (30)	.500	104.1	31.53
	600	80	1.031	208.9	63.25
	1000	140	1.750	341.1	103.29

Table V - II

Completion Cost for a Process Well

Cased with Eight-Inch Casing, to a Depth of 325 Feet.

Cement system:

Class G cement

2% CaCl_2

1/4-lb. of cellophane flakes (D-29)/sack of cement

System properties:

Slurry weight: 15.81 lb./gal.

Slurry yield: 1.14 ft.³/sack

Water mix: 4.97 gal./sack

Cement requirements:

For 325 ft. with 8-5/8" casing in a 12-1/4" diameter drilled hole.

Volume of annulus to be cemented: .4127 ft.³/linear ft.

Depth: 325 linear ft.

Cement required: 134 ft.³+ 50% excess: 67 ft.³Total: 201 ft.³201 ft.³

=

176 sacks of cement

1.14 ft.³/sack

Table V - II

(Continued)

Itemized Completion Costs

Item	Amount	Unit Cost	Total Cost
Class G Cement	176 sacks	\$ 4.35/sack	\$765.60
CaCl ₂	350 lbs.	.15/lb.	52.50
Cellophane Flakes	44 lbs.	.60/lb.	26.40
Cementer	1	525.00	525.00
Cementing Unit Mileage	150 mi.	1.25/mi.	187.50
Blending Charge	183 ft. ³	.60/ft. ³	109.80
Delivery Charge	1263 lb.	.41/lb.	517.83
8 5/8" Guide Shoe	1	124.00	124.00
8 5/8" Differential			
Float Collar	1	519.00	519.00
Thread Locks	2	14.00	28.00
8 5/8" Stop Ring	1	13.00	13.00
8 5/8" Centralizers	2	38.00	76.00
5 5/8" Wooden Plug	1	25.15	25.15

Total cost for the well completion = \$ 2969.78

Completion cost per foot = \$ 9.14

In this study, standard pipe sizes ranging from two inches to 20 inches are considered; however, optimization of the well diameter shows that the largest well casing required for this study is 14 inches.

The selection of the line pipe needed to case the process wells is based upon the design criteria presented in Chapter IV. Table V - I shows the calculated wall thicknesses required for well casing. The table also gives the specifications and costs of the casing selected for this study. The casing selection and casing costs are functions of both pipe diameter and seam depth.

The pipe costs are provided by pipe suppliers in the Rocky Mountain area. The costs are conservative because large orders of pipe are often obtained at a substantial discount whereas discounts are not considered here.

The individual item costs of completing a process well are listed in Table V - II. This table presents the completion costs for one specific case in the study. The case represented in Table V - II is for a seam depth of 300 ft., a seam thickness of 30 ft., and a nominal casing size of eight in. The method for calculating completion costs is similar for each of the cases considered in this study.

The completion cost data are provided by well service companies operating in the Rocky Mountain area. These data are conservative because the large number of wells completed annually should result in cost savings not considered in this analysis. Items such as the cementing unit mileage charge are greatly reduced if several wells are completed as one contract.

The completion costs are placed on a dollar-per-foot basis and plotted in Figure 5.2. The costs presented in this Figure are also dependent upon seam depth and casing size. The three curves shown on the graph are for each of the seam depths considered in this study.

The total cost for a process well is determined by summing the drilling cost, casing cost, and completion cost. The cost for these services is based on the assumption that they would be contracted.

Figure 5.3 presents the total cost of a process well for the various casing sizes considered. The costs presented in Figure 5.3 are on a dollar-per-foot basis for a cased and completed well. The three curves shown are for the three depths considered in this study.

FIGURE 5.2
COMPLETION COSTS VS. CASING SIZE AT SEAM DEPTHS OF: 300, 600, and 1000 FEET

FIGURE 5.3

TOTAL COST OF A CASED AND COMPLETED PROCESS WELL VS. CASING SIZE FOR THE THREE SEAM DEPTHS CONSIDERED

Process Piping and Pipe Related Items

This section provides the cost information for the process piping discussed in Chapter IV. The individual items dealt with in this section are:

1. Pipe.
2. Flanges.
3. Blind flanges.
4. Orifice flanges.
5. Pipe elbows.
6. Pipe tees.
7. Pipe crosses.
8. Valves.
9. Control valves and related items.
10. Orifice plates.
11. Blank plates.
12. Flange bolts and nuts.

The line pipe cost data are provided by two local pipe distributors. The design criteria presented in Chapter IV are used to select the pipe schedules required. Tables V - III, V - IV, and V - V present the specifications and costs for the pipe selected. Pipe cost is a function of pipe diameter, seam depth, and the specific use of the pipe. The four specific uses of the pipe are discussed in Chapter IV. Pipe is used for the low and high-pressure air distribution systems, the gas collection system, and on the wellheads. Table V - III contains information pertaining to pipe used on the product gas collection system; Table V - IV presents information pertaining to the pipe selected for the low-pressure air distribution system; and Table V - V contains information pertaining to pipe used on the high-pressure air distribution system. Specifications of the pipe used on the wellhead systems are identical to the specifications of the pipe used to case the process wells. Thus, information pertaining to pipe for the wellhead systems is contained in Table V - I.

Table V - III
Specifications and Costs of the Pipe Considered
for the Product Gas Collection System.

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost (\$/ft)
2	300	ST	.154	3.653	1.53
	600	ST	.154	3.653	1.53
	1000	ST	.154	3.653	1.53
3	300	ST	.216	7.58	3.05
	600	ST	.216	7.58	3.05
	1000	ST	.216	7.58	3.05
4	300	ST	.237	10.79	4.16
	600	ST	.237	10.79	4.16
	1000	ST	.237	10.79	4.16
5	300	ST	.258	14.62	5.40
	600	ST	.258	14.62	5.40
	1000	ST	.258	14.62	5.40
6	300	ST	.280	18.98	6.38
	600	ST	.280	18.98	6.38
	1000	ST	.280	18.98	6.38
8	300	ST	.322	28.56	9.13
	600	ST	.322	28.56	9.13
	1000	ST	.322	28.56	9.13
10	300	ST	.365	40.5	12.84
	600	ST	.365	40.5	12.84
	1000	ST	.365	40.5	12.84
12	300	ST	.375	49.6	15.58
	600	ST	.375	49.6	15.58
	1000	ST	.375	49.6	15.58
14	300	ST	.375	54.6	17.00
	600	ST	.375	54.6	17.00
	1000	ST	.375	54.6	17.00
16	300	ST	.375	62.6	19.31
	600	ST	.375	62.6	19.31
	1000	ST	.375	62.6	19.31
18	300	ST	.375	70.6	21.58
	600	ST	.375	70.6	21.58
	1000	30	.438	82.2	25.12
20	300	ST	.375	78.6	23.80
	600	ST	.375	78.6	23.80
	1000	XS	.500	104.1	31.53

Table V - III

(Continued)

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost (\$/ft)
22	300	ST	.375	86.6	25.98
	600	ST	.375	86.6	25.98
	1000	XS	.500	114.8	34.44
24	300	ST	.375	94.6	28.11
	600	ST	.375	94.6	28.11
	1000	30	.562	140.7	41.82
20	300	ST	.375	102.6	30.21
	600	ST	.375	102.6	30.21
	1000	*			
28	300	ST	.375	110.7	32.27
	600	ST	.375	110.7	32.27
	1000	*			
30	300	ST	.375	118.7	34.27
	600	XS	.500	157.6	45.50
	1000	*			
32	300	ST	.375	126.7	36.23
	600	XS	.500	168.2	48.09
	1000	*			
34	300	ST	.375	134.7	38.13
	600	XS	.500	178.9	50.65
	1000	*			
36	300	ST	.375	142.7	40.00
	600	XS	.500	189.6	53.14
	1000	*			
42	300	ST	.375	166.7	45.31
	600	*			
	1000	*			
48	300	ST	.375	190.8	50.26
	600	*			
	1000	*			

*Pipe schedule required is not commercial stock.

Table V - IV
Specifications and Costs of the Pipe Considered
for the Low-Pressure Air Distribution System.

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost (\$/ft)
2	300	ST	.154	3.653	1.53
	600	ST	.154	3.653	1.53
	1000	ST	.154	3.653	1.53
3	300	ST	.216	7.58	3.05
	600	ST	.216	7.58	3.05
	1000	ST	.216	7.58	3.05
4	300	ST	.237	10.79	4.16
	600	ST	.237	10.79	4.16
	1000	ST	.237	10.79	4.16
5	300	ST	.258	14.62	5.40
	600	ST	.258	14.62	5.40
	1000	ST	.258	14.62	5.40
6	300	ST	.280	18.98	6.38
	600	ST	.280	18.98	6.38
	1000	ST	.280	18.98	6.38
8	300	ST	.322	28.56	9.13
	600	ST	.322	28.56	9.13
	1000	ST	.322	28.56	9.13
10	300	ST	.365	40.5	12.84
	600	ST	.365	40.5	12.84
	1000	ST	.365	40.5	12.84
12	300	ST	.375	49.6	15.58
	600	ST	.375	49.6	15.58
	1000	ST	.375	49.6	15.58
14	300	ST	.375	54.6	17.00
	600	ST	.375	54.6	17.00
	1000	ST	.375	54.6	17.00
16	300	ST	.375	62.6	19.31
	600	ST	.375	62.6	19.31
	1000	ST	.375	62.6	19.31
18	300	ST	.375	70.6	21.58
	600	ST	.375	70.6	21.58
	1000	ST	.375	70.6	21.58
20	300	ST	.375	78.6	23.80
	600	ST	.375	78.6	23.80
	1000	ST	.375	78.6	23.80

Table V - IV

(Continued)

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost (\$/ft)
22	300	ST	.375	86.6	25.98
	600	ST	.375	86.6	25.98
	1000	ST	.375	86.6	25.98
24	300	ST	.375	94.6	28.11
	600	ST	.375	94.6	28.11
	1000	ST	.375	94.6	28.11
26	300	ST	.375	102.6	30.21
	600	ST	.375	102.6	30.21
	1000	XS	.500	136.2	40.10
28	300	ST	.375	110.7	32.27
	600	ST	.375	110.7	32.27
	1000	XS	.500	146.9	42.84
30	300	ST	.375	118.7	34.27
	600	ST	.375	118.7	34.27
	1000	XS	.500	157.6	45.50
32	300	ST	.375	126.7	36.23
	600	ST	.375	126.7	36.23
	1000	XS	.500	168.2	48.09
34	300	ST	.375	134.7	38.13
	600	ST	.375	134.7	38.13
	1000	XS	.500	178.9	50.65
36	300	ST	.375	142.7	40.00
	600	ST	.375	142.7	40.00
	1000	XS	.500	189.6	53.14
42	300	ST	.375	166.7	45.31
	600	ST	.375	166.7	45.31
	1000	*			
48	300	ST	.375	190.8	50.26
	600	XS	.500	253.7	66.82
	1000	*			

*Pipe schedule required is not commercial stock.

Table V - V
 Specifications and Costs of the Pipe Considered
 for the High Pressure Air Distribution System.

Nominal Pipe Size (in.)	Seam Depth (ft.)	Pipe Schedule	Wall Thickness (in.)	Pipe Weight (lb/ft)	Pipe Cost (\$/ft)
2	300	ST	.154	3.653	1.53
	600	ST	.154	3.653	1.53
	1000	ST	.154	3.653	1.53
3	300	ST	.216	7.58	3.05
	600	ST	.216	7.58	3.05
	1000	ST	.216	7.58	3.05
4	300	ST	.237	10.79	4.16
	600	ST	.237	10.79	4.16
	1000	ST	.237	10.79	4.16
5	300	ST	.258	14.62	5.40
	600	ST	.258	14.62	5.40
	1000	ST	.258	14.62	5.40
6	300	ST	.280	18.98	6.38
	600	ST	.280	18.98	6.38
	1000	ST	.280	18.98	6.38
8	300	ST	.322	28.56	9.13
	600	ST	.322	28.56	9.13
	1000	XS	.500	43.4	13.87
10	300	ST	.365	40.5	12.84
	600	ST	.365	40.5	12.84
	1000	XS	.500	54.7	17.34

These three tables provide the ranges of the pipe sizes considered. Twenty-two nominal pipe sizes, ranging from 2" to 48", are considered for the gas gathering system and the low-pressure air distribution system; seven nominal sizes, ranging from 2" to 10", are considered for the high-pressure air distribution system; and twelve nominal sizes, ranging from 2" to 22", are considered for the wellhead piping.

The optimization technique used in determining the pipe diameters is discussed in Chapters III and IV. The resulting nominal pipe sizes selected vary greatly with each specific case. The size selected for the gas gathering system is strongly dependent on the seam depth and the optimum sizes selected vary from 20" to 48" for the different cases studied. The optimum sizes selected for the low pressure air distribution system vary from 18" to 36", while the optimum sizes selected for the high-pressure air injection system vary from 2" to 4". The sizes selected for the wellhead piping range from 4" to 14".

The cost data for the flanges are provided by the same pipe distributors providing the cost data for the pipe. Listed in the following pages are the cost data for the flanges. Included here are costs pertaining to the regular raised-face slip-on flanges, raised-face blind flanges, raised-face slip-on orifice flanges, and the stud bolts with nuts required for these flanges.

The design criteria required to determine the flange class are presented in Chapter IV. The determination of the amount of each item that is required is also discussed in Chapter IV. Again, as with the line pipe, the costs of these items are dependent upon the nominal size, the seam depth, and the specific use for each flange. (i.e., flanges used on wellheads are subject to more stress than flanges on the low-pressure air distribution system.) Table V - VI contains the flange classes selected. The selection of the flange classes is based on the operating pressures for each depth considered as well as the maximum temperatures presented in Table IV - I.

The cost data for 150, 300, and 600 # flanges are presented in Table V - VII. Cost data for the 150 and 300 # flanges range in size from 2" nominal to 48" nominal. The size range for the 600 # flanges is from 2" to 20". 600 # flanges are required only on the wellhead and high pressure air system, and the largest size needed is 20" nominal.

Table V - VIII presents information regarding flange bolts; the number of bolt holes per flange, the bolt dimensions, and bolt cost are provided in Table V - VIII. The cost data are provided by local bolt distributors for bolts meeting grade eight specifications.

Table V - VI

Flange Classes Selected for Use in This Study

Piping System	Seam Depth In Feet	ANSI Flange Class Required
High-Pressure	300	300 #
Air System	600	600 #
	1000	600 #
Low-Pressure	300	150 #
Air Distribution	600	300 #
System	1000	300 #
Product Gas	300	150 #
Collection System	600	300 #
	1000	300 #
Wellhead	300	300 #
Piping	600	600 #
	1000	600 #

The cost data for the elbows, tees, and crosses are provided by the same source as for the pipe and flange cost data. Again, the schedules selected for these items are dependent upon the particular use for each item, the seam depth for the case considered, and the size of the item. These items, as with the line pipe and flanges, are constructed of grade A106 carbon steel.

Table V - IX contains the cost data for the pipe elbows, tees, and crosses.

The valves in a UCG operation must be of special design. A straight-through full-bore valve is desirable to reduce particulate erosion and condensate build-up in the valve. A no-leak positive-seal is also required to insure the safety of personnel performing maintenance duties on the surface piping. Finally, special materials of construction are required for valve operation at high temperatures. Valves with these characteristics can be obtained from a number of manufacturers. The valve cost data are presented in Figure 5.4.

Control valves are butterfly valves with an actuator, control positioner, I/P transducer, and related items required for automatic control and computer interface. The electronic equipment required for automatic control and computer interfacing are presented in Table V - X, along with the cost of the respective items. The items tabulated are

Table V - VII

Cost Data for Flanges

(All Flanges Are Constructed of Carbon Steel Grade A106B)

Nominal Pipe Size (in.)	Unit Cost in \$ Per Flange								
	Regular Flange			Blind Flange			Orifice Flange		
ANSI Class	150#	300#	600#	150#	300#	600#	150#	300#	600#
2	8.32	11.70	14.63	8.52	12.55	14.30	54.18	56.39	57.35
3	11.57	15.80	20.93	11.90	17.94	22.17	64.22	66.85	67.99
4	14.63	24.05	37.38	15.99	24.77	40.11	82.74	86.13	107.57
5	19.50	39.00	111.80	22.04	46.87	116.35	95.41	99.32	148.09
6	23.40	39.72	111.80	24.83	46.87	116.35	108.07	112.50	188.60
8	35.10	64.81	149.50	41.73	70.20	184.60	158.95	165.46	277.34
10	67.60	120.25	334.75	87.10	140.40	273.65	276.68	278.64	394.42
12	102.70	165.75	432.25	113.10	187.85	354.90	307.84	320.45	553.71
14	139.75	307.45	510.25	182.00	295.75	544.70	438.66	456.62	713.00
16	162.50	334.75	588.25	202.15	349.05	734.50	506.14	526.87	872.00
18	204.10	361.40	666.25	234.00	455.00	884.00	581.52	605.33	1032.00
20	261.95	507.00	744.25	289.25	520.00	1165.45	681.14	709.03	1191.00
22	309.08	575.25		371.13	741.00		775.56	807.32	
24	356.20	643.50		455.00	962.00		869.98	905.61	
26	428.68	835.42		693.00	1208.00		976.87	1016.88	
28	501.17	1027.33		932.00	1455.00		1083.76	1128.14	
30	573.65	1219.25		1170.00	1701.00		1190.65	1239.41	
32	646.13	1411.17		1408.00	1947.00		1297.53	1450.67	
34	718.62	1603.08		1647.00	2194.00		1404.42	1689.94	
36	791.10	1795.00		1885.00	2440.00		1511.31	1860.20	
42	1008.55	2370.75		2000.00	3179.00		1831.98	2500.00	
48	1226.00	2946.50		3315.00	3918.00		2152.63	3132.79	

Table V - VIII

Cost Data for Stud Bolts

(All Bolts: Alloy Steel SAE Grade 8)

Nominal Flange Size (in.)	ANSI Class	Number of Bolt Holes per Flange	Stud Bolt Size		Unit Cost (\$ per bolt with nuts)
			Diameter (in.)	Length (in.)	
2	150	4	5/8	3 1/4	.42
	300	8	5/8	3 1/2	.43
	600	8	5/8	4 1/4	.46
3	150	4	5/8	3 3/4	.44
	300	8	3/4	4 1/4	.64
	600	8	3/4	5	.68
4	150	8	5/8	3 3/4	.44
	300	8	3/4	4 1/2	.65
	600	8	7/8	5 3/4	1.00
5	150	8	3/4	4	.63
	300	8	3/4	4 3/4	.67
	600	8	1	6 1/2	1.41
6	150	8	3/4	4	.63
	300	12	3/4	5	.68
	600	12	1	6 3/4	1.44
8	150	8	3/4	4 1/4	.64
	300	12	7/8	5 1/2	.98
	600	12	1 1/8	7 3/4	1.91
10	150	12	7/8	4 3/4	.92
	300	16	1	6 1/4	1.39
	600	16	1 1/4	8 1/2	2.49
12	150	12	7/8	4 3/4	.92
	300	16	1 1/8	6 3/4	1.80
	600	20	1 1/4	8 3/4	2.52
14	150	12	1	5 1/4	1.28
	300	20	1 1/8	7	1.82
	600	20	1 3/8	9 1/4	3.38
16	150	16	1	5 1/2	1.31
	300	20	1 1/4	7 1/2	2.35
	600	20	1 1/2	10	4.22
18	150	16	1 1/8	6	1.71
	300	24	1 1/4	7 3/4	2.39
	600	20	1 5/8	10 3/4	6.35

Table V - VIII

(Continued)

Nominal Flange Size (in.)	ANSI Class	Number of Bolt Holes per Flange	Stud Bolt Size Diameter (in.)	Length (in.)	Unit Cost (\$ per bolt with nuts)
20	150	20	1 1/8	6 1/4	1.74
	300	24	1 1/4	8 1/4	2.45
	600	24	1 5/8	11 1/2	6.52
22	150	20	1 1/4	6 1/2	2.23
	300	24	1 1/2	8 3/4	3.98
24	150	20	1 1/4	7	2.28
	300	24	1 1/2	9 1/4	4.07
26	150	24	1 1/4	8 3/8	2.46
	300	28	1 5/8	10	6.18
28	150	28	1 1/4	8 5/8	2.50
	300	28	1 5/8	10 1/2	6.29
30	150	28	1 1/4	8 7/8	2.53
	300	28	1 3/4	11 1/4	7.53
32	150	28	1 1/2	9 3/4	4.17
	300	28	1 7/8	12	9.15
34	150	32	1 1/2	9 7/8	4.20
	300	28	1 7/8	12 1/4	9.22
36	150	32	1 1/2	10 5/8	4.33
	300	32	2	12 3/4	10.64
42	150	36	2	12	10.38
	300	36	2	13 3/4	10.99
48	150	36	2	12	10.38
	300	40	2	13 3/4	10.99

Table V - IX

Cost Information for Pipe Elbows, Tees, and Crosses.

Nominal Pipe Size (in.)	Schedule	Unit Cost (\$)		
		Elbow	Tee	Cross
2	ST	3.12	10.73	40.95
	XS	4.36	12.03	50.95
	160	*	17.88	80.00
3	ST	5.53	14.82	58.18
	XS	8.32	19.83	77.35
	160	*	23.71	113.00
4	ST	8.97	20.22	75.60
	XS	14.11	32.50	97.57
	160	*	35.77	154.00
5	ST	16.06	31.98	116.45
	XS	28.60	46.41	163.51
	160	*	60.91	273.00
6	ST	25.29	36.66	157.30
	XS	37.96	51.29	229.45
	160	*	75.85	382.00
8	ST	40.11	68.12	252.20
	XS	69.55	104.91	353.00
	160	*	151.38	636.00
10	ST	78.46	110.63	436.80
	XS	126.75	163.15	560.00
	160	*	279.09	1246.00
12	ST	117.65	157.95	569.40
	XS	174.85	232.05	713.00
	160	*	444.00	1872.00
14	ST	198.25	302.90	775.00
	XS	266.50	469.95	987.00
	160	*	898.00	2774.00
16	ST	276.90	362.05	1012.00
	XS	365.30	557.70	1285.00
	160	*	1066.00	4094.00
18	ST	369.85	601.90	1281.00
	XS	441.35	763.75	1623.00
	160	*	1462.00	5780.00
20	ST	476.45	915.85	1582.00
	XS	599.95	1196.00	1989.00
	160	*	2289.00	7898.00

Table V - IX

(Continued)

Nominal Pipe Size (in.)	Schedule	Unit Cost (\$)		
		Elbow	Tee	Cross
22	ST	*	1064.70	1914.00
	XS	*	1305.00	2374.00
24	ST	*	1213.55	2273.00
	XT	*	1696.00	2848.00
26	ST	*	1541.00	2668.00
	XS	*	2038.00	3305.00
28	ST	*	1922.00	3094.00
	XS	*	2484.00	3698.00
30	ST	*	2361.00	3552.00
	XS	*	2986.00	4380.00
32	ST	*	2863.00	4041.00
	XS	*	3548.00	4985.00
34	ST	*	3430.00	4562.00
	XS	*	4171.00	5619.00
36	ST	*	4068.00	5114.00
	XS	*	4859.00	6280.00
42	ST	*	6442.00	6198.00
	XS	*	7333.00	7624.00
48	ST	*	9595.00	7139.00
	XS	*	10473.00	9017.00

*Not required in analysis.

FIGURE 5.4
VALVE COST AS A FUNCTION OF NOMINAL SIZE

Table V - X
Electronic Equipment Necessary
for Control Valve Use.

Item	Amount Required Per '5' Control Valves in Use	Unit Cost Per Item (\$)	Total Cost Per '5' Control Valves in Use
Computer Set Point			
Stations	5	335.20	\$1676.00
Power Supply	1	410.40	410.40
Backup Power Supply	0.333	445.60	148.53
Instrument Case	1	1029.60	1029.60
Transfer Station	1	493.60	493.20
Controller	5	869.60	4348.00
Total cost for all items/5 valves in use			= \$8105.73
Additional cost per individual control valve			= \$1621.15

required for every five control valves in use. The individual costs for each of these items are provided as well as the additional cost per control valve resulting from the inclusion of these items.

Table V - XI presents the cost of the various control valves considered. Also tabulated are the total costs of these control valves including the electronic controls. These data are provided by the manufacturer. In a UCG operation of this type, many control valves are required and the purchase of a large quantity of control valves may result in a discount from the costs in this table.

Figure 5.5 presents the cost data for the orifice plates and blank plates. Two curves are presented in this figure. The upper curve is the orificete plate cost data, while the lower curve pertains to the cost of blank plates.

Compression Facility

This section provides information regarding the cost of the compression facility required for the proposed UCG operation. Discussion provided in this section includes:

1. Compressor costs.
2. Steam boiler costs.
3. Steam turbine costs.
4. Gas cleanup costs.
5. Cost of needed accessories and the building to house the compression train.

The costs presented in this section are reduced to a dollar per installed-horsepower-of-compression basis.

The compressor costs are provided by a major compressor manufacturer. Discussion of the compressor sizing and selection are included in Chapters III and IV. Table V - XII presents the compressor costs as well as the mechanical efficiency for each type of compressor needed.

Air compression requires 12,000 to nearly 100,000 horsepower which falls into the range of constant unit cost. The cost of the reciprocation compressor presented in this table applies to the 400-horsepower range.

Table V - XI
Total Cost for Control Valves
and Related Items.

Nominal Control Valve Size (in.)	Unit Cost of Valve with Actuator, Positioner, and I/P Transducer (\$)	Total Cost of Valve and Electronic Equipment Required (\$)
2	852.77	2474.
3	860.29	2482.
4	958.05	2580.
5	1010.69	2632.
6	1052.05	2673.
8	1138.56	2760.
10	1221.25	2843.
12	1334.05	2955.
14	1548.37	3170.
16	1740.13	3361.
18	2176.29	3797.
20	2608.69	4230.

FIGURE 5.5

COST DATA FOR ORIFICE PLATES AND BLANK PLATES AS A FUNCTION OF NOMINAL SIZE

Table V - XII

Compressor Costs

Type	Mechanical Efficiency	Unit Cost (\$/hp)
Axial-Flow	85%	120
Reciprocating	95%	120

The costs of the boilers are provided by a national boiler manufacturer. The steam turbine costs are also provided by a national manufacturer. The cost of accessories for these items as well as the cost of the gas-cleanup equipment is obtained from the literature. (3, 33) A detailed listing of the cost of these items and the source of the cost data are presented in Table V - XIII. Brief descriptions of this equipment are also presented in Chapter IV.

Site Needs

The costs of the items classed as site facilities are determined from purchases for similar items made by the Laramie Energy Technology Center. The time of purchase of each item is accounted for by the addition of an 8% annual inflation rate over the last three years. The total cost for these items contains 10% contingency.

The cost information discussed in this section pertains to:

1. Buildings.
2. Heavy equipment.
3. Shop equipment.
4. Major electronic equipment.

Individual costs for these items are presented in Table V - XIV and discussions of these items are presented in Chapter IV.

Personnel

This section provides information regarding the cost of the personnel required for the proposed UCG operation. The personnel wages and salaries are determined from current levels in the Rocky Mountain area for jobs of equivalent status. The plant personnel are divided into two categories: salaried personnel and hourly wage earners. The salaried personnel include the professional staff; i.e. the plant manager, engineers.

Table V - XIII

Cost of Items in the Compressor Train

Item	Source of Cost Data	Cost in \$ per Installed Compression HP.
A. Steam cycle		
1. Steam boilers	*	100.00
2. Steam turbines	*	36.02
3. Heat exchangers	Ref. #33	2.75
4. Tanks, vessels, and drums	Ref. #33	1.12
5. Water treatment	Ref. #33	1.79
6. Condensor and auxiliaries	Ref. #33	3.13
7. Stack requirements	Ref. #33	7.22
B. Gas cleanup (see Chapter IV)	Ref. # 3	68.60
C. Structural needs for equipment housing		
1. Concrete	Ref. #33	16.67
2. Miscellaneous iron and steel	Ref. #33	17.64
3. Earthwork	Ref. #33	17.64
4. Heating, ventilating, and air conditioning	Ref. #33	1.27
5. Piping	Ref. #33	33.19
6. Controls and instrumenta- tion for compression train, steam cycle, and gas cleanup	Ref. #33	8.26
D. Related costs		
1. Architecture and finish	Ref. #33	8.86
2. Engineering and home office fees	Ref. #33	37.06
3. Other owners costs 7% of total	Ref. #33	20.48
Total cost for these items in \$ per installed compression Hp.		382

*Data provided by the manufacturer.

Table V - XIV
Cost of Site Needs

Item	Unit Cost	Amount Required	Total Cost
<hr/>			
A. Buildings	\$38.60/sq. ft.		
1. Shops, supply room, and storage space		2500 sq. ft.	\$ 96,500
2. Offices, computer, labora- tory, and control room		2500 sq. ft.	96,500
3. Compression train, steam cycle, gas cleanup, and controls		12,000 sq. ft.	Included in the cost for the compression facility
Building Total Cost			<u>\$193,000</u>
B. Heavy Equipment			
1. 30-ton cherry picker	\$100,000	2	\$200,000
2. Pulling rig	15,000	1	15,000
3. Medium-size forklift	20,000	2	40,000
4. Scraper	80,000	1	80,000
5. D-9, Caterpillar	300,000	1	300,000
6. Ten-yard payloader	220,000	1	220,000
7. Two-ton truck	10,000	1	10,000
8. 3/4-ton pickup truck	6,000	5	30,000
Heavy Equipment Total Cost			<u>\$895,000</u>

Table V - XIV
(Continued)

Item	Unit Cost	Amount Required	Total Cost
C. Shop Equipment			
1. Trailer-mounted arc-welder	\$5,000	2	\$ 10,000
2. Stationary arc-welder	3,500	1	3,500
3. Tools (lathe, wrenches, etc.)			150,000
Shop Equipment Total Cost			<u>\$163,500</u>
D. Major Electronic Equipment			
1. 518K Memory of CPU system and accessories			\$150,000
2. Gas Chromatograph	\$15,000	3	45,000
Major Electronic Equipment Total Cost			<u>\$195,000</u>
Total Cost of Site Needs		\$1,446,500	
Total Cost of Site Needs + 10% Contingency =		\$1,591,150	

Table V - XV
Personnel Costs

Job Title	Hours Worked per Week		Base Pay Schedule (overtime not included)		
	Base	Overtime	(\$/hour)	(\$/month)	(\$/year)
A. Professional Staff					
1. Plant Supervisor		*	*	3333.	40000.
2. Engineer		*	*	2500.	30000.
3. Geologist		*	*	2500.	30000.
B. Supervisory Staff					
1. Shift Foreman	40	4	8.00	1387.	16640.
2. Maintenance Foreman	40	4	10.00	1733.	20800.
3. Fabrication Foreman	40	4	10.00	1733.	20800.
C. Labor Staff					
1. Secretary	40	4	4.50	780.	9360.
2. Welder	40	4	9.75	1690.	20280.
3. Heavy Equipment Operator	40	4	9.50	1646.	19760.
4. Mechanic	40	4	9.00	1560.	18720.
5. Maintenance	40	4	8.00	1387.	16640.
6. Technician	40	4	7.00	1213.	14560.
7. Unskilled Labor	40	4	6.00	1040.	12480.

*Salaried personnel, no credit for overtime.

and the geologist. The hourly wage earners include the foremen, skilled laborers, technicians, and unskilled laborers. Included in labor costs is four hours average per week, overtime for each wage earner. The wage rate for this overtime is one and one-half times the regular wage rate. In addition, a 50% overhead on salaries and wages is assumed for all plant personnel. The overhead is to pay for business expenses resulting from the employee payroll and to pay for employee benefits provided by the company.

Table V - XV provides information regarding the salaries and wage rates used in this study. The wages and salaries presented in this table do not include the overhead factor previously mentioned.

Coal Royalties

The coal royalty charge for recovering coal by UCG is difficult to determine. Presently, no legal statutes deal with underground coal gasification and no basis for the charge of coal royalties exists for this process.

A royalty payment of \$.10/MMBTU of energy recovered is used in this study. This basis is selected to be equitable compared to the charge of royalties for both coal mining and natural gas production.

Royalties for coal mining are currently paid on the tons of coal recovered. These royalties are not based upon the amount of coal in place nor are additional royalties charged for the coal not recovered. The payment of natural gas royalties is similar in that royalties are based upon natural gas produced. Currently \$.10/MMBTU's recovered is the average royalty paid for natural gas production. This is also comparable to taxes for coal production in the state of Montana.

Contingencies

In general, there are two types of contingency factors commonly used in economic analyses. The first type, the project contingency, is intended to cover additional equipment cost over-runs that may result from a more detailed design of a specific project at a known site. The second type of contingency, the process contingency, is a capital cost contingency applied to unproven technology to reduce the economic impact of the uncertainty in the design and cost of the commercial scale process.

Individual project contingency factors are desirable for each major cost item of the process. In this study, the project contingency factors are not obvious. The factors appear as excess equipment purchases, conservative design assumption, overhead, or contingency factors. For clarification, consider the surface piping system: the first contingency

factor incorporated into the assessment of the surface piping needs is the purchase of all piping items with 10% excess. The excess purchase is a contingency factor to insure that the assumed life of this equipment does not significantly affect the economics if the assumption is in error. The second factor is the neglect of discounts in the price of equipment that normally result from the large quantities of the required purchases. This proves to be a safeguard against unforeseen escalation in the equipment costs. Also, the duplication of the surface piping systems behaves as a contingency by allowing ample time for plant operators to perform the tasks required for relaying the gasification.

Similarly, the compressors are designed to operate at 90% of maximum capacity and the cost of site facilities are calculated using a 10% contingency factor. The contingency factors included in the drilling costs are not as obvious. The major contingency factor in the drilling assessment is the conservative module development schedule. This schedule provides the plant with the capability to increase gas production if necessary. Also, the sensitivity variables utilized in the study behave as contingency factors for the efficiency of the gasification process. In summary, project contingencies are considered for each major equipment section of the plant.

The process contingency is used because UCG currently is not a commercially proven process in the free world. A 20% process contingency is used in the calculation of the total capital cost of the UCG facility. The actual amount of contingency in each case is calculated to be equal to 20% of the cost of the installed capital. The installed capital cost is considered to be the sum of the start-up drilling cost, the cost of the compression facility, the cost of pipe and pipe related items, the cost of buildings and related facilities, and the salaries paid to plant personnel during the construction period of two years. The contingency is then added to the installed capital cost to obtain the total capital cost. These moneys are assumed to be initially spent and, therefore, the contingency is also depreciated over the plant life. In an actual venture these moneys would most likely be held in a liquid savings account until a need for additional funds developed. The assumption that the contingency is spent immediately must be made to avoid any assumptions regarding the spending schedule and earning potential of this money.

CHAPTER VI

ECONOMIC METHOD

After equipment and personnel requirements have been determined, the economic evaluation of the process can be completed. Utility financing is the basis chosen for this work. The economic parameters used are those recommended by the Electric Power Research Institute (EPRI) and are listed in Table VI - I.

Table VI - I
Economic Parameters for Utility Financing

(All cost data are in 1978 dollars)

Plant load factor	= 90%
Depreciation	= Straight-line over plant life
Debt to equity ratio	= 50/50
Bond interest rate	= 9% annually*
Bond life	= 25 years
Plant life	= 25 years
Tax life	= 25 years
Return on equity after taxes	= 12% annually
Income tax	= 52%**
Paid-up royalties	= 0***
Salvage value	= 0
Construction period	= 2 years****
Process Contingency	= 20% of capital cost

* This value is higher than EPRI's recommended value, but is more consistent with current rates.

** This is considered to be 48% federal and 4% state and local.

*** Applies to federal coal leases. Paid up royalties on private leases are set by negotiation.

**** This value is chosen on the basis of LETC's operational experience.

Investment and Annual Expenses

Both capital investment and the annual operating expenses must be determined. For this analysis the capital investment is the sum of the following items:

1. The initial drilling cost for the start-up wells.
2. Compressors, drivers, and gas cleanup facilities.
3. Pipe, pipe accessories, valves, and metering and control equipment.
4. Buildings and related facilities.
5. Salaries paid to plant personnel during the construction period of two years.
6. The process contingency.

Next, the annual operating costs are calculated as the sum of all the yearly expense items due to plant operation. The annual operating expenses are:

1. The cost of drilling new process wells as the UCG project proceeds.
2. The cost of additional pipe and accessories.
3. Personnel salaries.
4. Coal royalties.
5. The cost of plant maintenance (2.5% of capital items 2 and 4).
6. Property taxes and insurance (2.5% of capital items 2, 3, and 4).
7. Depreciation.*

$$\text{*Annual depreciation} = \frac{\text{Capital Investment} - \text{Salvage Value}}{\text{Tax Life}}$$

The total investment is the sum of the capital investment and the working capital. For this analysis, the working capital is considered to be the equivalent of one month's operating expenses. This amount for the working capital is suggested by Peters and Timmerhaus in Plant Design and Economics for Chemical Engineers. (30)

Loan payments on capital debt are calculated on the annual 9% bond interest rate. The total loan is distributed over the two year construction period as 40% of the debt borrowed during the first year of construction and 60% the second year. This distribution is based on the construction schedule for plant fabrication (see Appendix F). The calculation of the total annual loan payment is performed using equations 6.1 through 6.7.

For the first year of construction:

$$A_{L1} = .40 A_{CI} D_I \quad (6.1)$$

Where A_{L1} = Amount borrowed during the first year of plant construction.

A_{CI} = Capital investment. (Including process contingency.)

D_I = The percentage of the capital investment that is debt.

$$T_{L1} = T_P + 2 \quad (6.2)$$

Where: T_{L1} = The life of the first year's loan.

T_P = Plant life.

$$C_{L1} = A_{L1} I_B (1+I_B)^{T_{L1}} / [(1+I_B)^{T_{L1}} - 1] \quad (6.3)$$

Where: C_{L1} = The annual payment on the money borrowed for the first year.

I_B = The annual bond interest rate.

For the second year of construction:

$$A_{L2} = .60 A_{CI} D_I \quad (6.4)$$

Where: A_{L2} = The amount borrowed during the second year of plant construction.

$$T_{L2} = T_P + 1 \quad (6.5)$$

Where: T_{L2} = The life of the second year's loan.

$$C_{L2} = A_{L2} I_B (1+I_B)^{T_{L2}} / [(1+I_B)^{T_{L2}} - 1] \quad (6.6)$$

Where: C_{L2} = The annual payment on the money borrowed for the second year.

The total annual loan payment is:

$$C_{TL} = C_{L1} + C_{L2} \quad (6.7)$$

Where: C_{TL} = The total annual payment on the money borrowed.

The equity is also distributed over the two-year construction period as 40% of the total equity allocated the first year and the remaining 60% the second year. Equations (6.8) and (6.9) are used to calculate the equity in the first and second years of construction.

$$E_1 = .40 A_{CI} E_I \quad (6.8)$$

Where: E_1 = The equity in the plant at the end of the first year of plant construction.

E_I = The percent of the capital investment that is equity.

$$E_2 = .60 A_{CI} E_I \quad (6.9)$$

The required annual cash flow is calculated from the total annual expenses, the equity, and the rate of return on equity. The total annual expenses are:

$$A_{TA} = A_{OP} + C_{TL} \quad (6.10)$$

Where: A_{TA} = The total annual expenses.

A_{OP} = The annual operating cost.

Cash Flow Calculation

The first step in calculating the required annual cash flow is the determination of the present worth of the money required to construct the UCG plant and start up the plant. The present worth is calculated at the time of plant start up.

Also, all cost payments and expenses are assumed to occur at the end of each year.

The present worth of the money required for the first year of calculations is:

$$P_1 = (E_1 + C_{L1} + A_{WC}) (1 + I_E) \quad (6.11)$$

Where: P_1 = The present worth of the money required for the first year of construction.

A_{WC} = The working capital.

I_E = The rate of return on equity.

For the second year of construction:

$$P_2 = (E_2 + C_{L2} + C_{L1}) \quad (6.12)$$

Where: P_2 = The present worth of the money required for the second year of construction.

For the working capital:

$$P_{WC} = (A_{WC} + S) / (1 + I_E)^{T_P} \quad (6.13)$$

Where: P_{WC} = The present worth of the working capital.

S = The salvage value.

The present worth factor for the cash flow is calculated next:

$$F_{PW} = [(1 + I_E)^{T_P} - 1] / [I_E (1 + I_E)^{T_P}] \quad (6.14)$$

Where: F_{PW} = The present worth factor used in the cash flow calculation.

The required annual cash flow is now calculated using equation (6.15).

$$A_{CF} = (P_1 + P_2 - P_{WC}) / F_{PW} \quad (6.15)$$

Where: A_{CF} = The required annual cash flow in dollars at the time of plant start up.

Net Profit and Gross Earnings

The next step in the calculation of the required dirty-gas selling price is the calculation of the required annual net profit. The net profit is defined by equation (6.16).

$$A_{NP} = A_{CF} - A_D \quad (6.16)$$

Where: A_{NP} = The annual net profit after taxes.

A_D = The annual depreciation.

The net profit required is the money owed to the investors as return on the equity. The total annual revenues, or gross earnings, must be sufficient to produce the required net profit and also pay the total annual expenses and income tax. The gross earnings are calculated using equation (6.17).

$$A_{GE} = A_{NP}/(1-I_T) + A_{TA} \quad (6.17)$$

Where: A_{GE} = The annual gross earnings.

I_T = The income tax rate.

Dirty Gas Selling Price

In the proposed UCG operation, the dirty gas is considered as the only source of plant revenue. Thus, the required dirty-gas selling price is readily calculated from the cumulative annual dirty-gas production rate and the gross earnings. The desired dirty-gas selling price is placed upon a dollars-per-million-BTU basis. Equation (6.18) is used to calculate the millions of BTU's of gas produced annually and equation (6.19) is used to determine the required dirty-gas selling price.

$$Q_{DA} = (24)(365)\eta_P Q_d / 10^6 \quad (6.18)$$

Where: Q_{DA} = The total energy delivered to the consumer annually in the millions of BTUs.

$$C_{SP} = A_{GE}/Q_{DA} \quad (6.19)$$

Where: C_{SP} = The dirty-gas selling price in \$/10⁶ BTU.

