United States General Accounting Office 133471

GAO

Report to the Chairman, Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives

June 1987

ALTERNATIVE FUELS

Parachute Creek Shale Oil Project's Economic and Operational Outlook

133471

039483

GAO/RCED-87-126

GAO United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-223418

June 18, 1987

The Honorable John D. Dingell
Chairman, Subcommittee on Oversight
and Investigations
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

Your November 13, 1985, letter asked us to assist your Subcommittee in investigating activities of the U.S. Synthetic Fuels Corporation (SFC). As part of this request, we issued a fact sheet entitled Synthetic Fuels Corporation Officer Separation Benefits (GAO/RCED-86-199FS) in July 1986.

As agreed with your office, this report assesses the economic and technical viability of the SFC-assisted Parachute Creek shale oil project and makes recommendations aimed at minimizing additional federal outlays on the project.

As arranged with your office, we plan to distribute copies of this report to interested parties and make copies available to others upon request one day after the date of this letter.

This work was performed under the direction of Flora H. Milans, Associate Director. Other major contributors to this report are listed in appendix III.

Sincerely yours,

J. Dexter Peach

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

The Energy Security Act established the Synthetic Fuels Corporation (SFC) in 1980 to help develop commercial synthetic fuels production and reduce U.S. dependence on imported oil through financial assistance to eligible projects. In 1981, Union Oil Company was awarded $400 million in price guarantees by the Department of Energy (DOE) for synthetic crude oil produced by its Parachute Creek shale oil project in Colorado. In October 1985, SFC awarded an additional $500 million in price and loan guarantees to Union to modify the project's technology. In December 1985, the Congress abolished SFC, effective April 1986, and transferred responsibility for the guarantees to the Secretary of the Treasury.

The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, concerned about the wisdom of awarding Union an additional $500 million, asked GAO to assess the project's economic and operational outlook and how much financial assistance, including tax effects, the government could potentially provide to Union for the project.

Background

Synthetic shale oil is produced by heating shale rock that contains a substance called kerogen, an organic material that yields oil when heated. The Parachute Creek project is designed to produce up to 10,400 barrels a day of shale oil. According to Union, if the project is successful, commercialization of the technology has the potential to produce several hundred billion barrels of oil from the nation's shale oil reserves when oil prices are high enough to provide commercial incentives to exploit them.

SFC assumed responsibility for the $400 million DOE award in 1982. It awarded the additional $500 million in price and loan guarantees on the condition that Union modify the project's technology to solve technical problems that had been preventing operations since the project was constructed in 1983. The price guarantees assure Union a minimum price for the project's synthetic crude oil. A lawsuit by several Members of Congress and others challenging the validity of the October 1985 award agreement was filed in a federal court in June 1986 and was pending as of May 1, 1987.

The major technical problem preventing operations was in the project's system to cool and remove spent shale. SFC awarded the additional $500 million as an incentive to install a fluidized bed combustor, a device that would replace the project's spent-shale cooling system and also lower operating costs through improved plant efficiencies. SFC had determined that Union could probably not achieve sustained production or operate the project profitably without adding the combustor. As of May 1987, Union was continuing to design the combustor and evaluate its viability. Union indicated it will decide whether to proceed with the combustor installation by June 30, 1987.

Results in Brief

The project's economic viability after price supports end is uncertain because it is heavily dependent on oil prices, which have been volatile in recent years. SFC's analysis of economic viability, done before the October 1985 award and before a sharp drop in oil prices in 1986, indicated that the project would have a positive total after-tax cash flow of $271 million from 1995 through 2005 if the combustor is installed.

Using more recent oil price forecasts, GAO calculated that for the same period the project's after-tax cash flow would be negative by as much as $286 million, depending on which forecast was used. Furthermore, the cash flow would diminish if production tax credits are eliminated or if further technical problems occur.

Total federal assistance received by Union over the life of the project, according to GAO's calculations, could be from $968 million to $1.5 billion, including tax effects and price guarantees.

The project's technical viability with or without the fluidized bed combustor is uncertain. As of June 1987, Union was operating the project without the combustor for limited periods. Because of this, Union and Treasury officials were encouraged about the technical viability of the project without a combustor. However, technical problems were not completely solved and there is potential for new problems from adding the combustor.

GAO believes that because of the uncertainty of the project's economic and technical viability, it would not be in the government's best interest to expend an additional $500 million in financial assistance to install the combustor.

GAO's Analysis

Economic Viability

When project oil is sold, Union will be paid the difference between the oil's market price and a guaranteed price, whenever the market price is lower. As of January 1987, Union was guaranteed $45 a barrel for production without the combustor. With the combustor, the guaranteed price for production was about $75 a barrel as of January 1987.

GAO used third quarter 1985 and first quarter 1986 price and inflation forecasts by Chase Econometrics, Inc., and Wharton Econometric Forecasting Associates, Inc., in SFC's model of the project's economics. GAO and SFC after-tax cash-flow calculations differed primarily because, for comparable forecast periods, SFC's oil price assumptions exceeded Chase's and Wharton's forecasts by an average of 44 to 95 percent. For example, in October 1985, SFC projected crude oil prices to be $69 a barrel in 1996, the year after it projected price supports to be exhausted. At a comparable time, Chase and Wharton forecasted 1996 prices to be about $40 and $47 a barrel, respectively.

Production tax credits, which permit Union to reduce tax liabilities by about $3 per barrel of oil produced by the project, influence the project's profitability. GAO determined that the project's total after-tax cash flow could decrease by as much as $134 million if the credits are eliminated before 1994, when they are projected to take effect.

In September 1986, on the basis of an updated analysis, Union told Treasury officials that if the current plant can produce more than 5,000 barrels a day, which it believed was likely, the economic attractiveness of adding the combustor would be reduced. Union also stated that if it adds the combustor, it may cease operations after the $900 million in price guarantee supports is exhausted, unless future oil prices rise significantly above current forecasts.

Through December 1986, Union reported that it had invested $961 million in the project, up from $472 million budgeted in 1981. It plans to invest an additional $562 million if it adds the combustor.

Technical Viability

As of February 1, 1987, Union had operated the plant since November 1986 for periods of up to a week between unscheduled shutdowns, at production rates of up to 4,500 barrels of shale oil a day. The shutdowns ranged from several hours to over 2 weeks. Union began selling the project's oil in December 1986 and began collecting price guarantee support payments from Treasury in April 1987. However, in March and April 1987, the plant was shut down for about 6 weeks for planned technical modifications and has been operating nearly continuously since mid-April. Therefore, GAO concluded that the project's technical viability without the combustor was still uncertain.

A commercial-scale fluidized bed combustor that burns oil shale has never been built before. Union and SFC recognized that adding the combustor could result in additional operational problems because of the pioneer nature of the technology, but they also believed that any problems that might arise if the combustor is installed could be resolved. Nevertheless, because the extent of the problems that might occur and the difficulty of solving them is not known, GAO concluded that the technical viability of the project with the combustor is also uncertain.

Terms of the Agreement

Under the agreement, Union has the option of not installing the combustor if certain criteria are not met, such as if it estimates that (1) construction costs will exceed $286 million in 1985 dollars or (2) the incremental real rate of return from installing the combustor will be less than 18 percent.

Treasury is obligated to provide the additional $500 million in assistance unless Union terminates the combustor installation program or does not meet the terms of the assistance agreement. For example, Treasury could rescind the assistance if Union does not submit a construction cost estimate and other information by June 30, 1987.

Recommendations

In view of the economic and technical issues facing the combustor's installation, GAO recommends that the Secretary of the Treasury rescind the additional $500 million in assistance if the terms of the agreement are not met. If the terms are met and Union elects to proceed with the combustor, GAO recommends that the Secretary use the analysis in this report to critically evaluate Union's proposal and explore the government's options for minimizing additional outlays on this project.

Agency Comments

As requested by the Chairman's office, GAO did not obtain official agency comments on a draft of this report but did obtain and incorporate the views of responsible Union and Treasury officials.

Contents

Abbreviations

DOE	Department of Energy
GAO	General Accounting Office
OPEC	Organization of Petroleum Exporting Countries
PPI	Producer Price Index
SFC	U.S. Synthetic Fuels Corporation
SPAN	Synfuels Project Analysis Network

Introduction

Background

The U.S. Synthetic Fuels Corporation (SFC), a quasi-official federal agency, was established in 1980 by the Energy Security Act to stimulate development of commercial synthetic fuels production from domestic resources and help the nation achieve energy security through reduced dependence on imported oil. The act authorized SFC to solicit proposals for synthetic fuels projects and award financial assistance to qualified concerns submitting proposals acceptable to its board of directors.