The procedure presented in this chapter is the economic method for the calculation of the required dirty-gas selling price. Clarification regarding the use of this economic method may be found in the following chapter where the base case is discussed.

Summary

Chapters III, IV, V, and VI have described in detail the respective methods of analysis of:

1. The process dynamics.
2. The equipment design.
3. The pricing of equipment, facilities, services, and labor.
4. The economic method.

These descriptions are intentionally lengthy. The author's intent is to provide insight into the current state of knowledge regarding UCG operation and into the intricacies involved in a commercial plant design. The resulting economic data are presented in the following chapter, and these data show UCG's potential for commercialization.

CHAPTER VII

RESULTS AND CONCLUSIONS

This chapter presents the results of the economic analysis described in Chapters III, IV, V, and VI. Detailed results for a base case are presented as well as the sensitivity of the base case to changes in operational data. Results for both equity and utility financing are presented. A comparison is made from these results to other economic analyses. In addition, conclusions drawn from the data are discussed.

Base Case

A single case is selected and discussed in depth. This base case is selected to be a conservative representation of current UCG technology, that is, values selected for the chosen sensitivity variables are intended to be pessimistic in comparison with actual Hanna field test results. Values of the sensitivity variables for the base case are given in Table VII - I.

Table VII - I

Sensitivity Variables Selected
for Base Case

Seam Depth	= 600 ft.
Seam Thickness	= 30 ft.
Well Spacing	= 100 ft.
Product Gas HHV	= 125 BTU/scf
VCSE	= 65%
Leakage Rate	= 10%

The coal seam selected for the base case is representative of a number of coal seams in the Western United States that are currently not economically recoverable with conventional mining techniques. The 100-foot value selected for the well spacing is a reasonable extension of current technology. As mentioned, the product gas heating value, the VCSE, and the leakage rate are conservative values based on the results of the Hanna experiments.

The results for the base case are presented in Tables VII - II through VII - VIII. Table VII - II presents the process dynamics for the base case. Of particular interest are the favorable energy return ratio, the small ground-area affected, the compressor requirements for high-pressure air as compared to the low-pressure air requirements, and the pipe sizes resulting from the economic optimization.

Information concerning the total investment and total annual expenses is presented in Tables VII - III and VII - IV, respectively. The breakdowns presented in the tables identify the air compression as the major single investment item for this case, and several items (1, 2, 3, 5, and 6) as important contributors in the total annual expenses for the base case.

The calculation of the required dirty-gas selling price is described in Chapter VI. This calculation for the base case is presented in Table VII - V. The calculation is performed using the capital investment, working capital, the total annual operating costs (Tables VII - III and VII -IV), and the economic bases discussed in Chapter VI.

Table VII - V shows the required dirty-gas selling price is \$1.42/MMBTU. This analysis indicates the price for the produced gas is potentially competitive with the current cost of natural gas. The literature (3) indicates a cost of approximately \$.25/MMBTU to clean the product gas; and with the addition of this cost, the economics are still favorable. However, it must be pointed out that the low-BTU gas produced by UCG is expensive to transport. Thus, the use of such gas requires a near-site market or near-site usage. Also, the potential cost of environmental protection and restoration is not addressed in this study. These facts must be considered in any final economic analysis when environmental data are available and plant location and market for the gas are known.

Also of interest, is the contribution of individual cost items to the resulting gas selling price for the base case. This information is presented in Table VII - VI in terms of both total cost and percentage cost. This cost breakdown is also illustrated in Figure 7.1.

The gas price breakdowns presented in both Table VII - VI and Figure 7.1 identify the air compression cost as the major contributor to the gas price in the base case. Several annual cost items (1, 2, and 3) also represent significant portions of the dirty-gas selling price.

Table VII - VII presents a comparison of gas selling prices resulting from the use of two different economic bases. The two bases considered are:

1. The utility finance basis selected for this analysis and discussed in Chapter VI.
2. The equity finance basis.

The two bases result in a very different gas price. Utility financing is favorable in that a low gas selling price results. On the other hand, equity financing is expensive and results in high gas prices. Table VII - VII illustrates this fact. The equity finance basis results in a gas selling price that is 41% higher than the utility basis. However, the gas price of \$2.00/MMBTU is also potentially competitive with natural gas prices on a BTU basis.

Table VII - II

Process Dynamics for the Base Case

Plant Characteristics:

Total Energy Production Rate	= 1.14×10^9 BTU/hr.
Plant Energy Consumption Rate	= 2.4×10^8 BTU/hr.
Energy Return Ratio	= 4.8
Total Area Gasified During Plant Life (25 years)	= .834 sq. mi.

Module Characteristics:

Module Consumption Rate	= .283 mod./day
Number of Operating Modules	= 25
Life of One Module	= 87 days
Maximum Air Injection Rate	= 7500 scf/min.
Average Air Injection Rate	= 4363 scf/min.

Compression:

Low Pressure Air:

Horsepower Required	= 28,175
Horsepower Purchased	= 31,905
Number of Compression Stages	= 3
Discharge Pressure	= 223.32 psia
Air Capacity at 90% Load	= 110078 scf/min.

High Pressure Air:

Horsepower Required	= 99
Horsepower Purchased	= 110
Number of Compression Stages	= 1
Discharge Pressure	= 754.10 psia
Air Capacity at 90% Load	= 1003 scf/min.

Drilling:

Nominal Well Size	= 5 in.
Drilling Cost	= \$23.74/ft. cased and completed
Casing Depth	= 625 ft.
Wells Required for Start Up	= 125
Wells Required Annually	= 93

Nominal Pipe Sizes Selected for the Surface Piping:

Linkage Line	= 2 in.
Injection Line	= 30 in.
Production Line	= 34 in.

Table VII - III

Breakdown of Total Investment for the Base Case

<u>Expense Item</u>	<u>% of Total Investment</u>
1. <u>Drilling</u> Unit Cost = \$23.74/ft. 125 Wells Required for Start up Drilling Cost = \$1.87 MM	5.98%
2. <u>Air Compression</u> Low-Pressure Air Unit Cost = \$502/hp 31905 hp Required for Operation High-Pressure Air Unit Cost = \$502/hp 110 hp Required for Operation Compression Cost = \$16.07 MM	51.45%
3. <u>Piping and Accessories</u> Pipe Cost = \$.70 MM Piping Accessories = \$.82 MM Flow, Control and Metering = \$.67 MM Valves = \$1.00 MM Total Pipe Cost = \$3.18 MM	10.18%
4. <u>Site Facilities</u> Heavy Equipment = \$1.16 MM Computer and Electrical Equipment = \$.22 MM Buildings = \$.21 MM Total Site Costs = \$1.59 MM	5.09%
5. <u>Working Capital</u> = \$.51 MM	1.63%
6. <u>Salaries During Construction</u> = \$2.90 MM	9.28%
7. <u>Contingency</u> = \$5.12 MM	16.40%

Investment Requirements

Total Investment = \$31.24 MM

Capital Investment = \$30.73 MM

Working Capital = \$.51 MM

Table VII - IV
Breakdown of the Total Annual
Expenses for the Base Case

	<u>Expense Item</u>	<u>% of Total Annual Cost</u>
1.	<u>Drilling</u> Unit Cost = \$23.74/ft. 93 wells/yr. Required Drilling Cost = \$1.39 MM	18.20%
2.	<u>Coal</u> Unit Cost = \$.10 MM BTU Recovered 8960562 MM BTU/yr. Recovered Coal Cost = \$.90 MM	11.73%
3.	<u>Salaries</u> = \$1.45 MM	18.97%
4.	<u>Pipe</u> = \$.17 MM	2.22%
5.	<u>Depreciation</u> = \$1.23 MM	16.09%
6.	<u>Loan Payment</u> = \$1.54 MM	20.18%
7.	<u>Maintenance Costs</u> = \$.44 MM	5.78%
8.	<u>Property Taxes and Insurance</u> = \$.52 MM	6.28%

Total Annual Operating Expenses = \$6.10 MM

Loan Payment = \$1.54 MM

Total Annual Expenditure = \$7.64 MM

Table VII - V

Calculation of the Gas Selling Price for the Base Case

<u>Item</u>	<u>Equation</u>	<u>Item's Value for the Base Case</u>
First year's loan (A_{L1})	$A_{L1} = .40 A_{CI} D_I$ (EQN 6.1)	\$6.15 MM
Life of first year's loan (T_{L1})	$T_{L1} = T_P + 2$ (EQN 6.2)	27 years
Annual payment on first year's loan (D_{L1})	$C_{L1} = \frac{A_{L1} I_B (1+I_B)^{T_{L1}}}{[(1+I_B)^{T_{L2}-1}]}$ (EQN 6.3)	\$.61 MM
Second year's loan (A_{L2})	$A_{L2} = .60 A_{CI} D_I$ (EQN 6.4)	\$9.22 MM
Life of second year's loan (T_{L2})	$T_{L2} = T_P + 1$ (EQN 6.5)	26 years
Annual payment on second year's loan (C_{L2})	$C_{L2} = \frac{A_{L2} I_B (1+I_B)^{T_{L2}}}{[(1+I_B)^{T_{L2}-1}]}$ (EQN 6.6)	
Total annual loan payment (C_{TL})	$C_{TL} = C_{L1} + C_{L2}$ (EQN 6.7)	\$1.54 MM
First year's equity (E_1)	$E_1 = .40 A_{CI} E_I$ (EQN 6.8)	\$6.15 MM

Table VII - V

(Continued)

Second year's equity (E_2)	$E_2 = .60 A_{CI} E$ (EQN 6.9)	\$ 9.22 MM
Total annual expenses (A_{TA})	$A_{TA} = A_{OP} + C_{TL}$ (EQN 6.10)	\$ 7.64
Present worth of first year of construction money (P_1)	$P_1 = (E_1 + C_{L1} + A_{WC})(1 + I_E)$ (EQN 6.11)	\$ 8.14 MM
Present worth of second year of construction money (P_2)	$P_2 = (E_2 + C_{L2} + C_{L1})$ (EQN 6.12)	\$10.76 MM
Present worth of recovered working capital (P_{WC})	$P_{WC} = \frac{(A_{WC} + S)}{(1 + I_E)^{T_P}}$ (EQN 6.13)	\$.03 MM
Present worth factor for cash flow calculation (F_{PW})	$F_{PW} = \frac{[(1 + I_E)^{T_P} - 1]}{[I_E(1 + I_E)^{T_P}]}$ (EQN 6.14)	\$ 7.84
Required annual cash flow (A_{CF})	$A_{CF} = \frac{(P_1 + P_2 - P_{WC})}{F_{PW}}$ (EQN 6.15)	\$ 2.41 MM
Annual net profit (after taxes) (A_{NP})	$A_{NP} = A_{CF} - A_D$ (EQN 6.16)	\$ 1.18 MM

Table VII - V

(Continued)

Annual gross earnings (before taxes) (A_{GE})	$A_{GE} = \frac{A_{NP}}{(1-I_T)} + A_{TA}$ (EQN 6.17)	\$10.09 MM
Total energy annually for sale (MMBTU) (Q_{DA})	$Q_{DA} = \frac{(24)(365) \eta_P Q_D}{10^6}$ (EQN 6.18)	7.0956x106MMBTU
The required dirty gas selling price in \$/MMBTU (C_{SP})	$C_{SP} = \frac{A_{GE}}{Q_{DA}}$ (EQN 6.19)	<u><u>\$1.42/MMBTU</u></u>

The Dirty Gas Selling Price = \$ 1.42/MMBTU*

*All costs presented are in 1978 dollars.

Table VII - VI
Contributions of Individual Cost Items
to the Gas Price for the Base Case

<u>Cost Item</u>	<u>Contribution to the Gas Price</u>	<u>% of the Gas Price</u>
<u>Capital Investment</u>		
1. Drilling	5¢/MMBTU	4.2%
2. Air Compression	57¢/MMBTU	40.19%
3. Pipe and Accessories	10¢/MMBTU	7.1%
a. Pipe = 2¢/MMBTU		
b. Accessories = 3¢/MMBTU		
c. Flow Control and Metering = 2¢/MMBTU		
d. Valves = 3¢/MMBTU		
4. Site Facilities	5¢/MMBTU	3.5%
5. Construction Salaries	8¢/MMBTU	5.6%
Total Contribution of the Capital Investment	86¢/MMBTU	60.5%
<u>Annual Costs</u>		
1. Drilling	20¢/MMBTU	14.1%
2. Coal Royalties	13¢/MMBTU	9.2%
3. Annual Salaries	21¢/MMBTU	14.8%
4. Pipe	2¢/MMBTU	1.4%
Total Contribution of the Annual Costs	56¢/MMBTU	39.5%

FIGURE 7.1

CONTRIBUTIONS OF INDIVIDUAL COST ITEMS TO THE GAS PRICE FOR THE BASE CASE

Table VII - VII
Comparison of Gas Selling Prices
for the Base Case Using Utility
and Equity Finance Bases.

	Utility Finance Basis	Equity Finance Basis
Debt	50%	0
Equity	50%	100%
Bond Interest	9%	---
Return on Equity	12%	15%
Plant Load Factor	90%	90%
Income Tax Rate	52%	52%
Plant Life	25 years	25 years
Contingency	20%	20%
Required Annual Cash Flow	\$2.41 MM/yr.	\$5.13 MM/yr.
Required Dirty Gas Selling Price	\$1.42/MMBTU	\$2.00/MMBTU

The equity finance basis is considered in this study for two reasons:

1. Equity finance is a probable basis of finance for a current venture in UCG.

2. Much useful information is obtained by comparing the economic potential of UCG when financed by the equity basis to the economic potential of this process when financed by the utility basis.

A current business venture in UCG would most likely be conducted by one of three different types of corporations:

1. A public utility, such as an electric power company.
2. An oil company.
3. A coal lease holder, such as a coal mining company.

A public utility would most likely use the utility finance basis and for this reason that basis is considered in detail. An oil company venturing into UCG may use the utility finance basis or the equity finance basis, depending upon the structure of the corporation and its

subsidiaries. A coal lease holder would probably fund a UCG venture by using equity financing. Thus, by providing cost data for both the equity finance basis and the utility finance, these data are more complete.

In addition to providing more data to indicate the economic potential of UCG, the consideration of equity financing is of value for comparison to the economic data generated using the utility finance basis. A high and low range of data results when these two finance bases are considered. (These data are useful to identify those cases considered that would require a conservative basis for financing in order to make a profit.) The sensitivity of these data to the economic basis also results directly.

Due to the volume of the data generated in this study, data generated using the equity finance basis are provided in the appendices and are not discussed further in this chapter. Appendix H provides curves for comparing the effect of equity financing for the effect of utility financing on gas price sensitivity to each of the selected variables. Appendix J contains brief results, for all 1296 cases considered, calculated using the equity finance basis. Appendix I provides graphs of the effect of each sensitivity variable on the dirty gas selling price calculated based on equity financing.

Table VII - VIII presents results obtained by selectively imposing an unfavorable 50% change on the input data for values of the items tabled. The term unfavorable change implies that the input data are changed so as to result in an increase in the calculated gas price. The table presents the gas price resulting from the unfavorable 50% change in the values considered for each item and these results are also presented in Figure 7.2. The bar graph in Figure 7.2 illustrates the magnitude of the effect on the gas price. These data identify the steam cycle efficiency, compression cost, personnel salaries, and drilling cost, respectively, as affecting the gas selling price the most.

The Economic Effect of the Sensitivity Variables

The economic sensitivities are displayed in Figures 7.3 through 7.8. The value of each of the sensitivity variables is assumed to be the same as for the base case unless otherwise specified on the graph. Of the six sensitivity variables, four have major economic impact within the respective ranges of values considered. These four variables are: seam depth, seam thickness, well spacing, and product gas HHV. The seam depth, seam thickness, and well spacing can be fixed on selection of a specific seam. The product gas HHV, however, cannot be accurately predetermined. For this reason, the economic effect of the product gas HHV is included in every graph.

Figure 7.3 illustrates the effect of the gas heating value on the gas selling price which decreases by 69% if the product gas HHV increases from 100 to 175 BTU/scf. The reasons for the significant effect of the gas heating value are illustrated by Figures 3.1 and 3.2. Figure 3.1 shows the relationship of the thermal efficiency to the gas HHV. This relationship is nearly linear with the thermal efficiency increasing as the gas HHV increases. Thus, at the higher heating values, less coal is gasified to maintain a constant energy production rate than at the low gas HHVs. This results in reduced coal and drilling costs at higher gas HHVs due to the decreased coal consumption. A decrease in the pipe needs also results due to a reduction in the well field expansion.

Figure 3.2 shows the relationship of the ratio of the dry gas production rate to air injection rate as a function of the gas HHV. The figure shows that more gas is produced per volume of air injected at the higher gas HHV's. This relation indicates that compression costs decrease as the gas HHV increases. Table VII - IX provides data in support of these conclusions. These data clearly show that the drilling, coal, pipe, and compression costs decrease with increasing gas heating value.

Figure 7.4 illustrates the importance of the seam depth to the economics of UCG. The dirty-gas selling price is 67% higher at a seam depth of 1000 feet compared to 300 feet for the base case HHV of 125 BTU/scf. The reason for this is that both the annual and investment drilling costs increased by 200% over this depth range and the compression costs are 115% higher at a depth of 1000 feet compared to 300 feet. The four curves at different gas HHVs also show that the economics are more sensitive to depth at lower gas HHVs than at more favorable values.

Figures 7.5 and 7.6 show that the gas selling price is greatly influenced by very thin seams or by close well spacing. This occurs because both of these variables directly affect the amount of coal that can be recovered from a single pair of process wells and consequently directly affect the amount of drilling that is required. However, as the seam thickness or well spacing increases, the contribution to the total cost by the drilling decreases sharply. The effect of the seam thickness on the economics of UCG is shown by a 41% increase in price as the thickness decreases from 50 feet to 10 feet. The well spacing produces a 49% increase in gas selling price as its value is decreased from 200 feet to 60 feet.

Table VII - VIII
Sensitivity of the Base Case Gas Price
to Selected Input Data

<u>Item</u>	<u>% Change in Base Case Value</u>	<u>Resulting Gas Price (\$/MMBTU)</u>	<u>% Increase in Gas Price</u>
Drilling Cost	+ 50%	1.55	9.2%
Compression Cost	+ 50%	1.71	20.42%
Salaries	+ 50%	1.57	10.6 %
Maintenance Cost	+ 50%	1.45	2.1 %
Property Taxes and Insurance	+ 50%	1.46	2.8 %
Working Capital	+ 50%	1.43	.7 %
Pipe and Accessories	+ 50%	1.47	3.5 %
Coal Cost	+ 50%	1.49	4.9 %
Site Facilities	+ 50%	1.45	2.1 %
Steam Cycle	- 50%	1.82	28.2 %

FIGURE 7.2

SENSITIVITY OF THE BASE CASE GAS PRICE TO A 1% CHANGE IN SELECTED INPUT DATA

ECONOMIC SENSITIVITY TO THE PRODUCT GAS HEATING VALUE

FIGURE 7.3

Table VII - IX

The Effect of the Gas Heating Value
on Economics.

(All sensitivity variables are equal to the
base case values except the gas HHV.)

Product Gas HHV (BTU/scf)		100	125	150	175
<hr/>					
Capital Investment Item					
1.	Start-Up Drilling Cost	\$ 2.8 MM	\$ 1.9 MM	\$ 1.6 MM	\$ 1.4 MM
2.	Air Compression Cost	\$22.6 MM	\$16.1 MM	\$12.0 MM	\$ 9.4 MM
3.	Cost of Pipe and Accessories	\$ 3.9 MM	\$ 3.2 MM	\$ 2.6 MM	\$ 2.2 MM
Annual Expenses					
1.	Annual Drilling Cost	\$ 2.9 MM	\$1.39 MM	\$1.21 MM	\$1.04 MM
2.	Annual Coal Cost	\$.97 MM	\$.90 MM	\$.85 MM	\$.82 MM
3.	Annual Pipe and Accessories Cost	\$.18 MM	\$.71 MM	\$.13 MM	\$.11 MM

Figures 7.7 and 7.8 show the effects of the VCSE and of the gas leakage rate on the gas price. For the chosen ranges of variables, both effects are relatively small.

The effect of the VCSE on the economics is a 9% increase in the gas selling price for a VCSE of 50% compared to the 80% value. Similarly, an 18% increase in the gas price is produced as the leakage rate increases from 0% to 20%.

Comparison of Economic Results with Previous Analyses

The purpose of this section is to compare the results of the economic model presented in this work to the results of previous economic analyses. Chapter II described several of the previous analyses of the economics of UCG.

The first analysis of UCG economics discussed in Chapter II is by Jennings. (10) Since this analysis was performed (1975), cost data have changed substantially, and knowledge of the UCG process has greatly increased due to the enormous increase in UCG operating data currently available. For these reasons, a comparison of results from this analysis to those presented by Jennings is not included here.

The remaining economic analyses discussed in Chapter II were performed by four different organizations:

1. Bechtel Corporation. (11, 12, 13)
2. Gulf Research and Development Company. (14)
3. The Stanford Research Insititute. (15, 16)
4. The University of Texas. (17, 18)

A comparison of the results of this analysis to the results of the most current comparable work from each of these organizations is provided in this section.

Table VII - X provides a summary of important economic parameters used by Buder and Terichow. (13) Included in this table are values used by Buder for the sensitivity variables. Table VII - XI presents a comparison between the results of Buder and Terichow to the results obtained from this economic model using the values for the parameters presented in Table VII - X.

The results of Buder and Terichow are in reasonable agreement with the results obtained by using this model. The gas price of Buder and Terichow presented in 1978 dollars is calculated from the 1977 price

ECONOMIC SENSITIVITY TO THE COAL SEAM DEPTH

FIGURE 7.4

FIGURE 7.5
ECONOMIC SENSITIVITY TO THE COAL SEAM THICKNESS

FIGURE 7.6

ECONOMIC SENSITIVITY TO THE PROCESS WELL SPACING

ECONOMIC SENSITIVITY TO THE VOLUMETRIC COMBUSTION SWEEP EFFICIENCY

FIGURE 7.7

ECONOMIC SENSITIVITY TO THE LEAKAGE RATE

FIGURE 7.8

with an annual inflation rate of 8%. With the consideration of inflation, a \$.20/MMBTU difference exists in the gas prices. The difference between the gas price of Buder and Terichow and the gas price calculated using this model is attributed to the different capital costs reported.

A comparison to the results of Garon and Swartz (14) of Gulf is difficult due to significant differences in the UCG plant design considered by them to the plant design previously discussed in this work. One significant difference is that Garon and Swartz compress their sales gas to 175 psig. This adds \$.20 to the gas cost. Also, the price presented by Garon and Swartz is for a cleaned product gas. The cost of cleaning the gas is approximately \$.25/MMBTU.

The values for economic parameters and sensitivity variables used by Garon and Swartz are presented in Table VII - XII. These values are used as input data into this model and the resulting gas selling price is presented in Table VII - XII. The gas price calculated using this model is adjusted to account for the product gas cleaning and compression. This adjusted price is 12% lower than the price reported by Garon and Swartz placed on a comparable basis.

The gas selling price reported by Moll, et al. (16) agrees quite well with the gas selling price for a comparable case calculated using this model. The comparable price calculated is equal to the price reported by Moll, et al.

Table VII - XIII presents information used to compare the results of this model to those of Moll, et al. of the Stanford Research Institute. The table shows the difference in the reported gas selling price and capital investments between the two analyses. The gas price reported by Moll is for a clean gas and this accounts for all of the difference in these results. By adding \$.25/MMBTU to the dirty gas price, the two methods result in equal gas prices. The difference in the capital investment, therefore, is due to the expense associated with the purchase of gas cleanup equipment.

Table VII - XIV presents the values for the parameters in the economic basis and values for the sensitivity variables used to compare the results of this model to results reported by Edgar. (18) The comparable gas selling price calculated using this model is 82% higher than the comparable gas price reported by Edgar. This discrepancy lies in both the reported capital investment and annual expenses. The difference in the reported capital investment results from differences in so many items that no attempt is made to reconcile them.

Table VII - X

Values of Important Parameters

Used by Buder and Terrichow. (13)

Economic Basis (1977 Dollars)

Debt/Equity	=	75/25
Depreciation	=	Sraight-Line
Return on Equity		
After Taxes	=	15%
Bond Interest	=	9% Annually
Income Tax	=	50%
Plant Life	=	20 Years
Plant Size	=	500 mgwe
Contingency	=	20%

Sensitivity Variables

Seam Thickness	=	20 Feet
Seam Depth	=	500 Feet
Gas HHV	=	170 BTU/scf
Sweep Efficiency	=	75%
Well Spacing	=	100 Feet
Leakage Rate	=	0

Coal Properties

Hanna Coal		
Coal HHV	=	9000 BTU/lb. AR

Table VII - XI

Comparison of Results:

Buder and Terichow (13) to This Model

Result Summary (Millions of Dollars)

<u>Capital Cost Item</u>	<u>Buder and Terichow</u>	<u>Boysen and Gunn</u>
Site, Preparation, Buildings	2.6 *	8.0
Air Compression	10.6 *	39.2
Drilling	1.5 *	6.8
Pipes and Accessories	20.6 *	12.3
Others	<u>20.7 *</u>	<u>14.5</u>
Total Capital Cost	50.6 *	80.8
Annual Expense Item		
Drilling	4.6 *	4.5
Coal	3.0 *	4.0
Salaries and Materials	3.8 *	7.5
Fuel and Power	9.1 *	---
Others	<u>10.1 *</u>	<u>15.2</u>
Total Annual Cost	30.6 *	31.2
Cost of Raw Gas		
Selling Price (\$/MMBTU) in 1978 Dollars	.76	.96
Reported Selling Price	.70 *	

* Cost data in 1977 dollars. All other cost data are in 1978 dollars.

Table VII - XII

Comparison of Results:

Garon and Swartz (14) to This Model

Economic Basis

Plant Life	=	25 Years
Depreciation	=	Straight-Line
Debt/Equity	=	75/25
Bond Interest	=	8.5% Annually
Return on Equity		
After Taxes	=	15%
Income Tax	=	52%
Contingency	=	15%

Sensitivity Variables Values

Seam Thickness	=	30 Feet
Seam Depth	=	350 Feet
Gas HHV	=	178 BTU/scf
Sweep Efficiency	=	85%
Well Spacing	=	300 Feet
Leakage Rate	=	0

Comparison of Gas Prices

	Garon and Swartz	Boysen and Gunn
Comparable Basis:	\$1.30/MMBTU	\$1.16/MMBTU
Clean Gas (25¢/MMBTU)		
175 psig Delivery Pressure		
(\$.20/MMBTU)		
1978 Dollars		
Reports Price	\$1.25/MMBTU	\$.71/MMBTU
	(June 1977 Dollars)	(1978 Dollars)
	(Cleaned Gas)	(Dirty Gas)

Table VII - XIII

Comparison of Results:

Moll, et al. (16) to This Model

Economic Basis

Plant Life	=	20 Years
Depreciation	=	Straight-Line
Debt/Equity	=	65/35
Bond Interest	=	10% Annually
Return on Equity		
After Taxes	=	15%
Income Tax	=	52%
Contingency	=	20%

Sensitivity Variable Values

Seam Thickness	=	30 Feet
Seam Depth	=	570 Feet
Gas HHV	=	150 BTU/scf
Sweep Efficiency	=	75%
Well Spacing	=	100 Feet
Leakage Rate	=	0

Results:

	Moll, et al. (1977 Dollars)	Boysen and Gunn (1978 Dollars)
Total Investment	\$155.0 MM	\$113.8 MM
Operating Costs	\$ 35.2 MM	\$ 33.9 MM

Comparison of Gas Prices

Comparable Basis:

Clean Gas 1978 Dollars	\$ 1.40/MMBTU	\$ 1.40/MMBTU
------------------------	---------------	---------------

Reported Price:

\$ 1.30/MMBTU (Clean Gas, 1977 Dollars)	\$ 1.15/MMBTU (Dirty Gas, 1978 Dollars)
---	---

Summary of Comparisons

Table VII - XV presents a summary of the four comparisons made. All four of these studies are preliminary cost estimates. Of the four studies, three used the results of actual UCG field tests in their analyses. (13, 14, 16) The agreement between this model and those studies using field test data is well within the accuracy of a preliminary cost estimate. (30) This is important because the conceptual UCG plant design differs significantly between each of these studies. It must be concluded, therefore, that the use of field test data is critical to obtain both accurate economic data and accurate economic sensitivities to process variables. (The need for field data to obtain accurate economic sensitivities has been previously discussed in Chapter III.)

Complete Results

As stated in previous chapters, a total of 1296 different combinations of values for the sensitivity variables are considered. Summaries of the results of the economic calculations for each case are provided in Appendix G based on utility financing. Appendix J contains similar data, however, equity financing is considered to generate these data. The total investment, annual expenses, gas selling price, and energy return ratio are provided for each case.

Research Implications of the Economic Analysis

The economic results of this study lead to several important conclusions. The most significant economic factor is the coal seam depth-to-thickness ratio. Table VII - XVI provides data illustrating this observation. Column I in this table represent a favorable depth-to-thickness ratio. Gas prices are quite competitive even with a low heating value, low sweep efficiency, and high gas leakage. Column I is representative of the Hanna test site where the Hanna No. 1 seam is 30 feet thick and lies at an average depth of roughly 300 feet. Column II represents a less favorable 100-to-1 depth-to-thickness ratio. Only for an average gas heating value of 175 BTU/scf does the gas selling price become marginally attractive. It is concluded that the gasification of a thick seam can be economically attractive, even if almost everything goes wrong (low heating value, high leakage, etc.). Gasification of a thin seam, however, must be engineered very carefully because minor problems can lead to an uneconomical operation. This conclusion also indicates the importance of a marketing study. The transportation of low-BTU gas more than a few miles is prohibitively expensive, yet most of the nation's thick coal seams lie in remote locations in the western states. A marketing study is critical in this situation. In addition, water resources may be a limiting factor if on-site use of gas requires a large surface plant or a sizable community of workers.

Table VII - XIV

Comparison of Results:

Edgar (18) to This Model

Economic Basis

Plant Life	=	20 Years
Depreciation	=	Straight Line
Debt/Equity	=	75/25
Bond Interest	=	9% Annually
Return on Equity		
After Taxes	=	15%
Income Tax	=	48%
Contingency	=	0%

Sensitivity Variable Values

Seam Thickness	=	10 Feet
Seam Depth	=	600 Feet
Gas HHV	=	125 BTU/scf
Sweep Efficiency	=	80%
Well Spacing	=	75 Feet
Leakage Rate	=	10%

Comparison of Gas Prices

	Edgar	Boysen and Gunn
Comparable Basis: Clean Gas 1978 Dollars	\$1.08/MMBTU	\$1.97/MMBTU
Reported Gas Price	\$.93/MMBTU (Clean Gas, 1976 Dollars)	\$1.82/MMBTU (Dirty Gas, 1978 Dollars)

Table VII - XV

Summary of Comparisons

Reference No.	Authors	% Difference in Gas Price on a Comparable Basis*
13	Buder and Terichow	21%
14	Garon and Swartz	-12%
16	Moll et al.	0%
18	Edgar	45%

$$*\% \text{ Difference} = \frac{\text{Gas Price (this work)} - \text{Gas Price (literature)}}{\text{Gas Price (this work)}} \times 100$$

Two of the sensitivity variables, gas leakage and the volumetric combustion sweep efficiency, have a relatively minor effect on the gas selling price. For this reason the most unfavorable values considered for these variables were used in preparing Table VII - XVI.

Gas heating value and well spacing have an important impact on UCG economics. The benefits of wider well spacing, however, rapidly diminish beyond about 150 feet. The reason is that well spacing primarily affects drilling costs. With 60-foot spacing, the drilling and completion of wells represents 36% of the annual operating expenses. With 150-foot spacing, these costs are only 13% of the annual operating expenses; therefore, still wider spacing affects only a minor component of the gas selling price. This well spacing, therefore, appears near optimum for minimizing cost while retaining the flexibility and greater dependability of shorter well spacings. This is the value chosen for Table VII - XVI. In the authors' opinion, there seems no major obstacle to well spacings of 150 feet. The crux of the problem is to achieve linkage over this distance because once linkage is achieved successfully no serious problems are anticipated for forward gasification. Reverse combustion and directional drilling are two promising methods of linking. Directional drilling is technically proven for distances even greater than 150 feet. This method, however, is not cost effective at the present time. Reverse combustion is very cost effective, but it has not been adequately tested at distances greater than 60 feet.

The results discussed above indicate several high priority research objectives. Major uncertainties, which also have a major economic impact, are well spacing and gas heating values. The capability to link reliably over distances of 150 feet or more needs to be investigated. Forward gasification over these distances also needs to be studied. Research into the factors affecting gas heating value must receive continued attention. Methods for maximizing heating value must be devised and tested in the field. Finally, marketing, subsidence, and environmental impact potentially can have a major economic influence on UCG. For the present, however, these three factors remain almost complete unknowns, and for this reason, they have not been incorporated into this analysis.

Conclusions

Based upon the economic data generated from this analysis, the following conclusions are drawn:

1. Site selection is crucial to obtaining favorable economics for UCG operation. Within the ranges of values considered in this study, the smaller the ratio of the coal seam depth to the seam thickness the more favorable the economics.

2. UCG appears to be an economical fuel source given a favorable seam selection and a market for the fuel. An example to illustrate this claim is the selection of a coal seam 300 feet deep and 50 feet thick. The least favorable case for this seam yields a required gas selling price of \$1.73/MMBTU. If a 100-foot well spacing is assumed, the least favorable case then results in a gas selling price of \$1.43/MMBTU.
3. The gas selling price is especially sensitive to seam thickness, well spacing, and product gas HHV.
4. The use of field test data and theoretical correlations is critical in the analysis of economic potential and economic sensitivity of UCG.
5. The results of this study are in agreement with previous studies using UCG field test data.

Table VII - XVI

Required Dirty-Gas Selling Price as
a Function of the Gas Heating Value.

Well Spacing	150 ft.
Volumetric Combustion	
Sweep Efficiency	50%
Gas Leakage	20%

	<u>I</u>	<u>II</u>
Seam Thickness, ft.	30	10
Seam Depth, ft.	300	1000
Depth-to-Thickness Ratio	10	100

<u>Heating Value (BTU/scf)</u>	<u>\$/MMBTU</u>	<u>\$/MMBTU</u>
100	\$1.39	\$3.32
125	1.15	2.43
150	1.01	1.99
175	.92	1.70

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APPENDIX A

NOMENCLATURE

A_{CF}	The required annual cash flow in \$ based on the time of plant start-up.
A_{CI}	The capital investment in \$.
A_D	The annual depreciation in \$.
A_{GE}	The annual gross earnings in \$ (before taxes).
A_{L1}	The amount of money borrowed during the first year of plant construction in \$.
A_{L2}	The amount of money borrowed during the second year of plant construction in \$.
A_{NP}	The annual net profit in \$ (after taxes).
A_{OP}	The total annual operating expenses in \$.
A_{TA}	The total annual expenditures in \$.
A_{WC}	The working capital in \$.
b	The coal seam thickness in ft.
B_L	The compression horsepower required to provide the low-pressure air required in Hp.
B_T	The total compression horsepower required to provide both the low-pressure air required and the high-pressure air required in Hp.
C_L	Contingency for linkage air requirements.
C_{L1}	The annual payment on the money borrowed for the first year of plant construction in \$.
C_{L2}	The annual payment on the money borrowed for the second year of plant construction in \$.
C_{SP}	The required dirty gas selling price in \$/MM.
C_{TI}	The total annual payment on the money borrowed for plant construction in \$.
D_1	The fraction of the capital investment that is debt.

d_{WS}	The process well spacing in ft.
E_1	The equity applied during the first year of plant construction in \$.
E^2	The equity applied during the second year of plant construction in \$.
E_I	The fraction of the capital investment that is equity.
F_{PW}	The present-worth factor used in the calculation of the cash flow.
H_C	The analytically determined coal higher heating value in BTU/lb. (as received basis).
H_{DG}	The dry gas higher heating value in BTU/scf.
H_T	The higher heating value of the coal liquids produced in BTU/lb.
I_B	The annual bond interest rate.
I_E	The rate of return on equity after taxes.
I_T	The income tax rate.
ℓ_{CS}	The length of pipe required for the capital investment for one of the surface piping systems in ft.
ℓ_e	The length of surface pipe required for the first year's well field expansion in ft.
ℓ_I	The length of a surface piping system required for start-up in ft.
M_A	The air injection rate in lb./hr.
M_C	The coal consumption rate in lb./hr.
M_{CM}	The mass of coal in one module in lbs.
M_{DG}	The dry gas production rate in lb./hr.
M_T	The production rate of coal liquids in lb./hr.
M_{WG}	The wet gas production rate in lb./hr.
M_{WR}	The amount of aquifer water consumed by reaction in lbs./hr.
N_S	The number of stages of compression.

P_1	The present worth of the investment required for the first year of plant construction in \$ at plant start-up.
P_2	The present worth of the investment required for the second year of plant construction in \$ at plant start-up.
P_A	The atmospheric pressure in psia.
P_{CD}	The required compressor discharge pressure in psia.
P_H	The hydrostatic seam pressure in psia.
P_L	The pressure drop in the injection piping and injection wells in psia.
P_M	The number of modules in operation.
P_{WC}	The present worth of the working capital in \$ at plant start-up.
Q_C	The gross heat content of the coal consumed in BTS/hr.
Q_D	The energy sufficient to produce 100 MGWE in BTU/hr.
Q_{DA}	The energy delivered to the consumer annually in 10^6 BTU.
Q_{DG}	The heat content of the dry gas in BTU/hr. (Note: sensible and latent heat in the dry gas is not included in Q_{DG}).
Q_M	The heat recovered from one module in a usable form in BTU.
Q_P	The total plant energy production rate in BTU/hr.
Q_R	The energy required to operate the UCG facility in BTU/hr.
Q_T	The heat content of the coal liquids produced in BTU/hr.
R_M	The module consumption rate in modules/hr.
S	The salvage value in \$.
T_I	The inlet air temperature in °R.
T_{L1}	The life of the first-year loan in years.
T_{L2}	The life of the second-year loan in years.
T_M	The time required to gasify one module in days
T_P	The plant life in years.
V_{DG}	The total volume of dry gas produced from one module in scf.

W_A	The air injection rate in scf./hr.
W_{DG}	The dry gas flowrate in scf./hr.
W_{GA}	The total air flowrate required for forward gasification in scf./min.
W_L	The air required per foot of link in mscf./ft.
W_{LA}	The total air flowrate required for reverse combustion linking in scf./min.
W_{MA}	The maximum air injection rate in a process well in scf./min.
W_{WG}	The wet gas flowrate in scf./min.
X_{CC}	The weight % of carbon in the coal.
X_{CDG}	The weight % of carbon in the dry product gas.
X_{CT}	The weight % of carbon in the coal liquids.
X_{HC}	The weight % of elemental hydrogen in the coal.
X_{HDG}	The weight % of elemental hydrogen in the dry gas.
X_{HW}	The weight % of elemental hydrogen in water.
X_L	The leakage rate.
X_{OA}	The weight % of elemental oxygen in air.
X_{OC}	The weight % of elemental oxygen in the coal.
X_{OW}	The weight % of elemental oxygen in water.
X_{OWG}	The weight % of elemental oxygen in the wet product gas.
X_{QDG}	The percent of the total energy produced that is in the form of the dry gas HHV.
Y_{NA}	The mole percent N_2 in air.
Y_{NDG}	The mole percent N_2 in the dry product gas.
Y_{WWG}	The mole percent H_2O in the wet product gas.
Z_C	The compression ratio per stage of compression.
$Z_{G/A}$	The ratio of the volume of dry gas produced per volume of air injected.

Greek Letters

β_T	The total compression horsepower in HP.
γ	The ratio of specific heats.
η_{CS}	The volumetric combustion sweep efficiency.
η_{LP}	The gasification compressor efficiency.
η_P	The plant load factor.
η_S	The steam cycle efficiency.
η_{TE}	The process thermal efficiency.
ρ_C	The coal density in lb./ft. ³ .

WELL PATTERN, PHASE I OF THE HANNA II EXPERIMENT

FIGURE B.1

WELL PATTERN, PHASE 1 OF THE HANNA II EXPERIMENT

WELL PATTERN, HANNA II EXPERIMENT, PHASE II & III

⊙ INSTRUMENTATION WELL

○ INJECTION/PRODUCTION WELL

FIGURE B.2

WELL PATTERN, HANNA II EXPERIMENT, PHASES.2 AND 3

WELL PATTERN, HANNA III EXPERIMENT

FIGURE B. 3

WELL PATTERN, HANNA III EXPERIMENT

WELL PATTERN, HANNA IV

FIGURE B.4

WELL PATTERN, HANNA IV EXPERIMENT (ORIGINAL LAYOUT)

APPENDIX C
EXPERIMENTAL DATA USED IN CORRELATIONS NECESSARY
TO EVALUATE THE PROCESS DYNAMICS

This appendix presents the data used to derive the correlations discussed in Chapter III. These data are from the Hanna II (Phases 2 and 3) and Hanna III field tests conducted by the Laramie Energy Technology Center of the United States Department of Energy.

Table C - I

Hanna Field Test Data

Field Test	Julian Date and Year	Product Gas HHV (BTU/scf)	% Thermal Efficiency	Dry Gas Produced Air Inj. (scf/scf)	Wet Gas Produced Air Inj. (scf/scf)
II-3*	199, 1976	105.1	64.8	1.33	1.73
II-3	200, 1976	101.6	63.6	1.31	1.69
II-3	201, 1976	103.9	64.5	1.31	1.68
II-3	202, 1976	99.6	62.6	1.30	1.66
II-3	203, 1976	101.9	63.5	1.31	1.66
II-3	204, 1976	103.7	64.5	1.32	1.69
II-3	205, 1976	95.4	60.6	1.30	1.67
II-3	206, 1976	97.8	60.9	1.30	1.70
II-3	211, 1976	91.6	58.5	1.29	1.62
III	208, 1977	105.8	65.2	1.36	1.53
III	209, 1977	93.6	62.2	1.28	1.46
II-3	195, 1976	131.3	73.7	1.44	1.74
II-3	196, 1976	121.4	70.1	1.39	1.81
III	196, 1977	133.1	77.6	1.43	1.63
III	198, 1977	125.7	75.6	1.42	1.58
III	199, 1977	120.7	73.5	1.41	1.57
III	200, 1977	121.0	73.9	1.39	1.59
III	201, 1977	126.5	75.4	1.40	1.59
III	202, 1977	124.0	74.8	1.39	1.56
III	203, 1977	124.5	74.6	1.39	1.51

Table C - I

(Continued)

Field Test	Julian Date and Year	Product Gas HHV (BTU/scf)	% Thermal Efficiency	Dry Gas Produced Air Inj. (scf/scf)	Wet Gas Produced Air Inj. (scf/scf)
III	204, 1977	124.4	75.3	1.40	1.64
III	206, 1977	122.0	73.5	1.40	1.54
II-2	145, 1976	152.2	88.7	1.53	1.62
II-2	146, 1976	154.0	82.8	1.49	1.61
II-2	147, 1976	146.2	79.7	1.48	1.58
II-2	148, 1976	146.1	79.5	1.47	1.59
II-3	192, 1976	148.8	79.1	1.52	1.83
II-3	193, 1976	140.2	76.0	1.49	1.78
III	186, 1977	153.9	81.0	1.64	1.98
III	188, 1977	146.7	78.5	1.56	1.77
III	189, 1977	152.2	80.2	1.57	1.73
III	190, 1977	152.0	80.1	1.53	1.69
III	192, 1977	157.4	83.5	1.57	1.84
II-2	127, 1976	174.8	91.7	1.65	1.82
II-2	129, 1976	175.3	90.6	1.64	1.78
II-2	138, 1976	175.9	90.2	1.62	1.68
II-2	136, 1976	176.4	90.3	1.63	1.63
II-3	177, 1976	173.9	89.0	1.58	1.89
II-3	178, 1976	173.3	93.1	1.62	1.98
II-3	186, 1976	173.1	92.1	1.63	1.89
II-3	187, 1976	175.5	91.0	1.62	1.87
III	180, 1977	177.4	88.5	1.58	1.68
III	183, 1977	175.9	89.4	1.63	2.01

*II-2 implies Hanna II, Phase 2. Correspondingly, II-3 is Hanna II, Phase 3, and III is the Hanna III test.

APPENDIX D
PHYSICAL AND CHEMICAL PROPERTIES
OF HANNA #1 COAL

Table D - I

Properties of Hanna #1 Coal

(Properties are reported on an "As Received" basis.)

		From Hanna II, Phases 2 and 3 Core Analyses	From Hanna III Core Analyses
<u>Proximate Analysis:</u>			
Fixed Carbon	(wt. %)	31.91	29.84
Volatiles	(wt. %)	30.55	30.58
Ash	(wt. %)	28.92	31.33
Moisture	(wt. %)	8.62	8.25
<u>Ultimate Analysis:</u>			
Carbon	(wt. %)	45.34	43.85
Hydrogen	(wt. %)	4.68	4.41
Oxygen	(wt. %)	19.27	18.71
Nitrogen	(wt. %)	1.14	1.02
Sulfur	(wt. %)	.65	.68
Ash	(wt. %)	28.92	31.33

Values Used In The Economic Model:

Coal Higher Heating Value = 8200 BTU/lb.

Coal Density = 90 lb./ft.³

APPENDIX E
AIR REQUIREMENTS FOR
REVERSE COMBUSTION LINKING.

Table E - I

Linkage Air Requirements

Well Spacing (ft.)	Linkage Air Requirement* (mscf/ft. of well spacing)
60	25
100	34
150	45
200	55

*These values are selected based on data from LETC's field tests.

Some uncertainty exists in these numbers and a contingency is included in the calculation of the compressor size required to provide high-pressure air for linking. The reader is referred to Chapter III for additional information regarding the contingency.

FIGURE F.1
PLANT CONSTRUCTION SCHEDULE

APPENDIX G

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL
FEASIBILITY OF UNDERGROUND COAL GASIFICATION CALCULATED
USING A UTILITY FINANCE BASIS

A brief summary of the results of the economic analysis discussed in this paper is provided in this appendix. These results are calculated based upon utility financing. These results are tabulated in Table G-I which begins on the following page. Values of the sensitivity variables, total investment, annual operating expenses, resulting dirty-gas selling price, and energy return ratio are presented for each of the 1296 cases considered.

A copy of the program developed for this economic analysis is available upon request from Dr. Robert Gunn of the Chemical Engineering Dept. of the University of Wyoming.

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* * *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* * *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1	60.	10.	300.	100.	50.	0	*	41.672	14.651	*	2.54	5.82
2	100.	10.	300.	100.	50.	0	*	35.290	9.610	*	1.75	5.92
3	150.	10.	300.	100.	50.	0	*	32.968	8.011	*	1.49	5.99
4	200.	10.	300.	100.	50.	0	*	30.673	7.039	*	1.33	6.00
5	60.	30.	300.	100.	50.	0	*	29.562	9.755	*	1.71	6.11
6	100.	30.	300.	100.	50.	0	*	26.471	7.003	*	1.28	6.10
7	150.	30.	300.	100.	50.	0	*	25.769	6.299	*	1.17	6.21
8	200.	30.	300.	100.	50.	0	*	25.385	5.991	*	1.12	6.24
9	60.	50.	300.	100.	50.	0	*	26.344	8.008	*	1.44	6.15
10	100.	50.	300.	100.	50.	0	*	25.091	6.580	*	1.21	6.17
11	150.	50.	300.	100.	50.	0	*	24.208	5.936	*	1.10	6.26
12	200.	50.	300.	100.	50.	0	*	24.673	5.793	*	1.09	6.30
13	60.	10.	600.	100.	50.	0	*	54.203	20.178	*	3.46	3.92
14	100.	10.	600.	100.	50.	0	*	47.030	13.037	*	2.36	3.98
15	150.	10.	600.	100.	50.	0	*	43.900	10.388	*	1.95	4.00
16	200.	10.	600.	100.	50.	0	*	41.349	8.986	*	1.72	4.00
17	60.	30.	600.	100.	50.	0	*	39.950	12.994	*	2.28	4.08
18	100.	30.	600.	100.	50.	0	*	36.906	9.368	*	1.73	4.11
19	150.	30.	600.	100.	50.	0	*	35.614	8.191	*	1.55	4.13
20	200.	30.	600.	100.	50.	0	*	34.542	7.510	*	1.44	4.12
21	60.	50.	600.	100.	50.	0	*	36.750	11.088	*	1.97	4.12
22	100.	50.	600.	100.	50.	0	*	34.868	8.671	*	1.61	4.15
23	150.	50.	600.	100.	50.	0	*	33.575	7.511	*	1.43	4.12
24	200.	50.	600.	100.	50.	0	*	33.495	7.220	*	1.39	4.15
25	60.	10.	1000.	100.	50.	0	*	71.498	32.333	*	5.38	3.18
26	100.	10.	1000.	100.	50.	0	*	61.237	18.994	*	3.36	3.23
27	150.	10.	1000.	100.	50.	0	*	55.287	13.337	*	2.49	3.23
28	200.	10.	1000.	100.	50.	0	*	54.322	12.208	*	2.32	3.24
29	60.	30.	1000.	100.	50.	0	*	50.801	17.493	*	3.04	3.28
30	100.	30.	1000.	100.	50.	0	*	48.521	13.365	*	2.42	3.32
31	150.	30.	1000.	100.	50.	0	*	46.697	11.106	*	2.08	3.33
32	200.	30.	1000.	100.	50.	0	*	44.823	9.686	*	1.86	3.33
33	60.	50.	1000.	100.	50.	0	*	48.343	16.769	*	2.91	3.33
34	100.	50.	1000.	100.	50.	0	*	45.617	12.079	*	2.21	3.35
35	150.	50.	1000.	100.	50.	0	*	43.307	9.674	*	1.84	3.34
36	200.	50.	1000.	100.	50.	0	*	43.219	9.237	*	1.78	3.35
37	60.	10.	300.	125.	50.	0	*	31.982	11.137	*	1.93	7.55
38	100.	10.	300.	125.	50.	0	*	27.590	7.761	*	1.40	7.45
39	150.	10.	300.	125.	50.	0	*	25.411	6.458	*	1.19	7.77
40	200.	10.	300.	125.	50.	0	*	24.559	6.034	*	1.12	7.71

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
41	60.	30.	300.	125.	50.	0	*	23.061	7.579	*	1.33	7.89
42	100.	30.	300.	125.	50.	0	*	21.216	6.017	*	1.08	7.97
43	150.	30.	300.	125.	50.	0	*	20.817	5.460	*	1.00	8.02
44	200.	30.	300.	125.	50.	0	*	20.305	5.197	*	.96	8.04
45	60.	50.	300.	125.	50.	0	*	21.142	6.899	*	1.21	8.03
46	100.	50.	300.	125.	50.	0	*	20.185	5.687	*	1.03	8.06
47	150.	50.	300.	125.	50.	0	*	19.511	5.176	*	.95	8.21
48	200.	50.	300.	125.	50.	0	*	19.683	5.026	*	.93	8.08
49	60.	10.	600.	125.	50.	0	*	40.650	15.968	*	2.71	5.10
50	100.	10.	600.	125.	50.	0	*	35.459	10.449	*	1.87	5.20
51	150.	10.	600.	125.	50.	0	*	33.147	8.400	*	1.55	5.19
52	200.	10.	600.	125.	50.	0	*	31.196	7.304	*	1.37	5.19
53	60.	30.	600.	125.	50.	0	*	30.480	10.493	*	1.82	5.35
54	100.	30.	600.	125.	50.	0	*	28.226	7.677	*	1.40	5.37
55	150.	30.	600.	125.	50.	0	*	27.283	6.756	*	1.25	5.40
56	200.	30.	600.	125.	50.	0	*	26.347	6.208	*	1.17	5.39
57	60.	50.	600.	125.	50.	0	*	28.104	9.015	*	1.59	5.40
58	100.	50.	600.	125.	50.	0	*	26.618	7.124	*	1.30	5.43
59	150.	50.	600.	125.	50.	0	*	25.727	6.211	*	1.16	5.39
60	200.	50.	600.	125.	50.	0	*	25.648	6.005	*	1.13	5.43
61	60.	10.	1000.	125.	50.	0	*	52.273	24.749	*	4.10	4.15
62	100.	10.	1000.	125.	50.	0	*	44.869	14.733	*	2.58	4.18
63	150.	10.	1000.	125.	50.	0	*	40.033	10.337	*	1.90	4.19
64	200.	10.	1000.	125.	50.	0	*	39.683	9.511	*	1.78	4.22
65	60.	30.	1000.	125.	50.	0	*	37.330	13.563	*	2.34	4.29
66	100.	30.	1000.	125.	50.	0	*	35.536	10.004	*	1.81	4.30
67	150.	30.	1000.	125.	50.	0	*	33.893	8.237	*	1.54	4.32
68	200.	30.	1000.	125.	50.	0	*	33.300	7.713	*	1.45	4.36
69	60.	50.	1000.	125.	50.	0	*	35.239	12.137	*	2.11	4.32
70	100.	50.	1000.	125.	50.	0	*	33.917	9.563	*	1.73	4.38
71	150.	50.	1000.	125.	50.	0	*	32.311	7.710	*	1.44	4.37
72	200.	50.	1000.	125.	50.	0	*	31.568	7.143	*	1.35	4.34
73	60.	10.	300.	150.	50.	0	*	27.167	9.953	*	1.71	9.20
74	100.	10.	300.	150.	50.	0	*	23.490	6.974	*	1.25	9.72
75	150.	10.	300.	150.	50.	0	*	21.458	5.805	*	1.06	9.76
76	200.	10.	300.	150.	50.	0	*	20.901	5.469	*	1.00	9.87
77	60.	30.	300.	150.	50.	0	*	19.561	6.024	*	1.18	10.04
78	100.	30.	300.	150.	50.	0	*	18.162	5.481	*	.98	10.23
79	150.	30.	300.	150.	50.	0	*	17.513	4.941	*	.89	10.29
80	200.	30.	300.	150.	50.	0	*	17.217	4.718	*	.86	10.33

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
81	60.	50.	300.	150.	50.	0	*	17.958	6.217	*	1.08	10.24
82	100.	50.	300.	150.	50.	0	*	17.148	5.153	*	.92	10.37
83	150.	50.	300.	150.	50.	0	*	16.765	4.705	*	.85	10.41
84	200.	50.	300.	150.	50.	0	*	16.921	4.585	*	.83	10.41
85	60.	10.	600.	150.	50.	0	*	33.550	13.956	*	2.35	6.37
86	100.	10.	600.	150.	50.	0	*	29.209	9.133	*	1.62	6.56
87	150.	10.	600.	150.	50.	0	*	27.148	7.109	*	1.30	6.54
88	200.	10.	600.	150.	50.	0	*	25.612	6.400	*	1.19	6.59
89	60.	30.	600.	150.	50.	0	*	25.170	9.211	*	1.50	6.81
90	100.	30.	600.	150.	50.	0	*	23.018	6.721	*	1.20	6.84
91	150.	30.	600.	150.	50.	0	*	22.327	5.941	*	1.09	6.88
92	200.	30.	600.	150.	50.	0	*	21.610	5.465	*	1.01	6.87
93	60.	50.	600.	150.	50.	0	*	22.992	7.908	*	1.37	6.88
94	100.	50.	600.	150.	50.	0	*	21.945	6.277	*	1.13	6.92
95	150.	50.	600.	150.	50.	0	*	21.028	5.466	*	1.00	6.88
96	200.	50.	600.	150.	50.	0	*	20.913	5.287	*	.98	6.92
97	60.	10.	1000.	150.	50.	0	*	42.586	21.289	*	3.50	5.24
98	100.	10.	1000.	150.	50.	0	*	36.423	12.651	*	2.19	5.32
99	150.	10.	1000.	150.	50.	0	*	32.315	8.874	*	1.61	5.34
100	200.	10.	1000.	150.	50.	0	*	31.924	8.156	*	1.50	5.38
101	60.	30.	1000.	150.	50.	0	*	30.000	11.652	*	1.98	5.49
102	100.	30.	1000.	150.	50.	0	*	28.303	8.512	*	1.52	5.50
103	150.	30.	1000.	150.	50.	0	*	27.142	7.079	*	1.30	5.52
104	200.	30.	1000.	150.	50.	0	*	26.455	6.614	*	1.23	5.57
105	60.	50.	1000.	150.	50.	0	*	28.296	10.446	*	1.79	5.53
106	100.	50.	1000.	150.	50.	0	*	26.491	7.585	*	1.36	5.54
107	150.	50.	1000.	150.	50.	0	*	25.532	6.616	*	1.22	5.59
108	200.	50.	1000.	150.	50.	0	*	24.939	6.072	*	1.13	5.56
109	60.	10.	300.	175.	50.	0	*	23.441	8.898	*	1.52	11.19
110	100.	10.	300.	175.	50.	0	*	20.722	6.379	*	1.13	11.45
111	150.	10.	300.	175.	50.	0	*	18.973	5.360	*	.97	11.62
112	200.	10.	300.	175.	50.	0	*	18.222	5.015	*	.91	11.78
113	60.	30.	300.	175.	50.	0	*	17.403	6.266	*	1.08	12.26
114	100.	30.	300.	175.	50.	0	*	15.922	5.029	*	.89	12.39
115	150.	30.	300.	175.	50.	0	*	15.592	4.598	*	.82	12.48
116	200.	30.	300.	175.	50.	0	*	15.258	4.400	*	.79	12.52
117	60.	50.	300.	175.	50.	0	*	15.840	5.696	*	.98	12.50
118	100.	50.	300.	175.	50.	0	*	15.232	4.781	*	.84	12.58
119	150.	50.	300.	175.	50.	0	*	14.833	4.387	*	.78	12.62
120	200.	50.	300.	175.	50.	0	*	14.855	4.279	*	.77	12.67

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
121	60.	10.	600.	175.	50.	0	*	20.580	12.260	*	2.06	7.78
122	100.	10.	600.	175.	50.	0	*	25.030	8.138	*	1.43	7.95
123	150.	10.	600.	175.	50.	0	*	23.087	6.365	*	1.15	7.95
124	200.	10.	600.	175.	50.	0	*	21.827	5.756	*	1.05	8.06
125	60.	30.	600.	175.	50.	0	*	21.675	8.221	*	1.41	8.33
126	100.	30.	600.	175.	50.	0	*	19.881	6.072	*	1.08	8.37
127	150.	30.	600.	175.	50.	0	*	19.114	5.385	*	.97	8.42
128	200.	30.	600.	175.	50.	0	*	18.660	4.985	*	.91	8.41
129	60.	50.	600.	175.	50.	0	*	19.872	7.103	*	1.23	8.42
130	100.	50.	600.	175.	50.	0	*	18.753	5.674	*	1.01	8.47
131	150.	50.	600.	175.	50.	0	*	18.075	4.979	*	.90	8.42
132	200.	50.	600.	175.	50.	0	*	17.884	4.819	*	.88	8.47
133	60.	10.	1000.	175.	50.	0	*	35.920	18.438	*	3.02	6.34
134	100.	10.	1000.	175.	50.	0	*	30.653	11.048	*	1.90	6.47
135	150.	10.	1000.	175.	50.	0	*	27.129	7.810	*	1.40	6.49
136	200.	10.	1000.	175.	50.	0	*	26.200	6.793	*	1.25	6.48
137	60.	30.	1000.	175.	50.	0	*	25.557	10.247	*	1.74	6.65
138	100.	30.	1000.	175.	50.	0	*	23.890	7.531	*	1.33	6.70
139	150.	30.	1000.	175.	50.	0	*	22.939	6.306	*	1.14	6.73
140	200.	30.	1000.	175.	50.	0	*	22.529	5.919	*	1.08	6.79
141	60.	50.	1000.	175.	50.	0	*	23.905	9.189	*	1.57	6.71
142	100.	50.	1000.	175.	50.	0	*	22.592	6.752	*	1.20	6.75
143	150.	50.	1000.	175.	50.	0	*	21.632	5.911	*	1.07	6.81
144	200.	50.	1000.	175.	50.	0	*	21.417	5.468	*	1.01	6.78
145	60.	10.	300.	100.	65.	0	*	40.307	12.707	*	2.24	5.82
146	100.	10.	300.	100.	65.	0	*	34.653	8.804	*	1.62	5.90
147	150.	10.	300.	100.	65.	0	*	32.421	7.532	*	1.42	5.95
148	200.	10.	300.	100.	65.	0	*	30.295	6.707	*	1.28	6.05
149	60.	30.	300.	100.	65.	0	*	28.197	8.098	*	1.46	6.11
150	100.	30.	300.	100.	65.	0	*	26.207	6.628	*	1.22	6.16
151	150.	30.	300.	100.	65.	0	*	25.594	6.068	*	1.14	6.20
152	200.	30.	300.	100.	65.	0	*	25.211	5.791	*	1.09	6.28
153	60.	50.	300.	100.	65.	0	*	25.898	7.400	*	1.33	6.20
154	100.	50.	300.	100.	65.	0	*	24.881	6.277	*	1.16	6.22
155	150.	50.	300.	100.	65.	0	*	24.084	5.755	*	1.08	6.23
156	200.	50.	300.	100.	65.	0	*	24.295	5.581	*	1.05	6.29
157	60.	10.	600.	100.	65.	0	*	52.811	17.341	*	3.04	3.93
158	100.	10.	600.	100.	65.	0	*	46.147	11.759	*	2.17	3.99
159	150.	10.	600.	100.	65.	0	*	42.791	9.599	*	1.82	4.05
160	200.	10.	600.	100.	65.	0	*	40.839	8.526	*	1.65	4.03

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
161	60.	30.	600.	100.	65.	0	*	39.552	11.591	*	2.08	4.11
162	100.	30.	600.	100.	65.	0	*	36.556	8.730	*	1.63	4.12
163	150.	30.	600.	100.	65.	0	*	35.338	7.817	*	1.49	4.15
164	200.	30.	600.	100.	65.	0	*	34.156	7.232	*	1.39	4.14
165	60.	50.	600.	100.	65.	0	*	36.444	10.064	*	1.82	4.14
166	100.	50.	600.	100.	65.	0	*	34.606	8.149	*	1.53	4.16
167	150.	50.	600.	100.	65.	0	*	33.401	7.266	*	1.39	4.14
168	200.	50.	600.	100.	65.	0	*	33.352	7.026	*	1.36	4.16
169	60.	10.	1000.	100.	65.	0	*	69.452	26.956	*	4.59	3.20
170	100.	10.	1000.	100.	65.	0	*	60.217	16.705	*	3.03	3.24
171	150.	10.	1000.	100.	65.	0	*	54.283	12.239	*	2.32	3.24
172	200.	10.	1000.	100.	65.	0	*	53.250	11.270	*	2.17	3.26
173	60.	30.	1000.	100.	65.	0	*	50.279	15.357	*	2.73	3.29
174	100.	30.	1000.	100.	65.	0	*	48.045	12.130	*	2.24	3.33
175	150.	30.	1000.	100.	65.	0	*	45.453	9.848	*	1.89	3.31
176	200.	30.	1000.	100.	65.	0	*	44.477	9.221	*	1.79	3.34
177	60.	50.	1000.	100.	65.	0	*	47.945	14.753	*	2.62	3.34
178	100.	50.	1000.	100.	65.	0	*	45.366	11.096	*	2.07	3.35
179	150.	50.	1000.	100.	65.	0	*	43.042	9.199	*	1.77	3.34
180	200.	50.	1000.	100.	65.	0	*	43.044	8.868	*	1.72	3.36
181	60.	10.	300.	125.	65.	0	*	31.123	9.818	*	1.73	7.51
182	100.	10.	300.	125.	65.	0	*	27.165	7.184	*	1.31	7.64
183	150.	10.	300.	125.	65.	0	*	25.060	6.149	*	1.14	7.97
184	200.	10.	300.	125.	65.	0	*	24.072	5.753	*	1.08	7.99
185	60.	30.	300.	125.	65.	0	*	22.771	6.935	*	1.23	7.99
186	100.	30.	300.	125.	65.	0	*	21.005	5.713	*	1.04	8.06
187	150.	30.	300.	125.	65.	0	*	20.638	5.274	*	.97	8.10
188	200.	30.	300.	125.	65.	0	*	20.130	5.036	*	.93	8.12
189	60.	50.	300.	125.	65.	0	*	20.912	6.370	*	1.13	8.11
190	100.	50.	300.	125.	65.	0	*	20.015	5.440	*	.99	8.14
191	150.	50.	300.	125.	65.	0	*	19.397	5.023	*	.92	8.15
192	200.	50.	300.	125.	65.	0	*	19.540	4.892	*	.91	8.15
193	60.	10.	600.	125.	65.	0	*	39.721	13.778	*	2.39	5.13
194	100.	10.	600.	125.	65.	0	*	34.819	9.453	*	1.72	5.23
195	150.	10.	600.	125.	65.	0	*	32.732	7.842	*	1.47	5.27
196	200.	10.	600.	125.	65.	0	*	30.834	6.948	*	1.32	5.27
197	60.	30.	600.	125.	65.	0	*	30.191	9.395	*	1.66	5.37
198	100.	30.	600.	125.	65.	0	*	27.940	7.169	*	1.32	5.40
199	150.	30.	600.	125.	65.	0	*	27.112	6.471	*	1.21	5.43
200	200.	30.	600.	125.	65.	0	*	26.135	6.004	*	1.13	5.42

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
201	60.	50.	600.	125.	65.	0	*	27.892	8.212	*	1.47	5.40
202	100.	50.	600.	125.	65.	0	*	26.461	6.743	*	1.24	5.45
203	150.	50.	600.	125.	65.	0	*	25.598	6.024	*	1.13	5.42
204	200.	50.	600.	125.	65.	0	*	25.532	5.848	*	1.11	5.45
205	60.	10.	1000.	125.	65.	0	*	50.957	20.768	*	3.51	4.19
206	100.	10.	1000.	125.	65.	0	*	44.240	12.981	*	2.32	4.25
207	150.	10.	1000.	125.	65.	0	*	39.542	9.520	*	1.78	4.25
208	200.	10.	1000.	125.	65.	0	*	39.247	8.875	*	1.68	4.27
209	60.	30.	1000.	125.	65.	0	*	36.868	11.927	*	2.10	4.32
210	100.	30.	1000.	125.	65.	0	*	35.038	9.114	*	1.67	4.33
211	150.	30.	1000.	125.	65.	0	*	33.607	7.787	*	1.47	4.34
212	200.	30.	1000.	125.	65.	0	*	33.130	7.378	*	1.40	4.38
213	60.	50.	1000.	125.	65.	0	*	34.967	10.821	*	1.92	4.34
214	100.	50.	1000.	125.	65.	0	*	33.161	8.291	*	1.54	4.34
215	150.	50.	1000.	125.	65.	0	*	32.172	7.373	*	1.39	4.38
216	200.	50.	1000.	125.	65.	0	*	31.253	6.849	*	1.31	4.36
217	60.	10.	300.	150.	65.	0	*	26.545	8.795	*	1.54	9.51
218	100.	10.	300.	150.	65.	0	*	23.059	6.457	*	1.17	9.70
219	150.	10.	300.	150.	65.	0	*	21.135	5.517	*	1.01	9.80
220	200.	10.	300.	150.	65.	0	*	20.390	5.193	*	.96	9.99
221	60.	30.	300.	150.	65.	0	*	19.315	6.254	*	1.10	10.19
222	100.	30.	300.	150.	65.	0	*	17.838	5.171	*	.93	10.28
223	150.	30.	300.	150.	65.	0	*	17.374	4.775	*	.87	10.40
224	200.	30.	300.	150.	65.	0	*	17.090	4.580	*	.84	10.43
225	60.	50.	300.	150.	65.	0	*	17.721	5.742	*	1.01	10.35
226	100.	50.	300.	150.	65.	0	*	16.990	4.907	*	.88	10.39
227	150.	50.	300.	150.	65.	0	*	16.672	4.579	*	.83	10.43
228	200.	50.	300.	150.	65.	0	*	16.824	4.473	*	.82	10.48
229	60.	10.	600.	150.	65.	0	*	32.751	12.008	*	2.06	6.53
230	100.	10.	600.	150.	65.	0	*	28.599	8.251	*	1.48	6.64
231	150.	10.	600.	150.	65.	0	*	26.589	6.658	*	1.23	6.62
232	200.	10.	600.	150.	65.	0	*	25.211	6.077	*	1.14	6.70
233	60.	30.	600.	150.	65.	0	*	24.919	8.254	*	1.44	6.87
234	100.	30.	600.	150.	65.	0	*	22.844	6.306	*	1.14	6.89
235	150.	30.	600.	150.	65.	0	*	22.137	5.682	*	1.05	6.93
236	200.	30.	600.	150.	65.	0	*	21.443	5.291	*	.98	6.91
237	60.	50.	600.	150.	65.	0	*	22.885	7.210	*	1.27	6.92
238	100.	50.	600.	150.	65.	0	*	21.773	5.923	*	1.08	6.96
239	150.	50.	600.	150.	65.	0	*	20.867	5.290	*	.98	6.91
240	200.	50.	600.	150.	65.	0	*	20.812	5.150	*	.96	6.96

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING	COAL SEAM THICKNESS	DEPTH TO TOP OF SEAM	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
241	60.	10.	1000.	150.	65.	0	*	41.553	17.833	*	2.99	5.33
242	100.	10.	1000.	150.	65.	0	*	35.925	11.152	*	1.97	5.41
243	150.	10.	1000.	150.	65.	0	*	31.931	8.176	*	1.51	5.42
244	200.	10.	1000.	150.	65.	0	*	31.419	7.588	*	1.42	5.45
245	60.	30.	1000.	150.	65.	0	*	29.712	10.268	*	1.78	5.52
246	100.	30.	1000.	150.	65.	0	*	28.108	7.825	*	1.42	5.53
247	150.	30.	1000.	150.	65.	0	*	26.937	6.698	*	1.24	5.55
248	200.	30.	1000.	150.	65.	0	*	26.321	6.328	*	1.18	5.60
249	60.	50.	1000.	150.	65.	0	*	28.077	9.313	*	1.63	5.55
250	100.	50.	1000.	150.	65.	0	*	26.344	7.077	*	1.29	5.56
251	150.	50.	1000.	150.	65.	0	*	25.422	6.318	*	1.17	5.61
252	200.	50.	1000.	150.	65.	0	*	24.840	5.882	*	1.10	5.58
253	60.	10.	300.	175.	65.	0	*	23.031	7.905	*	1.37	11.59
254	100.	10.	300.	175.	65.	0	*	20.136	5.864	*	1.05	11.83
255	150.	10.	300.	175.	65.	0	*	18.538	5.072	*	.92	12.07
256	200.	10.	300.	175.	65.	0	*	17.982	4.808	*	.88	12.10
257	60.	30.	300.	175.	65.	0	*	17.009	5.719	*	1.00	12.44
258	100.	30.	300.	175.	65.	0	*	15.735	4.768	*	.85	12.55
259	150.	30.	300.	175.	65.	0	*	15.428	4.445	*	.80	12.62
260	200.	30.	300.	175.	65.	0	*	15.104	4.271	*	.77	12.66
261	60.	50.	300.	175.	65.	0	*	15.685	5.294	*	.92	12.63
262	100.	50.	300.	175.	65.	0	*	15.081	4.565	*	.81	12.69
263	150.	50.	300.	175.	65.	0	*	14.703	4.267	*	.77	12.73
264	200.	50.	300.	175.	65.	0	*	14.690	4.160	*	.75	12.71
265	60.	10.	600.	175.	65.	0	*	28.067	10.615	*	1.82	7.94
266	100.	10.	600.	175.	65.	0	*	24.612	7.373	*	1.31	8.08
267	150.	10.	600.	175.	65.	0	*	22.800	6.000	*	1.10	8.06
268	200.	10.	600.	175.	65.	0	*	21.593	5.495	*	1.01	8.19
269	60.	30.	600.	175.	65.	0	*	21.473	7.393	*	1.28	8.37
270	100.	30.	600.	175.	65.	0	*	19.751	5.703	*	1.02	8.39
271	150.	30.	600.	175.	65.	0	*	19.002	5.168	*	.94	8.47
272	200.	30.	600.	175.	65.	0	*	18.523	4.835	*	.89	8.45
273	60.	50.	600.	175.	65.	0	*	19.726	6.497	*	1.14	8.43
274	100.	50.	600.	175.	65.	0	*	18.649	5.376	*	.97	8.51
275	150.	50.	600.	175.	65.	0	*	17.957	4.830	*	.88	8.45
276	200.	50.	600.	175.	65.	0	*	17.808	4.701	*	.86	8.51
277	60.	10.	1000.	175.	65.	0	*	34.930	15.478	*	2.58	6.46
278	100.	10.	1000.	175.	65.	0	*	30.217	9.765	*	1.72	6.56
279	150.	10.	1000.	175.	65.	0	*	26.817	7.215	*	1.32	6.56
280	200.	10.	1000.	175.	65.	0	*	25.923	6.402	*	1.19	6.54

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
281	60.	30.	1000.	175.	65.	0	*	25.214	9.037	*	1.56	6.70
282	100.	30.	1000.	175.	65.	0	*	23.726	6.947	*	1.24	6.72
283	150.	30.	1000.	175.	65.	0	*	22.736	5.970	*	1.09	6.74
284	200.	30.	1000.	175.	65.	0	*	22.419	5.674	*	1.05	6.82
285	60.	50.	1000.	175.	65.	0	*	23.711	8.216	*	1.43	6.74
286	100.	50.	1000.	175.	65.	0	*	22.475	6.316	*	1.14	6.75
287	150.	50.	1000.	175.	65.	0	*	21.549	5.656	*	1.04	6.81
288	200.	50.	1000.	175.	65.	0	*	21.339	5.307	*	.98	6.80
289	60.	10.	300.	100.	80.	0	*	38.376	10.707	*	1.94	5.87
290	100.	10.	300.	100.	80.	0	*	33.410	7.952	*	1.49	5.95
291	150.	10.	300.	100.	80.	0	*	31.865	7.188	*	1.36	6.04
292	200.	10.	300.	100.	80.	0	*	30.009	6.513	*	1.25	6.05
293	60.	30.	300.	100.	80.	0	*	28.015	7.611	*	1.38	6.21
294	100.	30.	300.	100.	80.	0	*	26.026	6.359	*	1.18	6.20
295	150.	30.	300.	100.	80.	0	*	25.313	5.898	*	1.11	6.23
296	200.	30.	300.	100.	80.	0	*	24.951	5.665	*	1.07	6.25
297	60.	50.	300.	100.	80.	0	*	25.715	6.988	*	1.27	6.23
298	100.	50.	300.	100.	80.	0	*	24.599	6.026	*	1.12	6.25
299	150.	50.	300.	100.	80.	0	*	23.972	5.644	*	1.06	6.26
300	200.	50.	300.	100.	80.	0	*	24.198	5.502	*	1.04	6.26
301	60.	10.	600.	100.	80.	0	*	52.187	15.573	*	2.78	3.98
302	100.	10.	600.	100.	80.	0	*	45.702	10.940	*	2.05	4.03
303	150.	10.	600.	100.	80.	0	*	42.303	9.145	*	1.75	4.05
304	200.	10.	600.	100.	80.	0	*	40.527	8.252	*	1.61	4.06
305	60.	30.	600.	100.	80.	0	*	39.186	10.687	*	1.94	4.11
306	100.	30.	600.	100.	80.	0	*	36.372	8.350	*	1.58	4.13
307	150.	30.	600.	100.	80.	0	*	35.205	7.588	*	1.46	4.16
308	200.	30.	600.	100.	80.	0	*	34.027	7.091	*	1.37	4.15
309	60.	50.	600.	100.	80.	0	*	36.178	9.400	*	1.73	4.15
310	100.	50.	600.	100.	80.	0	*	34.471	7.845	*	1.49	4.17
311	150.	50.	600.	100.	80.	0	*	33.241	7.099	*	1.37	4.14
312	200.	50.	600.	100.	80.	0	*	33.206	6.906	*	1.34	4.17
313	60.	10.	1000.	100.	80.	0	*	68.276	23.663	*	4.11	3.23
314	100.	10.	1000.	100.	80.	0	*	59.651	15.253	*	2.81	3.27
315	150.	10.	1000.	100.	80.	0	*	53.845	11.566	*	2.22	3.26
316	200.	10.	1000.	100.	80.	0	*	52.827	10.753	*	2.09	3.28
317	60.	30.	1000.	100.	80.	0	*	49.941	14.013	*	2.53	3.31
318	100.	30.	1000.	100.	80.	0	*	47.816	11.363	*	2.13	3.34
319	150.	30.	1000.	100.	80.	0	*	45.277	9.493	*	1.83	3.32
320	200.	30.	1000.	100.	80.	0	*	44.324	8.953	*	1.75	3.35

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
321	60.	50.	1000.	100.	80.	0	*	47.146	12.748	*	2.32	3.32
322	100.	50.	1000.	100.	80.	0	*	45.142	10.480	*	1.97	3.36
323	150.	50.	1000.	100.	80.	0	*	42.916	8.916	*	1.73	3.35
324	200.	50.	1000.	100.	80.	0	*	42.213	8.405	*	1.65	3.33
325	60.	10.	300.	125.	80.	0	*	38.441	9.952	*	1.60	7.67
326	100.	10.	300.	125.	80.	0	*	26.746	6.773	*	1.25	7.89
327	150.	10.	300.	125.	80.	0	*	24.749	5.927	*	1.11	8.00
328	200.	10.	300.	125.	80.	0	*	23.954	5.616	*	1.06	8.08
329	60.	30.	300.	125.	80.	0	*	22.424	6.490	*	1.17	8.06
330	100.	30.	300.	125.	80.	0	*	20.862	5.496	*	1.01	8.11
331	150.	30.	300.	125.	80.	0	*	20.535	5.158	*	.95	8.15
332	200.	30.	300.	125.	80.	0	*	20.020	4.949	*	.92	8.17
333	60.	50.	300.	125.	80.	0	*	20.600	5.996	*	1.08	8.16
334	100.	50.	300.	125.	80.	0	*	19.894	5.258	*	.96	8.18
335	150.	50.	300.	125.	80.	0	*	19.306	4.932	*	.91	8.19
336	200.	50.	300.	125.	80.	0	*	19.324	4.804	*	.89	8.19
337	60.	10.	600.	125.	80.	0	*	39.293	12.402	*	2.19	5.24
338	100.	10.	600.	125.	80.	0	*	34.431	8.820	*	1.63	5.26
339	150.	10.	600.	125.	80.	0	*	32.415	7.486	*	1.41	5.34
340	200.	10.	600.	125.	80.	0	*	30.510	6.723	*	1.28	5.31
341	60.	30.	600.	125.	80.	0	*	29.596	8.708	*	1.56	5.40
342	100.	30.	600.	125.	80.	0	*	27.810	6.872	*	1.28	5.42
343	150.	30.	600.	125.	80.	0	*	26.965	6.284	*	1.18	5.45
344	200.	30.	600.	125.	80.	0	*	26.035	5.894	*	1.12	5.43
345	60.	50.	600.	125.	80.	0	*	27.744	7.707	*	1.40	5.42
346	100.	50.	600.	125.	80.	0	*	26.316	6.480	*	1.20	5.47
347	150.	50.	600.	125.	80.	0	*	25.471	5.895	*	1.11	5.43
348	200.	50.	600.	125.	80.	0	*	25.455	5.760	*	1.09	5.46
349	60.	10.	1000.	125.	80.	0	*	50.251	18.277	*	3.15	4.24
350	100.	10.	1000.	125.	80.	0	*	43.860	11.887	*	2.16	4.29
351	150.	10.	1000.	125.	80.	0	*	39.253	9.016	*	1.70	4.28
352	200.	10.	1000.	125.	80.	0	*	38.888	8.474	*	1.62	4.30
353	60.	30.	1000.	125.	80.	0	*	36.650	10.923	*	1.95	4.34
354	100.	30.	1000.	125.	80.	0	*	34.881	8.610	*	1.60	4.34
355	150.	30.	1000.	125.	80.	0	*	33.490	7.520	*	1.43	4.35
356	200.	30.	1000.	125.	80.	0	*	32.933	7.161	*	1.37	4.39
357	60.	50.	1000.	125.	80.	0	*	34.799	9.996	*	1.80	4.35
358	100.	50.	1000.	125.	80.	0	*	33.017	7.926	*	1.48	4.35
359	150.	50.	1000.	125.	80.	0	*	32.085	7.150	*	1.36	4.39
360	200.	50.	1000.	125.	80.	0	*	31.168	6.717	*	1.29	4.36

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
361	60.	10.	300.	150.	80.	0	*	26.222	8.073	*	1.43	9.73
362	100.	10.	300.	150.	80.	0	*	22.815	6.113	*	1.12	9.89
363	150.	10.	300.	150.	80.	0	*	20.943	5.338	*	.98	9.97
364	200.	10.	300.	150.	80.	0	*	20.214	5.056	*	.94	10.07
365	60.	30.	300.	150.	80.	0	*	19.165	5.032	*	1.05	10.23
366	100.	30.	300.	150.	80.	0	*	17.674	4.973	*	.96	10.36
367	150.	30.	300.	150.	80.	0	*	17.252	4.662	*	.85	10.41
368	200.	30.	300.	150.	80.	0	*	16.960	4.497	*	.82	10.50
369	60.	50.	300.	150.	80.	0	*	17.603	5.449	*	.97	10.42
370	100.	50.	300.	150.	80.	0	*	16.894	4.769	*	.86	10.45
371	150.	50.	300.	150.	80.	0	*	16.562	4.475	*	.81	10.48
372	200.	50.	300.	150.	80.	0	*	16.727	4.414	*	.81	10.58
373	60.	10.	600.	150.	80.	0	*	32.256	10.808	*	1.89	6.63
374	100.	10.	600.	150.	80.	0	*	28.348	7.707	*	1.40	6.72
375	150.	10.	600.	150.	80.	0	*	26.385	6.398	*	1.19	6.69
376	200.	10.	600.	150.	80.	0	*	25.032	5.895	*	1.11	6.76
377	60.	30.	600.	150.	80.	0	*	24.708	7.643	*	1.35	6.91
378	100.	30.	600.	150.	80.	0	*	22.734	6.035	*	1.10	6.92
379	150.	30.	600.	150.	80.	0	*	22.051	5.526	*	1.02	6.96
380	200.	30.	600.	150.	80.	0	*	21.362	5.197	*	.97	6.94
381	60.	50.	600.	150.	80.	0	*	22.642	6.761	*	1.21	6.95
382	100.	50.	600.	150.	80.	0	*	21.698	5.716	*	1.05	6.98
383	150.	50.	600.	150.	80.	0	*	20.800	5.189	*	.96	6.93
384	200.	50.	600.	150.	80.	0	*	20.710	5.066	*	.94	6.98
385	60.	10.	1000.	150.	80.	0	*	40.926	15.700	*	2.68	5.48
386	100.	10.	1000.	150.	80.	0	*	35.625	10.214	*	1.84	5.47
387	150.	10.	1000.	150.	80.	0	*	31.717	7.747	*	1.44	5.46
388	200.	10.	1000.	150.	80.	0	*	31.229	7.260	*	1.37	5.49
389	60.	30.	1000.	150.	80.	0	*	29.535	9.403	*	1.66	5.55
390	100.	30.	1000.	150.	80.	0	*	27.983	7.401	*	1.35	5.55
391	150.	30.	1000.	150.	80.	0	*	26.846	6.468	*	1.21	5.57
392	200.	30.	1000.	150.	80.	0	*	26.177	6.142	*	1.15	5.62
393	60.	50.	1000.	150.	80.	0	*	27.889	8.590	*	1.52	5.57
394	100.	50.	1000.	150.	80.	0	*	26.185	6.750	*	1.24	5.57
395	150.	50.	1000.	150.	80.	0	*	25.354	6.133	*	1.14	5.62
396	200.	50.	1000.	150.	80.	0	*	24.732	5.760	*	1.08	5.59
397	60.	10.	300.	175.	80.	0	*	22.661	7.262	*	1.28	11.76
398	100.	10.	300.	175.	80.	0	*	19.799	5.572	*	1.01	12.06
399	150.	10.	300.	175.	80.	0	*	18.318	4.911	*	.90	12.16
400	200.	10.	300.	175.	80.	0	*	17.770	4.679	*	.86	12.29