The financial assistance was intended to encourage private industry to develop commercial synthetic fuels production technology that it might have otherwise considered too risky or costly to develop. For example, oil markets have been volatile in the past, and there were risks that oil prices would not follow a growth pattern required to make some synthetic fuels projects economically viable. Also, according to a 1981 Rand Corporation report, pioneer commercial technology in large energy process plants can be expected to experience large cost overruns and produce at less-than-designed production rates.[1] However, according to the report, succeeding plants using such a newly developed technology can be expected to be built and operated more economically than the initial pioneer plant as a result of lessons learned during the pioneer effort.

SFC began operating in 1980, and U.S. Treasury funds totaling $16.5 billion were made available to it for making assistance awards, including $4.3 billion transferred from the Department of Energy (DOE). However, by 1985 the Congress had reduced the total funds available to SFC to $7.9 billion. Then, in December 1985, after debate over the need for a national synthetic fuels program, the Congress rescinded all of SFC's unobligated funds authorized for financial assistance and abolished SFC, effective April 18, 1986 (Public Law 99-190, Dec. 19, 1985). When it was abolished, SFC had obligated $1.7 billion in financial assistance to four projects. Responsibility for SFC's financial assistance obligations transferred to the Secretary of the Treasury in February 1986.

One of the projects awarded SFC assistance was a shale oil project located near Parachute, Colorado, which is owned and being developed by Union Oil Company of California, a subsidiary of Unocal Corporation. Shale oil is produced from shale rock containing a substance called kerogen, an organic material that yields oil when heated. The oil can be further processed into refinable crude oil.

[1] See Edward W. Merrow, et al., Understanding Cost Growth and Performance Shortfalls in Pioneer Process Plants, September 1981, The Rand Corporation.

According to Union, the project's technology, if successful, will provide a means to access 3.3 billion barrels of potentially recoverable shale oil on Unocal property and several hundred billion barrels of national oil shale reserves when crude oil market conditions make it economical to exploit the reserves. The project is designed to produce 10,400 barrels a day of high-grade synthetic crude oil from mined oil shale. Net U.S. oil imports averaged 5.3 million barrels a day in 1986 and, according to a March 1987 DOE report to the President, are expected to rise to between 8 million to 10 million barrels a day in the mid-1990s—about one-half or more of total projected U.S. oil consumption.

The Union project, called the Parachute Creek program, was awarded a total of up to $900 million in price and loan guarantees—up to $400 million in price guarantees through a competitive solicitation by DOE in 1981 and up to $500 million in price and loan guarantees by SFC through an October 1985 amendment to the DOE award.[2] The additional $500 million in price and loan guarantees is contingent on Union's modifying the project's technology with a fluidized bed combustor. This device should increase plant efficiency and decrease operating expenses by burning residual carbon contained in the spent shale to produce steam-generated electricity and heat for other plant uses. It is also a potential solution to a technical problem that has prevented the project from achieving sustained continuous operations.

Objectives, Scope, and Methodology

SFC awarded the additional $500 million in price and loan guarantee assistance to the Parachute Creek shale oil project while the Congress was debating the need for continuing a national synthetic fuels program. Concerned about SFC's activities and the wisdom of awarding the additional $500 million in assistance, on November 13, 1985, the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked us to assist his office in reviewing SFC activities. In subsequent meetings with the Chairman's office, we were requested to provide information on (1) the separation benefits provided to SFC officers and board directors and (2) the economic and technical viability of Union Oil Company's Parachute Creek shale oil project and the net financial assistance from the government, including tax effects,

[2]Several Members of Congress and Friends of the Earth, an environmental advocacy group, filed a lawsuit challenging the validity of the October 1985 amended agreement between SFC and Union (Metzenbaum v. Baker, No. 86-1564 (D.D.C. filed June 5, 1986)). The suit was still pending as of May 1, 1987.

that could accrue to Union for the project. We were also asked to provide information on the impact that a repeal of production tax credits would have on the project's economics.