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING	COAL SEAM THICKNESS	DEPTH TO TOP OF SEAM	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
401	60.	30.	300.	175.	80.	0	16.838	5.391	.95	12.45
402	100.	30.	300.	175.	80.	0	15.642	4.621	.83	12.64
403	150.	30.	300.	175.	80.	0	15.356	4.356	.79	12.71
404	200.	30.	300.	175.	80.	0	15.028	4.205	.76	12.74
405	60.	50.	300.	175.	80.	0	15.548	5.023	.88	12.62
406	100.	50.	300.	175.	80.	0	14.961	4.437	.79	12.76
407	150.	50.	300.	175.	80.	0	14.645	4.184	.75	12.79
408	200.	50.	300.	175.	80.	0	14.588	4.103	.74	12.78
409	60.	10.	600.	175.	80.	0	27.642	9.580	1.66	8.07
410	100.	10.	600.	175.	80.	0	24.424	6.915	1.25	8.22
411	150.	10.	600.	175.	80.	0	22.644	5.778	1.07	8.13
412	200.	10.	600.	175.	80.	0	21.463	5.341	.99	8.26
413	60.	30.	600.	175.	80.	0	21.343	6.874	1.21	8.41
414	100.	30.	600.	175.	80.	0	19.658	5.480	.99	8.43
415	150.	30.	600.	175.	80.	0	18.890	5.023	.92	8.48
416	200.	30.	600.	175.	80.	0	18.462	4.753	.87	8.45
417	60.	50.	600.	175.	80.	0	19.627	6.117	1.08	8.46
418	100.	50.	600.	175.	80.	0	18.542	5.185	.94	8.50
419	150.	50.	600.	175.	80.	0	17.908	4.741	.87	8.45
420	200.	50.	600.	175.	80.	0	17.757	4.633	.85	8.53
421	60.	10.	1000.	175.	80.	0	34.550	13.669	2.32	6.54
422	100.	10.	1000.	175.	80.	0	29.980	8.966	1.60	6.62
423	150.	10.	1000.	175.	80.	0	26.622	6.846	1.26	6.62
424	200.	10.	1000.	175.	80.	0	25.720	6.174	1.15	6.59
425	60.	30.	1000.	175.	80.	0	25.062	8.296	1.45	6.74
426	100.	30.	1000.	175.	80.	0	23.616	6.575	1.19	6.74
427	150.	30.	1000.	175.	80.	0	22.655	5.772	1.06	6.76
428	200.	30.	1000.	175.	80.	0	22.350	5.525	1.03	6.82
429	60.	50.	1000.	175.	80.	0	23.519	7.589	1.33	6.77
430	100.	50.	1000.	175.	80.	0	22.350	6.040	1.10	6.77
431	150.	50.	1000.	175.	80.	0	21.486	5.497	1.01	6.83
432	200.	50.	1000.	175.	80.	0	21.225	5.198	.97	6.79
433	60.	10.	300.	100.	50.	10	46.745	16.272	2.82	5.20
434	100.	10.	300.	100.	50.	10	39.449	10.529	1.92	5.33
435	150.	10.	300.	100.	50.	10	36.621	8.715	1.63	5.35
436	200.	10.	300.	100.	50.	10	34.039	7.600	1.45	5.36
437	60.	30.	300.	100.	50.	10	31.474	9.687	1.72	5.48
438	100.	30.	300.	100.	50.	10	29.292	7.561	1.39	5.53
439	150.	30.	300.	100.	50.	10	28.341	6.746	1.26	5.57
440	200.	30.	300.	100.	50.	10	27.743	6.381	1.21	5.59

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
441	60.	50.	300.	100.	50.	10	*	29.128	8.788	*	1.56	5.58
442	100.	50.	300.	100.	50.	10	*	27.579	7.068	*	1.30	5.60
443	150.	50.	300.	100.	50.	10	*	26.836	6.346	*	1.19	5.62
444	200.	50.	300.	100.	50.	10	*	26.240	6.109	*	1.16	5.62
445	60.	10.	600.	100.	50.	10	*	61.843	22.875	*	3.93	3.51
446	100.	10.	600.	100.	50.	10	*	53.492	14.617	*	2.66	3.57
447	150.	10.	600.	100.	50.	10	*	49.747	11.548	*	2.18	3.60
448	200.	10.	600.	100.	50.	10	*	46.804	9.928	*	1.91	3.60
449	60.	30.	600.	100.	50.	10	*	45.187	14.540	*	2.56	3.67
450	100.	30.	600.	100.	50.	10	*	41.515	10.343	*	1.92	3.68
451	150.	30.	600.	100.	50.	10	*	39.919	8.988	*	1.71	3.72
452	200.	30.	600.	100.	50.	10	*	38.858	8.220	*	1.59	3.71
453	60.	50.	600.	100.	50.	10	*	41.398	12.330	*	2.20	3.70
454	100.	50.	600.	100.	50.	10	*	39.121	9.540	*	1.78	3.73
455	150.	50.	600.	100.	50.	10	*	37.785	8.198	*	1.57	3.71
456	200.	50.	600.	100.	50.	10	*	37.536	7.882	*	1.52	3.73
457	60.	10.	1000.	100.	50.	10	*	93.038	37.400	*	6.23	2.86
458	100.	10.	1000.	100.	50.	10	*	71.033	21.778	*	3.87	2.90
459	150.	10.	1000.	100.	50.	10	*	63.766	15.119	*	2.83	2.90
460	200.	10.	1000.	100.	50.	10	*	62.783	13.810	*	2.64	2.92
461	60.	30.	1000.	100.	50.	10	*	58.306	19.930	*	3.47	2.95
462	100.	30.	1000.	100.	50.	10	*	54.978	14.281	*	2.62	2.96
463	150.	30.	1000.	100.	50.	10	*	52.642	11.698	*	2.23	2.97
464	200.	30.	1000.	100.	50.	10	*	51.571	10.845	*	2.09	3.00
465	60.	50.	1000.	100.	50.	10	*	54.820	17.708	*	3.11	2.97
466	100.	50.	1000.	100.	50.	10	*	52.252	13.614	*	2.50	3.01
467	150.	50.	1000.	100.	50.	10	*	49.546	10.809	*	2.07	3.00
468	200.	50.	1000.	100.	50.	10	*	48.837	9.910	*	1.93	2.99
469	60.	10.	300.	125.	50.	10	*	35.461	12.205	*	2.12	6.74
470	100.	10.	300.	125.	50.	10	*	30.493	8.406	*	1.52	6.78
471	150.	10.	300.	125.	50.	10	*	27.873	6.910	*	1.28	6.95
472	200.	10.	300.	125.	50.	10	*	26.832	6.444	*	1.20	7.10
473	60.	30.	300.	125.	50.	10	*	25.047	8.123	*	1.43	7.04
474	100.	30.	300.	125.	50.	10	*	23.227	6.429	*	1.16	7.25
475	150.	30.	300.	125.	50.	10	*	22.733	5.795	*	1.07	7.30
476	200.	30.	300.	125.	50.	10	*	22.315	5.510	*	1.02	7.33
477	60.	50.	300.	125.	50.	10	*	23.194	7.409	*	1.30	7.18
478	100.	50.	300.	125.	50.	10	*	22.049	6.053	*	1.10	7.34
479	150.	50.	300.	125.	50.	10	*	21.205	5.459	*	1.00	7.36
480	200.	50.	300.	125.	50.	10	*	21.314	5.273	*	.98	7.36

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
481	60.	10.	600.	125.	50.	10	*	45.835	17.858	*	3.04	4.59
482	100.	10.	600.	125.	50.	10	*	39.831	11.541	*	2.07	4.66
483	150.	10.	600.	125.	50.	10	*	36.524	8.791	*	1.64	4.65
484	200.	10.	600.	125.	50.	10	*	34.936	7.953	*	1.51	4.67
485	60.	30.	600.	125.	50.	10	*	33.965	11.570	*	2.01	4.82
486	100.	30.	600.	125.	50.	10	*	31.580	8.165	*	1.50	4.78
487	150.	30.	600.	125.	50.	10	*	30.204	7.096	*	1.33	4.79
488	200.	30.	600.	125.	50.	10	*	29.343	6.690	*	1.27	4.85
489	60.	50.	600.	125.	50.	10	*	31.373	9.495	*	1.69	4.80
490	100.	50.	600.	125.	50.	10	*	29.559	7.726	*	1.42	4.89
491	150.	50.	600.	125.	50.	10	*	28.362	6.668	*	1.25	4.87
492	200.	50.	600.	125.	50.	10	*	28.414	6.448	*	1.22	4.89
493	60.	10.	1000.	125.	50.	10	*	59.630	28.123	*	4.66	3.73
494	100.	10.	1000.	125.	50.	10	*	51.269	16.584	*	2.91	3.77
495	150.	10.	1000.	125.	50.	10	*	45.342	11.494	*	2.12	3.75
496	200.	10.	1000.	125.	50.	10	*	43.303	9.788	*	1.86	3.75
497	60.	30.	1000.	125.	50.	10	*	42.038	15.149	*	2.61	3.85
498	100.	30.	1000.	125.	50.	10	*	39.885	10.977	*	1.99	3.86
499	150.	30.	1000.	125.	50.	10	*	37.902	9.017	*	1.69	3.88
500	200.	30.	1000.	125.	50.	10	*	37.533	8.455	*	1.60	3.91
501	60.	50.	1000.	125.	50.	10	*	39.718	13.512	*	2.35	3.88
502	100.	50.	1000.	125.	50.	10	*	37.206	9.695	*	1.78	3.89
503	150.	50.	1000.	125.	50.	10	*	36.115	8.437	*	1.59	3.92
504	200.	50.	1000.	125.	50.	10	*	35.128	7.684	*	1.47	3.90
505	60.	10.	300.	150.	50.	10	*	29.853	10.843	*	1.87	8.33
506	100.	10.	300.	150.	50.	10	*	25.677	7.488	*	1.34	8.55
507	150.	10.	300.	150.	50.	10	*	23.504	6.181	*	1.13	8.78
508	200.	10.	300.	150.	50.	10	*	22.918	5.806	*	1.07	8.89
509	60.	30.	300.	150.	50.	10	*	21.279	7.310	*	1.27	9.05
510	100.	30.	300.	150.	50.	10	*	19.682	5.792	*	1.04	9.32
511	150.	30.	300.	150.	50.	10	*	19.056	5.204	*	.95	9.28
512	200.	30.	300.	150.	50.	10	*	18.758	4.944	*	.91	9.34
513	60.	50.	300.	150.	50.	10	*	19.507	6.621	*	1.15	9.24
514	100.	50.	300.	150.	50.	10	*	18.614	5.430	*	.97	9.35
515	150.	50.	300.	150.	50.	10	*	17.813	4.915	*	.89	9.36
516	200.	50.	300.	150.	50.	10	*	17.966	4.777	*	.87	9.36
517	60.	10.	600.	150.	50.	10	*	37.347	15.422	*	2.60	5.84
518	100.	10.	600.	150.	50.	10	*	32.382	9.992	*	1.77	5.86
519	150.	10.	600.	150.	50.	10	*	29.367	7.561	*	1.39	5.86
520	200.	10.	600.	150.	50.	10	*	28.233	6.869	*	1.28	5.93

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ MM BTU	ENERGY RETURN RATIO
521	60.	30.	600.	150.	50.	10	27.719	10.954	1.73	6.11
522	100.	30.	600.	150.	50.	10	25.546	7.378	1.28	6.09
523	150.	30.	600.	150.	50.	10	24.388	6.156	1.14	6.11
524	200.	30.	600.	150.	50.	10	23.582	5.302	1.08	6.19
525	60.	50.	600.	150.	50.	10	25.391	8.222	1.44	6.10
526	100.	50.	600.	150.	50.	10	23.930	6.725	1.21	6.24
527	150.	50.	600.	150.	50.	10	22.956	5.301	1.07	6.20
528	200.	50.	600.	150.	50.	10	22.970	5.517	1.05	6.24
529	60.	10.	1000.	150.	50.	10	47.991	23.381	3.93	4.74
530	100.	10.	1000.	150.	50.	10	40.710	14.334	2.44	4.79
531	150.	10.	1000.	150.	50.	10	36.182	9.739	1.77	4.80
532	200.	10.	1000.	150.	50.	10	34.013	8.203	1.53	4.79
533	60.	30.	1000.	150.	50.	10	33.456	12.086	2.20	4.94
534	100.	30.	1000.	150.	50.	10	31.431	9.293	1.66	4.96
535	150.	30.	1000.	150.	50.	10	29.738	7.633	1.41	4.97
536	200.	30.	1000.	150.	50.	10	29.579	7.162	1.34	5.02
537	60.	50.	1000.	150.	50.	10	31.414	11.487	1.98	4.98
538	100.	50.	1000.	150.	50.	10	29.315	8.215	1.48	4.99
539	150.	50.	1000.	150.	50.	10	28.214	7.138	1.32	5.03
540	200.	50.	1000.	150.	50.	10	27.596	6.513	1.22	5.01
541	60.	10.	300.	175.	50.	10	25.690	9.650	1.65	10.07
542	100.	10.	300.	175.	50.	10	22.192	6.745	1.20	10.50
543	150.	10.	300.	175.	50.	10	20.373	5.622	1.02	10.62
544	200.	10.	300.	175.	50.	10	19.778	5.283	.96	10.76
545	60.	30.	300.	175.	50.	10	18.481	6.593	1.14	10.95
546	100.	30.	300.	175.	50.	10	17.138	5.292	.94	11.18
547	150.	30.	300.	175.	50.	10	16.676	4.803	.86	11.25
548	200.	30.	300.	175.	50.	10	16.205	4.546	.82	11.20
549	60.	50.	300.	175.	50.	10	17.060	6.035	1.04	11.18
550	100.	50.	300.	175.	50.	10	16.271	5.000	.89	11.34
551	150.	50.	300.	175.	50.	10	15.669	4.559	.82	11.36
552	200.	50.	300.	175.	50.	10	16.007	4.437	.80	11.39
553	60.	10.	600.	175.	50.	10	31.607	13.474	2.26	7.06
554	100.	10.	600.	175.	50.	10	27.491	8.823	1.55	7.12
555	150.	10.	600.	175.	50.	10	24.961	6.741	1.23	7.16
556	200.	10.	600.	175.	50.	10	23.882	6.134	1.13	7.22
557	60.	30.	600.	175.	50.	10	23.608	8.900	1.52	7.48
558	100.	30.	600.	175.	50.	10	21.742	6.335	1.14	7.42
559	150.	30.	600.	175.	50.	10	20.627	5.509	1.01	7.45
560	200.	30.	600.	175.	50.	10	20.214	5.247	.96	7.55

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
601	60.	10.	1000.	100.	65.	10	80.702	31.038	5.29	2.90
602	100.	10.	1000.	100.	65.	10	69.777	19.072	3.46	2.93
603	150.	10.	1000.	100.	65.	10	62.736	13.842	2.64	2.92
604	200.	10.	1000.	100.	65.	10	61.550	12.728	2.47	2.93
605	60.	30.	1000.	100.	65.	10	57.346	17.306	3.08	2.96
606	100.	30.	1000.	100.	65.	10	54.567	15.871	2.45	2.97
607	150.	30.	1000.	100.	65.	10	52.309	11.034	2.13	2.98
608	200.	30.	1000.	100.	65.	10	51.165	10.307	2.01	3.01
609	60.	50.	1000.	100.	65.	10	54.343	15.673	2.82	2.98
610	100.	50.	1000.	100.	65.	10	51.091	11.689	2.21	2.98
611	150.	50.	1000.	100.	65.	10	49.239	10.259	1.99	3.01
612	200.	50.	1000.	100.	65.	10	48.635	9.550	1.88	2.99
613	60.	10.	300.	125.	65.	10	34.207	10.676	1.89	6.70
614	100.	10.	300.	125.	65.	10	29.699	7.702	1.41	7.03
615	150.	10.	300.	125.	65.	10	27.470	6.551	1.23	7.01
616	200.	10.	300.	125.	65.	10	26.409	6.128	1.15	7.09
617	60.	30.	300.	125.	65.	10	24.711	7.405	1.32	7.14
618	100.	30.	300.	125.	65.	10	23.018	6.063	1.11	7.32
619	150.	30.	300.	125.	65.	10	22.293	5.569	1.03	7.36
620	200.	30.	300.	125.	65.	10	22.160	5.333	1.00	7.39
621	60.	50.	300.	125.	65.	10	22.746	6.775	1.21	7.26
622	100.	50.	300.	125.	65.	10	21.890	5.750	1.05	7.39
623	150.	50.	300.	125.	65.	10	21.065	5.299	.98	7.40
624	200.	50.	300.	125.	65.	10	21.188	5.131	.96	7.40
625	60.	10.	600.	125.	65.	10	44.642	15.311	2.66	4.65
626	100.	10.	600.	125.	65.	10	39.134	10.414	1.90	4.68
627	150.	10.	600.	125.	65.	10	36.001	8.244	1.56	4.69
628	200.	10.	600.	125.	65.	10	34.180	7.510	1.43	4.74
629	60.	30.	600.	125.	65.	10	33.624	10.319	1.83	4.84
630	100.	30.	600.	125.	65.	10	31.238	7.638	1.42	4.80
631	150.	30.	600.	125.	65.	10	29.930	6.813	1.29	4.82
632	200.	30.	600.	125.	65.	10	29.107	6.461	1.23	4.88
633	60.	50.	600.	125.	65.	10	31.022	8.655	1.57	4.81
634	100.	50.	600.	125.	65.	10	29.381	7.278	1.35	4.91
635	150.	50.	600.	125.	65.	10	28.222	6.452	1.22	4.88
636	200.	50.	600.	125.	65.	10	28.287	6.273	1.20	4.91
637	60.	10.	1000.	125.	65.	10	58.014	23.526	3.98	3.75
638	100.	10.	1000.	125.	65.	10	50.245	14.535	2.61	3.82
639	150.	10.	1000.	125.	65.	10	44.734	10.547	1.98	3.81
640	200.	10.	1000.	125.	65.	10	42.766	9.185	1.76	3.79

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
561	60.	50.	600.	175.	50.	10	*	21.545	7.304	*	1.27	7.47
562	100.	50.	600.	175.	50.	10	*	20.617	6.058	*	1.08	7.63
563	150.	50.	600.	175.	50.	10	*	19.626	5.245	*	.96	7.56
564	200.	50.	600.	175.	50.	10	*	19.572	5.002	*	.93	7.61
565	60.	10.	1000.	175.	50.	10	*	39.961	20.545	*	3.36	5.71
566	100.	10.	1000.	175.	50.	10	*	34.035	12.166	*	2.10	5.82
567	150.	10.	1000.	175.	50.	10	*	30.138	8.497	*	1.53	5.84
568	200.	10.	1000.	175.	50.	10	*	28.354	7.195	*	1.33	5.83
569	60.	30.	1000.	175.	50.	10	*	27.923	11.197	*	1.90	6.00
570	100.	30.	1000.	175.	50.	10	*	26.398	8.150	*	1.44	6.02
571	150.	30.	1000.	175.	50.	10	*	24.945	6.737	*	1.23	6.06
572	200.	30.	1000.	175.	50.	10	*	24.672	6.327	*	1.17	6.12
573	60.	50.	1000.	175.	50.	10	*	26.405	10.026	*	1.71	6.05
574	100.	50.	1000.	175.	50.	10	*	24.630	7.248	*	1.30	6.06
575	150.	50.	1000.	175.	50.	10	*	23.762	6.326	*	1.16	6.14
576	200.	50.	1000.	175.	50.	10	*	23.095	5.781	*	1.07	6.10
577	60.	10.	300.	100.	65.	10	*	43.603	12.938	*	2.31	5.29
578	100.	10.	300.	100.	65.	10	*	37.587	9.193	*	1.71	5.31
579	150.	10.	300.	100.	65.	10	*	36.068	8.169	*	1.55	5.40
580	200.	10.	300.	100.	65.	10	*	33.614	7.226	*	1.39	5.46
581	60.	30.	300.	100.	65.	10	*	31.081	8.793	*	1.59	5.54
582	100.	30.	300.	100.	65.	10	*	29.023	7.106	*	1.32	5.58
583	150.	30.	300.	100.	65.	10	*	28.107	6.488	*	1.22	5.61
584	200.	30.	300.	100.	65.	10	*	27.528	6.161	*	1.17	5.63
585	60.	50.	300.	100.	65.	10	*	28.489	8.005	*	1.45	5.62
586	100.	50.	300.	100.	65.	10	*	27.231	6.700	*	1.25	5.64
587	150.	50.	300.	100.	65.	10	*	26.662	6.154	*	1.16	5.65
588	200.	50.	300.	100.	65.	10	*	26.680	5.935	*	1.13	5.65
589	60.	10.	600.	100.	65.	10	*	60.456	19.586	*	3.44	3.56
590	100.	10.	600.	100.	65.	10	*	52.562	13.155	*	2.44	3.58
591	150.	10.	600.	100.	65.	10	*	48.080	10.285	*	1.98	3.57
592	200.	10.	600.	100.	65.	10	*	46.224	9.404	*	1.83	3.62
593	60.	30.	600.	100.	65.	10	*	44.705	12.921	*	2.32	3.70
594	100.	30.	600.	100.	65.	10	*	41.193	9.646	*	1.81	3.71
595	150.	30.	600.	100.	65.	10	*	39.817	8.378	*	1.62	3.67
596	200.	30.	600.	100.	65.	10	*	38.438	7.900	*	1.53	3.72
597	60.	50.	600.	100.	65.	10	*	41.045	11.153	*	2.03	3.72
598	100.	50.	600.	100.	65.	10	*	38.820	8.962	*	1.69	3.74
599	150.	50.	600.	100.	65.	10	*	37.600	7.923	*	1.53	3.71
600	200.	50.	600.	100.	65.	10	*	37.368	7.650	*	1.49	3.75

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
641	60.	30.	1000.	125.	65.	10	*	41.608	13.298	*	2.34	3.88
642	100.	30.	1000.	125.	65.	10	*	39.483	10.037	*	1.85	3.89
643	150.	30.	1000.	125.	65.	10	*	37.662	8.522	*	1.62	3.90
644	200.	30.	1000.	125.	65.	10	*	37.408	8.090	*	1.55	3.94
645	60.	50.	1000.	125.	65.	10	*	39.483	12.028	*	2.14	3.91
646	100.	50.	1000.	125.	65.	10	*	36.910	9.004	*	1.68	3.90
647	150.	50.	1000.	125.	65.	10	*	35.939	8.041	*	1.53	3.94
648	200.	50.	1000.	125.	65.	10	*	34.969	7.434	*	1.43	3.91
649	60.	10.	300.	150.	65.	10	*	29.340	9.549	*	1.68	8.76
650	100.	10.	300.	150.	65.	10	*	25.280	6.915	*	1.26	8.72
651	150.	10.	300.	150.	65.	10	*	23.147	5.862	*	1.08	8.88
652	200.	10.	300.	150.	65.	10	*	22.362	5.503	*	1.02	8.98
653	60.	30.	300.	150.	65.	10	*	20.804	6.627	*	1.17	9.18
654	100.	30.	300.	150.	65.	10	*	19.397	5.438	*	.98	9.27
655	150.	30.	300.	150.	65.	10	*	18.862	5.014	*	.92	9.37
656	200.	30.	300.	150.	65.	10	*	18.371	4.782	*	.88	9.40
657	60.	50.	300.	150.	65.	10	*	19.307	6.189	*	1.08	9.33
658	100.	50.	300.	150.	65.	10	*	18.492	5.171	*	.93	9.37
659	150.	50.	300.	150.	65.	10	*	17.651	4.765	*	.87	9.43
660	200.	50.	300.	150.	65.	10	*	17.850	4.651	*	.85	9.43
661	60.	10.	600.	150.	65.	10	*	36.318	13.241	*	2.28	5.84
662	100.	10.	600.	150.	65.	10	*	31.772	8.994	*	1.62	5.94
663	150.	10.	600.	150.	65.	10	*	28.804	7.075	*	1.32	5.96
664	200.	10.	600.	150.	65.	10	*	27.889	6.525	*	1.23	6.03
665	60.	30.	600.	150.	65.	10	*	27.434	8.972	*	1.57	6.16
666	100.	30.	600.	150.	65.	10	*	25.264	6.621	*	1.21	6.11
667	150.	30.	600.	150.	65.	10	*	24.055	5.890	*	1.10	6.15
668	200.	30.	600.	150.	65.	10	*	23.442	5.617	*	1.05	6.23
669	60.	50.	600.	150.	65.	10	*	25.016	7.481	*	1.33	6.14
670	100.	50.	600.	150.	65.	10	*	23.741	6.328	*	1.16	6.27
671	150.	50.	600.	150.	65.	10	*	22.801	5.610	*	1.04	6.23
672	200.	50.	600.	150.	65.	10	*	22.864	5.467	*	1.02	6.27
673	60.	10.	1000.	150.	65.	10	*	46.483	19.937	*	3.34	4.80
674	100.	10.	1000.	150.	65.	10	*	40.128	12.320	*	2.19	4.87
675	150.	10.	1000.	150.	65.	10	*	35.500	8.920	*	1.65	4.88
676	200.	10.	1000.	150.	65.	10	*	33.434	7.687	*	1.45	4.86
677	60.	30.	1000.	150.	65.	10	*	33.125	11.311	*	1.97	4.97
678	100.	30.	1000.	150.	65.	10	*	31.215	8.514	*	1.55	4.98
679	150.	30.	1000.	150.	65.	10	*	29.566	7.212	*	1.34	5.00
680	200.	30.	1000.	150.	65.	10	*	29.432	6.839	*	1.29	5.04

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* * *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* * *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
681	60.	50.	1000.	150.	65.	10	*	31.174	10.203	*	1.79	5.00
682	100.	50.	1000.	150.	65.	10	*	29.162	7.644	*	1.40	5.01
683	150.	50.	1000.	150.	65.	10	*	28.091	6.801	*	1.27	5.05
684	200.	50.	1000.	150.	65.	10	*	27.491	6.381	*	1.19	5.02
685	60.	10.	300.	175.	65.	10	*	25.106	8.513	*	1.48	10.33
686	100.	10.	300.	175.	65.	10	*	21.713	6.230	*	1.12	10.54
687	150.	10.	300.	175.	65.	10	*	20.059	5.344	*	.98	10.76
688	200.	10.	300.	175.	65.	10	*	19.502	5.055	*	.93	10.89
689	60.	30.	300.	175.	65.	10	*	18.256	6.045	*	1.06	11.12
690	100.	30.	300.	175.	65.	10	*	16.937	5.004	*	.89	11.31
691	150.	30.	300.	175.	65.	10	*	16.499	4.635	*	.84	11.38
692	200.	30.	300.	175.	65.	10	*	16.003	4.416	*	.80	11.32
693	60.	50.	300.	175.	65.	10	*	16.831	5.574	*	.98	11.31
694	100.	50.	300.	175.	65.	10	*	16.108	4.762	*	.85	11.44
695	150.	50.	300.	175.	65.	10	*	15.522	4.425	*	.80	11.46
696	200.	50.	300.	175.	65.	10	*	15.875	4.326	*	.79	11.48
697	60.	10.	600.	175.	65.	10	*	30.898	11.618	*	1.99	7.15
698	100.	10.	600.	175.	65.	10	*	27.012	7.970	*	1.43	7.28
699	150.	10.	600.	175.	65.	10	*	24.314	6.295	*	1.16	7.26
700	200.	10.	600.	175.	65.	10	*	23.605	5.840	*	1.08	7.34
701	60.	30.	600.	175.	65.	10	*	23.376	7.969	*	1.39	7.54
702	100.	30.	600.	175.	65.	10	*	21.422	5.925	*	1.07	7.47
703	150.	30.	600.	175.	65.	10	*	20.498	5.313	*	.98	7.50
704	200.	30.	600.	175.	65.	10	*	20.103	5.091	*	.94	7.59
705	60.	50.	600.	175.	65.	10	*	21.304	6.687	*	1.18	7.51
706	100.	50.	600.	175.	65.	10	*	20.439	5.708	*	1.03	7.65
707	150.	50.	600.	175.	65.	10	*	19.495	5.000	*	.93	7.60
708	200.	50.	600.	175.	65.	10	*	19.487	4.953	*	.91	7.64
709	60.	10.	1000.	175.	65.	10	*	39.052	17.203	*	2.88	5.82
710	100.	10.	1000.	175.	65.	10	*	32.980	10.023	*	1.78	5.81
711	150.	10.	1000.	175.	65.	10	*	29.758	7.819	*	1.43	5.92
712	200.	10.	1000.	175.	65.	10	*	27.935	6.766	*	1.26	5.90
713	60.	30.	1000.	175.	65.	10	*	27.647	9.855	*	1.70	6.04
714	100.	30.	1000.	175.	65.	10	*	26.214	7.487	*	1.35	6.06
715	150.	30.	1000.	175.	65.	10	*	24.804	6.377	*	1.17	6.08
716	200.	30.	1000.	175.	65.	10	*	24.550	6.049	*	1.12	6.13
717	60.	50.	1000.	175.	65.	10	*	26.200	8.931	*	1.55	6.08
718	100.	50.	1000.	175.	65.	10	*	24.424	6.743	*	1.22	6.09
719	150.	50.	1000.	175.	65.	10	*	23.663	6.038	*	1.11	6.14
720	200.	50.	1000.	175.	65.	10	*	23.069	5.599	*	1.04	6.11

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
721	60.	10.	300.	100.	80.	10	*	42.922	11.787	*	2.14	5.32
722	100.	10.	300.	100.	80.	10	*	37.209	8.653	*	1.63	5.38
723	150.	10.	300.	100.	80.	10	*	34.149	7.417	*	1.42	5.42
724	200.	10.	300.	100.	80.	10	*	33.276	7.012	*	1.35	5.48
725	60.	30.	300.	100.	80.	10	*	30.841	8.225	*	1.50	5.57
726	100.	30.	300.	100.	90.	10	*	28.481	6.795	*	1.27	5.61
727	150.	30.	300.	100.	80.	10	*	27.819	6.302	*	1.19	5.64
728	200.	30.	300.	100.	80.	10	*	27.235	6.021	*	1.15	5.66
729	60.	50.	300.	100.	80.	10	*	28.301	7.541	*	1.38	5.64
730	100.	50.	300.	100.	80.	10	*	27.081	6.453	*	1.21	5.66
731	150.	50.	300.	100.	80.	10	*	26.429	6.010	*	1.14	5.67
732	200.	50.	300.	100.	80.	10	*	26.562	5.951	*	1.12	5.66
733	60.	10.	600.	100.	80.	10	*	59.204	17.514	*	3.13	3.58
734	100.	10.	600.	100.	80.	10	*	52.113	12.217	*	2.30	3.63
735	150.	10.	600.	100.	80.	10	*	47.652	9.839	*	1.91	3.60
736	200.	10.	600.	100.	80.	10	*	45.659	9.062	*	1.78	3.64
737	60.	30.	600.	100.	80.	10	*	44.315	11.890	*	2.17	3.71
738	100.	30.	600.	100.	80.	10	*	40.980	9.187	*	1.75	3.72
739	150.	30.	600.	100.	80.	10	*	39.647	8.162	*	1.59	3.68
740	200.	30.	600.	100.	80.	10	*	38.286	7.738	*	1.51	3.73
741	60.	50.	600.	100.	80.	10	*	40.947	10.094	*	1.88	3.69
742	100.	50.	600.	100.	80.	10	*	38.658	8.592	*	1.64	3.75
743	150.	50.	600.	100.	80.	10	*	37.328	7.720	*	1.50	3.72
744	200.	50.	600.	100.	80.	10	*	37.209	7.512	*	1.47	3.75
745	60.	10.	1000.	100.	80.	10	*	79.481	27.231	*	4.74	2.92
746	100.	10.	1000.	100.	80.	10	*	68.900	17.373	*	3.21	2.94
747	150.	10.	1000.	100.	80.	10	*	62.066	13.049	*	2.52	2.93
748	200.	10.	1000.	100.	80.	10	*	61.070	12.123	*	2.38	2.95
749	60.	30.	1000.	100.	80.	10	*	56.974	15.766	*	2.86	2.98
750	100.	30.	1000.	100.	80.	10	*	54.273	12.276	*	2.33	2.98
751	150.	30.	1000.	100.	80.	10	*	51.857	10.546	*	2.05	2.99
752	200.	30.	1000.	100.	80.	10	*	50.981	9.998	*	1.97	3.01
753	60.	50.	1000.	100.	80.	10	*	53.784	14.293	*	2.61	2.99
754	100.	50.	1000.	100.	80.	10	*	50.874	11.099	*	2.12	2.99
755	150.	50.	1000.	100.	80.	10	*	49.891	9.930	*	1.94	3.01
756	200.	50.	1000.	100.	80.	10	*	48.305	9.302	*	1.84	2.99
757	60.	10.	300.	125.	80.	10	*	33.682	9.753	*	1.75	6.83
758	100.	10.	300.	125.	80.	10	*	29.305	7.265	*	1.35	7.06
759	150.	10.	300.	125.	80.	10	*	26.978	6.284	*	1.18	6.98
760	200.	10.	300.	125.	80.	10	*	26.170	5.954	*	1.13	7.19

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
761	60.	30.	300.	125.	80.	10	*	24.503	6.950	*	1.25	7.21
762	100.	30.	300.	125.	80.	10	*	22.885	5.845	*	1.08	7.26
763	150.	30.	300.	125.	80.	10	*	22.478	5.460	*	1.02	7.30
764	200.	30.	300.	125.	80.	10	*	21.724	5.183	*	.97	7.36
765	60.	50.	300.	125.	80.	10	*	22.581	6.405	*	1.15	7.30
766	100.	50.	300.	125.	80.	10	*	21.645	5.543	*	1.02	7.33
767	150.	50.	300.	125.	80.	10	*	21.017	5.196	*	.96	7.34
768	200.	50.	300.	125.	80.	10	*	21.095	5.062	*	.95	7.43
769	60.	10.	600.	125.	80.	10	*	43.892	13.745	*	2.43	4.68
770	100.	10.	600.	125.	80.	10	*	38.501	9.678	*	1.79	4.73
771	150.	10.	600.	125.	80.	10	*	35.536	7.878	*	1.50	4.71
772	200.	10.	600.	125.	80.	10	*	33.920	7.270	*	1.40	4.78
773	60.	30.	600.	125.	80.	10	*	33.402	9.536	*	1.72	4.86
774	100.	30.	600.	125.	80.	10	*	31.073	7.333	*	1.38	4.81
775	150.	30.	600.	125.	80.	10	*	29.811	6.647	*	1.26	4.84
776	200.	30.	600.	125.	80.	10	*	28.998	6.339	*	1.21	4.89
777	60.	50.	600.	125.	80.	10	*	30.848	8.144	*	1.49	4.83
778	100.	50.	600.	125.	80.	10	*	29.235	6.996	*	1.31	4.91
779	150.	50.	500.	125.	80.	10	*	28.080	6.307	*	1.20	4.89
780	200.	50.	500.	125.	80.	10	*	28.202	6.174	*	1.18	4.92
781	60.	10.	1000.	125.	80.	10	*	56.993	20.629	*	3.55	3.80
782	100.	10.	1000.	125.	80.	10	*	49.584	13.260	*	2.42	3.84
783	150.	10.	1000.	125.	80.	10	*	44.375	9.962	*	1.89	3.84
784	200.	10.	1000.	125.	80.	10	*	42.422	8.830	*	1.71	3.82
785	60.	30.	1000.	125.	80.	10	*	41.274	12.128	*	2.17	3.90
786	100.	30.	1000.	125.	80.	10	*	39.409	9.494	*	1.77	3.91
787	150.	30.	1000.	125.	80.	10	*	37.510	8.214	*	1.57	3.91
788	200.	30.	1000.	125.	80.	10	*	37.092	7.823	*	1.51	3.94
789	60.	50.	1000.	125.	80.	10	*	39.205	11.060	*	2.00	3.91
790	100.	50.	1000.	125.	80.	10	*	36.772	8.592	*	1.62	3.91
791	150.	50.	1000.	125.	80.	10	*	35.830	7.793	*	1.49	3.95
792	200.	50.	1000.	125.	80.	10	*	34.867	7.284	*	1.41	3.92
793	60.	10.	300.	150.	80.	10	*	28.417	8.669	*	1.54	8.75
794	100.	10.	300.	150.	80.	10	*	24.708	6.483	*	1.19	8.89
795	150.	10.	300.	150.	80.	10	*	22.932	5.661	*	1.05	8.96
796	200.	10.	300.	150.	80.	10	*	22.162	5.351	*	1.00	9.12
797	60.	30.	300.	150.	80.	10	*	20.586	6.216	*	1.11	9.26
798	100.	30.	300.	150.	80.	10	*	19.274	5.252	*	.95	9.33
799	150.	30.	300.	150.	80.	10	*	18.778	4.908	*	.90	9.38
800	200.	30.	300.	150.	80.	10	*	18.274	4.699	*	.86	9.45

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
801	60.	50.	300.	150.	80.	10	*	19.134	5.770	*	1.03	9.39
802	100.	50.	300.	150.	80.	10	*	18.118	4.992	*	.91	9.41
803	150.	50.	300.	150.	80.	10	*	17.587	4.677	*	.85	9.43
804	200.	50.	300.	150.	80.	10	*	17.640	4.563	*	.84	9.47
805	60.	10.	600.	150.	80.	10	*	35.894	11.892	*	2.08	5.94
806	100.	10.	600.	150.	80.	10	*	31.471	8.376	*	1.53	6.02
807	150.	10.	600.	150.	80.	10	*	28.439	6.763	*	1.27	5.99
808	200.	10.	600.	150.	80.	10	*	27.719	6.324	*	1.20	6.11
809	60.	30.	600.	150.	80.	10	*	27.193	8.282	*	1.47	6.20
810	100.	30.	600.	150.	80.	10	*	25.127	6.360	*	1.17	6.14
811	150.	30.	600.	150.	80.	10	*	23.964	5.745	*	1.07	6.15
812	200.	30.	600.	150.	80.	10	*	23.350	5.510	*	1.03	6.25
813	60.	50.	600.	150.	80.	10	*	24.879	7.643	*	1.27	6.16
814	100.	50.	600.	150.	80.	10	*	23.654	6.090	*	1.12	6.26
815	150.	50.	600.	150.	80.	10	*	22.741	5.495	*	1.03	6.22
816	200.	50.	600.	150.	80.	10	*	22.756	5.373	*	1.01	6.29
817	60.	10.	1000.	150.	80.	10	*	45.952	17.518	*	2.99	4.86
818	100.	10.	1000.	150.	80.	10	*	39.776	11.250	*	2.03	4.92
819	150.	10.	1000.	150.	80.	10	*	35.034	8.399	*	1.57	4.91
820	200.	10.	1000.	150.	80.	10	*	33.218	7.395	*	1.41	4.89
821	60.	30.	1000.	150.	80.	10	*	32.812	10.305	*	1.82	4.98
822	100.	30.	1000.	150.	80.	10	*	31.074	8.033	*	1.48	4.99
823	150.	30.	1000.	150.	80.	10	*	29.377	6.932	*	1.30	5.00
824	200.	30.	1000.	150.	80.	10	*	29.273	6.631	*	1.26	5.06
825	60.	50.	1000.	150.	80.	10	*	30.938	9.377	*	1.67	5.01
826	100.	50.	1000.	150.	80.	10	*	29.063	7.294	*	1.35	5.01
827	150.	50.	1000.	150.	80.	10	*	27.966	6.579	*	1.24	5.06
828	200.	50.	1000.	150.	80.	10	*	27.421	6.176	*	1.17	5.03
829	60.	10.	300.	175.	80.	10	*	24.798	7.814	*	1.38	10.59
830	100.	10.	300.	175.	80.	10	*	21.482	5.901	*	1.07	10.76
831	150.	10.	300.	175.	80.	10	*	19.807	5.157	*	.95	10.86
832	200.	10.	300.	175.	80.	10	*	19.267	4.912	*	.91	11.07
833	60.	30.	300.	175.	80.	10	*	18.062	5.685	*	1.00	11.23
834	100.	30.	300.	175.	80.	10	*	16.787	4.829	*	.87	11.32
835	150.	30.	300.	175.	80.	10	*	16.381	4.525	*	.82	11.38
836	200.	30.	300.	175.	80.	10	*	15.997	4.348	*	.79	11.39
837	60.	50.	300.	175.	80.	10	*	16.720	5.290	*	.93	11.39
838	100.	50.	300.	175.	80.	10	*	16.032	4.629	*	.83	11.43
839	150.	50.	300.	175.	80.	10	*	15.426	4.338	*	.78	11.44
840	200.	50.	300.	175.	80.	10	*	15.772	4.266	*	.78	11.53

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING	COAL SEAM THICKNESS	DEPTH TO TOP OF SEAM	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
	IN FT.	IN FT.	IN FT.									