We issued a fact sheet describing the separation benefits on July 30, 1986 (GAO/RCED-86-199FS). This report presents our analysis of the Parachute Creek project issues we were asked to examine.

Based on agreements with the Chairman's office, our objectives for reviewing the project's economic viability and financial assistance were to

- determine the prices guaranteed to Union under the amended agreement;
- compare SFC's future crude oil price assumptions at the time of the October 1985 agreement and in the first quarter of 1986, after world oil prices had fallen, with forecasts that were available at comparable times by Union and several recognized econometric forecasting authorities;
- compare SFC's after-tax cash-flow projections for the project made in October 1985 using SFC's own economic and operational assumptions with SFC's projections using Union's assumptions;
- compare SFC's October 1985 and first quarter 1986 after-tax cash-flow projections with projections using crude oil price and inflation forecasts developed by the recognized econometric forecasting authorities;
- compare SFC's October 1985 and first quarter 1986 projections with projections using only crude oil price forecasts by the econometric forecasting authorities;
- estimate, in current and discounted-present values, the potential net financial assistance from the government that will accrue to Union under the amended agreement considering price guarantee payments, project tax credits, and net government receipts from project income taxes under two operating scenarios—operating with modified and unmodified technology—and at two points in time—when price supports end and at the end of the project's useful economic life.

Our objectives for reviewing the project's technical viability were to develop information on and describe

- the technical problems that Union has encountered with the project and the progress made in solving them,
- the technical problems that Union could encounter in the future if it installs a fluidized bed combustor, and

- the general likelihood that current and potential future technical problems can be solved to permit sustained oil production with each technology.

In conducting our analyses, we reviewed information memorandum reports that Union submitted to SFC and such reports that contained detailed financial, technical, and other project-supporting information; SFC's staff findings reports that contained SFC's summary of its technical and financial analyses of the project; minutes of open and closed meetings of SFC's board of directors that pertained to discussions of the project; the agreements between Union and DOE and Union and SFC pertaining to assistance awards; SFC's general files and its project officer's files on the project; SFC's detailed financial analysis spreadsheets and computerized financial models for the project; and general literature on shale oil production and fluidized bed combustors. In addition, we reviewed Department of the Treasury documents related to updated information on project operations.

We also interviewed SFC officers, financial analysts, and engineers; DOE's Director of Oil, Gas, and Shale Technology; DOE's Program Manager for Combustion Systems, Office of Coal Utilization; DOE's Director and staff engineers, Extraction Projects Management Division, Morgantown (W.Va.) Energy Technology Center; and Unocal's Vice Presidents for Oil Shale Operations and Budgets and Planning, Energy Mining Division. In addition, we interviewed officials of Treasury's Office of Synthetic Fuels Projects.

For our economic analysis, we reviewed certain assumptions and calculations of two computer-based economic models of the project that SFC used to analyze the project and SFC's projections of the project's economic performance produced from the models in October 1985 and in the first quarter of 1986. Although we did not validate the models, within the limits of our review, we found no major problems with them. We then substituted alternative crude oil market price and inflation forecasts for comparable periods by two recognized economic forecasting authorities—Chase Econometrics, Inc., and Wharton Econometric Forecasting Associates, Inc.—into one of the models to produce comparative after-tax cash-flow calculations for the project. We also did not validate whether SFC's models were complete and correct with respect to tax considerations, but accepted SFC's treatment of taxes.

We made comparisons with SFC's October 1985 projections in order to provide perspective on the project's economic viability outlook at the time the amended agreement was signed. We also made similar comparisons with SFC's first quarter 1986 projections to see how the project's viability was affected by downward trends in market price forecasts resulting from changed crude oil market conditions that occurred after the amended agreement was signed. Both SFC's and our analyses assumed that Union would have been able to begin production in mid-1986 if it operated without the fluidized bed combustor and will be able to adhere to proposed construction and operating schedules if it decides to install the combustor. Details of our economic analysis methodology are described in appendix I.

The information provided in chapter 5 on technical viability is a synthesis of the information from our interviews and the written documents we reviewed. We did not assess environmental impact issues. Also, we did not independently verify the information Union provided to SFC, Treasury, or us on the plant's technical problems.