841	50.	10.	500.	175.	80.	10	*	30.560	10.464	*	1.82	7.27
842	100.	10.	500.	175.	80.	10	*	26.779	7.441	*	1.35	7.37
843	150.	10.	600.	175.	80.	10	*	24.128	6.048	*	1.12	7.34
844	200.	10.	600.	175.	80.	10	*	23.437	5.664	*	1.06	7.42
845	50.	30.	500.	175.	80.	10	*	23.232	7.387	*	1.30	7.58
846	100.	30.	500.	175.	80.	10	*	21.254	5.689	*	1.04	7.51
847	150.	30.	500.	175.	80.	10	*	20.421	5.191	*	.96	7.53
848	200.	30.	500.	175.	80.	10	*	20.030	5.000	*	.93	7.62
849	50.	50.	500.	175.	80.	10	*	21.196	6.309	*	1.13	7.54
850	100.	50.	500.	175.	80.	10	*	20.106	5.485	*	1.00	7.67
851	150.	50.	500.	175.	80.	10	*	19.437	4.973	*	.92	7.62
852	200.	50.	500.	175.	80.	10	*	19.391	4.872	*	.90	7.67
853	50.	10.	1000.	175.	80.	10	*	38.615	15.149	*	2.58	5.90
854	100.	10.	1000.	175.	80.	10	*	32.692	9.227	*	1.66	5.87
855	150.	10.	1000.	175.	80.	10	*	29.431	7.384	*	1.37	5.97
856	200.	10.	1000.	175.	80.	10	*	27.755	6.518	*	1.22	5.94
857	50.	30.	1000.	175.	80.	10	*	27.416	9.003	*	1.58	6.07
858	100.	30.	1000.	175.	80.	10	*	26.097	7.079	*	1.29	6.08
859	150.	30.	1000.	175.	80.	10	*	24.656	6.141	*	1.14	6.10
860	200.	30.	1000.	175.	80.	10	*	24.468	5.882	*	1.10	6.15
861	50.	50.	1000.	175.	80.	10	*	26.071	8.244	*	1.45	6.10
862	100.	50.	1000.	175.	80.	10	*	24.338	6.445	*	1.18	6.10
863	150.	50.	1000.	175.	80.	10	*	23.597	5.859	*	1.09	6.16
864	200.	50.	1000.	175.	80.	10	*	22.948	5.492	*	1.03	6.12
865	50.	10.	300.	100.	50.	20	*	51.271	16.689	*	2.93	4.58
866	100.	10.	300.	100.	50.	20	*	44.839	11.762	*	2.16	4.64
867	150.	10.	300.	100.	50.	20	*	41.617	9.655	*	1.82	4.70
868	200.	10.	300.	100.	50.	20	*	38.656	8.364	*	1.60	4.72
869	50.	30.	300.	100.	50.	20	*	35.571	10.740	*	1.91	4.84
870	100.	30.	300.	100.	50.	20	*	32.871	8.275	*	1.53	4.89
871	150.	30.	300.	100.	50.	20	*	31.878	7.346	*	1.39	4.91
872	200.	30.	300.	100.	50.	20	*	31.425	6.943	*	1.32	4.94
873	50.	50.	300.	100.	50.	20	*	32.637	9.676	*	1.73	4.93
874	100.	50.	300.	100.	50.	20	*	31.015	7.711	*	1.43	4.95
875	150.	50.	300.	100.	50.	20	*	29.841	6.863	*	1.30	4.96
876	200.	50.	300.	100.	50.	20	*	29.919	6.590	*	1.26	4.96
877	50.	10.	600.	100.	50.	20	*	73.192	26.610	*	4.58	3.15
878	100.	10.	600.	100.	50.	20	*	62.954	16.856	*	3.08	3.18
879	150.	10.	600.	100.	50.	20	*	56.987	12.513	*	2.39	3.17
880	200.	10.	600.	100.	50.	20	*	54.543	11.245	*	2.18	3.21

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
881	60.	30.	600.	100.	50.	20	*	52.082	15.491	*	2.77	3.23
882	100.	30.	600.	100.	50.	20	*	48.172	11.343	*	2.13	3.23
883	150.	30.	600.	100.	50.	20	*	45.919	9.744	*	1.88	3.26
884	200.	30.	600.	100.	50.	20	*	44.926	9.189	*	1.79	3.30
885	60.	50.	600.	100.	50.	20	*	47.933	13.386	*	2.42	3.27
886	100.	50.	600.	100.	50.	20	*	45.300	10.278	*	1.95	3.25
887	150.	50.	600.	100.	50.	20	*	43.390	9.152	*	1.77	3.31
888	200.	50.	600.	100.	50.	20	*	43.284	8.790	*	1.71	3.33
889	60.	10.	1000.	100.	50.	20	*	100.04	44.545	*	7.43	2.55
890	100.	10.	1000.	100.	50.	20	*	85.254	25.824	*	4.59	2.58
891	150.	10.	1000.	100.	50.	20	*	75.780	17.640	*	3.32	2.58
892	200.	10.	1000.	100.	50.	20	*	74.640	16.056	*	3.08	2.59
893	60.	30.	1000.	100.	50.	20	*	69.059	23.366	*	4.07	2.62
894	100.	30.	1000.	100.	50.	20	*	64.917	16.572	*	3.06	2.63
895	150.	30.	1000.	100.	50.	20	*	61.786	13.444	*	2.57	2.64
896	200.	30.	1000.	100.	50.	20	*	60.488	12.423	*	2.41	2.66
897	60.	50.	1000.	100.	50.	20	*	64.671	20.668	*	3.64	2.64
898	100.	50.	1000.	100.	50.	20	*	60.440	14.497	*	2.71	2.64
899	150.	50.	1000.	100.	50.	20	*	58.380	12.401	*	2.39	2.67
900	200.	50.	1000.	100.	50.	20	*	57.346	11.303	*	2.22	2.65
901	60.	10.	300.	125.	50.	20	*	39.549	13.532	*	2.35	5.93
902	100.	10.	300.	125.	50.	20	*	33.929	9.172	*	1.67	6.05
903	150.	10.	300.	125.	50.	20	*	31.217	7.516	*	1.40	6.11
904	200.	10.	300.	125.	50.	20	*	30.119	6.978	*	1.32	6.19
905	60.	30.	300.	125.	50.	20	*	27.874	8.898	*	1.57	6.34
906	100.	30.	300.	125.	50.	20	*	25.707	6.938	*	1.26	6.40
907	150.	30.	300.	125.	50.	20	*	25.118	6.214	*	1.15	6.45
908	200.	30.	300.	125.	50.	20	*	24.149	5.791	*	1.08	6.41
909	60.	50.	300.	125.	50.	20	*	25.575	8.062	*	1.42	6.46
910	100.	50.	300.	125.	50.	20	*	24.393	6.507	*	1.19	6.49
911	150.	50.	300.	125.	50.	20	*	23.637	5.842	*	1.08	6.51
912	200.	50.	300.	125.	50.	20	*	22.993	5.545	*	1.04	6.47
913	60.	10.	600.	125.	50.	20	*	52.717	20.372	*	3.47	4.08
914	100.	10.	600.	125.	50.	20	*	45.534	12.989	*	2.34	4.14
915	150.	10.	600.	125.	50.	20	*	41.473	9.748	*	1.83	4.13
916	200.	10.	600.	125.	50.	20	*	39.788	8.796	*	1.68	4.17
917	60.	30.	600.	125.	50.	20	*	38.208	12.080	*	2.13	4.21
918	100.	30.	600.	125.	50.	20	*	35.456	8.953	*	1.65	4.25
919	150.	30.	600.	125.	50.	20	*	33.836	7.712	*	1.46	4.27
920	200.	30.	600.	125.	50.	20	*	33.136	7.315	*	1.40	4.31

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
921	60.	50.	500.	125.	50.	20	*	35.139	10.456	*	1.87	4.27
922	100.	50.	600.	125.	50.	20	*	33.484	8.170	*	1.52	4.28
923	150.	50.	600.	125.	50.	20	*	32.135	7.292	*	1.38	4.32
924	200.	50.	600.	125.	50.	20	*	31.900	6.947	*	1.33	4.29
925	60.	10.	1000.	125.	50.	20	*	69.726	32.694	*	5.42	3.32
926	100.	10.	1000.	125.	50.	20	*	58.184	17.498	*	3.12	3.28
927	150.	10.	1000.	125.	50.	20	*	52.826	13.086	*	2.43	3.33
928	200.	10.	1000.	125.	50.	20	*	50.007	10.978	*	2.10	3.34
929	60.	30.	1000.	125.	50.	20	*	48.574	17.343	*	2.99	3.41
930	100.	30.	1000.	125.	50.	20	*	45.681	12.385	*	2.25	3.42
931	150.	30.	1000.	125.	50.	20	*	43.613	10.119	*	1.91	3.43
932	200.	30.	1000.	125.	50.	20	*	43.033	9.443	*	1.80	3.47
933	60.	50.	1000.	125.	50.	20	*	45.572	15.386	*	2.68	3.44
934	100.	50.	1000.	125.	50.	20	*	42.767	10.891	*	2.01	3.44
935	150.	50.	1000.	125.	50.	20	*	41.544	9.434	*	1.79	3.48
936	200.	50.	1000.	125.	50.	20	*	40.587	8.562	*	1.65	3.46
937	60.	10.	300.	150.	50.	20	*	33.403	12.000	*	2.07	7.32
938	100.	10.	300.	150.	50.	20	*	28.660	8.154	*	1.47	7.63
939	150.	10.	300.	150.	50.	20	*	26.092	6.661	*	1.23	7.72
940	200.	10.	300.	150.	50.	20	*	25.293	6.220	*	1.16	7.81
941	60.	30.	300.	150.	50.	20	*	23.236	7.875	*	1.37	8.04
942	100.	30.	300.	150.	50.	20	*	21.400	6.163	*	1.11	8.13
943	150.	30.	300.	150.	50.	20	*	20.945	5.536	*	1.01	8.19
944	200.	30.	300.	150.	50.	20	*	20.227	5.177	*	.95	8.15
945	60.	50.	300.	150.	50.	20	*	21.248	7.133	*	1.25	8.21
946	100.	50.	300.	150.	50.	20	*	20.231	5.777	*	1.04	8.25
947	150.	50.	300.	150.	50.	20	*	19.729	5.216	*	.95	8.29
948	200.	50.	300.	150.	50.	20	*	19.224	4.981	*	.92	8.22
949	60.	10.	600.	150.	50.	20	*	42.312	17.381	*	2.93	5.16
950	100.	10.	600.	150.	50.	20	*	36.678	11.108	*	1.98	5.26
951	150.	10.	600.	150.	50.	20	*	32.867	8.266	*	1.53	5.25
952	200.	10.	600.	150.	50.	20	*	31.757	7.503	*	1.41	5.27
953	60.	30.	600.	150.	50.	20	*	30.460	10.306	*	1.80	5.38
954	100.	30.	600.	150.	50.	20	*	28.122	7.629	*	1.39	5.42
955	150.	30.	600.	150.	50.	20	*	26.906	6.602	*	1.23	5.44
956	200.	30.	600.	150.	50.	20	*	26.385	6.265	*	1.17	5.51
957	60.	50.	600.	150.	50.	20	*	28.050	8.959	*	1.58	5.43
958	100.	50.	600.	150.	50.	20	*	26.396	6.951	*	1.27	5.45
959	150.	50.	600.	150.	50.	20	*	25.460	6.249	*	1.16	5.52
960	200.	50.	600.	150.	50.	20	*	25.352	5.943	*	1.12	5.47

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING	COAL SEAM THICKNESS	DEPTH TO TOP OF SEAM	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
961	60.	10.	1000.	150.	50.	20	54.797	27.327	4.49	4.21
962	100.	10.	1000.	150.	50.	20	45.197	14.476	2.55	4.17
963	150.	10.	1000.	150.	50.	20	41.103	10.870	1.99	4.25
964	200.	10.	1000.	150.	50.	20	38.566	8.063	1.70	4.25
965	60.	30.	1000.	150.	50.	20	37.913	14.509	2.48	4.38
966	100.	30.	1000.	150.	50.	20	35.667	10.345	1.86	4.40
967	150.	30.	1000.	150.	50.	20	33.810	8.425	1.56	4.41
968	200.	30.	1000.	150.	50.	20	32.957	7.532	1.42	4.38
969	60.	50.	1000.	150.	50.	20	35.365	12.866	2.21	4.42
970	100.	50.	1000.	150.	50.	20	33.038	9.075	1.65	4.43
971	150.	50.	1000.	150.	50.	20	32.059	7.850	1.46	4.47
972	200.	50.	1000.	150.	50.	20	31.062	7.183	1.34	4.44
973	60.	10.	300.	175.	50.	20	28.504	10.579	1.82	9.10
974	100.	10.	300.	175.	50.	20	24.451	7.284	1.30	9.17
975	150.	10.	300.	175.	50.	20	22.428	6.014	1.10	9.50
976	200.	10.	300.	175.	50.	20	21.794	5.630	1.04	9.55
977	60.	30.	300.	175.	50.	20	20.145	7.090	1.23	9.75
978	100.	30.	300.	175.	50.	20	18.544	5.608	1.00	9.93
979	150.	30.	300.	175.	50.	20	18.188	5.068	.92	10.01
980	200.	30.	300.	175.	50.	20	17.532	4.769	.87	9.96
981	60.	50.	300.	175.	50.	20	18.499	6.464	1.12	9.95
982	100.	50.	300.	175.	50.	20	17.575	5.286	.94	10.08
983	150.	50.	300.	175.	50.	20	16.964	4.782	.86	10.11
984	200.	50.	300.	175.	50.	20	16.654	4.587	.83	10.11
985	60.	10.	600.	175.	50.	20	35.518	15.068	2.53	6.24
986	100.	10.	600.	175.	50.	20	30.808	9.717	1.72	6.36
987	150.	10.	600.	175.	50.	20	27.564	7.287	1.33	6.30
988	200.	10.	600.	175.	50.	20	26.592	6.631	1.23	6.38
989	60.	30.	600.	175.	50.	20	25.646	9.044	1.56	6.52
990	100.	30.	600.	175.	50.	20	23.794	6.766	1.22	6.57
991	150.	30.	600.	175.	50.	20	22.759	5.889	1.08	6.60
992	200.	30.	600.	175.	50.	20	22.240	5.599	1.04	6.68
993	60.	50.	600.	175.	50.	20	23.738	7.906	1.38	6.62
994	100.	50.	600.	175.	50.	20	22.297	6.187	1.12	6.62
995	150.	50.	600.	175.	50.	20	21.620	5.598	1.03	6.70
996	200.	50.	600.	175.	50.	20	21.367	5.310	.98	6.64
997	60.	10.	1000.	175.	50.	20	45.559	23.298	3.82	5.12
998	100.	10.	1000.	175.	50.	20	37.355	12.411	2.17	5.13
999	150.	10.	1000.	175.	50.	20	33.960	9.385	1.70	5.19
1000	200.	10.	1000.	175.	50.	20	31.900	7.870	1.46	5.17

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN-FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1001	60.	30.	1000.	175.	50.	20	*	31.354	12.488	*	2.12	5.34
1002	100.	30.	1000.	175.	50.	20	*	29.558	8.970	*	1.60	5.36
1003	150.	30.	1000.	175.	50.	20	*	27.883	7.339	*	1.34	5.39
1004	200.	30.	1000.	175.	50.	20	*	27.281	6.592	*	1.23	5.35
1005	60.	50.	1000.	175.	50.	20	*	29.555	11.130	*	1.90	5.39
1006	100.	50.	1000.	175.	50.	20	*	27.475	7.989	*	1.42	5.40
1007	150.	50.	1000.	175.	50.	20	*	26.420	6.858	*	1.26	5.46
1008	200.	50.	1000.	175.	50.	20	*	25.777	6.236	*	1.16	5.42
1009	60.	10.	300.	100.	65.	20	*	49.846	14.555	*	2.61	4.65
1010	100.	10.	300.	100.	65.	20	*	42.811	10.214	*	1.91	4.67
1011	150.	10.	300.	100.	65.	20	*	40.945	9.020	*	1.72	4.76
1012	200.	10.	300.	100.	65.	20	*	38.078	7.934	*	1.54	4.77
1013	60.	30.	300.	100.	65.	20	*	35.095	9.711	*	1.76	4.89
1014	100.	30.	300.	100.	65.	20	*	32.527	7.753	*	1.45	4.94
1015	150.	30.	300.	100.	65.	20	*	31.581	7.048	*	1.34	4.96
1016	200.	30.	300.	100.	65.	20	*	31.160	6.694	*	1.29	4.98
1017	60.	50.	300.	100.	65.	20	*	32.103	8.797	*	1.60	4.97
1018	100.	50.	300.	100.	65.	20	*	30.607	7.256	*	1.36	4.99
1019	150.	50.	300.	100.	65.	20	*	29.611	6.636	*	1.26	5.00
1020	200.	50.	300.	100.	65.	20	*	29.709	6.394	*	1.23	4.99
1021	60.	10.	600.	100.	65.	20	*	71.270	22.723	*	4.00	3.18
1022	100.	10.	600.	100.	65.	20	*	61.369	15.047	*	2.80	3.20
1023	150.	10.	600.	100.	65.	20	*	56.052	11.649	*	2.26	3.21
1024	200.	10.	600.	100.	65.	20	*	53.912	10.625	*	2.09	3.24
1025	60.	30.	600.	100.	65.	20	*	51.368	13.828	*	2.52	3.23
1026	100.	30.	600.	100.	65.	20	*	47.823	10.600	*	2.02	3.27
1027	150.	30.	600.	100.	65.	20	*	45.530	9.315	*	1.81	3.26
1028	200.	30.	600.	100.	65.	20	*	44.353	8.820	*	1.73	3.32
1029	60.	50.	600.	100.	65.	20	*	47.374	12.117	*	2.23	3.27
1030	100.	50.	600.	100.	65.	20	*	44.909	9.696	*	1.86	3.26
1031	150.	50.	600.	100.	65.	20	*	43.040	8.789	*	1.71	3.30
1032	200.	50.	600.	100.	65.	20	*	43.100	8.523	*	1.67	3.34
1033	60.	10.	1000.	100.	65.	20	*	97.134	37.044	*	6.33	2.57
1034	100.	10.	1000.	100.	65.	20	*	83.263	22.415	*	4.08	2.60
1035	150.	10.	1000.	100.	65.	20	*	74.781	16.116	*	3.09	2.60
1036	200.	10.	1000.	100.	65.	20	*	73.431	14.824	*	2.89	2.61
1037	60.	30.	1000.	100.	65.	20	*	67.910	20.235	*	3.61	2.64
1038	100.	30.	1000.	100.	65.	20	*	64.422	15.122	*	2.84	2.64
1039	150.	30.	1000.	100.	65.	20	*	61.121	12.571	*	2.44	2.65
1040	200.	30.	1000.	100.	65.	20	*	60.141	11.808	*	2.32	2.67

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1641	60.	50.	1000.	100.	65.	20	*	63.800	18.105	*	3.26	2.65
1642	100.	50.	1000.	100.	65.	20	*	60.082	13.443	*	2.56	2.65
1643	150.	50.	1000.	100.	65.	20	*	57.998	11.751	*	2.29	2.68
1644	200.	50.	1000.	100.	65.	20	*	56.800	10.928	*	2.15	2.66
1645	60.	10.	300.	125.	65.	20	*	38.691	11.853	*	2.10	6.10
1646	100.	10.	300.	125.	65.	20	*	33.292	8.429	*	1.56	6.13
1647	150.	10.	300.	125.	65.	20	*	30.397	7.056	*	1.33	6.32
1648	200.	10.	300.	125.	65.	20	*	29.551	6.624	*	1.26	6.39
1649	60.	30.	300.	125.	65.	20	*	27.577	8.104	*	1.45	6.48
1650	100.	30.	300.	125.	65.	20	*	25.450	6.551	*	1.21	6.47
1651	150.	30.	300.	125.	65.	20	*	24.902	5.980	*	1.12	6.51
1652	200.	30.	300.	125.	65.	20	*	23.951	5.604	*	1.05	6.47
1653	60.	50.	300.	125.	65.	20	*	25.114	7.348	*	1.32	6.52
1654	100.	50.	300.	125.	65.	20	*	24.041	6.135	*	1.13	6.54
1655	150.	50.	300.	125.	65.	20	*	23.470	5.665	*	1.06	6.56
1656	200.	50.	300.	125.	65.	20	*	22.835	5.389	*	1.01	6.51
1657	60.	10.	600.	125.	65.	20	*	51.224	17.419	*	3.03	4.11
1658	100.	10.	600.	125.	65.	20	*	44.819	11.677	*	2.14	4.21
1659	150.	10.	600.	125.	65.	20	*	40.875	9.117	*	1.73	4.16
1660	200.	10.	600.	125.	65.	20	*	39.027	8.301	*	1.60	4.22
1661	60.	30.	600.	125.	65.	20	*	37.670	10.809	*	1.94	4.23
1662	100.	30.	600.	125.	65.	20	*	34.985	8.359	*	1.56	4.27
1663	150.	30.	600.	125.	65.	20	*	33.524	7.408	*	1.41	4.28
1664	200.	30.	600.	125.	65.	20	*	32.866	7.053	*	1.36	4.34
1665	60.	50.	600.	125.	65.	20	*	34.845	9.527	*	1.73	4.28
1666	100.	50.	600.	125.	65.	20	*	33.204	7.716	*	1.45	4.29
1667	150.	50.	600.	125.	65.	20	*	31.913	7.037	*	1.34	4.34
1668	200.	50.	600.	125.	65.	20	*	31.700	6.745	*	1.30	4.29
1669	60.	10.	1000.	125.	65.	20	*	68.188	27.273	*	4.62	3.36
1670	100.	10.	1000.	125.	65.	20	*	56.947	15.456	*	2.81	3.31
1671	150.	10.	1000.	125.	65.	20	*	51.993	11.968	*	2.26	3.36
1672	200.	10.	1000.	125.	65.	20	*	49.087	10.266	*	1.99	3.35
1673	60.	30.	1000.	125.	65.	20	*	48.051	15.161	*	2.68	3.44
1674	100.	30.	1000.	125.	65.	20	*	45.293	11.314	*	2.10	3.44
1675	150.	30.	1000.	125.	65.	20	*	43.297	9.532	*	1.82	3.45
1676	200.	30.	1000.	125.	65.	20	*	42.747	8.990	*	1.74	3.48
1677	60.	50.	1000.	125.	65.	20	*	45.169	13.608	*	2.42	3.46
1678	100.	50.	1000.	125.	65.	20	*	42.490	10.104	*	1.89	3.46
1679	150.	50.	1000.	125.	65.	20	*	41.311	8.966	*	1.72	3.49
1680	200.	50.	1000.	125.	65.	20	*	40.382	8.270	*	1.61	3.47

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1081	60.	10.	300.	150.	65.	20	*	32.168	10.433	*	1.83	7.60
1082	100.	10.	300.	150.	65.	20	*	27.806	7.447	*	1.36	7.73
1083	150.	10.	300.	150.	65.	20	*	25.640	6.299	*	1.17	8.03
1084	200.	10.	300.	150.	65.	20	*	24.667	5.882	*	1.10	7.91
1085	60.	30.	300.	150.	65.	20	*	22.880	7.147	*	1.26	8.16
1086	100.	30.	300.	150.	65.	20	*	21.130	5.811	*	1.05	8.23
1087	150.	30.	300.	150.	65.	20	*	20.713	5.321	*	.98	8.28
1088	200.	30.	300.	150.	65.	20	*	20.060	5.015	*	.93	8.24
1089	60.	50.	300.	150.	65.	20	*	20.969	6.538	*	1.16	8.29
1090	100.	50.	300.	150.	65.	20	*	20.062	5.484	*	1.00	8.33
1091	150.	50.	300.	150.	65.	20	*	19.520	5.034	*	.93	8.24
1092	200.	50.	300.	150.	65.	20	*	18.963	4.823	*	.89	8.29
1093	60.	10.	600.	150.	65.	20	*	41.273	14.884	*	2.57	5.19
1094	100.	10.	600.	150.	65.	20	*	35.903	9.965	*	1.80	5.28
1095	150.	10.	600.	150.	65.	20	*	32.368	7.727	*	1.45	5.29
1096	200.	10.	600.	150.	65.	20	*	31.390	7.111	*	1.35	5.38
1097	60.	30.	600.	150.	65.	20	*	30.030	9.223	*	1.64	5.40
1098	100.	30.	600.	150.	65.	20	*	27.904	7.155	*	1.32	5.43
1099	150.	30.	600.	150.	65.	20	*	26.657	6.327	*	1.19	5.47
1100	200.	30.	600.	150.	65.	20	*	26.227	6.055	*	1.14	5.54
1101	60.	50.	600.	150.	65.	20	*	27.722	8.145	*	1.46	5.46
1102	100.	50.	600.	150.	65.	20	*	26.176	6.591	*	1.22	5.48
1103	150.	50.	600.	150.	65.	20	*	25.287	6.030	*	1.13	5.54
1104	200.	50.	600.	150.	65.	20	*	25.100	5.760	*	1.09	5.49
1105	60.	10.	1000.	150.	65.	20	*	53.301	22.766	*	3.82	4.25
1106	100.	10.	1000.	150.	65.	20	*	44.086	12.730	*	2.29	4.25
1107	150.	10.	1000.	150.	65.	20	*	40.547	9.937	*	1.85	4.32
1108	200.	10.	1000.	150.	65.	20	*	38.084	8.497	*	1.62	4.31
1109	60.	30.	1000.	150.	65.	20	*	37.390	12.654	*	2.21	4.41
1110	100.	30.	1000.	150.	65.	20	*	35.133	9.427	*	1.72	4.42
1111	150.	30.	1000.	150.	65.	20	*	33.503	7.919	*	1.49	4.44
1112	200.	30.	1000.	150.	65.	20	*	32.776	7.229	*	1.38	4.40
1113	60.	50.	1000.	150.	65.	20	*	34.986	11.351	*	1.99	4.44
1114	100.	50.	1000.	150.	65.	20	*	32.853	8.417	*	1.55	4.44
1115	150.	50.	1000.	150.	65.	20	*	31.911	7.462	*	1.40	4.48
1116	200.	50.	1000.	150.	65.	20	*	30.858	6.845	*	1.30	4.46
1117	60.	10.	300.	175.	65.	20	*	27.826	9.312	*	1.63	9.16
1118	100.	10.	300.	175.	65.	20	*	24.066	6.719	*	1.22	9.36
1119	150.	10.	300.	175.	65.	20	*	21.994	5.685	*	1.05	9.55
1120	200.	10.	300.	175.	65.	20	*	21.280	5.357	*	.99	9.73

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ---

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1121	60.	30.	300.	175.	65.	20	*	19.894	6.472	*	1.14	9.90
1122	100.	30.	300.	175.	65.	20	*	18.369	5.314	*	.95	10.06
1123	150.	30.	300.	175.	65.	20	*	18.042	4.890	*	.89	10.12
1124	200.	30.	300.	175.	65.	20	*	17.246	4.599	*	.84	10.06
1125	60.	50.	300.	175.	65.	20	*	18.247	5.943	*	1.04	10.07
1126	100.	50.	300.	175.	65.	20	*	17.409	5.035	*	.90	10.11
1127	150.	50.	300.	175.	65.	20	*	16.847	4.643	*	.84	10.19
1128	200.	50.	300.	175.	65.	20	*	16.553	4.467	*	.81	10.13
1129	60.	10.	600.	175.	65.	20	*	34.701	12.937	*	2.22	6.32
1130	100.	10.	600.	175.	65.	20	*	30.158	9.736	*	1.57	6.43
1131	150.	10.	600.	175.	65.	20	*	27.183	6.825	*	1.26	6.42
1132	200.	10.	600.	175.	65.	20	*	26.253	6.293	*	1.18	6.50
1133	60.	30.	600.	175.	65.	20	*	25.276	8.117	*	1.43	6.58
1134	100.	30.	600.	175.	65.	20	*	23.610	6.351	*	1.16	6.63
1135	150.	30.	600.	175.	65.	20	*	22.563	5.657	*	1.05	6.65
1136	200.	30.	600.	175.	65.	20	*	22.100	5.419	*	1.01	6.73
1137	60.	50.	600.	175.	65.	20	*	23.491	7.218	*	1.28	6.66
1138	100.	50.	600.	175.	65.	20	*	22.097	5.863	*	1.07	6.66
1139	150.	50.	600.	175.	65.	20	*	21.464	5.410	*	1.00	6.74
1140	200.	50.	600.	175.	65.	20	*	21.214	5.172	*	.96	6.67
1141	60.	10.	1000.	175.	65.	20	*	44.354	19.451	*	3.25	5.18
1142	100.	10.	1000.	175.	65.	20	*	36.533	10.967	*	1.95	5.17
1143	150.	10.	1000.	175.	65.	20	*	33.508	8.601	*	1.58	5.26
1144	200.	10.	1000.	175.	65.	20	*	31.523	7.396	*	1.39	5.24
1145	60.	30.	1000.	175.	65.	20	*	30.966	10.924	*	1.89	5.38
1146	100.	30.	1000.	175.	65.	20	*	29.348	8.207	*	1.48	5.39
1147	150.	30.	1000.	175.	65.	20	*	27.654	6.911	*	1.28	5.41
1148	200.	30.	1000.	175.	65.	20	*	27.137	6.334	*	1.19	5.36
1149	60.	50.	1000.	175.	65.	20	*	29.269	9.854	*	1.72	5.41
1150	100.	50.	1000.	175.	65.	20	*	27.327	7.352	*	1.34	5.42
1151	150.	50.	1000.	175.	65.	20	*	26.308	6.529	*	1.21	5.47
1152	200.	50.	1000.	175.	65.	20	*	25.624	6.019	*	1.13	5.43
1153	60.	10.	300.	100.	80.	20	*	48.943	13.221	*	2.41	4.68
1154	100.	10.	300.	100.	80.	20	*	42.304	9.584	*	1.82	4.75
1155	150.	10.	300.	100.	80.	20	*	38.701	8.146	*	1.57	4.78
1156	200.	10.	300.	100.	80.	20	*	37.501	7.663	*	1.49	4.82
1157	60.	30.	300.	100.	80.	20	*	34.596	9.021	*	1.66	4.93
1158	100.	30.	300.	100.	80.	20	*	32.123	7.417	*	1.40	4.97
1159	150.	30.	300.	100.	80.	20	*	31.246	6.836	*	1.31	4.99
1160	200.	30.	300.	100.	80.	20	*	30.367	6.455	*	1.24	4.96

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1161	60.	50.	300.	100.	80.	20	*	31.879	8.267	*	1.52	4.99
1162	100.	50.	300.	100.	80.	20	*	30.429	7.812	*	1.32	5.01
1163	150.	50.	300.	100.	80.	20	*	29.340	6.471	*	1.23	5.02
1164	200.	50.	300.	100.	80.	20	*	29.561	6.297	*	1.21	5.01
1165	60.	10.	600.	100.	80.	20	*	69.954	20.286	*	3.64	3.19
1166	100.	10.	600.	100.	80.	20	*	60.877	13.962	*	2.64	3.23
1167	150.	10.	600.	100.	80.	20	*	55.327	11.114	*	2.17	3.19
1168	200.	10.	600.	100.	80.	20	*	53.319	10.249	*	2.03	3.23
1169	60.	30.	600.	100.	80.	20	*	50.874	12.779	*	2.36	3.25
1170	100.	30.	600.	100.	80.	20	*	47.406	10.114	*	1.95	3.26
1171	150.	30.	600.	100.	80.	20	*	45.326	9.064	*	1.77	3.27
1172	200.	30.	600.	100.	80.	20	*	44.176	8.628	*	1.70	3.31
1173	60.	50.	600.	100.	80.	20	*	47.109	11.350	*	2.12	3.28
1174	100.	50.	600.	100.	80.	20	*	44.711	9.361	*	1.81	3.27
1175	150.	50.	600.	100.	80.	20	*	42.884	8.589	*	1.68	3.31
1176	200.	50.	600.	100.	80.	20	*	42.905	8.300	*	1.64	3.28
1177	60.	10.	1000.	100.	80.	20	*	96.040	32.413	*	5.65	2.60
1178	100.	10.	1000.	100.	80.	20	*	82.058	20.367	*	3.78	2.61
1179	150.	10.	1000.	100.	80.	20	*	73.722	15.145	*	2.94	2.61
1180	200.	10.	1000.	100.	80.	20	*	72.699	14.090	*	2.78	2.62
1181	60.	30.	1000.	100.	80.	20	*	67.441	18.387	*	3.34	2.64
1182	100.	30.	1000.	100.	80.	20	*	63.786	14.094	*	2.69	2.65
1183	150.	30.	1000.	100.	80.	20	*	60.874	12.078	*	2.37	2.66
1184	200.	30.	1000.	100.	80.	20	*	59.779	11.413	*	2.26	2.68
1185	60.	50.	1000.	100.	80.	20	*	63.457	16.597	*	3.04	2.65
1186	100.	50.	1000.	100.	80.	20	*	59.600	12.669	*	2.44	2.66
1187	150.	50.	1000.	100.	80.	20	*	57.827	11.360	*	2.23	2.68
1188	200.	50.	1000.	100.	80.	20	*	56.720	10.593	*	2.11	2.66
1189	60.	10.	300.	125.	80.	20	*	38.160	10.820	*	1.95	6.22
1190	100.	10.	300.	125.	80.	20	*	32.956	7.938	*	1.48	6.22
1191	150.	10.	300.	125.	80.	20	*	30.090	6.792	*	1.29	6.32
1192	200.	10.	300.	125.	80.	20	*	29.204	6.420	*	1.23	6.34
1193	60.	30.	300.	125.	80.	20	*	27.304	7.564	*	1.37	6.47
1194	100.	30.	300.	125.	80.	20	*	25.094	6.244	*	1.16	6.52
1195	150.	30.	300.	125.	80.	20	*	24.604	5.802	*	1.09	6.55
1196	200.	30.	300.	125.	80.	20	*	23.669	5.482	*	1.03	6.51
1197	60.	50.	300.	125.	80.	20	*	24.946	6.927	*	1.25	6.55
1198	100.	50.	300.	125.	80.	20	*	23.906	5.939	*	1.10	6.57
1199	150.	50.	300.	125.	80.	20	*	23.228	5.525	*	1.04	6.59
1200	200.	50.	300.	125.	80.	20	*	22.721	5.314	*	1.00	6.54

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF.	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1201	60.	10.	600.	125.	80.	20	*	50.472	15.584	*	2.76	4.15
1202	100.	10.	600.	125.	80.	20	*	44.288	10.938	*	2.82	4.20
1203	150.	10.	600.	125.	80.	20	*	40.056	8.656	*	1.66	4.18
1204	200.	10.	600.	125.	80.	20	*	38.607	8.012	*	1.55	4.24
1205	60.	30.	600.	125.	80.	20	*	37.410	10.031	*	1.83	4.25
1206	100.	30.	600.	125.	80.	20	*	34.803	7.993	*	1.51	4.28
1207	150.	30.	600.	125.	80.	20	*	33.265	7.199	*	1.38	4.30
1208	200.	30.	600.	125.	80.	20	*	32.738	6.911	*	1.33	4.35
1209	60.	50.	600.	125.	80.	20	*	34.580	8.929	*	1.64	4.29
1210	100.	50.	600.	125.	80.	20	*	32.924	7.430	*	1.41	4.29
1211	150.	50.	600.	125.	80.	20	*	31.814	6.886	*	1.32	4.35
1212	200.	50.	600.	125.	80.	20	*	31.591	6.647	*	1.28	4.30
1213	60.	10.	1000.	125.	80.	20	*	67.055	23.913	*	4.13	3.38
1214	100.	10.	1000.	125.	80.	20	*	56.335	14.157	*	2.62	3.34
1215	150.	10.	1000.	125.	80.	20	*	51.298	11.250	*	2.15	3.39
1216	200.	10.	1000.	125.	80.	20	*	48.671	9.847	*	1.92	3.38
1217	60.	30.	1000.	125.	80.	20	*	47.642	13.785	*	2.47	3.45
1218	100.	30.	1000.	125.	80.	20	*	45.054	10.636	*	2.00	3.46
1219	150.	30.	1000.	125.	80.	20	*	43.044	9.156	*	1.76	3.47
1220	200.	30.	1000.	125.	80.	20	*	42.259	8.513	*	1.66	3.44
1221	60.	50.	1000.	125.	80.	20	*	44.859	12.485	*	2.26	3.47
1222	100.	50.	1000.	125.	80.	20	*	42.260	9.607	*	1.82	3.47
1223	150.	50.	1000.	125.	80.	20	*	41.167	8.675	*	1.67	3.50
1224	200.	50.	1000.	125.	80.	20	*	40.201	8.087	*	1.58	3.48
1225	60.	10.	300.	150.	80.	20	*	31.789	9.520	*	1.70	7.75
1226	100.	10.	300.	150.	80.	20	*	27.497	7.024	*	1.29	8.00
1227	150.	10.	300.	150.	80.	20	*	25.344	6.061	*	1.13	8.02
1228	200.	10.	300.	150.	80.	20	*	24.427	5.708	*	1.07	8.03
1229	60.	30.	300.	150.	80.	20	*	22.701	6.698	*	1.20	8.23
1230	100.	30.	300.	150.	80.	20	*	20.987	5.579	*	1.02	8.29
1231	150.	30.	300.	150.	80.	20	*	20.557	5.183	*	.96	8.34
1232	200.	30.	300.	150.	80.	20	*	19.945	4.931	*	.92	8.29
1233	60.	50.	300.	150.	80.	20	*	20.827	6.170	*	1.10	8.34
1234	100.	50.	300.	150.	80.	20	*	19.908	5.303	*	.97	8.37
1235	150.	50.	300.	150.	80.	20	*	19.431	4.916	*	.91	8.28
1236	200.	50.	300.	150.	80.	20	*	18.866	4.754	*	.88	8.33
1237	60.	10.	600.	150.	80.	20	*	40.768	13.322	*	2.34	5.28
1238	100.	10.	600.	150.	80.	20	*	35.547	9.250	*	1.70	5.35
1239	150.	10.	600.	150.	80.	20	*	32.068	7.389	*	1.39	5.33
1240	200.	10.	600.	150.	80.	20	*	31.029	6.862	*	1.31	5.42

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1241	60.	30.	600.	150.	80.	20	*	29.836	8.563	*	1.54	5.43
1242	100.	30.	600.	150.	80.	20	*	27.676	6.830	*	1.27	5.46
1243	150.	30.	600.	150.	80.	20	*	26.553	6.164	*	1.16	5.48
1244	200.	30.	600.	150.	80.	20	*	26.125	5.934	*	1.12	5.56
1245	60.	50.	600.	150.	80.	20	*	27.573	7.650	*	1.39	5.48
1246	100.	50.	600.	150.	80.	20	*	26.871	6.356	*	1.18	5.48
1247	150.	50.	600.	150.	80.	20	*	25.215	5.898	*	1.11	5.54
1248	200.	50.	600.	150.	80.	20	*	25.021	5.679	*	1.08	5.50
1249	60.	10.	1000.	150.	80.	20	*	52.653	19.940	*	3.41	4.31
1250	100.	10.	1000.	150.	80.	20	*	43.666	11.674	*	2.13	4.29
1251	150.	10.	1000.	150.	80.	20	*	40.886	9.332	*	1.76	4.36
1252	200.	10.	1000.	150.	80.	20	*	37.939	8.180	*	1.57	4.35
1253	60.	30.	1000.	150.	80.	20	*	37.162	11.515	*	2.04	4.43
1254	100.	30.	1000.	150.	80.	20	*	34.865	8.841	*	1.63	4.44
1255	150.	30.	1000.	150.	80.	20	*	33.379	7.617	*	1.44	4.45
1256	200.	30.	1000.	150.	80.	20	*	32.325	7.018	*	1.34	4.41
1257	60.	50.	1000.	150.	80.	20	*	34.809	10.421	*	1.86	4.45
1258	100.	50.	1000.	150.	80.	20	*	32.655	7.994	*	1.49	4.45
1259	150.	50.	1000.	150.	80.	20	*	31.766	7.207	*	1.37	4.49
1260	200.	50.	1000.	150.	80.	20	*	30.775	6.700	*	1.28	4.47
1261	60.	10.	300.	175.	80.	20	*	27.364	8.456	*	1.50	9.40
1262	100.	10.	300.	175.	80.	20	*	23.727	6.334	*	1.16	9.63
1263	150.	10.	300.	175.	80.	20	*	21.787	5.488	*	1.01	9.64
1264	200.	10.	300.	175.	80.	20	*	21.001	5.193	*	.96	9.82
1265	60.	30.	300.	175.	80.	20	*	19.678	6.067	*	1.08	9.99
1266	100.	30.	300.	175.	80.	20	*	18.285	5.099	*	.92	10.07
1267	150.	30.	300.	175.	80.	20	*	17.914	4.768	*	.87	10.13
1268	200.	30.	300.	175.	80.	20	*	17.158	4.524	*	.83	10.13
1269	60.	50.	300.	175.	80.	20	*	18.124	5.624	*	1.00	10.14
1270	100.	50.	300.	175.	80.	20	*	17.308	4.869	*	.88	10.17
1271	150.	50.	300.	175.	80.	20	*	16.734	4.548	*	.83	10.24
1272	200.	50.	300.	175.	80.	20	*	16.471	4.486	*	.80	10.17
1273	60.	10.	600.	175.	80.	20	*	34.313	11.605	*	2.02	6.46
1274	100.	10.	600.	175.	80.	20	*	29.874	8.129	*	1.48	6.52
1275	150.	10.	600.	175.	80.	20	*	26.882	6.528	*	1.22	6.49
1276	200.	10.	600.	175.	80.	20	*	26.050	6.090	*	1.15	6.57
1277	60.	30.	600.	175.	80.	20	*	25.115	7.554	*	1.35	6.62
1278	100.	30.	600.	175.	80.	20	*	23.445	6.091	*	1.12	6.66
1279	150.	30.	600.	175.	80.	20	*	22.472	5.519	*	1.03	6.68
1280	200.	30.	600.	175.	80.	20	*	22.012	5.315	*	.99	6.76

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1281	60.	50.	600.	175.	80.	20	*	23.378	6.794	*	1.22	6.69
1282	100.	50.	600.	175.	80.	20	*	22.007	5.677	*	1.04	6.68
1283	150.	50.	600.	175.	80.	20	*	21.394	5.298	*	.98	6.76
1284	200.	50.	600.	175.	80.	20	*	21.145	5.102	*	.95	6.69
1285	60.	10.	1000.	175.	80.	20	*	43.615	17.054	*	2.90	5.24
1286	100.	10.	1000.	175.	80.	20	*	36.201	10.078	*	1.82	5.22
1287	150.	10.	1000.	175.	80.	20	*	33.113	8.097	*	1.51	5.31
1288	200.	10.	1000.	175.	80.	20	*	31.133	7.085	*	1.34	5.29
1289	60.	30.	1000.	175.	80.	20	*	30.775	9.961	*	1.75	5.40
1290	100.	30.	1000.	175.	80.	20	*	29.151	7.724	*	1.41	5.41
1291	150.	30.	1000.	175.	80.	20	*	27.555	6.656	*	1.24	5.42
1292	200.	30.	1000.	175.	80.	20	*	27.046	6.181	*	1.17	5.38
1293	60.	50.	1000.	175.	80.	20	*	28.863	9.043	*	1.60	5.43
1294	100.	50.	1000.	175.	80.	20	*	27.182	6.998	*	1.29	5.43
1295	150.	50.	1000.	175.	80.	20	*	26.234	6.322	*	1.18	5.48
1296	200.	50.	1000.	175.	80.	20	*	25.557	5.898	*	1.11	5.45

?

APPENDIX H

THE IMPACT OF THE ECONOMIC BASIS ON THE ECONOMIC
SENSITIVITY OF THE DIRTY-GAS SELLING PRICE

Figures H.1 through H.6 display the economic sensitivity of the dirty-gas selling price to each of the sensitivity variables considered in this investigation. Two curves are provided on each figure. The upper curve represents the economic sensitivity calculated using an equity finance basis; the lower curve represents the sensitivity calculated using a utility finance basis.

COMPARATIVE ECONOMIC SENSITIVITIES TO THE PRODUCT GAS HHV

FIGURE H.1

COMPARATIVE ECONOMIC SENSITIVITIES TO THE COAL SEAM DEPTH

FIGURE H.2

COMPARATIVE ECONOMIC SENSITIVITIES TO THE COAL SEAM THICKNESS

FIGURE H.3

COMPARATIVE ECONOMIC SENSITIVITIES TO THE PROCESS WELL SPACING

FIGURE H.4

COMPARATIVE ECONOMIC SENSITIVITIES TO THE VCSE

FIGURE H.5

FIGURE H.6
COMPARATIVE ECONOMIC SENSITIVITY TO THE LEAKAGE RATE

APPENDIX I

THE ECONOMIC SENSITIVITY OF THE DIRTY-GAS SELLING
PRICE TO EACH OF THE SENSITIVITY VARIABLES
CALCULATED USING AN EQUITY FINANCE BASIS

Figures I.1 through I.6 contain sensitivity curves similar to those in Figures 7.3 through 7.8. The following curves provide the same sensitivities as the previous set; however, the data presented in Figures I.1 through I.6 are calculated using an equity finance basis while those data presented in Figures 7.3 through 7.8 are calculated using a utility finance basis.

ECONOMIC SENSITIVITY TO THE PRODUCT GAS HEATING VALUE

FIGURE I.1

ECONOMIC SENSITIVITY TO THE COAL SEAM DEPTH

FIGURE 1. 2

FIGURE I. 3

ECONOMIC SENSITIVITY TO THE COAL SEAM THICKNESS

ECONOMIC SENSITIVITY TO THE PROCESS WELL SPACING

FIGURE 1.4

FIGURE 1.5

ECONOMIC SENSITIVITY TO THE VCSE

ECONOMIC SENSITIVITY TO THE LEAKAGE RATE

FIGURE 1.6

APPENDIX J

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL
FEASIBILITY OF UNDERGROUND COAL GASIFICATION
CALCULATED USING AN EQUITY FINANCE BASIS

A brief summary of the results of the economic analysis discussed in the paper is provided in this appendix. These results are calculated based upon equity financing. These results are tabulated in Table J-I which begins on the following page. Important data are presented for each of the 1296 cases considered.

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1	60.	10.	300.	100.	50.	0	*	41.641	12.641	*	3.31	5.64
2	100.	10.	300.	100.	50.	0	*	35.248	7.883	*	2.40	5.85
3	150.	10.	300.	100.	50.	0	*	32.868	6.389	*	2.10	5.99
4	200.	10.	300.	100.	50.	0	*	30.673	5.523	*	1.90	6.00
5	60.	30.	300.	100.	50.	0	*	29.562	8.307	*	2.26	6.11
6	100.	30.	300.	100.	50.	0	*	26.433	5.708	*	1.77	6.17
7	150.	30.	300.	100.	50.	0	*	25.769	5.027	*	1.65	6.21
8	200.	30.	300.	100.	50.	0	*	25.385	4.738	*	1.60	6.24
9	60.	50.	300.	100.	50.	0	*	26.344	6.795	*	1.92	6.15
10	100.	50.	300.	100.	50.	0	*	25.042	5.354	*	1.67	6.25
11	150.	50.	300.	100.	50.	0	*	24.208	4.742	*	1.56	6.26
12	200.	50.	300.	100.	50.	0	*	24.633	4.576	*	1.55	6.30
13	60.	10.	600.	100.	50.	0	*	54.082	17.526	*	4.46	3.89
14	100.	10.	600.	100.	50.	0	*	47.030	10.723	*	3.24	3.98
15	150.	10.	600.	100.	50.	0	*	43.900	8.221	*	2.77	4.00
16	200.	10.	600.	100.	50.	0	*	41.349	6.940	*	2.49	4.00
17	60.	30.	600.	100.	50.	0	*	39.956	11.037	*	3.02	4.08
18	100.	30.	600.	100.	50.	0	*	36.906	7.549	*	2.42	4.11
19	150.	30.	600.	100.	50.	0	*	35.614	6.432	*	2.21	4.13
20	200.	30.	600.	100.	50.	0	*	34.542	5.809	*	2.08	4.12
21	60.	50.	600.	100.	50.	0	*	36.758	9.284	*	2.66	4.12
22	100.	50.	600.	100.	50.	0	*	34.868	6.951	*	2.26	4.15
23	150.	50.	600.	100.	50.	0	*	33.575	5.851	*	2.05	4.12
24	200.	50.	600.	100.	50.	0	*	33.495	5.571	*	2.01	4.15
25	60.	10.	1000.	100.	50.	0	*	71.552	28.884	*	6.71	3.17
26	100.	10.	1000.	100.	50.	0	*	61.467	16.013	*	4.51	3.21
27	150.	10.	1000.	100.	50.	0	*	55.297	10.608	*	3.52	3.23
28	200.	10.	1000.	100.	50.	0	*	54.287	9.531	*	3.33	3.23
29	60.	30.	1000.	100.	50.	0	*	50.801	15.008	*	3.98	3.28
30	100.	30.	1000.	100.	50.	0	*	48.521	10.977	*	3.33	3.32
31	150.	30.	1000.	100.	50.	0	*	46.697	8.800	*	2.95	3.33
32	200.	30.	1000.	100.	50.	0	*	44.823	7.468	*	2.69	3.33
33	60.	50.	1000.	100.	50.	0	*	48.343	14.404	*	3.81	3.33
34	100.	50.	1000.	100.	50.	0	*	45.617	9.832	*	3.06	3.35
35	150.	50.	1000.	100.	50.	0	*	43.307	7.533	*	2.65	3.34
36	200.	50.	1000.	100.	50.	0	*	43.219	7.099	*	2.58	3.35
37	60.	10.	300.	125.	50.	0	*	31.982	9.572	*	2.52	7.55
38	100.	10.	300.	125.	50.	0	*	27.590	6.404	*	1.91	7.45
39	150.	10.	300.	125.	50.	0	*	25.411	5.205	*	1.66	7.77
40	200.	10.	300.	125.	50.	0	*	24.559	4.822	*	1.58	7.71

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
41	60.	30.	300.	125.	50.	0	*	23.061	6.449	*	1.76	7.89
42	100.	30.	300.	125.	50.	0	*	21.216	4.974	*	1.48	7.97
43	150.	30.	300.	125.	50.	0	*	20.817	4.434	*	1.39	8.02
44	200.	30.	300.	125.	50.	0	*	20.269	4.203	*	1.34	8.17
45	60.	50.	300.	125.	50.	0	*	21.142	5.862	*	1.60	8.03
46	100.	50.	300.	125.	50.	0	*	20.185	4.694	*	1.40	8.06
47	150.	50.	300.	125.	50.	0	*	19.511	4.215	*	1.31	8.21
48	200.	50.	300.	125.	50.	0	*	19.641	4.063	*	1.29	8.20
49	60.	10.	600.	125.	50.	0	*	40.650	13.988	*	3.47	5.10
50	100.	10.	600.	125.	50.	0	*	35.459	8.706	*	2.53	5.20
51	150.	10.	600.	125.	50.	0	*	33.147	6.766	*	2.17	5.19
52	200.	10.	600.	125.	50.	0	*	31.196	5.764	*	1.95	5.19
53	60.	30.	600.	125.	50.	0	*	30.480	9.002	*	2.39	5.35
54	100.	30.	600.	125.	50.	0	*	28.226	6.287	*	1.92	5.37
55	150.	30.	600.	125.	50.	0	*	27.283	5.410	*	1.76	5.40
56	200.	30.	600.	125.	50.	0	*	26.340	4.910	*	1.66	5.40
57	60.	50.	600.	125.	50.	0	*	28.104	7.638	*	2.11	5.40
58	100.	50.	600.	125.	50.	0	*	26.618	5.813	*	1.80	5.43
59	150.	50.	600.	125.	50.	0	*	25.727	4.941	*	1.64	5.39
60	200.	50.	600.	125.	50.	0	*	25.648	4.738	*	1.61	5.43
61	60.	10.	1000.	125.	50.	0	*	52.097	22.258	*	5.06	4.11
62	100.	10.	1000.	125.	50.	0	*	44.969	12.534	*	3.41	4.18
63	150.	10.	1000.	125.	50.	0	*	40.033	8.364	*	2.65	4.19
64	200.	10.	1000.	125.	50.	0	*	39.683	7.552	*	2.52	4.22
65	60.	30.	1000.	125.	50.	0	*	37.330	11.740	*	3.03	4.29
66	100.	30.	1000.	125.	50.	0	*	35.536	8.256	*	2.47	4.30
67	150.	30.	1000.	125.	50.	0	*	33.893	6.565	*	2.17	4.32
68	200.	30.	1000.	125.	50.	0	*	33.300	6.068	*	2.07	4.36
69	60.	50.	1000.	125.	50.	0	*	35.239	10.413	*	2.76	4.32
70	100.	50.	1000.	125.	50.	0	*	33.917	7.894	*	2.36	4.38
71	150.	50.	1000.	125.	50.	0	*	32.311	6.123	*	2.05	4.37
72	200.	50.	1000.	125.	50.	0	*	31.568	5.583	*	1.94	4.34
73	60.	10.	300.	150.	50.	0	*	27.167	8.626	*	2.22	9.20
74	100.	10.	300.	150.	50.	0	*	23.460	5.825	*	1.68	9.55
75	150.	10.	300.	150.	50.	0	*	21.458	4.748	*	1.46	9.76
76	200.	10.	300.	150.	50.	0	*	20.901	4.439	*	1.39	9.87
77	60.	30.	300.	150.	50.	0	*	19.561	5.867	*	1.55	10.04
78	100.	30.	300.	150.	50.	0	*	18.162	4.589	*	1.31	10.23
79	150.	30.	300.	150.	50.	0	*	17.513	4.079	*	1.22	10.29
80	200.	30.	300.	150.	50.	0	*	17.217	3.870	*	1.18	10.33

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
81	60.	50.	300.	150.	50.	0	*	17.943	5.343	*	1.41	10.32
82	100.	50.	300.	150.	50.	0	*	17.148	4.311	*	1.24	10.37
83	150.	50.	300.	150.	50.	0	*	16.765	3.881	*	1.16	10.41
84	200.	50.	300.	150.	50.	0	*	16.921	3.752	*	1.15	10.41
85	60.	10.	600.	150.	50.	0	*	33.550	12.325	*	2.97	6.37
86	100.	10.	600.	150.	50.	0	*	29.209	7.700	*	2.16	6.56
87	150.	10.	600.	150.	50.	0	*	27.148	5.771	*	1.81	6.54
88	200.	10.	600.	150.	50.	0	*	25.612	5.137	*	1.66	6.59
89	60.	30.	600.	150.	50.	0	*	25.170	7.981	*	2.05	6.81
90	100.	30.	600.	150.	50.	0	*	23.018	5.589	*	1.63	6.84
91	150.	30.	600.	150.	50.	0	*	22.327	4.841	*	1.50	6.88
92	200.	30.	600.	150.	50.	0	*	21.610	4.399	*	1.41	6.87
93	60.	50.	600.	150.	50.	0	*	22.992	6.783	*	1.80	6.88
94	100.	50.	600.	150.	50.	0	*	21.945	5.198	*	1.54	6.92
95	150.	50.	600.	150.	50.	0	*	21.028	4.430	*	1.40	6.88
96	200.	50.	600.	150.	50.	0	*	20.900	4.259	*	1.37	6.95
97	60.	10.	1000.	150.	50.	0	*	42.544	19.235	*	4.28	5.22
98	100.	10.	1000.	150.	50.	0	*	36.423	10.870	*	2.87	5.32
99	150.	10.	1000.	150.	50.	0	*	32.315	7.283	*	2.21	5.34
100	200.	10.	1000.	150.	50.	0	*	31.924	6.583	*	2.10	5.38
101	60.	30.	1000.	150.	50.	0	*	30.000	10.189	*	2.54	5.49
102	100.	30.	1000.	150.	50.	0	*	28.303	7.122	*	2.04	5.50
103	150.	30.	1000.	150.	50.	0	*	27.142	5.741	*	1.80	5.52
104	200.	30.	1000.	150.	50.	0	*	26.455	5.309	*	1.72	5.57
105	60.	50.	1000.	150.	50.	0	*	28.296	9.065	*	2.32	5.53
106	100.	50.	1000.	150.	50.	0	*	26.491	6.283	*	1.86	5.54
107	150.	50.	1000.	150.	50.	0	*	25.528	5.359	*	1.69	5.60
108	200.	50.	1000.	150.	50.	0	*	24.934	4.843	*	1.60	5.57
109	60.	10.	300.	175.	50.	0	*	23.441	7.755	*	1.96	11.19
110	100.	10.	300.	175.	50.	0	*	20.722	5.362	*	1.52	11.45
111	150.	10.	300.	175.	50.	0	*	18.973	4.426	*	1.32	11.62
112	200.	10.	300.	175.	50.	0	*	18.222	4.118	*	1.25	11.78
113	60.	30.	300.	175.	50.	0	*	17.403	5.415	*	1.40	12.26
114	100.	30.	300.	175.	50.	0	*	15.922	4.248	*	1.18	12.39
115	150.	30.	300.	175.	50.	0	*	15.592	3.832	*	1.11	12.48
116	200.	30.	300.	175.	50.	0	*	15.248	3.652	*	1.07	12.62
117	60.	50.	300.	175.	50.	0	*	15.840	4.922	*	1.28	12.50
118	100.	50.	300.	175.	50.	0	*	15.232	4.034	*	1.13	12.58
119	150.	50.	300.	175.	50.	0	*	14.833	3.658	*	1.06	12.62
120	200.	50.	300.	175.	50.	0	*	14.844	3.551	*	1.05	12.77

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
121	60.	10.	600.	175.	50.	0	*	28.580	10.871	*	2.59	7.78
122	100.	10.	600.	175.	50.	0	*	25.038	6.911	*	1.89	7.95
123	150.	10.	600.	175.	50.	0	*	23.087	5.228	*	1.58	7.95
124	200.	10.	600.	175.	50.	0	*	21.827	4.681	*	1.46	8.06
125	60.	30.	600.	175.	50.	0	*	21.675	7.164	*	1.81	8.33
126	100.	30.	600.	175.	50.	0	*	19.881	5.096	*	1.45	8.37
127	150.	30.	600.	175.	50.	0	*	19.114	4.445	*	1.33	8.42
128	200.	30.	600.	175.	50.	0	*	18.660	4.066	*	1.26	8.41
129	60.	50.	600.	175.	50.	0	*	19.872	6.131	*	1.59	8.42
130	100.	50.	600.	175.	50.	0	*	18.753	4.753	*	1.36	8.47
131	150.	50.	600.	175.	50.	0	*	18.075	4.089	*	1.24	8.42
132	200.	50.	600.	175.	50.	0	*	17.884	3.938	*	1.21	8.47
133	60.	10.	1000.	175.	50.	0	*	35.867	16.707	*	3.68	6.31
134	100.	10.	1000.	175.	50.	0	*	30.634	9.550	*	2.47	6.44
135	150.	10.	1000.	175.	50.	0	*	27.129	6.476	*	1.91	6.49
136	200.	10.	1000.	175.	50.	0	*	26.200	5.502	*	1.74	6.48
137	60.	30.	1000.	175.	50.	0	*	25.557	9.003	*	2.21	6.65
138	100.	30.	1000.	175.	50.	0	*	23.890	6.359	*	1.77	6.70
139	150.	30.	1000.	175.	50.	0	*	22.939	5.177	*	1.57	6.73
140	200.	30.	1000.	175.	50.	0	*	22.528	4.809	*	1.50	6.79
141	60.	50.	1000.	175.	50.	0	*	23.902	8.027	*	2.01	6.74
142	100.	50.	1000.	175.	50.	0	*	22.592	5.643	*	1.62	6.75
143	150.	50.	1000.	175.	50.	0	*	21.632	4.846	*	1.48	6.81
144	200.	50.	1000.	175.	50.	0	*	21.417	4.412	*	1.41	6.78
145	60.	10.	300.	100.	65.	0	*	40.307	10.730	*	2.99	5.82
146	100.	10.	300.	100.	65.	0	*	34.653	7.095	*	2.27	5.90
147	150.	10.	300.	100.	65.	0	*	32.421	5.930	*	2.02	5.95
148	200.	10.	300.	100.	65.	0	*	30.295	5.209	*	1.84	6.05
149	60.	30.	300.	100.	65.	0	*	28.197	6.712	*	1.98	6.11
150	100.	30.	300.	100.	65.	0	*	26.207	5.336	*	1.71	6.16
151	150.	30.	300.	100.	65.	0	*	25.594	4.804	*	1.61	6.20
152	200.	30.	300.	100.	65.	0	*	25.211	4.545	*	1.56	6.28
153	60.	50.	300.	100.	65.	0	*	25.898	6.127	*	1.91	6.20
154	100.	50.	300.	100.	65.	0	*	24.881	5.050	*	1.52	6.22
155	150.	50.	300.	100.	65.	0	*	24.057	4.573	*	1.53	6.29
156	200.	50.	300.	100.	65.	0	*	24.295	4.380	*	1.51	6.29
157	60.	10.	600.	100.	65.	0	*	52.946	14.740	*	4.02	3.94
158	100.	10.	600.	100.	65.	0	*	46.147	9.484	*	3.83	3.99
159	150.	10.	600.	100.	65.	0	*	42.791	7.484	*	2.62	4.05
160	200.	10.	600.	100.	65.	0	*	40.839	6.505	*	2.41	4.03

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
161	60.	30.	600.	100.	65.	0	*	39.552	9.648	*	2.81	4.11
162	100.	30.	600.	100.	65.	0	*	36.556	6.926	*	2.32	4.12
163	150.	30.	600.	100.	65.	0	*	35.338	6.069	*	2.15	4.15
164	200.	30.	600.	100.	65.	0	*	34.156	5.542	*	2.03	4.14
165	60.	50.	600.	100.	65.	0	*	36.444	9.270	*	2.50	4.14
166	100.	50.	600.	100.	65.	0	*	34.606	6.441	*	2.18	4.16
167	150.	50.	600.	100.	65.	0	*	33.401	5.614	*	2.01	4.14
168	200.	50.	600.	100.	65.	0	*	33.352	5.376	*	1.98	4.16
169	60.	10.	1000.	100.	65.	0	*	69.452	23.570	*	5.88	3.20
170	100.	10.	1000.	100.	65.	0	*	60.217	13.742	*	4.15	3.24
171	150.	10.	1000.	100.	65.	0	*	54.283	9.556	*	3.33	3.24
172	200.	10.	1000.	100.	65.	0	*	53.225	8.636	*	3.16	3.26
173	60.	30.	1000.	100.	65.	0	*	50.279	12.889	*	3.66	3.29
174	100.	30.	1000.	100.	65.	0	*	48.045	9.761	*	3.14	3.33
175	150.	30.	1000.	100.	65.	0	*	45.453	7.600	*	2.73	3.31
176	200.	30.	1000.	100.	65.	0	*	44.477	7.019	*	2.62	3.34
177	60.	50.	1000.	100.	65.	0	*	47.345	12.399	*	3.51	3.34
178	100.	50.	1000.	100.	65.	0	*	45.366	8.858	*	2.91	3.35
179	150.	50.	1000.	100.	65.	0	*	43.032	7.072	*	2.57	3.34
180	200.	50.	1000.	100.	65.	0	*	43.044	6.737	*	2.52	3.36
181	60.	10.	300.	125.	65.	0	*	31.123	8.291	*	2.31	7.51
182	100.	10.	300.	125.	65.	0	*	27.165	5.846	*	1.82	7.64
183	150.	10.	300.	125.	65.	0	*	25.060	4.912	*	1.61	7.97
184	200.	10.	300.	125.	65.	0	*	24.072	4.564	*	1.53	7.99
185	60.	30.	300.	125.	65.	0	*	22.771	5.817	*	1.66	7.99
186	100.	30.	300.	125.	65.	0	*	21.005	4.679	*	1.43	8.06
187	150.	30.	300.	125.	65.	0	*	20.638	4.257	*	1.36	8.10
188	200.	30.	300.	125.	65.	0	*	20.138	4.043	*	1.31	8.12
189	60.	50.	300.	125.	65.	0	*	20.912	5.344	*	1.52	8.11
190	100.	50.	300.	125.	65.	0	*	20.015	4.455	*	1.36	8.14
191	150.	50.	300.	125.	65.	0	*	19.397	4.067	*	1.28	8.15
192	200.	50.	300.	125.	65.	0	*	19.540	3.929	*	1.27	8.15
193	60.	10.	600.	125.	65.	0	*	39.721	11.835	*	3.13	5.13
194	100.	10.	600.	125.	65.	0	*	34.801	7.738	*	2.37	5.20
195	150.	10.	600.	125.	65.	0	*	32.732	6.227	*	2.08	5.27
196	200.	10.	600.	125.	65.	0	*	30.834	5.424	*	1.89	5.27
197	60.	30.	600.	125.	65.	0	*	30.191	7.914	*	2.22	5.37
198	100.	30.	600.	125.	65.	0	*	27.940	5.792	*	1.84	5.40
199	150.	30.	600.	125.	65.	0	*	27.112	5.132	*	1.72	5.43
200	200.	30.	600.	125.	65.	0	*	26.135	4.713	*	1.62	5.42

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
201	60.	50.	600.	125.	65.	0	27.880	6.846	1.99	5.42
202	100.	50.	600.	125.	65.	0	26.461	5.438	1.74	5.45
203	150.	50.	600.	125.	65.	0	25.598	4.760	1.61	5.42
204	200.	50.	600.	125.	65.	0	25.532	4.587	1.58	5.45
205	60.	10.	1000.	125.	65.	0	50.957	18.288	4.45	4.19
206	100.	10.	1000.	125.	65.	0	44.240	10.807	3.15	4.25
207	150.	10.	1000.	125.	65.	0	39.542	7.568	2.52	4.25
208	200.	10.	1000.	125.	65.	0	39.247	6.935	2.41	4.27
209	60.	30.	1000.	125.	65.	0	36.868	10.120	2.78	4.32
210	100.	30.	1000.	125.	65.	0	35.038	7.388	2.33	4.33
211	150.	30.	1000.	125.	65.	0	33.607	6.127	2.09	4.34
212	200.	30.	1000.	125.	65.	0	33.130	5.741	2.02	4.38
213	60.	50.	1000.	125.	65.	0	34.967	9.105	2.57	4.34
214	100.	50.	1000.	125.	65.	0	33.161	6.656	2.15	4.34
215	150.	50.	1000.	125.	65.	0	32.172	5.784	1.99	4.38
216	200.	50.	1000.	125.	65.	0	31.253	5.304	1.89	4.36
217	60.	10.	300.	150.	65.	0	26.545	7.494	2.03	9.51
218	100.	10.	300.	150.	65.	0	23.059	5.323	1.60	9.70
219	150.	10.	300.	150.	65.	0	21.134	4.477	1.41	9.87
220	200.	10.	300.	150.	65.	0	20.398	4.187	1.34	9.99
221	60.	30.	300.	150.	65.	0	19.315	5.307	1.46	10.19
222	100.	30.	300.	150.	65.	0	17.838	4.294	1.26	10.28
223	150.	30.	300.	150.	65.	0	17.374	3.920	1.19	10.40
224	200.	30.	300.	150.	65.	0	17.090	3.738	1.15	10.43
225	60.	50.	300.	150.	65.	0	17.721	4.873	1.34	10.35
226	100.	50.	300.	150.	65.	0	16.980	4.073	1.20	10.45
227	150.	50.	300.	150.	65.	0	16.662	3.760	1.14	10.49
228	200.	50.	300.	150.	65.	0	16.824	3.644	1.13	10.48
229	60.	10.	600.	150.	65.	0	32.751	10.408	2.67	6.53
230	100.	10.	600.	150.	65.	0	28.599	6.845	2.01	6.64
231	150.	10.	600.	150.	65.	0	26.589	5.346	1.73	6.62
232	200.	10.	600.	150.	65.	0	25.211	4.833	1.60	6.70
233	60.	30.	600.	150.	65.	0	24.919	7.033	1.91	6.87
234	100.	30.	600.	150.	65.	0	22.844	5.181	1.57	6.89
235	150.	30.	600.	150.	65.	0	22.137	4.590	1.46	6.93
236	200.	30.	600.	150.	65.	0	21.443	4.234	1.38	6.91
237	60.	50.	600.	150.	65.	0	22.805	6.092	1.70	6.92
238	100.	50.	600.	150.	65.	0	21.773	4.852	1.48	6.96
239	150.	50.	600.	150.	65.	0	20.867	4.261	1.37	6.91
240	200.	50.	600.	150.	65.	0	20.812	4.123	1.34	6.96

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
241	60.	10.	1000.	150.	65.	0	*	41.553	15.815	*	3.76	5.33
242	100.	10.	1000.	150.	65.	0	*	35.925	9.389	*	2.64	5.41
243	150.	10.	1000.	150.	65.	0	*	31.931	6.602	*	2.10	5.42
244	200.	10.	1000.	150.	65.	0	*	31.419	6.037	*	2.00	5.45
245	60.	30.	1000.	150.	65.	0	*	29.713	8.814	*	2.33	5.52
246	100.	30.	1000.	150.	65.	0	*	28.108	6.442	*	1.94	5.53
247	150.	30.	1000.	150.	65.	0	*	26.937	5.370	*	1.74	5.55
248	200.	30.	1000.	150.	65.	0	*	26.321	5.029	*	1.67	5.60
249	60.	50.	1000.	150.	65.	0	*	28.077	7.938	*	2.15	5.55
250	100.	50.	1000.	150.	65.	0	*	26.344	5.780	*	1.78	5.56
251	150.	50.	1000.	150.	65.	0	*	25.422	5.064	*	1.65	5.61
252	200.	50.	1000.	150.	65.	0	*	24.840	4.655	*	1.57	5.58
253	60.	10.	300.	175.	65.	0	*	23.031	6.778	*	1.80	11.59
254	100.	10.	300.	175.	65.	0	*	20.136	4.875	*	1.43	11.83
255	150.	10.	300.	175.	65.	0	*	18.538	4.159	*	1.27	12.07
256	200.	10.	300.	175.	65.	0	*	17.982	3.922	*	1.21	12.10
257	60.	30.	300.	175.	65.	0	*	17.009	4.886	*	1.31	12.44
258	100.	30.	300.	175.	65.	0	*	15.735	3.996	*	1.14	12.55
259	150.	30.	300.	175.	65.	0	*	15.428	3.687	*	1.09	12.62
260	200.	30.	300.	175.	65.	0	*	15.104	3.528	*	1.05	12.66
261	60.	50.	300.	175.	65.	0	*	15.685	4.526	*	1.21	12.63
262	100.	50.	300.	175.	65.	0	*	15.081	3.824	*	1.09	12.69
263	150.	50.	300.	175.	65.	0	*	14.703	3.545	*	1.04	12.73
264	200.	50.	300.	175.	65.	0	*	14.690	3.437	*	1.02	12.71
265	60.	10.	600.	175.	65.	0	*	28.067	9.246	*	2.34	7.94
266	100.	10.	600.	175.	65.	0	*	24.612	6.164	*	1.77	8.08
267	150.	10.	600.	175.	65.	0	*	22.800	4.877	*	1.52	8.06
268	200.	10.	600.	175.	65.	0	*	21.589	4.430	*	1.42	8.15
269	60.	30.	600.	175.	65.	0	*	21.473	6.342	*	1.68	8.37
270	100.	30.	600.	175.	65.	0	*	19.748	4.734	*	1.39	8.42
271	150.	30.	600.	175.	65.	0	*	19.002	4.233	*	1.29	8.47
272	200.	30.	600.	175.	65.	0	*	18.523	3.922	*	1.23	8.45
273	60.	50.	600.	175.	65.	0	*	19.726	5.531	*	1.50	8.43
274	100.	50.	600.	175.	65.	0	*	18.649	4.460	*	1.31	8.51
275	150.	50.	600.	175.	65.	0	*	17.957	3.946	*	1.21	8.45
276	200.	50.	600.	175.	65.	0	*	17.808	3.824	*	1.19	8.51
277	60.	10.	1000.	175.	65.	0	*	34.930	13.784	*	3.23	6.46
278	100.	10.	1000.	175.	65.	0	*	30.217	8.284	*	2.28	6.56
279	150.	10.	1000.	175.	65.	0	*	26.817	5.895	*	1.81	6.56
280	200.	10.	1000.	175.	65.	0	*	25.923	5.123	*	1.67	6.54

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
281	60.	30.	1000.	175.	65.	0	*	25.214	7.805	*	2.03	6.70
282	100.	30.	1000.	175.	65.	0	*	23.726	5.781	*	1.69	6.72
283	50.	30.	1000.	175.	65.	0	*	22.734	4.852	*	1.52	6.76
284	200.	30.	1000.	175.	65.	0	*	22.415	4.569	*	1.47	6.82
285	60.	50.	1000.	175.	65.	0	*	23.711	7.056	*	1.87	6.74
286	100.	50.	1000.	175.	65.	0	*	22.475	5.213	*	1.56	6.77
287	50.	50.	1000.	175.	65.	0	*	21.541	4.596	*	1.44	6.83
288	200.	50.	1000.	175.	65.	0	*	21.335	4.255	*	1.38	6.80
289	60.	10.	300.	100.	80.	0	*	38.376	8.919	*	2.65	5.87
290	100.	10.	300.	100.	80.	0	*	33.410	6.302	*	2.11	5.95
291	50.	10.	300.	100.	80.	0	*	31.865	5.613	*	1.96	6.04
292	200.	10.	300.	100.	80.	0	*	30.009	5.029	*	1.81	6.05
293	60.	30.	300.	100.	80.	0	*	28.015	6.232	*	1.91	6.21
294	100.	30.	300.	100.	80.	0	*	26.026	5.074	*	1.67	6.20
295	50.	30.	300.	100.	80.	0	*	25.313	4.648	*	1.58	6.23
296	200.	30.	300.	100.	80.	0	*	24.951	4.432	*	1.54	6.25
297	60.	50.	300.	100.	80.	0	*	25.719	5.722	*	1.75	6.23
298	100.	50.	300.	100.	80.	0	*	24.599	4.812	*	1.58	6.25
299	50.	50.	300.	100.	80.	0	*	23.972	4.461	*	1.51	6.26
300	200.	50.	300.	100.	80.	0	*	24.198	4.386	*	1.49	6.26
301	60.	10.	600.	100.	80.	0	*	52.089	13.010	*	3.75	3.96
302	100.	10.	600.	100.	80.	0	*	45.702	8.684	*	2.90	4.03
303	50.	10.	600.	100.	80.	0	*	42.303	7.053	*	2.54	4.05
304	200.	10.	600.	100.	80.	0	*	40.512	6.245	*	2.36	4.05
305	60.	30.	600.	100.	80.	0	*	39.186	8.758	*	2.67	4.11
306	100.	30.	600.	100.	80.	0	*	36.372	6.553	*	2.26	4.13
307	50.	30.	600.	100.	80.	0	*	35.205	5.847	*	2.11	4.16
308	200.	30.	600.	100.	80.	0	*	34.027	5.407	*	2.01	4.15
309	60.	50.	600.	100.	80.	0	*	36.178	7.617	*	2.40	4.15
310	100.	50.	600.	100.	80.	0	*	34.471	6.141	*	2.13	4.17
311	50.	50.	600.	100.	80.	0	*	33.234	5.457	*	1.99	4.14
312	200.	50.	600.	100.	80.	0	*	33.206	5.262	*	1.96	4.17
313	60.	10.	1000.	100.	80.	0	*	68.276	20.323	*	5.37	3.23
314	100.	10.	1000.	100.	80.	0	*	59.651	12.312	*	3.92	3.27
315	50.	10.	1000.	100.	80.	0	*	53.845	8.902	*	3.23	3.26
316	200.	10.	1000.	100.	80.	0	*	52.827	8.137	*	3.08	3.28
317	60.	30.	1000.	100.	80.	0	*	49.941	11.556	*	3.46	3.31
318	100.	30.	1000.	100.	80.	0	*	47.816	9.002	*	3.02	3.34
319	50.	30.	1000.	100.	80.	0	*	45.277	7.252	*	2.68	3.32
320	200.	30.	1000.	100.	80.	0	*	44.324	6.758	*	2.57	3.35

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
321	60.	50.	1000.	100.	80.	0	47.146	10.426	3.20	3.32
322	100.	50.	1000.	100.	80.	0	45.142	8.250	2.82	3.36
323	150.	50.	1000.	100.	80.	0	42.916	6.791	2.53	3.35
324	200.	50.	1000.	100.	80.	0	42.210	6.316	2.43	3.33
325	60.	10.	300.	125.	80.	0	30.441	7.456	2.17	7.67
326	100.	10.	300.	125.	80.	0	26.746	5.454	1.75	7.89
327	150.	10.	300.	125.	80.	0	24.749	4.705	1.57	8.00
328	200.	10.	300.	125.	80.	0	23.954	4.433	1.50	8.08
329	60.	30.	300.	125.	80.	0	22.424	5.388	1.58	8.06
330	100.	30.	300.	125.	80.	0	20.862	4.468	1.39	8.11
331	150.	30.	300.	125.	80.	0	20.535	4.146	1.34	8.15
332	200.	30.	300.	125.	80.	0	20.020	3.962	1.29	8.17
333	60.	50.	300.	125.	80.	0	20.600	4.983	1.46	8.16
334	100.	50.	300.	125.	80.	0	19.894	4.278	1.33	8.18
335	150.	50.	300.	125.	80.	0	19.306	3.980	1.27	8.19
336	200.	50.	300.	125.	80.	0	19.324	3.851	1.25	8.19
337	60.	10.	600.	125.	80.	0	39.293	10.475	2.92	5.24
338	100.	10.	600.	125.	80.	0	34.481	7.121	2.27	5.26
339	150.	10.	600.	125.	80.	0	32.415	5.885	2.02	5.34
340	200.	10.	600.	125.	80.	0	30.510	5.214	1.85	5.31
341	60.	30.	600.	125.	80.	0	29.996	7.233	2.12	5.40
342	100.	30.	600.	125.	80.	0	27.810	5.500	1.79	5.42
343	150.	30.	600.	125.	80.	0	26.965	4.952	1.69	5.45
344	200.	30.	600.	125.	80.	0	26.035	4.607	1.60	5.43
345	60.	50.	600.	125.	80.	0	27.744	6.342	1.91	5.42
346	100.	50.	600.	125.	80.	0	26.316	5.182	1.69	5.47
347	150.	50.	600.	125.	80.	0	25.471	4.637	1.59	5.43
348	200.	50.	600.	125.	80.	0	25.455	4.502	1.57	5.46
349	60.	10.	1000.	125.	80.	0	50.251	15.823	4.08	4.24
350	100.	10.	1000.	125.	80.	0	43.860	9.727	2.98	4.29
351	150.	10.	1000.	125.	80.	0	39.253	7.076	2.43	4.28
352	200.	10.	1000.	125.	80.	0	38.888	6.550	2.35	4.30
353	60.	30.	1000.	125.	80.	0	36.650	9.122	2.63	4.34
354	100.	30.	1000.	125.	80.	0	34.881	6.889	2.25	4.34
355	150.	30.	1000.	125.	80.	0	33.490	5.864	2.05	4.35
356	200.	30.	1000.	125.	80.	0	32.933	5.532	1.99	4.39
357	60.	50.	1000.	125.	80.	0	34.799	8.285	2.44	4.35
358	100.	50.	1000.	125.	80.	0	33.017	6.297	2.10	4.35
359	150.	50.	1000.	125.	80.	0	32.085	5.564	1.96	4.39
360	200.	50.	1000.	125.	80.	0	31.168	5.175	1.87	4.36

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
361	60.	10.	300.	150.	80.	0	26.222	6.786	1.92	9.73
362	100.	10.	300.	150.	80.	0	22.815	4.989	1.54	9.89
363	150.	10.	300.	150.	80.	0	20.943	4.305	1.37	9.97
364	200.	10.	300.	150.	80.	0	20.214	4.059	1.31	10.07
365	60.	30.	300.	150.	80.	0	19.165	4.951	1.40	10.28
366	100.	30.	300.	150.	80.	0	17.674	4.104	1.23	10.36
367	150.	30.	300.	150.	80.	0	17.252	3.813	1.17	10.41
368	200.	30.	300.	150.	80.	0	16.960	3.662	1.14	10.50
369	60.	50.	300.	150.	80.	0	17.603	4.585	1.29	10.42
370	100.	50.	300.	150.	80.	0	16.894	3.938	1.17	10.45
371	150.	50.	300.	150.	80.	0	16.558	3.661	1.12	10.53
372	200.	50.	300.	150.	80.	0	16.727	3.590	1.12	10.58
373	60.	10.	600.	150.	80.	0	32.256	9.229	2.49	6.63
374	100.	10.	600.	150.	80.	0	28.348	6.312	1.93	6.72
375	150.	10.	600.	150.	80.	0	26.385	5.096	1.68	6.69
376	200.	10.	600.	150.	80.	0	25.032	4.659	1.57	6.76
377	60.	30.	600.	150.	80.	0	24.708	6.430	1.81	6.91
378	100.	30.	600.	150.	80.	0	22.734	4.916	1.53	6.92
379	150.	30.	600.	150.	80.	0	22.051	4.439	1.43	6.96
380	200.	30.	600.	150.	80.	0	21.362	4.143	1.37	6.94
381	60.	50.	600.	150.	80.	0	22.642	5.648	1.63	6.95
382	100.	50.	600.	150.	80.	0	21.688	4.648	1.45	6.98
383	150.	50.	600.	150.	80.	0	20.800	4.163	1.35	6.93
384	200.	50.	600.	150.	80.	0	20.710	4.044	1.33	6.98
385	60.	10.	1000.	150.	80.	0	40.890	13.707	3.44	5.38
386	100.	10.	1000.	150.	80.	0	35.609	8.463	2.50	5.45
387	150.	10.	1000.	150.	80.	0	31.708	6.181	2.03	5.44
388	200.	10.	1000.	150.	80.	0	31.229	5.717	1.95	5.49
389	60.	30.	1000.	150.	80.	0	29.535	7.954	2.21	5.55
390	100.	30.	1000.	150.	80.	0	27.983	6.022	1.87	5.55
391	150.	30.	1000.	150.	80.	0	26.846	5.143	1.71	5.57
392	200.	30.	1000.	150.	80.	0	26.177	4.845	1.64	5.62
393	60.	50.	1000.	150.	80.	0	27.889	7.221	2.04	5.57
394	100.	50.	1000.	150.	80.	0	26.185	5.460	1.73	5.57
395	150.	50.	1000.	150.	80.	0	25.354	4.882	1.62	5.62
396	200.	50.	1000.	150.	80.	0	24.732	4.538	1.55	5.59
397	60.	10.	300.	175.	80.	0	22.661	6.151	1.70	11.76
398	100.	10.	300.	175.	80.	0	19.799	4.599	1.37	12.06
399	150.	10.	300.	175.	80.	0	18.318	4.009	1.24	12.16
400	200.	10.	300.	175.	80.	0	17.770	3.804	1.19	12.29