At the direction of the Chairman's office, we did not obtain official comments on this report from either Union Oil Company or Treasury's Office of Synthetic Fuels Projects, the successor to SFC. However, as agreed with his office, we discussed a statement of facts with Union officials and discussed the contents of this report with Treasury officials. On the basis of these discussions, we made clarifications in the report where appropriate. We also incorporated comments by an independent chemical engineer and an independent geologist, each familiar with oil shale technology, who performed technical reviews of the draft report. Our work was performed in accordance with generally accepted government auditing standards.

Parachute Creek Project Description

Project History

The Parachute Creek shale oil project was initially planned to be built in several phases. Phase I was designed to produce 10,400 barrels of synthetic crude oil per stream day from mined oil shale using a process being developed by Union called "Unishale B."[1] Subsequent phases were planned to produce a total of 80,000 barrels per day in four increments of 20,000 barrels per day using a more efficient technology being developed by Union called "Unishale C."

With each technology, shale oil is produced by heating crushed oil shale in a device called a retort. The Unishale C technology also uses a device called a fluidized bed combustor, which burns residual carbon contained in the spent shale from the retort to produce steam-generated electricity and heat for other plant uses. (See p. 24.)

In July 1981, under provisions of the Energy Security Act, DOE awarded $400 million in price guarantees to Union for the phase I project. The award agreement permitted DOE and Union to share the risk of developing pioneer shale oil technology by committing DOE to pay Union the difference between a price based on the market prices of certain refined petroleum products and a predetermined guaranteed price, whenever the guaranteed price was greater.

Responsibility for administering the award was transferred to SFC in February 1982, and construction of the phase I facility was completed in September 1983. In December 1983, SFC signed a letter of intent to provide up to $2.7 billion in additional price guarantees for a phase II project consisting of two 21,000-barrels-per-day facilities.

The phase II award was never made because of a combination of circumstances. Because five of its seven board directors resigned in early 1984, SFC's board of directors did not have a quorum to finalize the phase II award from April 1984 until November 1984. During this time, the Congress reduced SFC's total appropriation to $7.9 billion. In addition, Union had been experiencing technical problems with the phase I facility and had been unable to establish sustained production. Because of these constraints, SFC and Union began to explore the feasibility of retrofitting the phase II technology to the phase I facility in April 1985 and canceled the phase II plans in August 1985.

[1]Barrels per stream day refers to the average daily production rate for a given time period, such as a year, for the number of days the plant is operating. In this report, barrels per day means the same as barrels per stream day.

The technical problems prevented Union from establishing sustained production between October 1983, after construction was completed, through July 1985. During this time, Union made over 40 start-up attempts. In July 1985, Union suspended start-up operations to develop solutions to the remaining technical problems while the plans and agreement for installing the phase II technology were being developed.

In October 1985, SFC and Union amended the phase I agreement to provide up to $500 million in additional financial assistance to Union for retrofitting the phase I facility with phase II technology (Unishale C). The agreement also modified terms under which the initial $400 million assistance would be granted. (See p. 19.)

According to SFC officials and board meeting minutes, SFC believed the addition of a fluidized bed combustor was the most viable solution to the technical problems being experienced and would enable the phase I plant to begin sustained operations. SFC also believed by the time of the amended agreement that the phase I technology (Unishale B) had only about a 10-percent chance of succeeding. In addition, SFC believed that development of the combustor technology, which increases plant efficiency, would make the shale oil technology more attractive for future commercial applications. One of SFC's criteria for awarding financial assistance to synthetic fuels projects was whether they had commercial replication potential. Union is required to make the technology commercially available to responsible third parties, through licensing or other arrangements, at reasonable commercial terms.

In May 1986, Union began plant-testing potential problem solutions and completed the tests in September 1986. Union reported that during this time, it operated the plant continuously for periods of from several hours duration up to a week, with scheduled and unscheduled shutdowns of between several hours and a week. Shale feed rates during these tests were at up to half of design capacity, and oil production rates were about 3,000 barrels a day.

In November 1986, after reviewing test results, Union restarted the plant in an attempt to establish sustained continuous operations and determine the plant's reliable production capacity. Through January 1987, the plant had been operating at production rates of up to 4,500 barrels a day for periods of from several hours duration to a week, with unscheduled shutdown periods of several hours to over 2 weeks.