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
401	60.	30.	300.	175.	80.	0	*	16.693	4.563	*	1.26	12.54
402	100.	30.	300.	175.	80.	0	*	15.642	3.852	*	1.12	12.64
403	150.	30.	300.	175.	80.	0	*	15.356	3.601	*	1.07	12.71
404	200.	30.	300.	175.	80.	0	*	15.028	3.466	*	1.04	12.74
405	60.	50.	300.	175.	80.	0	*	15.539	4.263	*	1.17	12.71
406	100.	50.	300.	175.	80.	0	*	14.961	3.702	*	1.07	12.76
407	150.	50.	300.	175.	80.	0	*	14.645	3.464	*	1.03	12.79
408	200.	50.	300.	175.	80.	0	*	14.588	3.386	*	1.01	12.78
409	60.	10.	600.	175.	80.	0	*	27.642	8.228	*	2.18	8.07
410	100.	10.	600.	175.	80.	0	*	24.424	5.714	*	1.70	8.22
411	150.	10.	600.	175.	80.	0	*	22.644	4.662	*	1.49	8.13
412	200.	10.	600.	175.	80.	0	*	21.463	4.282	*	1.39	8.26
413	60.	30.	600.	175.	80.	0	*	21.343	5.827	*	1.61	8.41
414	100.	30.	600.	175.	80.	0	*	19.658	4.513	*	1.36	8.43
415	150.	30.	600.	175.	80.	0	*	18.890	4.093	*	1.27	8.48
416	200.	30.	600.	175.	80.	0	*	18.462	3.843	*	1.22	8.45
417	60.	50.	600.	175.	80.	0	*	19.627	5.154	*	1.45	8.46
418	100.	50.	600.	175.	80.	0	*	18.539	4.274	*	1.28	8.53
419	150.	50.	600.	175.	80.	0	*	17.907	3.860	*	1.20	8.48
420	200.	50.	600.	175.	80.	0	*	17.757	3.758	*	1.18	8.53
421	60.	10.	1000.	175.	80.	0	*	34.550	11.986	*	2.96	6.54
422	100.	10.	1000.	175.	80.	0	*	29.980	7.494	*	2.16	6.62
423	150.	10.	1000.	175.	80.	0	*	26.622	5.533	*	1.76	6.62
424	200.	10.	1000.	175.	80.	0	*	25.720	4.905	*	1.63	6.59
425	60.	30.	1000.	175.	80.	0	*	25.062	7.068	*	1.92	6.74
426	100.	30.	1000.	175.	80.	0	*	23.616	5.413	*	1.63	6.74
427	150.	30.	1000.	175.	80.	0	*	22.655	4.655	*	1.49	6.76
428	200.	30.	1000.	175.	80.	0	*	22.350	4.423	*	1.44	6.82
429	60.	50.	1000.	175.	80.	0	*	23.519	6.436	*	1.77	6.77
430	100.	50.	1000.	175.	80.	0	*	22.350	4.940	*	1.52	6.77
431	150.	50.	1000.	175.	80.	0	*	21.486	4.437	*	1.41	6.83
432	200.	50.	1000.	175.	80.	0	*	21.225	4.150	*	1.36	6.79
433	60.	10.	300.	100.	50.	10	*	46.745	13.985	*	3.69	5.20
434	100.	10.	300.	100.	50.	10	*	39.449	8.586	*	2.66	5.33
435	150.	10.	300.	100.	50.	10	*	36.621	6.907	*	2.31	5.35
436	200.	10.	300.	100.	50.	10	*	34.039	5.918	*	2.08	5.36
437	60.	30.	300.	100.	50.	10	*	31.474	8.142	*	2.30	5.48
438	100.	30.	300.	100.	50.	10	*	29.292	6.117	*	1.94	5.53
439	150.	30.	300.	100.	50.	10	*	28.341	5.346	*	1.79	5.57
440	200.	30.	300.	100.	50.	10	*	27.743	5.010	*	1.72	5.59

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
441	60.	50.	300.	100.	50.	10	*	29.128	7.358	*	2.11	5.58
442	100.	50.	300.	100.	50.	10	*	27.579	5.709	*	1.82	5.60
443	150.	50.	300.	100.	50.	10	*	26.836	5.021	*	1.69	5.62
444	200.	50.	300.	100.	50.	10	*	26.840	4.783	*	1.66	5.62
445	60.	10.	600.	100.	50.	10	*	61.843	19.856	*	5.07	3.51
446	100.	10.	600.	100.	50.	10	*	53.492	11.984	*	3.65	3.57
447	150.	10.	600.	100.	50.	10	*	49.747	9.091	*	3.10	3.60
448	200.	10.	600.	100.	50.	10	*	46.804	7.612	*	2.79	3.60
449	60.	30.	600.	100.	50.	10	*	45.187	12.325	*	3.40	3.67
450	100.	30.	600.	100.	50.	10	*	41.510	8.298	*	2.69	3.69
451	150.	30.	600.	100.	50.	10	*	39.919	7.015	*	2.45	3.72
452	200.	30.	600.	100.	50.	10	*	38.853	6.297	*	2.31	3.71
453	60.	50.	600.	100.	50.	10	*	41.398	10.296	*	2.97	3.70
454	100.	50.	600.	100.	50.	10	*	39.121	7.609	*	2.51	3.73
455	150.	50.	600.	100.	50.	10	*	37.785	6.329	*	2.28	3.71
456	200.	50.	600.	100.	50.	10	*	37.536	6.024	*	2.22	3.73
457	60.	10.	1000.	100.	50.	10	*	83.038	33.374	*	7.77	2.86
458	100.	10.	1000.	100.	50.	10	*	71.033	18.291	*	5.19	2.90
459	150.	10.	1000.	100.	50.	10	*	63.766	11.970	*	4.02	2.90
460	200.	10.	1000.	100.	50.	10	*	62.783	10.705	*	3.81	2.92
461	60.	30.	1000.	100.	50.	10	*	58.306	17.077	*	4.55	2.95
462	100.	30.	1000.	100.	50.	10	*	54.978	11.572	*	3.65	2.96
463	150.	30.	1000.	100.	50.	10	*	52.642	9.095	*	3.21	2.97
464	200.	30.	1000.	100.	50.	10	*	51.571	8.293	*	3.06	3.00
465	60.	50.	1000.	100.	50.	10	*	54.820	15.021	*	4.13	2.97
466	100.	50.	1000.	100.	50.	10	*	52.252	11.039	*	3.47	3.01
467	150.	50.	1000.	100.	50.	10	*	49.546	8.358	*	2.99	3.00
468	200.	50.	1000.	100.	50.	10	*	48.837	7.492	*	2.84	2.99
469	60.	10.	300.	125.	50.	10	*	35.337	10.486	*	2.78	6.63
470	100.	10.	300.	125.	50.	10	*	30.493	6.906	*	2.09	6.78
471	150.	10.	300.	125.	50.	10	*	27.853	5.540	*	1.80	6.87
472	200.	10.	300.	125.	50.	10	*	26.832	5.120	*	1.70	7.10
473	60.	30.	300.	125.	50.	10	*	25.011	6.910	*	1.89	7.18
474	100.	30.	300.	125.	50.	10	*	23.227	5.286	*	1.60	7.25
475	150.	30.	300.	125.	50.	10	*	22.733	4.675	*	1.49	7.30
476	200.	30.	300.	125.	50.	10	*	22.315	4.409	*	1.44	7.33
477	60.	50.	300.	125.	50.	10	*	23.136	6.287	*	1.74	7.31
478	100.	50.	300.	125.	50.	10	*	22.049	4.968	*	1.51	7.34
479	150.	50.	300.	125.	50.	10	*	21.205	4.414	*	1.40	7.36
480	200.	50.	300.	125.	50.	10	*	21.314	4.222	*	1.38	7.36

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
481	60.	10.	600.	125.	50.	10	45.749	15.625	3.89	4.56
482	100.	10.	600.	125.	50.	10	39.777	9.597	2.81	4.62
483	150.	10.	600.	125.	50.	10	36.496	6.994	2.32	4.61
484	200.	10.	600.	125.	50.	10	34.936	6.227	2.16	4.67
485	60.	30.	600.	125.	50.	10	33.965	9.907	2.64	4.82
486	100.	30.	600.	125.	50.	10	31.580	6.608	2.09	4.78
487	150.	30.	600.	125.	50.	10	30.204	5.605	1.90	4.79
488	200.	30.	600.	125.	50.	10	29.343	5.240	1.81	4.85
489	60.	50.	600.	125.	50.	10	31.373	7.955	2.27	4.80
490	100.	50.	600.	125.	50.	10	29.559	6.270	1.97	4.89
491	150.	50.	600.	125.	50.	10	28.362	5.268	1.78	4.87
492	200.	50.	600.	125.	50.	10	28.414	5.044	1.75	4.89
493	60.	10.	1000.	125.	50.	10	59.278	25.221	5.74	3.72
494	100.	10.	1000.	125.	50.	10	51.166	14.090	3.87	3.75
495	150.	10.	1000.	125.	50.	10	45.342	9.258	2.97	3.75
496	200.	10.	1000.	125.	50.	10	43.303	7.648	2.66	3.75
497	60.	30.	1000.	125.	50.	10	42.038	13.095	3.39	3.85
498	100.	30.	1000.	125.	50.	10	39.885	9.014	2.73	3.86
499	150.	30.	1000.	125.	50.	10	37.902	7.145	2.40	3.88
500	200.	30.	1000.	125.	50.	10	37.533	6.600	2.30	3.91
501	60.	50.	1000.	125.	50.	10	39.718	11.568	3.09	3.88
502	100.	50.	1000.	125.	50.	10	37.206	7.861	2.47	3.89
503	150.	50.	1000.	125.	50.	10	36.115	6.653	2.26	3.92
504	200.	50.	1000.	125.	50.	10	35.128	5.947	2.12	3.90
505	60.	10.	300.	150.	50.	10	29.853	9.385	2.42	8.33
506	100.	10.	300.	150.	50.	10	25.677	6.226	1.82	8.55
507	150.	10.	300.	150.	50.	10	23.504	5.023	1.57	8.78
508	200.	10.	300.	150.	50.	10	22.918	4.676	1.50	8.89
509	60.	30.	300.	150.	50.	10	21.268	6.273	1.67	9.11
510	100.	30.	300.	150.	50.	10	19.682	4.825	1.40	9.32
511	150.	30.	300.	150.	50.	10	19.056	4.266	1.30	9.28
512	200.	30.	300.	150.	50.	10	18.588	4.042	1.25	9.42
513	60.	50.	300.	150.	50.	10	19.442	5.703	1.52	9.41
514	100.	50.	300.	150.	50.	10	18.614	4.515	1.32	9.35
515	150.	50.	300.	150.	50.	10	17.813	4.039	1.22	9.36
516	200.	50.	300.	150.	50.	10	17.966	3.892	1.21	9.36
517	60.	10.	600.	150.	50.	10	37.347	13.606	3.29	5.84
518	100.	10.	600.	150.	50.	10	32.382	8.403	2.37	5.86
519	150.	10.	600.	150.	50.	10	29.367	6.113	1.94	5.86
520	200.	10.	600.	150.	50.	10	28.233	5.476	1.81	5.93

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
521	60.	30.	600.	150.	50.	10	*	27.719	8.700	*	2.25	6.11
522	100.	30.	600.	150.	50.	10	*	25.546	5.820	*	1.76	6.09
523	150.	30.	600.	150.	50.	10	*	24.380	4.954	*	1.59	6.11
524	200.	30.	600.	150.	50.	10	*	23.582	4.638	*	1.52	6.19
525	60.	50.	600.	150.	50.	10	*	25.384	6.985	*	1.92	6.13
526	100.	50.	600.	150.	50.	10	*	23.930	5.547	*	1.66	6.24
527	150.	50.	600.	150.	50.	10	*	22.956	4.669	*	1.50	6.20
528	200.	50.	600.	150.	50.	10	*	22.970	4.484	*	1.47	6.24
529	60.	10.	1000.	150.	50.	10	*	47.803	21.598	*	4.81	4.70
530	100.	10.	1000.	150.	50.	10	*	40.710	12.042	*	3.19	4.79
531	150.	10.	1000.	150.	50.	10	*	36.182	7.957	*	2.45	4.80
532	200.	10.	1000.	150.	50.	10	*	34.013	6.524	*	2.17	4.79
533	60.	30.	1000.	150.	50.	10	*	33.456	11.255	*	2.82	4.94
534	100.	30.	1000.	150.	50.	10	*	31.431	7.748	*	2.25	4.96
535	150.	30.	1000.	150.	50.	10	*	29.738	6.167	*	1.96	4.97
536	200.	30.	1000.	150.	50.	10	*	29.579	5.702	*	1.89	5.02
537	60.	50.	1000.	150.	50.	10	*	31.414	9.953	*	2.56	4.98
538	100.	50.	1000.	150.	50.	10	*	29.315	6.772	*	2.03	4.99
539	150.	50.	1000.	150.	50.	10	*	28.214	5.746	*	1.84	5.03
540	200.	50.	1000.	150.	50.	10	*	27.596	5.151	*	1.74	5.01
541	60.	10.	300.	175.	50.	10	*	25.690	8.396	*	2.13	10.07
542	100.	10.	300.	175.	50.	10	*	22.160	5.660	*	1.61	10.30
543	150.	10.	300.	175.	50.	10	*	20.373	4.620	*	1.40	10.62
544	200.	10.	300.	175.	50.	10	*	19.778	4.309	*	1.33	10.76
545	60.	30.	300.	175.	50.	10	*	18.469	5.694	*	1.48	11.05
546	100.	30.	300.	175.	50.	10	*	17.138	4.451	*	1.26	11.18
547	150.	30.	300.	175.	50.	10	*	16.676	3.984	*	1.17	11.25
548	200.	30.	300.	175.	50.	10	*	16.205	3.749	*	1.12	11.20
549	60.	50.	300.	175.	50.	10	*	17.042	5.206	*	1.36	11.28
550	100.	50.	300.	175.	50.	10	*	16.271	4.201	*	1.19	11.34
551	150.	50.	300.	175.	50.	10	*	15.659	3.791	*	1.11	11.43
552	200.	50.	300.	175.	50.	10	*	16.007	3.650	*	1.10	11.39
553	60.	10.	600.	175.	50.	10	*	31.607	11.939	*	2.85	7.06
554	100.	10.	600.	175.	50.	10	*	27.491	7.475	*	2.06	7.12
555	150.	10.	600.	175.	50.	10	*	24.961	5.512	*	1.69	7.16
556	200.	10.	600.	175.	50.	10	*	23.882	4.957	*	1.57	7.22
557	60.	30.	600.	175.	50.	10	*	23.608	7.748	*	1.96	7.48
558	100.	30.	600.	175.	50.	10	*	21.742	5.266	*	1.54	7.42
559	150.	30.	600.	175.	50.	10	*	20.627	4.493	*	1.39	7.45
560	200.	30.	600.	175.	50.	10	*	20.214	4.251	*	1.34	7.55

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
561	60.	50.	600.	175.	50.	10	*	21.545	5.249	*	1.67	7.47
562	100.	50.	600.	175.	50.	10	*	20.617	5.045	*	1.47	7.63
563	150.	50.	600.	175.	50.	10	*	19.626	4.278	*	1.32	7.56
564	200.	50.	600.	175.	50.	10	*	19.572	4.118	*	1.30	7.61
565	60.	10.	1000.	175.	50.	10	*	39.961	18.618	*	4.10	5.71
566	100.	10.	1000.	175.	50.	10	*	34.066	10.500	*	2.73	5.80
567	150.	10.	1000.	175.	50.	10	*	30.125	7.013	*	2.09	5.82
568	200.	10.	1000.	175.	50.	10	*	28.354	5.797	*	1.86	5.83
569	60.	30.	1000.	175.	50.	10	*	27.923	9.838	*	2.41	6.00
570	100.	30.	1000.	175.	50.	10	*	26.398	6.855	*	1.94	6.02
571	150.	30.	1000.	175.	50.	10	*	24.945	5.508	*	1.69	6.06
572	200.	30.	1000.	175.	50.	10	*	24.672	5.111	*	1.62	6.12
573	60.	50.	1000.	175.	50.	10	*	26.405	8.738	*	2.20	6.05
574	100.	50.	1000.	175.	50.	10	*	24.626	6.041	*	1.76	6.08
575	150.	50.	1000.	175.	50.	10	*	23.762	5.156	*	1.60	6.14
576	200.	50.	1000.	175.	50.	10	*	23.095	4.642	*	1.50	6.10
577	60.	10.	300.	100.	65.	10	*	43.599	10.807	*	3.12	5.23
578	100.	10.	300.	100.	65.	10	*	37.587	7.338	*	2.41	5.31
579	150.	10.	300.	100.	65.	10	*	36.068	6.386	*	2.22	5.40
580	200.	10.	300.	100.	65.	10	*	33.614	5.563	*	2.01	5.46
581	60.	30.	300.	100.	65.	10	*	31.081	7.265	*	2.16	5.54
582	100.	30.	300.	100.	65.	10	*	29.023	5.674	*	1.86	5.58
583	150.	30.	300.	100.	65.	10	*	28.107	5.100	*	1.75	5.61
584	200.	30.	300.	100.	65.	10	*	27.528	4.800	*	1.68	5.63
585	60.	50.	300.	100.	65.	10	*	28.489	6.603	*	1.98	5.62
586	100.	50.	300.	100.	65.	10	*	27.231	5.356	*	1.75	5.64
587	150.	50.	300.	100.	65.	10	*	26.662	4.837	*	1.66	5.65
588	200.	50.	300.	100.	65.	10	*	26.680	4.616	*	1.63	5.65
589	60.	10.	600.	100.	65.	10	*	60.456	16.623	*	4.56	3.56
590	100.	10.	600.	100.	65.	10	*	52.562	10.563	*	3.41	3.58
591	150.	10.	600.	100.	65.	10	*	48.080	7.906	*	2.87	3.57
592	200.	10.	600.	100.	65.	10	*	46.224	7.115	*	2.69	3.62
593	60.	30.	600.	100.	65.	10	*	44.705	10.723	*	3.15	3.70
594	100.	30.	600.	100.	65.	10	*	41.193	7.611	*	2.58	3.71
595	150.	30.	600.	100.	65.	10	*	39.817	6.407	*	2.36	3.67
596	200.	30.	600.	100.	65.	10	*	38.438	5.997	*	2.25	3.72
597	60.	50.	600.	100.	65.	10	*	41.045	9.132	*	2.79	3.72
598	100.	50.	600.	100.	65.	10	*	38.820	7.044	*	2.41	3.74
599	150.	50.	600.	100.	65.	10	*	37.590	6.065	*	2.23	3.72
600	200.	50.	600.	100.	65.	10	*	37.368	5.800	*	2.18	3.75

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
601	60.	10.	1000.	100.	65.	10	*	80.525	27.110	*	6.78	2.89
602	100.	10.	1000.	100.	65.	10	*	69.777	15.637	*	4.76	2.93
603	150.	10.	1000.	100.	65.	10	*	62.736	10.740	*	3.81	2.92
604	200.	10.	1000.	100.	65.	10	*	61.517	9.682	*	3.62	2.93
605	60.	30.	1000.	100.	65.	10	*	57.346	14.490	*	4.15	2.96
606	100.	30.	1000.	100.	65.	10	*	54.567	10.378	*	3.46	2.97
607	150.	30.	1000.	100.	65.	10	*	52.309	8.445	*	3.10	2.98
608	200.	30.	1000.	100.	65.	10	*	51.165	7.773	*	2.97	3.01
609	60.	50.	1000.	100.	65.	10	*	54.343	13.001	*	3.83	2.98
610	100.	50.	1000.	100.	65.	10	*	51.091	9.165	*	3.16	2.98
611	150.	50.	1000.	100.	65.	10	*	49.230	7.824	*	2.90	3.01
612	200.	50.	1000.	100.	65.	10	*	48.635	7.141	*	2.79	2.99
613	60.	10.	300.	125.	65.	10	*	34.207	8.997	*	2.52	6.70
614	100.	10.	300.	125.	65.	10	*	29.699	6.238	*	1.97	7.03
615	150.	10.	300.	125.	65.	10	*	27.470	5.195	*	1.74	7.01
616	200.	10.	300.	125.	65.	10	*	26.409	4.824	*	1.65	7.09
617	60.	30.	300.	125.	65.	10	*	24.711	6.192	*	1.78	7.14
618	100.	30.	300.	125.	65.	10	*	23.018	4.929	*	1.54	7.32
619	150.	30.	300.	125.	65.	10	*	22.293	4.469	*	1.45	7.36
620	200.	30.	300.	125.	65.	10	*	22.160	4.239	*	1.41	7.39
621	60.	50.	300.	125.	65.	10	*	22.746	5.658	*	1.63	7.26
622	100.	50.	300.	125.	65.	10	*	21.890	4.671	*	1.46	7.39
623	150.	50.	300.	125.	65.	10	*	21.065	4.260	*	1.37	7.40
624	200.	50.	300.	125.	65.	10	*	21.188	4.086	*	1.35	7.40
625	60.	10.	600.	125.	65.	10	*	44.548	13.142	*	3.49	4.61
626	100.	10.	600.	125.	65.	10	*	39.134	8.486	*	2.63	4.68
627	150.	10.	600.	125.	65.	10	*	36.001	6.465	*	2.23	4.69
628	200.	10.	600.	125.	65.	10	*	34.180	5.620	*	2.07	4.74
629	60.	30.	600.	125.	65.	10	*	33.624	8.668	*	2.46	4.84
630	100.	30.	600.	125.	65.	10	*	31.230	6.096	*	2.00	4.80
631	150.	30.	600.	125.	65.	10	*	29.930	5.334	*	1.85	4.82
632	200.	30.	600.	125.	65.	10	*	29.107	5.022	*	1.77	4.88
633	60.	50.	600.	125.	65.	10	*	31.022	7.129	*	2.14	4.81
634	100.	50.	600.	125.	65.	10	*	29.381	5.829	*	1.90	4.91
635	150.	50.	600.	125.	65.	10	*	28.222	5.057	*	1.75	4.88
636	200.	50.	600.	125.	65.	10	*	28.207	4.874	*	1.72	4.91
637	60.	10.	1000.	125.	65.	10	*	58.014	20.703	*	5.05	3.75
638	100.	10.	1000.	125.	65.	10	*	50.245	12.065	*	3.54	3.82
639	150.	10.	1000.	125.	65.	10	*	44.734	8.338	*	2.81	3.81
640	200.	10.	1000.	125.	65.	10	*	42.766	7.069	*	2.56	3.79

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
641	60.	30.	1000.	125.	65.	10	41.608	11.258	3.11	3.88
642	100.	30.	1000.	125.	65.	10	39.483	8.091	2.59	3.89
643	150.	30.	1000.	125.	65.	10	37.662	6.661	2.32	3.90
644	200.	30.	1000.	125.	65.	10	37.408	6.239	2.25	3.94
645	60.	50.	1000.	125.	65.	10	39.483	10.090	2.87	3.91
646	100.	50.	1000.	125.	65.	10	36.910	7.183	2.36	3.90
647	150.	50.	1000.	125.	65.	10	35.939	6.264	2.20	3.94
648	200.	50.	1000.	125.	65.	10	34.969	5.704	2.08	3.91
649	60.	10.	300.	150.	65.	10	29.340	8.111	2.22	8.76
650	100.	10.	300.	150.	65.	10	25.280	5.670	1.73	8.72
651	150.	10.	300.	150.	65.	10	23.147	4.721	1.51	8.88
652	200.	10.	300.	150.	65.	10	22.362	4.400	1.44	8.98
653	60.	30.	300.	150.	65.	10	20.804	5.606	1.55	9.18
654	100.	30.	300.	150.	65.	10	19.341	4.525	1.35	9.42
655	150.	30.	300.	150.	65.	10	18.862	4.084	1.27	9.37
656	200.	30.	300.	150.	65.	10	18.371	3.876	1.22	9.40
657	60.	50.	300.	150.	65.	10	19.307	5.162	1.44	9.33
658	100.	50.	300.	150.	65.	10	18.252	4.277	1.27	9.41
659	150.	50.	300.	150.	65.	10	17.651	3.896	1.20	9.43
660	200.	50.	300.	150.	65.	10	17.850	3.771	1.19	9.43
661	60.	10.	600.	150.	65.	10	36.318	11.467	2.95	5.84
662	100.	10.	600.	150.	65.	10	31.772	7.431	2.21	5.94
663	150.	10.	600.	150.	65.	10	28.917	5.658	1.86	5.95
664	200.	10.	600.	150.	65.	10	27.889	5.147	1.75	6.03
665	60.	30.	600.	150.	65.	10	27.434	7.628	2.08	6.16
666	100.	30.	600.	150.	65.	10	25.263	5.379	1.68	6.13
667	150.	30.	600.	150.	65.	10	24.055	4.703	1.54	6.15
668	200.	30.	600.	150.	65.	10	23.442	4.460	1.49	6.23
669	60.	50.	600.	150.	65.	10	25.016	6.253	1.80	6.14
670	100.	50.	600.	150.	65.	10	23.741	5.158	1.60	6.27
671	150.	50.	600.	150.	65.	10	22.801	4.485	1.47	6.23
672	200.	50.	600.	150.	65.	10	22.864	4.338	1.45	6.27
673	60.	10.	1000.	150.	65.	10	46.483	17.679	4.20	4.80
674	100.	10.	1000.	150.	65.	10	40.128	10.350	2.93	4.87
675	150.	10.	1000.	150.	65.	10	35.500	7.169	2.31	4.88
676	200.	10.	1000.	150.	65.	10	33.434	6.035	2.07	4.86
677	60.	30.	1000.	150.	65.	10	33.129	9.690	2.58	4.97
678	100.	30.	1000.	150.	65.	10	31.215	6.978	2.13	4.98
679	150.	30.	1000.	150.	65.	10	29.566	5.753	1.89	5.00
680	200.	30.	1000.	150.	65.	10	29.432	5.385	1.84	5.04

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ /MM BTU	ENERGY RETURN RATIO
681	60.	50.	1000.	150.	65.	10.	*	31.174	8.675	*	2.37	5.00
682	100.	50.	1000.	150.	65.	10.	*	29.162	6.208	*	1.94	5.01
683	150.	50.	1000.	150.	65.	10.	*	28.091	5.414	*	1.79	5.05
684	200.	50.	1000.	150.	65.	10.	*	27.491	4.943	*	1.70	5.02
685	60.	10.	300.	175.	65.	10.	*	25.106	7.284	*	1.95	10.33
686	100.	10.	300.	175.	65.	10.	*	21.713	5.162	*	1.52	10.54
687	150.	10.	300.	175.	65.	10.	*	20.059	4.356	*	1.35	10.76
688	200.	10.	300.	175.	65.	10.	*	19.502	4.094	*	1.29	10.89
689	60.	30.	300.	175.	65.	10.	*	18.256	5.151	*	1.40	11.12
690	100.	30.	300.	175.	65.	10.	*	16.937	4.172	*	1.21	11.31
691	150.	30.	300.	175.	65.	10.	*	16.499	3.823	*	1.14	11.38
692	200.	30.	300.	175.	65.	10.	*	16.083	3.625	*	1.10	11.32
693	60.	50.	300.	175.	65.	10.	*	16.831	4.749	*	1.29	11.31
694	100.	50.	300.	175.	65.	10.	*	16.108	3.971	*	1.15	11.44
695	150.	50.	300.	175.	65.	10.	*	15.522	3.662	*	1.09	11.46
696	200.	50.	300.	175.	65.	10.	*	15.875	3.545	*	1.08	11.48
697	60.	10.	600.	175.	65.	10.	*	30.898	10.111	*	2.56	7.15
698	100.	10.	600.	175.	65.	10.	*	27.012	6.642	*	1.93	7.28
699	150.	10.	600.	175.	65.	10.	*	24.314	5.097	*	1.61	7.26
700	200.	10.	600.	175.	65.	10.	*	23.605	4.676	*	1.52	7.34
701	60.	30.	600.	175.	65.	10.	*	23.376	6.825	*	1.82	7.54
702	100.	30.	600.	175.	65.	10.	*	21.422	4.870	*	1.47	7.47
703	150.	30.	600.	175.	65.	10.	*	20.498	4.303	*	1.36	7.50
704	200.	30.	600.	175.	65.	10.	*	20.103	4.100	*	1.31	7.59
705	60.	50.	600.	175.	65.	10.	*	21.304	5.641	*	1.58	7.51
706	100.	50.	600.	175.	65.	10.	*	20.439	4.703	*	1.41	7.65
707	150.	50.	600.	175.	65.	10.	*	19.495	4.119	*	1.30	7.60
708	200.	50.	600.	175.	65.	10.	*	19.487	3.993	*	1.28	7.64
709	60.	10.	1000.	175.	65.	10.	*	39.052	15.308	*	3.60	5.82
710	100.	10.	1000.	175.	65.	10.	*	32.988	8.403	*	2.40	5.81
711	150.	10.	1000.	175.	65.	10.	*	29.758	6.353	*	1.99	5.92
712	200.	10.	1000.	175.	65.	10.	*	27.935	5.387	*	1.78	5.90
713	60.	30.	1000.	175.	65.	10.	*	27.647	8.504	*	2.22	6.04
714	100.	30.	1000.	175.	65.	10.	*	26.214	6.198	*	1.84	6.06
715	150.	30.	1000.	175.	65.	10.	*	24.804	5.154	*	1.64	6.08
716	200.	30.	1000.	175.	65.	10.	*	24.550	4.838	*	1.58	6.13
717	60.	50.	1000.	175.	65.	10.	*	26.200	7.648	*	2.04	6.08
718	100.	50.	1000.	175.	65.	10.	*	24.424	5.541	*	1.68	6.09
719	150.	50.	1000.	175.	65.	10.	*	23.663	4.872	*	1.55	6.14
720	200.	50.	1000.	175.	65.	10.	*	23.009	4.464	*	1.47	6.11

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
721	60.	10.	300.	100.	80.	10	*	42.922	9.674	*	2.94	5.32
722	100.	10.	300.	100.	80.	10	*	37.209	6.815	*	2.32	5.38
723	150.	10.	300.	100.	80.	10	*	34.149	5.728	*	2.06	5.42
724	200.	10.	300.	100.	80.	10	*	33.276	5.365	*	1.97	5.48
725	60.	30.	300.	100.	80.	10	*	30.841	6.706	*	2.08	5.57
726	100.	30.	300.	100.	80.	10	*	28.481	5.389	*	1.80	5.61
727	150.	30.	300.	100.	80.	10	*	27.819	4.927	*	1.71	5.64
728	200.	30.	300.	100.	80.	10	*	27.235	4.674	*	1.66	5.66
729	60.	50.	300.	100.	80.	10	*	28.301	6.147	*	1.90	5.64
730	100.	50.	300.	100.	80.	10	*	27.081	5.116	*	1.71	5.66
731	150.	50.	300.	100.	80.	10	*	26.429	4.703	*	1.63	5.67
732	200.	50.	300.	100.	80.	10	*	26.562	4.538	*	1.61	5.66
733	60.	10.	600.	100.	80.	10	*	59.204	14.606	*	4.23	3.58
734	100.	10.	600.	100.	80.	10	*	52.113	9.643	*	3.27	3.63
735	150.	10.	600.	100.	80.	10	*	47.652	7.480	*	2.80	3.60
736	200.	10.	600.	100.	80.	10	*	45.659	6.800	*	2.63	3.64
737	60.	30.	600.	100.	80.	10	*	44.315	9.707	*	2.99	3.71
738	100.	30.	600.	100.	80.	10	*	40.980	7.161	*	2.51	3.72
739	150.	30.	600.	100.	80.	10	*	39.647	6.199	*	2.32	3.68
740	200.	30.	600.	100.	80.	10	*	38.286	5.842	*	2.22	3.73
741	60.	50.	600.	100.	80.	10	*	40.947	8.073	*	2.64	3.69
742	100.	50.	600.	100.	80.	10	*	38.658	6.681	*	2.36	3.75
743	150.	50.	600.	100.	80.	10	*	37.328	5.872	*	2.19	3.72
744	200.	50.	600.	100.	80.	10	*	37.205	5.671	*	2.16	3.75
745	60.	10.	1000.	100.	80.	10	*	79.292	23.372	*	6.21	2.90
746	100.	10.	1000.	100.	80.	10	*	68.900	13.975	*	4.49	2.94
747	150.	10.	1000.	100.	80.	10	*	62.066	9.970	*	3.68	2.93
748	200.	10.	1000.	100.	80.	10	*	61.070	9.098	*	3.52	2.95
749	60.	30.	1000.	100.	80.	10	*	56.974	12.962	*	3.92	2.98
750	100.	30.	1000.	100.	80.	10	*	54.273	9.594	*	3.34	2.98
751	150.	30.	1000.	100.	80.	10	*	51.857	7.970	*	3.02	2.99
752	200.	30.	1000.	100.	80.	10	*	50.981	7.472	*	2.92	3.01
753	60.	50.	1000.	100.	80.	10	*	53.784	11.644	*	3.61	2.99
754	100.	50.	1000.	100.	80.	10	*	50.874	8.503	*	3.07	2.99
755	150.	50.	1000.	100.	80.	10	*	49.091	7.499	*	2.85	3.01
756	200.	50.	1000.	100.	80.	10	*	48.305	6.908	*	2.74	2.99
757	60.	10.	300.	125.	80.	10	*	33.682	8.097	*	2.36	6.83
758	100.	10.	300.	125.	80.	10	*	29.305	5.819	*	1.89	7.06
759	150.	10.	300.	125.	80.	10	*	26.978	4.952	*	1.69	6.98
760	200.	10.	300.	125.	80.	10	*	26.170	4.661	*	1.62	7.19

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
761	60.	30.	300.	125.	80.	10	*	24.503	5.745	*	1.71	7.21
762	100.	30.	300.	125.	80.	10	*	22.885	4.715	*	1.50	7.26
763	150.	30.	300.	125.	80.	10	*	22.188	4.345	*	1.43	7.40
764	200.	30.	300.	125.	80.	10	*	21.724	4.111	*	1.38	7.36
765	60.	50.	300.	125.	80.	10	*	22.581	5.295	*	1.57	7.30
766	100.	50.	300.	125.	80.	10	*	21.624	4.482	*	1.42	7.42
767	150.	50.	300.	125.	80.	10	*	20.981	4.165	*	1.36	7.43
768	200.	50.	300.	125.	80.	10	*	21.095	4.021	*	1.34	7.43
769	60.	10.	600.	125.	80.	10	*	43.892	11.592	*	3.25	4.68
770	100.	10.	600.	125.	80.	10	*	38.601	7.774	*	2.51	4.73
771	150.	10.	600.	125.	80.	10	*	35.536	6.121	*	2.16	4.71
772	200.	10.	600.	125.	80.	10	*	33.920	5.592	*	2.03	4.78
773	60.	30.	600.	125.	80.	10	*	33.402	7.893	*	2.34	4.86
774	100.	30.	600.	125.	80.	10	*	31.073	5.798	*	1.96	4.81
775	150.	30.	600.	125.	80.	10	*	29.811	5.173	*	1.82	4.84
776	200.	30.	600.	125.	80.	10	*	28.998	4.904	*	1.75	4.89
777	60.	50.	600.	125.	80.	10	*	30.848	6.624	*	2.06	4.83
778	100.	50.	600.	125.	80.	10	*	29.226	5.555	*	1.85	4.92
779	150.	50.	600.	125.	80.	10	*	28.080	4.919	*	1.72	4.89
780	200.	50.	600.	125.	80.	10	*	28.202	4.779	*	1.71	4.92
781	60.	10.	1000.	125.	80.	10	*	56.993	17.844	*	4.61	3.80
782	100.	10.	1000.	125.	80.	10	*	49.584	10.818	*	3.34	3.84
783	150.	10.	1000.	125.	80.	10	*	44.375	7.769	*	2.72	3.84
784	200.	10.	1000.	125.	80.	10	*	42.422	6.730	*	2.58	3.82
785	60.	30.	1000.	125.	80.	10	*	41.274	10.100	*	2.94	3.90
786	100.	30.	1000.	125.	80.	10	*	39.409	7.549	*	2.51	3.91
787	150.	30.	1000.	125.	80.	10	*	37.518	6.358	*	2.27	3.91
788	200.	30.	1000.	125.	80.	10	*	37.092	5.988	*	2.20	3.94
789	60.	50.	1000.	125.	80.	10	*	39.205	9.132	*	2.73	3.91
790	100.	50.	1000.	125.	80.	10	*	36.772	6.776	*	2.30	3.91
791	150.	50.	1000.	125.	80.	10	*	35.830	6.021	*	2.16	3.95
792	200.	50.	1000.	125.	80.	10	*	34.867	5.558	*	2.06	3.92
793	60.	10.	300.	150.	80.	10	*	28.417	7.274	*	2.07	8.75
794	100.	10.	300.	150.	80.	10	*	24.708	5.266	*	1.65	8.89
795	150.	10.	300.	150.	80.	10	*	22.932	4.530	*	1.48	8.96
796	200.	10.	300.	150.	80.	10	*	22.162	4.257	*	1.41	9.12
797	60.	30.	300.	150.	80.	10	*	20.586	5.205	*	1.49	9.26
798	100.	30.	300.	150.	80.	10	*	19.274	4.303	*	1.31	9.33
799	150.	30.	300.	150.	80.	10	*	18.778	3.974	*	1.25	9.38
800	200.	30.	300.	150.	80.	10	*	18.274	3.798	*	1.21	9.45

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* TOTAL INVESTMENT IN \$ MM.	ANNUAL OPERATING EXPENSE IN \$ MM.	* REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
801	60.	50.	300.	150.	80.	10	19.134	4.831	1.38	9.39
802	100.	50.	300.	150.	80.	10	18.112	4.102	1.24	9.46
803	150.	50.	300.	150.	80.	10	17.579	3.812	1.18	9.48
804	200.	50.	300.	150.	80.	10	17.640	3.694	1.17	9.47
805	60.	10.	600.	150.	80.	10	35.894	10.134	2.75	5.94
806	100.	10.	600.	150.	80.	10	31.471	6.826	2.12	6.02
807	150.	10.	600.	150.	80.	10	28.439	5.359	1.80	5.99
808	200.	10.	600.	150.	80.	10	27.719	4.954	1.71	6.11
809	60.	30.	600.	150.	80.	10	27.193	6.947	1.98	6.20
810	100.	30.	600.	150.	80.	10	25.127	5.121	1.64	6.14
811	150.	30.	600.	150.	80.	10	23.961	4.565	1.52	6.18
812	200.	30.	600.	150.	80.	10	23.350	4.357	1.47	6.25
813	60.	50.	600.	150.	80.	10	24.879	5.819	1.73	6.16
814	100.	50.	600.	150.	80.	10	23.646	4.927	1.56	6.29
815	150.	50.	600.	150.	80.	10	22.730	4.375	1.45	6.25
816	200.	50.	600.	150.	80.	10	22.756	4.250	1.43	6.29
817	60.	10.	1000.	150.	80.	10	45.913	15.280	3.84	4.85
818	100.	10.	1000.	150.	80.	10	39.755	9.294	2.77	4.91
819	150.	10.	1000.	150.	80.	10	35.034	6.669	2.22	4.91
820	200.	10.	1000.	150.	80.	10	33.205	5.753	2.03	4.88
821	60.	30.	1000.	150.	80.	10	32.812	8.695	2.43	4.98
822	100.	30.	1000.	150.	80.	10	31.074	6.501	2.06	4.99
823	150.	30.	1000.	150.	80.	10	29.375	5.483	1.85	5.01
824	200.	30.	1000.	150.	80.	10	29.273	5.185	1.80	5.06
825	60.	50.	1000.	150.	80.	10	38.938	7.858	2.24	5.01
826	100.	50.	1000.	150.	80.	10	29.062	5.862	1.89	5.02
827	150.	50.	1000.	150.	80.	10	27.966	5.190	1.76	5.06
828	200.	50.	1000.	150.	80.	10	27.421	4.820	1.68	5.03
829	60.	10.	300.	175.	80.	10	24.798	6.597	1.84	10.59
830	100.	10.	300.	175.	80.	10	21.482	4.844	1.47	10.76
831	150.	10.	300.	175.	80.	10	19.807	4.181	1.32	10.86
832	200.	10.	300.	175.	80.	10	19.267	3.963	1.26	11.07
833	60.	30.	300.	175.	80.	10	18.062	4.799	1.34	11.23
834	100.	30.	300.	175.	80.	10	16.787	4.003	1.18	11.32
835	150.	30.	300.	175.	80.	10	16.374	3.720	1.12	11.45
836	200.	30.	300.	175.	80.	10	15.997	3.560	1.09	11.39
837	60.	50.	300.	175.	80.	10	16.720	4.470	1.24	11.39
838	100.	50.	300.	175.	80.	10	16.026	3.843	1.13	11.50
839	150.	50.	300.	175.	80.	10	15.415	3.581	1.07	11.52
840	200.	50.	300.	175.	90.	10	15.772	3.489	1.07	11.53

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO

841	60.	10.	600.	175.	80.	10.	*	30.560	8.969	*	2.39	7.27
842	100.	10.	600.	175.	80.	10.	*	26.779	6.124	*	1.85	7.37
843	150.	10.	600.	175.	80.	10.	*	24.128	4.853	*	1.57	7.34
844	200.	10.	600.	175.	90.	10.	*	23.437	4.507	*	1.49	7.42
845	60.	30.	600.	175.	80.	10.	*	23.232	6.247	*	1.73	7.58
846	100.	30.	600.	175.	80.	10.	*	21.254	4.642	*	1.43	7.51
847	150.	30.	600.	175.	80.	10.	*	20.421	4.184	*	1.34	7.53
848	200.	30.	600.	175.	80.	10.	*	20.030	4.012	*	1.30	7.62
849	60.	50.	600.	175.	80.	10.	*	21.196	5.268	*	1.52	7.54
850	100.	50.	600.	175.	80.	10.	*	20.106	4.496	*	1.37	7.67
851	150.	50.	600.	175.	80.	10.	*	19.437	4.015	*	1.28	7.62
852	200.	50.	600.	175.	80.	10.	*	19.391	3.915	*	1.26	7.67
853	60.	10.	1000.	175.	80.	10.	*	38.615	13.267	*	3.29	5.90
854	100.	10.	1000.	175.	80.	10.	*	32.692	7.615	*	2.27	5.87
855	150.	10.	1000.	175.	80.	10.	*	29.431	5.932	*	1.91	5.97
856	200.	10.	1000.	175.	80.	10.	*	27.755	5.147	*	1.74	5.94
857	60.	30.	1000.	175.	80.	10.	*	27.416	7.650	*	2.09	6.07
858	100.	30.	1000.	175.	80.	10.	*	26.097	5.794	*	1.77	6.08
859	150.	30.	1000.	175.	80.	10.	*	24.656	4.925	*	1.60	6.10
860	200.	30.	1000.	175.	80.	10.	*	24.468	4.674	*	1.56	6.15
861	60.	50.	1000.	175.	80.	10.	*	26.071	6.965	*	1.94	6.10
862	100.	50.	1000.	175.	80.	10.	*	24.338	5.246	*	1.63	6.10
863	150.	50.	1000.	175.	80.	10.	*	23.597	4.695	*	1.53	6.16
864	200.	50.	1000.	175.	80.	10.	*	22.948	4.359	*	1.45	6.12
865	60.	10.	300.	100.	50.	20.	*	51.132	14.203	*	3.88	4.52
866	100.	10.	300.	100.	50.	20.	*	44.839	9.553	*	2.99	4.64
867	150.	10.	300.	100.	50.	20.	*	41.617	7.599	*	2.60	4.70
868	200.	10.	300.	100.	50.	20.	*	38.656	6.452	*	2.32	4.72
869	60.	30.	300.	100.	50.	20.	*	35.571	8.994	*	2.57	4.84
870	100.	30.	300.	100.	50.	20.	*	32.871	6.654	*	2.14	4.89
871	150.	30.	300.	100.	50.	20.	*	31.878	5.771	*	1.98	4.91
872	200.	30.	300.	100.	50.	20.	*	31.425	5.389	*	1.91	4.94
873	60.	50.	300.	100.	50.	20.	*	32.637	8.072	*	2.34	4.93
874	100.	50.	300.	100.	50.	20.	*	31.015	6.101	*	2.01	4.95
875	150.	50.	300.	100.	50.	20.	*	29.841	5.389	*	1.85	4.96
876	200.	50.	300.	100.	50.	20.	*	29.919	5.111	*	1.82	4.96
877	60.	10.	600.	100.	50.	20.	*	72.897	23.072	*	5.93	3.13
878	100.	10.	600.	100.	50.	20.	*	62.759	13.760	*	4.24	3.15
879	150.	10.	600.	100.	50.	20.	*	56.987	9.695	*	3.45	3.17
880	200.	10.	600.	100.	50.	20.	*	54.543	8.544	*	3.20	3.21

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* * *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* * *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
881	60.	30.	600.	100.	50.	20	*	52.082	12.933	*	3.73	3.23
882	100.	30.	600.	100.	50.	20	*	48.172	8.964	*	3.03	3.23
883	150.	30.	600.	100.	50.	20	*	45.919	7.472	*	2.73	3.26
884	200.	30.	600.	100.	50.	20	*	44.826	6.969	*	2.62	3.30
885	60.	50.	600.	100.	50.	20	*	47.933	11.028	*	3.31	3.27
886	100.	50.	600.	100.	50.	20	*	45.287	8.053	*	2.79	3.27
887	150.	50.	600.	100.	50.	20	*	43.390	7.005	*	2.58	3.31
888	200.	50.	600.	100.	50.	20	*	43.284	6.646	*	2.52	3.33
889	60.	10.	1000.	100.	50.	20	*	99.711	39.765	*	9.28	2.54
890	100.	10.	1000.	100.	50.	20	*	85.370	21.654	*	6.19	2.57
891	150.	10.	1000.	100.	50.	20	*	75.796	13.896	*	4.73	2.57
892	200.	10.	1000.	100.	50.	20	*	74.592	12.363	*	4.47	2.59
893	60.	30.	1000.	100.	50.	20	*	69.059	19.985	*	5.35	2.62
894	100.	30.	1000.	100.	50.	20	*	64.917	13.372	*	4.26	2.63
895	150.	30.	1000.	100.	50.	20	*	61.786	10.388	*	3.73	2.64
896	200.	30.	1000.	100.	50.	20	*	60.484	9.430	*	3.54	2.67
897	60.	50.	1000.	100.	50.	20	*	64.671	17.497	*	4.84	2.64
898	100.	50.	1000.	100.	50.	20	*	60.440	11.513	*	3.84	2.64
899	150.	50.	1000.	100.	50.	20	*	58.374	9.515	*	3.48	2.67
900	200.	50.	1000.	100.	50.	20	*	57.337	8.465	*	3.29	2.66
901	60.	10.	300.	125.	50.	20	*	39.422	11.622	*	3.09	5.83
902	100.	10.	300.	125.	50.	20	*	33.882	7.512	*	2.30	5.97
903	150.	10.	300.	125.	50.	20	*	31.217	5.975	*	1.99	6.11
904	200.	10.	300.	125.	50.	20	*	30.119	5.490	*	1.88	6.19
905	60.	30.	300.	125.	50.	20	*	27.874	7.531	*	2.09	6.34
906	100.	30.	300.	125.	50.	20	*	25.707	5.672	*	1.74	6.40
907	150.	30.	300.	125.	50.	20	*	25.118	4.974	*	1.62	6.45
908	200.	30.	300.	125.	50.	20	*	24.125	4.607	*	1.53	6.49
909	60.	50.	300.	125.	50.	20	*	25.575	6.808	*	1.90	6.46
910	100.	50.	300.	125.	50.	20	*	24.393	5.306	*	1.64	6.49
911	150.	50.	300.	125.	50.	20	*	23.637	4.676	*	1.53	6.51
912	200.	50.	300.	125.	50.	20	*	22.966	4.418	*	1.46	6.53
913	60.	10.	600.	125.	50.	20	*	52.717	17.803	*	4.45	4.08
914	100.	10.	600.	125.	50.	20	*	45.534	10.750	*	3.19	4.14
915	150.	10.	600.	125.	50.	20	*	41.473	7.700	*	2.60	4.13
916	200.	10.	600.	125.	50.	20	*	39.788	6.829	*	2.42	4.17
917	60.	30.	600.	125.	50.	20	*	38.288	10.206	*	2.84	4.21
918	100.	30.	600.	125.	50.	20	*	35.456	7.204	*	2.31	4.25
919	150.	30.	600.	125.	50.	20	*	33.836	6.040	*	2.09	4.27
920	200.	30.	600.	125.	50.	20	*	33.125	5.679	*	2.01	4.32

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
921	60.	50.	600.	125.	50.	20	*	35.139	8.730	*	2.52	4.27
922	100.	50.	600.	125.	50.	20	*	33.434	6.518	*	2.15	4.28
923	150.	50.	600.	125.	50.	20	*	32.124	5.707	*	1.98	4.33
924	200.	50.	600.	125.	50.	20	*	31.900	5.369	*	1.92	4.29
925	60.	10.	1000.	125.	50.	20	*	69.330	29.371	*	6.70	3.28
926	100.	10.	1000.	125.	50.	20	*	58.184	14.640	*	4.20	3.28
927	150.	10.	1000.	125.	50.	20	*	52.826	10.480	*	3.41	3.33
928	200.	10.	1000.	125.	50.	20	*	49.812	8.487	*	3.02	3.33
929	60.	30.	1000.	125.	50.	20	*	48.574	14.969	*	3.90	3.41
930	100.	30.	1000.	125.	50.	20	*	45.681	10.135	*	3.10	3.42
931	150.	30.	1000.	125.	50.	20	*	43.613	7.965	*	2.72	3.43
932	200.	30.	1000.	125.	50.	20	*	43.033	7.315	*	2.61	3.47
933	60.	50.	1000.	125.	50.	20	*	45.572	13.155	*	3.53	3.44
934	100.	50.	1000.	125.	50.	20	*	42.767	8.783	*	2.81	3.44
935	150.	50.	1000.	125.	50.	20	*	41.544	7.381	*	2.56	3.48
936	200.	50.	1000.	125.	50.	20	*	40.587	6.553	*	2.41	3.46
937	60.	10.	300.	150.	50.	20	*	33.403	10.368	*	2.69	7.32
938	100.	10.	300.	150.	50.	20	*	28.604	6.751	*	2.00	7.51
939	150.	10.	300.	150.	50.	20	*	26.070	5.379	*	1.71	7.62
940	200.	10.	300.	150.	50.	20	*	25.293	4.972	*	1.63	7.81
941	60.	30.	300.	150.	50.	20	*	23.236	6.738	*	1.80	8.04
942	100.	30.	300.	150.	50.	20	*	21.400	5.111	*	1.51	8.13
943	150.	30.	300.	150.	50.	20	*	20.945	4.504	*	1.40	8.19
944	200.	30.	300.	150.	50.	20	*	20.227	4.180	*	1.33	8.15
945	60.	50.	300.	150.	50.	20	*	21.248	6.093	*	1.64	8.21
946	100.	50.	300.	150.	50.	20	*	20.231	4.782	*	1.42	8.25
947	150.	50.	300.	150.	50.	20	*	19.729	4.244	*	1.32	8.29
948	200.	50.	300.	150.	50.	20	*	19.224	4.934	*	1.27	8.22
949	60.	10.	600.	150.	50.	20	*	42.312	15.322	*	3.72	5.16
950	100.	10.	600.	150.	50.	20	*	36.616	9.320	*	2.66	5.20
951	150.	10.	600.	150.	50.	20	*	32.833	6.651	*	2.14	5.20
952	200.	10.	600.	150.	50.	20	*	31.757	5.935	*	2.00	5.27
953	60.	30.	600.	150.	50.	20	*	30.460	8.815	*	2.36	5.38
954	100.	30.	600.	150.	50.	20	*	28.122	6.245	*	1.91	5.42
955	150.	30.	600.	150.	50.	20	*	26.906	5.274	*	1.73	5.44
956	200.	30.	600.	150.	50.	20	*	26.385	4.962	*	1.67	5.51
957	60.	50.	600.	150.	50.	20	*	28.839	7.589	*	2.18	5.45
958	100.	50.	600.	150.	50.	20	*	26.396	5.651	*	1.76	5.45
959	150.	50.	600.	150.	50.	20	*	25.460	4.993	*	1.64	5.52
960	200.	50.	600.	150.	50.	20	*	25.352	4.691	*	1.59	5.47

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING	COAL SEAM THICKNESS	DEPTH TO TOP OF SEAM	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
961	60.	10.	1000.	150.	50.	20	*	54.797	24.681	*	5.50	4.21
962	100.	10.	1000.	150.	50.	20	*	45.197	12.260	*	3.39	4.17
963	150.	10.	1000.	150.	50.	20	*	41.103	8.845	*	2.75	4.25
964	200.	10.	1000.	150.	50.	20	*	38.566	7.159	*	2.42	4.25
965	60.	30.	1000.	150.	50.	20	*	37.913	12.661	*	3.18	4.38
966	100.	30.	1000.	150.	50.	20	*	35.667	8.592	*	2.52	4.40
967	150.	30.	1000.	150.	50.	20	*	33.810	6.757	*	2.19	4.41
968	200.	30.	1000.	150.	50.	20	*	32.957	5.904	*	2.04	4.38
969	60.	50.	1000.	150.	50.	20	*	35.365	11.138	*	2.87	4.42
970	100.	50.	1000.	150.	50.	20	*	33.039	7.449	*	2.26	4.43
971	150.	50.	1000.	150.	50.	20	*	32.059	6.268	*	2.06	4.47
972	200.	50.	1000.	150.	50.	20	*	31.062	5.568	*	1.92	4.44
973	60.	10.	300.	175.	50.	20	*	28.504	9.188	*	2.34	9.10
974	100.	10.	300.	175.	50.	20	*	24.451	6.083	*	1.75	9.17
975	150.	10.	300.	175.	50.	20	*	22.428	4.910	*	1.51	9.50
976	200.	10.	300.	175.	50.	20	*	21.794	4.556	*	1.44	9.55
977	60.	30.	300.	175.	50.	20	*	20.132	6.109	*	1.60	9.82
978	100.	30.	300.	175.	50.	20	*	18.544	4.698	*	1.34	9.93
979	150.	30.	300.	175.	50.	20	*	18.180	4.175	*	1.26	10.07
980	200.	30.	300.	175.	50.	20	*	17.521	3.908	*	1.19	10.02
981	60.	50.	300.	175.	50.	20	*	18.479	5.563	*	1.46	10.03
982	100.	50.	300.	175.	50.	20	*	17.575	4.423	*	1.27	10.08
983	150.	50.	300.	175.	50.	20	*	16.951	3.949	*	1.18	10.17
984	200.	50.	300.	175.	50.	20	*	16.654	3.768	*	1.14	10.11
985	60.	10.	600.	175.	50.	20	*	35.518	13.342	*	3.19	6.24
986	100.	10.	600.	175.	50.	20	*	30.808	8.206	*	2.29	6.36
987	150.	10.	600.	175.	50.	20	*	27.564	5.929	*	1.85	6.30
988	200.	10.	600.	175.	50.	20	*	26.552	5.319	*	1.72	6.38
989	60.	30.	600.	175.	50.	20	*	25.646	7.790	*	2.04	6.52
990	100.	30.	600.	175.	50.	20	*	23.794	5.596	*	1.66	6.57
991	150.	30.	600.	175.	50.	20	*	22.759	4.767	*	1.51	6.60
992	200.	30.	600.	175.	50.	20	*	22.229	4.505	*	1.45	6.71
993	60.	50.	600.	175.	50.	20	*	23.730	6.744	*	1.82	6.62
994	100.	50.	600.	175.	50.	20	*	22.297	5.090	*	1.54	6.62
995	150.	50.	600.	175.	50.	20	*	21.610	4.535	*	1.43	6.73
996	200.	50.	600.	175.	50.	20	*	21.358	4.259	*	1.38	6.67
997	60.	10.	1000.	175.	50.	20	*	45.367	21.133	*	4.66	5.07
998	100.	10.	1000.	175.	50.	20	*	37.326	10.580	*	2.86	5.11
999	150.	10.	1000.	175.	50.	20	*	33.944	7.712	*	2.33	5.17
1000	200.	10.	1000.	175.	50.	20	*	31.900	6.296	*	2.06	5.17

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1001	60.	30.	1000.	175.	50.	20.	*	31.354	10.961	*	2.70	5.34
1002	100.	30.	1000.	175.	50.	20.	*	29.561	7.521	*	2.15	5.37
1003	150.	30.	1000.	175.	50.	20.	*	27.883	5.965	*	1.86	5.39
1004	200.	30.	1000.	175.	50.	20.	*	27.281	5.245	*	1.74	5.35
1005	60.	50.	1000.	175.	50.	20.	*	29.555	9.688	*	2.45	5.39
1006	100.	50.	1000.	175.	50.	20.	*	27.473	6.561	*	1.93	5.41
1007	150.	50.	1000.	175.	50.	20.	*	26.420	5.556	*	1.75	5.46
1008	200.	50.	1000.	175.	50.	20.	*	25.771	4.965	*	1.64	5.43
1009	60.	10.	300.	100.	65.	20.	*	49.753	12.127	*	3.53	4.60
1010	100.	10.	300.	100.	65.	20.	*	42.811	8.181	*	2.71	4.67
1011	150.	10.	300.	100.	65.	20.	*	40.945	6.995	*	2.48	4.76
1012	200.	10.	300.	100.	65.	20.	*	38.070	6.049	*	2.25	4.77
1013	60.	30.	300.	100.	65.	20.	*	35.095	7.984	*	2.41	4.89
1014	100.	30.	300.	100.	65.	20.	*	32.527	6.147	*	2.06	4.94
1015	150.	30.	300.	100.	65.	20.	*	31.581	5.487	*	1.93	4.96
1016	200.	30.	300.	100.	65.	20.	*	31.160	5.152	*	1.87	4.98
1017	60.	50.	300.	100.	65.	20.	*	32.103	7.217	*	2.19	4.97
1018	100.	50.	300.	100.	65.	20.	*	30.607	5.745	*	1.93	4.99
1019	150.	50.	300.	100.	65.	20.	*	29.611	5.172	*	1.81	5.00
1020	200.	50.	300.	100.	65.	20.	*	29.709	4.925	*	1.78	4.99
1021	60.	10.	600.	100.	65.	20.	*	71.378	19.376	*	5.35	3.09
1022	100.	10.	600.	100.	65.	20.	*	61.369	12.019	*	3.94	3.20
1023	150.	10.	600.	100.	65.	20.	*	56.001	8.885	*	3.30	3.19
1024	200.	10.	600.	100.	65.	20.	*	53.878	7.962	*	3.09	3.22
1025	60.	30.	600.	100.	65.	20.	*	51.368	11.298	*	3.48	3.23
1026	100.	30.	600.	100.	65.	20.	*	47.823	8.236	*	2.91	3.27
1027	150.	30.	600.	100.	65.	20.	*	45.530	7.061	*	2.66	3.26
1028	200.	30.	600.	100.	65.	20.	*	44.353	6.622	*	2.56	3.32
1029	60.	50.	600.	100.	65.	20.	*	47.374	9.782	*	3.11	3.27
1030	100.	50.	600.	100.	65.	20.	*	44.909	7.474	*	2.70	3.26
1031	150.	50.	600.	100.	65.	20.	*	43.018	6.666	*	2.51	3.32
1032	200.	50.	600.	100.	65.	20.	*	43.100	6.388	*	2.48	3.34
1033	60.	10.	1000.	100.	65.	20.	*	97.134	32.306	*	8.13	2.57
1034	100.	10.	1000.	100.	65.	20.	*	83.263	18.315	*	5.63	2.60
1035	150.	10.	1000.	100.	65.	20.	*	74.674	12.436	*	4.49	2.59
1036	200.	10.	1000.	100.	65.	20.	*	73.431	11.187	*	4.26	2.61
1037	60.	30.	1000.	100.	65.	20.	*	67.910	16.899	*	4.87	2.64
1038	100.	30.	1000.	100.	65.	20.	*	64.422	11.941	*	4.04	2.64
1039	150.	30.	1000.	100.	65.	20.	*	61.121	9.544	*	3.58	2.65
1040	200.	30.	1000.	100.	65.	20.	*	60.141	8.828	*	3.44	2.67

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1041	60.	50.	1000.	100.	65.	20	*	63.800	14.968	*	4.45	2.65
1042	100.	50.	1000.	100.	65.	20	*	60.082	10.473	*	3.68	2.65
1043	150.	50.	1000.	100.	65.	20	*	57.998	8.879	*	3.37	2.68
1044	200.	50.	1000.	100.	65.	20	*	55.880	8.008	*	3.21	2.66
1045	60.	10.	300.	125.	65.	20	*	38.602	9.965	*	2.82	6.03
1046	100.	10.	300.	125.	65.	20	*	33.292	6.787	*	2.18	6.13
1047	150.	10.	300.	125.	65.	20	*	30.397	5.555	*	1.90	6.32
1048	200.	10.	300.	125.	65.	20	*	29.529	5.167	*	1.81	6.33
1049	60.	30.	300.	125.	65.	20	*	27.577	6.749	*	1.96	6.48
1050	100.	30.	300.	125.	65.	20	*	25.450	5.297	*	1.68	6.47
1051	150.	30.	300.	125.	65.	20	*	24.902	4.750	*	1.58	6.51
1052	200.	30.	300.	125.	65.	20	*	23.951	4.421	*	1.50	6.47
1053	60.	50.	300.	125.	65.	20	*	25.114	6.113	*	1.78	6.52
1054	100.	50.	300.	125.	65.	20	*	24.041	4.949	*	1.58	6.54
1055	150.	50.	300.	125.	65.	20	*	23.470	4.586	*	1.49	6.56
1056	200.	50.	300.	125.	65.	20	*	22.835	4.262	*	1.44	6.51
1057	60.	10.	600.	125.	65.	20	*	51.224	14.911	*	3.98	4.11
1058	100.	10.	600.	125.	65.	20	*	44.735	9.476	*	2.98	4.15
1059	150.	10.	600.	125.	65.	20	*	40.875	7.096	*	2.50	4.16
1060	200.	10.	600.	125.	65.	20	*	39.027	6.370	*	2.33	4.22
1061	60.	30.	600.	125.	65.	20	*	37.670	8.956	*	2.64	4.23
1062	100.	30.	600.	125.	65.	20	*	34.985	6.632	*	2.22	4.27
1063	150.	30.	600.	125.	65.	20	*	33.624	5.745	*	2.04	4.28
1064	200.	30.	600.	125.	65.	20	*	32.866	5.427	*	1.97	4.34
1065	60.	50.	600.	125.	65.	20	*	34.845	7.812	*	2.38	4.28
1066	100.	50.	600.	125.	65.	20	*	33.284	6.076	*	2.07	4.29
1067	150.	50.	600.	125.	65.	20	*	31.913	5.459	*	1.94	4.34
1068	200.	50.	600.	125.	65.	20	*	31.700	5.177	*	1.89	4.29
1069	60.	10.	1000.	125.	65.	20	*	68.188	23.953	*	5.89	3.36
1070	100.	10.	1000.	125.	65.	20	*	56.947	12.652	*	3.87	3.31
1071	150.	10.	1000.	125.	65.	20	*	51.993	9.399	*	3.23	3.36
1072	200.	10.	1000.	125.	65.	20	*	49.087	7.836	*	2.90	3.35
1073	60.	30.	1000.	125.	65.	20	*	48.051	12.805	*	3.57	3.44
1074	100.	30.	1000.	125.	65.	20	*	45.293	9.080	*	2.94	3.44
1075	150.	30.	1000.	125.	65.	20	*	43.297	7.391	*	2.63	3.45
1076	200.	30.	1000.	125.	65.	20	*	42.747	6.874	*	2.53	3.48
1077	60.	50.	1000.	125.	65.	20	*	45.169	11.390	*	3.26	3.46
1078	100.	50.	1000.	125.	65.	20	*	42.490	8.006	*	2.68	3.46
1079	150.	50.	1000.	125.	65.	20	*	41.311	6.923	*	2.49	3.49
1080	200.	50.	1000.	125.	65.	20	*	40.382	6.271	*	2.36	3.47

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1081	60.	10.	300.	150.	65.	20	*	32.168	8.856	*	2.43	7.60
1082	100.	10.	300.	150.	65.	20	*	27.806	6.078	*	1.88	7.73
1083	150.	10.	300.	150.	65.	20	*	25.640	5.834	*	1.65	8.03
1084	200.	10.	300.	150.	65.	20	*	24.657	4.665	*	1.56	7.91
1085	60.	30.	300.	150.	65.	20	*	22.830	6.024	*	1.69	8.16
1086	100.	30.	300.	150.	65.	20	*	21.130	4.771	*	1.45	8.23
1087	150.	30.	300.	150.	65.	20	*	20.713	4.300	*	1.37	8.28
1088	200.	30.	300.	150.	65.	20	*	20.050	4.025	*	1.30	8.24
1089	60.	50.	300.	150.	65.	20	*	20.969	5.509	*	1.55	8.29
1090	100.	50.	300.	150.	65.	20	*	20.062	4.497	*	1.37	8.33
1091	150.	50.	300.	150.	65.	20	*	19.520	4.072	*	1.29	8.24
1092	200.	50.	300.	150.	65.	20	*	18.963	3.888	*	1.24	8.29
1093	60.	10.	600.	150.	65.	20	*	41.273	12.868	*	3.33	5.19
1094	100.	10.	600.	150.	65.	20	*	35.903	8.198	*	2.47	5.28
1095	150.	10.	600.	150.	65.	20	*	32.368	6.129	*	2.05	5.29
1096	200.	10.	600.	150.	65.	20	*	31.390	5.560	*	1.93	5.38
1097	60.	30.	600.	150.	65.	20	*	30.038	7.749	*	2.19	5.40
1098	100.	30.	600.	150.	65.	20	*	27.902	5.783	*	1.84	5.45
1099	150.	30.	600.	150.	65.	20	*	26.657	5.011	*	1.68	5.47
1100	200.	30.	600.	150.	65.	20	*	26.227	4.759	*	1.63	5.54
1101	60.	50.	600.	150.	65.	20	*	27.722	6.783	*	1.97	5.46
1102	100.	50.	600.	150.	65.	20	*	26.176	5.300	*	1.71	5.48
1103	150.	50.	600.	150.	65.	20	*	25.287	4.781	*	1.60	5.54
1104	200.	50.	600.	150.	65.	20	*	25.100	4.520	*	1.56	5.49
1105	60.	10.	1000.	150.	65.	20	*	53.301	20.177	*	4.81	4.25
1106	100.	10.	1000.	150.	65.	20	*	44.086	10.553	*	3.11	4.25
1107	150.	10.	1000.	150.	65.	20	*	40.547	7.937	*	2.60	4.32
1108	200.	10.	1000.	150.	65.	20	*	38.084	6.614	*	2.33	4.31
1109	60.	30.	1000.	150.	65.	20	*	37.398	10.823	*	2.90	4.41
1110	100.	30.	1000.	150.	65.	20	*	35.133	7.697	*	2.37	4.42
1111	150.	30.	1000.	150.	65.	20	*	33.503	6.265	*	2.11	4.44
1112	200.	30.	1000.	150.	65.	20	*	32.776	5.608	*	1.99	4.40
1113	60.	50.	1000.	150.	65.	20	*	34.986	9.637	*	2.64	4.44
1114	100.	50.	1000.	150.	65.	20	*	32.853	6.797	*	2.16	4.44
1115	150.	50.	1000.	150.	65.	20	*	31.911	5.885	*	2.00	4.48
1116	200.	50.	1000.	150.	65.	20	*	30.858	5.319	*	1.88	4.46
1117	60.	10.	300.	175.	65.	20	*	27.826	7.949	*	2.14	9.16
1118	100.	10.	300.	175.	65.	20	*	24.066	5.535	*	1.66	9.36
1119	150.	10.	300.	175.	65.	20	*	21.994	4.601	*	1.45	9.55
1120	200.	10.	300.	175.	65.	20	*	21.280	4.307	*	1.39	9.73

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* * *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* * *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1121	60.	30.	300.	175.	65.	20	*	19.894	5.497	*	1.51	9.90
1122	100.	30.	300.	175.	65.	20	*	18.369	4.411	*	1.30	10.06
1123	150.	30.	300.	175.	65.	20	*	18.042	4.002	*	1.23	10.12
1124	200.	30.	300.	175.	65.	20	*	17.246	3.750	*	1.16	10.06
1125	60.	50.	300.	175.	65.	20	*	18.247	5.049	*	1.38	10.07
1126	100.	50.	300.	175.	65.	20	*	17.393	4.181	*	1.23	10.17
1127	150.	50.	300.	175.	65.	20	*	16.847	3.814	*	1.16	10.19
1128	200.	50.	300.	175.	65.	20	*	16.549	3.653	*	1.12	10.17
1129	60.	10.	600.	175.	65.	20	*	34.701	11.243	*	2.96	6.32
1130	100.	10.	600.	175.	65.	20	*	30.158	7.254	*	2.13	6.43
1131	150.	10.	600.	175.	65.	20	*	27.183	5.484	*	1.77	6.42
1132	200.	10.	600.	175.	65.	20	*	26.253	4.997	*	1.67	6.50
1133	60.	30.	600.	175.	65.	20	*	25.276	6.878	*	1.90	6.50
1134	100.	30.	600.	175.	65.	20	*	23.610	5.188	*	1.60	6.63
1135	150.	30.	600.	175.	65.	20	*	22.563	4.545	*	1.47	6.65
1136	200.	30.	600.	175.	65.	20	*	22.100	4.329	*	1.42	6.73
1137	60.	50.	600.	175.	65.	20	*	23.491	6.065	*	1.72	6.66
1138	100.	50.	600.	175.	65.	20	*	22.097	4.774	*	1.48	6.66
1139	150.	50.	600.	175.	65.	20	*	21.464	4.351	*	1.40	6.74
1140	200.	50.	600.	175.	65.	20	*	21.214	4.125	*	1.36	6.67
1141	60.	10.	1000.	175.	65.	20	*	44.354	17.298	*	4.07	5.18
1142	100.	10.	1000.	175.	65.	20	*	36.533	9.172	*	2.63	5.17
1143	150.	10.	1000.	175.	65.	20	*	33.508	6.949	*	2.21	5.26
1144	200.	10.	1000.	175.	65.	20	*	31.523	5.839	*	1.98	5.24
1145	60.	30.	1000.	175.	65.	20	*	30.966	9.410	*	2.46	5.38
1146	100.	30.	1000.	175.	65.	20	*	29.348	6.763	*	2.03	5.39
1147	150.	30.	1000.	175.	65.	20	*	27.654	5.548	*	1.80	5.41
1148	200.	30.	1000.	175.	65.	20	*	27.137	4.994	*	1.70	5.36
1149	60.	50.	1000.	175.	65.	20	*	29.269	8.421	*	2.26	5.41
1150	100.	50.	1000.	175.	65.	20	*	27.327	6.006	*	1.85	5.42
1151	150.	50.	1000.	175.	65.	20	*	26.308	5.231	*	1.70	5.47
1152	200.	50.	1000.	175.	65.	20	*	25.624	4.754	*	1.61	5.43
1153	60.	10.	300.	100.	80.	20	*	48.943	10.811	*	3.32	4.68
1154	100.	10.	300.	100.	80.	20	*	42.304	7.493	*	2.61	4.75
1155	150.	10.	300.	100.	80.	20	*	38.701	6.231	*	2.29	4.76
1156	200.	10.	300.	100.	80.	20	*	37.591	5.807	*	2.19	4.82
1157	60.	30.	300.	100.	80.	20	*	34.596	7.316	*	2.30	4.93
1158	100.	30.	300.	100.	80.	20	*	32.123	5.830	*	2.00	4.97
1159	150.	30.	300.	100.	80.	20	*	31.246	5.291	*	1.89	4.99
1160	200.	30.	300.	100.	80.	20	*	30.367	4.952	*	1.81	4.96

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	*	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	*	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1161	60.	50.	300.	100.	80.	20	*	31.879	6.696	*	2.11	4.99
1162	100.	50.	300.	100.	80.	20	*	30.429	5.508	*	1.89	5.01
1163	150.	50.	300.	100.	80.	20	*	29.340	5.020	*	1.78	5.02
1164	200.	50.	300.	100.	80.	20	*	29.561	4.834	*	1.76	5.01
1165	60.	10.	600.	100.	80.	20	*	69.787	16.877	*	4.94	3.17
1166	100.	10.	600.	100.	80.	20	*	60.877	10.954	*	3.77	3.23
1167	150.	10.	600.	100.	80.	20	*	55.327	8.373	*	3.20	3.19
1168	200.	10.	600.	100.	80.	20	*	53.319	7.606	*	3.02	3.23
1169	60.	30.	600.	100.	80.	20	*	50.874	10.270	*	3.31	3.25
1170	100.	30.	600.	100.	80.	20	*	47.405	7.768	*	2.83	3.26
1171	150.	30.	600.	100.	80.	20	*	45.326	6.818	*	2.62	3.27
1172	200.	30.	600.	100.	80.	20	*	44.176	6.439	*	2.52	3.31
1173	60.	50.	600.	100.	80.	20	*	47.109	9.025	*	3.00	3.28
1174	100.	50.	600.	100.	80.	20	*	44.711	7.148	*	2.64	3.27
1175	150.	50.	600.	100.	80.	20	*	42.884	6.465	*	2.48	3.31
1176	200.	50.	600.	100.	80.	20	*	42.905	6.174	*	2.44	3.28
1177	60.	10.	1000.	100.	80.	20	*	95.612	27.723	*	7.42	2.59
1178	100.	10.	1000.	100.	80.	20	*	81.982	16.326	*	5.30	2.61
1179	150.	10.	1000.	100.	80.	20	*	73.722	11.495	*	4.32	2.61
1180	200.	10.	1000.	100.	80.	20	*	72.699	10.487	*	4.14	2.62
1181	60.	30.	1000.	100.	80.	20	*	67.441	15.067	*	4.60	2.64
1182	100.	30.	1000.	100.	80.	20	*	63.786	10.540	*	3.88	2.65
1183	150.	30.	1000.	100.	80.	20	*	60.874	9.062	*	3.58	2.66
1184	200.	30.	1000.	100.	80.	20	*	59.779	8.450	*	3.38	2.68
1185	60.	50.	1000.	100.	80.	20	*	63.457	13.470	*	4.22	2.65
1186	100.	50.	1000.	100.	80.	20	*	59.600	9.720	*	3.55	2.66
1187	150.	50.	1000.	100.	80.	20	*	57.827	8.494	*	3.31	2.68
1188	200.	50.	1000.	100.	80.	20	*	56.720	7.781	*	3.17	2.66
1189	60.	10.	300.	125.	80.	20	*	38.160	8.943	*	2.66	6.22
1190	100.	10.	300.	125.	80.	20	*	32.956	6.312	*	2.10	6.22
1191	150.	10.	300.	125.	80.	20	*	30.090	5.305	*	1.85	6.32
1192	200.	10.	300.	125.	80.	20	*	29.204	4.976	*	1.77	6.34
1193	60.	30.	300.	125.	80.	20	*	27.304	6.220	*	1.88	6.47
1194	100.	30.	300.	125.	80.	20	*	25.094	5.007	*	1.63	6.52
1195	150.	30.	300.	125.	80.	20	*	24.604	4.587	*	1.55	6.55
1196	200.	30.	300.	125.	80.	20	*	23.669	4.312	*	1.47	6.51
1197	60.	50.	300.	125.	80.	20	*	24.946	5.699	*	1.72	6.55
1198	100.	50.	300.	125.	80.	20	*	23.906	4.760	*	1.55	6.57
1199	150.	50.	300.	125.	80.	20	*	23.228	4.378	*	1.47	6.59
1200	200.	50.	300.	125.	80.	20	*	22.721	4.192	*	1.42	6.54

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN %	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1201	60.	10.	600.	125.	80.	20	*	50.477	13.197	*	3.70	4.15
1202	100.	10.	600.	125.	80.	20	*	44.280	8.653	*	2.84	4.20
1203	150.	10.	600.	125.	80.	20	*	40.066	6.674	*	2.41	4.18
1204	200.	10.	600.	125.	80.	20	*	38.607	6.101	*	2.27	4.24
1205	60.	30.	600.	125.	80.	20	*	37.410	8.189	*	2.53	4.25
1206	100.	30.	600.	125.	80.	20	*	34.803	5.273	*	2.16	4.28
1207	150.	30.	600.	125.	80.	20	*	33.265	5.554	*	2.00	4.30
1208	200.	30.	600.	125.	80.	20	*	32.738	5.291	*	1.94	4.35
1209	60.	50.	600.	125.	80.	20	*	34.580	7.224	*	2.29	4.29
1210	100.	50.	600.	125.	80.	20	*	32.924	5.806	*	2.02	4.30
1211	150.	50.	600.	125.	80.	20	*	31.814	5.313	*	1.91	4.35
1212	200.	50.	600.	125.	80.	20	*	31.591	5.084	*	1.87	4.30
1213	60.	10.	1000.	125.	80.	20	*	66.930	20.643	*	5.37	3.37
1214	100.	10.	1000.	125.	80.	20	*	56.335	11.379	*	3.67	3.34
1215	150.	10.	1000.	125.	80.	20	*	51.298	8.713	*	3.11	3.39
1216	200.	10.	1000.	125.	80.	20	*	48.671	7.437	*	2.83	3.38
1217	60.	30.	1000.	125.	80.	20	*	47.642	11.443	*	3.36	3.45
1218	100.	30.	1000.	125.	80.	20	*	45.054	8.411	*	2.84	3.46
1219	150.	30.	1000.	125.	80.	20	*	43.044	7.026	*	2.57	3.47
1220	200.	30.	1000.	125.	80.	20	*	42.259	6.420	*	2.45	3.44
1221	60.	50.	1000.	125.	80.	20	*	44.859	10.277	*	3.09	3.47
1222	100.	50.	1000.	125.	80.	20	*	42.260	7.519	*	2.61	3.47
1223	150.	50.	1000.	125.	80.	20	*	41.167	6.637	*	2.44	3.50
1224	200.	50.	1000.	125.	80.	20	*	40.201	6.096	*	2.33	3.48
1225	60.	10.	300.	150.	80.	20	*	31.789	7.959	*	2.29	7.75
1226	100.	10.	300.	150.	80.	20	*	27.497	5.668	*	1.81	8.00
1227	150.	10.	300.	150.	80.	20	*	25.344	4.810	*	1.61	8.02
1228	200.	10.	300.	150.	80.	20	*	24.427	4.501	*	1.53	8.03
1229	60.	30.	300.	150.	80.	20	*	22.701	5.582	*	1.62	8.23
1230	100.	30.	300.	150.	80.	20	*	20.987	4.545	*	1.41	8.29
1231	150.	30.	300.	150.	80.	20	*	20.557	4.170	*	1.34	8.34
1232	200.	30.	300.	150.	80.	20	*	19.945	3.947	*	1.29	8.29
1233	60.	50.	300.	150.	80.	20	*	20.827	5.147	*	1.49	8.34
1234	100.	50.	300.	150.	80.	20	*	19.908	4.322	*	1.34	8.37
1235	150.	50.	300.	150.	80.	20	*	19.431	3.958	*	1.27	8.28
1236	200.	50.	300.	150.	80.	20	*	18.866	3.823	*	1.23	8.33
1237	60.	10.	600.	150.	80.	20	*	40.768	11.324	*	3.09	5.28
1238	100.	10.	600.	150.	80.	20	*	35.547	7.498	*	2.36	5.35
1239	150.	10.	600.	150.	80.	20	*	32.068	5.805	*	1.99	5.33
1240	200.	10.	600.	150.	80.	20	*	31.029	5.328	*	1.89	5.42

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	* *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	* *	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1241	60.	30.	600.	150.	80.	20	*	29.836	7.096	*	2.09	5.43
1242	100.	30.	600.	150.	80.	20	*	27.676	5.464	*	1.78	5.46
1243	150.	30.	600.	150.	80.	20	*	26.553	4.852	*	1.66	5.48
1244	200.	30.	600.	150.	80.	20	*	26.125	4.643	*	1.61	5.56
1245	60.	50.	600.	150.	80.	20	*	27.573	6.293	*	1.90	5.48
1246	100.	50.	600.	150.	80.	20	*	26.071	5.069	*	1.67	5.48
1247	150.	50.	600.	150.	80.	20	*	25.286	4.655	*	1.58	5.55
1248	200.	50.	600.	150.	80.	20	*	25.021	4.443	*	1.54	5.50
1249	60.	10.	1000.	150.	80.	20	*	52.653	17.371	*	4.39	4.31
1250	100.	10.	1000.	150.	80.	20	*	43.566	9.523	*	2.94	4.29
1251	150.	10.	1000.	150.	80.	20	*	40.006	7.356	*	2.50	4.36
1252	200.	10.	1000.	150.	80.	20	*	37.989	6.301	*	2.28	4.35
1253	60.	30.	1000.	150.	80.	20	*	37.162	9.691	*	2.73	4.43
1254	100.	30.	1000.	150.	80.	20	*	34.865	7.122	*	2.28	4.44
1255	150.	30.	1000.	150.	80.	20	*	33.379	5.968	*	2.06	4.45
1256	200.	30.	1000.	150.	80.	20	*	32.325	5.419	*	1.95	4.41
1257	60.	50.	1000.	150.	80.	20	*	34.809	8.711	*	2.51	4.45
1258	100.	50.	1000.	150.	80.	20	*	32.655	6.383	*	2.10	4.45
1259	150.	50.	1000.	150.	80.	20	*	31.766	5.638	*	1.96	4.49
1260	200.	50.	1000.	150.	80.	20	*	30.775	5.178	*	1.86	4.47
1261	60.	10.	300.	175.	80.	20	*	27.364	7.154	*	2.01	9.40
1262	100.	10.	300.	175.	80.	20	*	23.727	5.165	*	1.60	9.63
1263	150.	10.	300.	175.	80.	20	*	21.787	4.413	*	1.42	9.64
1264	200.	10.	300.	175.	80.	20	*	21.001	4.157	*	1.36	9.82
1265	60.	30.	300.	175.	80.	20	*	19.678	5.101	*	1.44	9.99
1266	100.	30.	300.	175.	80.	20	*	18.200	4.205	*	1.26	10.13
1267	150.	30.	300.	175.	80.	20	*	17.906	3.887	*	1.20	10.19
1268	200.	30.	300.	175.	80.	20	*	17.150	3.679	*	1.15	10.13
1269	60.	50.	300.	175.	80.	20	*	18.124	4.735	*	1.33	10.14
1270	100.	50.	300.	175.	80.	20	*	17.300	4.019	*	1.20	10.23
1271	150.	50.	300.	175.	80.	20	*	16.734	3.724	*	1.14	10.24
1272	200.	50.	300.	175.	80.	20	*	16.471	3.595	*	1.11	10.17
1273	60.	10.	600.	175.	80.	20	*	34.313	9.926	*	2.66	6.46
1274	100.	10.	600.	175.	80.	20	*	29.874	6.658	*	2.03	6.52
1275	150.	10.	600.	175.	80.	20	*	26.882	5.201	*	1.72	6.49
1276	200.	10.	600.	175.	80.	20	*	26.050	4.803	*	1.63	6.57
1277	60.	30.	600.	175.	80.	20	*	25.116	6.320	*	1.81	6.62
1278	100.	30.	600.	175.	80.	20	*	23.445	4.935	*	1.55	6.66
1279	150.	30.	600.	175.	80.	20	*	22.472	4.410	*	1.44	6.68
1280	200.	30.	600.	175.	80.	20	*	22.012	4.228	*	1.40	6.76

RESULTS OF AN ECONOMIC SENSITIVITY STUDY FOR COMMERCIAL FEASIBILITY OF UNDERGROUND COAL GASIFICATION ----

BRIEF SUMMARY

VALUES FOR THE SENSITIVITY VARIABLES

CASE NO.	WELL SPACING IN FT.	COAL SEAM THICKNESS IN FT.	DEPTH TO TOP OF SEAM IN FT.	DRY GAS HHV IN BTU/SCF	COAL RESOURCE AFFECTED IN % *	LEAKAGE RATE IN % *	TOTAL INVESTMENT IN \$ MM	ANNUAL OPERATING EXPENSE IN \$ MM	REQUIRED DIRTY GAS SELLING PRICE IN \$ / MM BTU	ENERGY RETURN RATIO
1281	60.	50.	600.	175.	80.	20	23.370	5.645	1.65	6.69
1282	100.	50.	600.	175.	80.	20	22.807	4.592	1.45	6.68
1283	150.	50.	600.	175.	80.	20	21.394	4.242	1.38	6.76
1284	200.	50.	600.	175.	80.	20	21.145	4.058	1.35	6.69
1285	60.	10.	1000.	175.	80.	20	43.615	14.929	3.71	5.24
1286	100.	10.	1000.	175.	80.	20	36.201	8.297	2.50	5.22
1287	150.	10.	1000.	175.	80.	20	33.113	6.463	2.12	5.31
1288	200.	10.	1000.	175.	80.	20	31.133	5.546	1.92	5.29
1289	60.	30.	1000.	175.	80.	20	30.775	9.452	2.32	5.40
1290	100.	30.	1000.	175.	80.	20	29.151	6.288	1.95	5.41
1291	150.	30.	1000.	175.	80.	20	27.555	5.296	1.76	5.42
1292	200.	30.	1000.	175.	80.	20	27.046	4.845	1.67	5.38
1293	60.	50.	1000.	175.	80.	20	28.863	7.627	2.13	5.43
1294	100.	50.	1000.	175.	80.	20	27.182	5.658	1.79	5.43
1295	150.	50.	1000.	175.	80.	20	26.234	5.027	1.67	5.48
1296	200.	50.	1000.	175.	80.	20	25.557	4.636	1.59	5.45