Union began selling the project's crude oil in December 1986 and began receiving price guarantee payments from Treasury in April 1987. Under the amended agreement, price guarantee payments are based on the difference in the guaranteed price and the market price of the crude oil sold, as defined by the agreement. Treasury's first payment to Union was $424,865 for 12,570 barrels at $33.80 a barrel, which was based on a guaranteed price of $44.93 a barrel and a market price of $11.13 a barrel.

According to a Union official, through December 1986, Union had invested approximately $961 million of its own funds in the project ($434 million after taxes). It estimated that the Unishale C modification program will cost an additional $562 million in construction and start-up costs. Also, according to Union officials, Union has set June 30, 1987, as its milestone date for deciding whether to proceed with constructing the fluidized bed combustor. This date coincides with the date that Treasury can rescind the additional $500 million in financial assistance if Union does not meet certain requirements specified in the agreement related to installing the combustor. (See below.)

Project Assistance Terms and Conditions

The October 1985 amended agreement granted Union an additional $500 million in financial assistance, contingent on installing the combustor, as follows: an initial $173 million in price guarantees; a loan guarantee that insures 100 percent of a $300 million commercial loan against default for financing up to 55 percent of the total modification costs, including capital and start-up costs; and a $27 million reserve for accrued interest payable to the lender in case of default on the loan. As Union repays the loan principal, the amount set aside for the loan guarantee and interest reserve convert to price guarantees, providing Union up to $500 million in additional price supports.

The amended agreement also extended the time period during which Union is eligible to receive the original $400 million in price supports. The original phase I agreement had specified that Union could receive price guarantee payments beginning in mid-1983 until no later than mid-1990. Under the amended agreement, Union is eligible for the price guarantee payments for 10 years after initial commercial production or until December 31, 2002, whichever occurs first. In addition, the amended agreement removed a 20-million-barrel ceiling on the production eligible for price guarantee support and removed a minimum production rate requirement. Under the original agreement, SFC had the option to terminate financial assistance if, beginning on July 1, 1984, the project produced less than 3.3 million barrels of synthetic crude oil in any consecutive 24-month period.

The agreement allows Union to not install the Unishale C technology whenever certain criteria related to Union's calculations of the real rate of return from adding the Unishale C technology, cost to construct the Unishale C technology, and after-tax cash flow are not met. For example, until Union formally submits a detailed cost estimate, financial projections, and a project master schedule to Treasury for installing the Unishale C technology, Union has the option to terminate the Unishale C installation program if construction cost estimates exceed $286 million in 1985 constant dollars or the real rate of return of the incremental after-tax cash flow from adding the Unishale C technology is estimated to be less than 18 percent. The rate of return and construction cost criteria change slightly after these estimates are submitted and at subsequent milestones. After construction costs exceed 25 percent of the initial detailed estimate, Union can also elect to terminate the Unishale C installation program if Union calculates that project after-tax cash flows will not meet specified minimums.

Under the terms of the agreement, Treasury is obligated to provide the additional $500 million in assistance as long as Union does not terminate the Unishale C program and meets the terms of the agreement. The agreement allows Treasury the option to rescind the additional financial assistance if, for example, Union terminates the Unishale C installation program; defaults on the federally guaranteed loan; or does not formally submit a detailed construction cost estimate, financial projections, and a master schedule for the Unishale C installation by June 30, 1987.

If Union terminates the Unishale C installation program and the additional price and loan guarantees are rescinded, Union could still operate the phase I facility using the Unishale B technology and receive the $400 million committed under the original agreement. Should Union proceed with the Unishale C modifications, it can abandon the project when price supports run out if, in good faith, its financial projections indicate that continuing the project would not be a prudent business decision.

Guaranteed Prices

Market prices, as defined in the amended agreement, will determine the length of time Union receives price guarantees (within the time and dollar limits of the agreement). Market prices are defined by the agreement essentially as the higher of (1) the weighted average prices received by Union for synthetic crude oil product sales or (2) the fair market value of the product determined by average posted prices of equivalent crude oils specified in the agreement. During the price guarantee payment period, the government will pay Union the difference between the guaranteed price and the market price, when the market price is lower. The more the guaranteed price exceeds the market price, the shorter the time span during which Union will receive and expend available price guarantee payments. Conversely, the smaller the difference between the guaranteed and market prices, the longer the time span during which Union will receive price guarantee payments.

Under the amended agreement, the guaranteed price for the project operating with Unishale C technology is the sum of the guaranteed price for operating with Unishale B technology—about $47 per barrel when the agreement was signed—and a supplement of $30 per barrel. However, the supplement does not apply if Unishale B technology is used for production. The base guarantee price and supplemental are each scheduled to be adjusted for inflation by the Producer Price Index (PPI), excluding food.

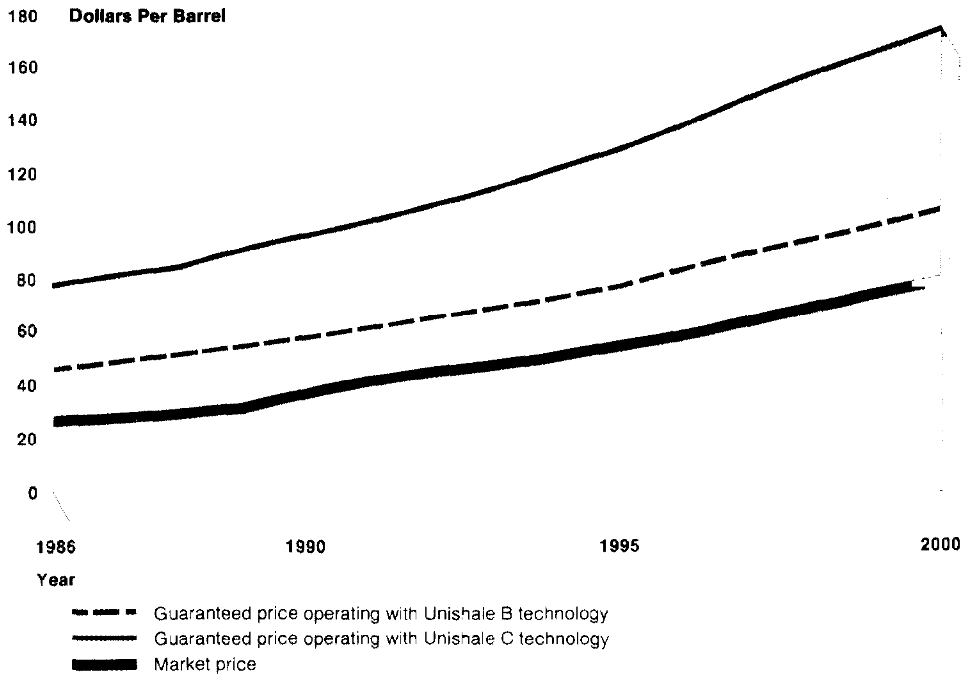
According to a first quarter 1986 SFC analysis for the modified project, when the project achieves peak production in 1991, the guaranteed price with the supplement is projected to be an inflation-adjusted $101 per barrel. SFC projected that the prevailing market price at that time will be about $40 per barrel. Figure 2.1 shows a graphic comparison of SFC's projected guarantee prices for production with each technology and its estimated market prices.

The prices shown in figure 2.1 project a different price guarantee picture than was originally anticipated by Union for the project. According to Union officials, the guaranteed price was originally set at a level slightly lower than market prices existing in 1980; on the basis of price projections at the time, Union expected to profit from the project without ever collecting price guarantee assistance from the government. To illustrate how the market prices changed from expectations, Union officials provided the information shown in figure 2.2. The figure shows a phase I guaranteed price, in 1985 constant dollars, roughly equivalent to the prices existing before the unexpected actual market declines that occurred from 1980 to 1986. The figure also shows Union's September 1986 market price projections through the revised price guarantee eligibility period.

Profit Sharing

The amended agreement also requires Union to pay the government a percentage of the project's cumulative after-tax cash flow exceeding

Figure 2.1: SFC's First Quarter 1986 Market and Guaranteed Price Projections for Unishale B and Unishale C Operations



Source: Produced from SFC's First Quarter 1986 data.

$225 million, in 1985 dollars, for a period of 16 years after initial production. The profit-sharing provision is designed to offset the cost of price guarantee assistance.

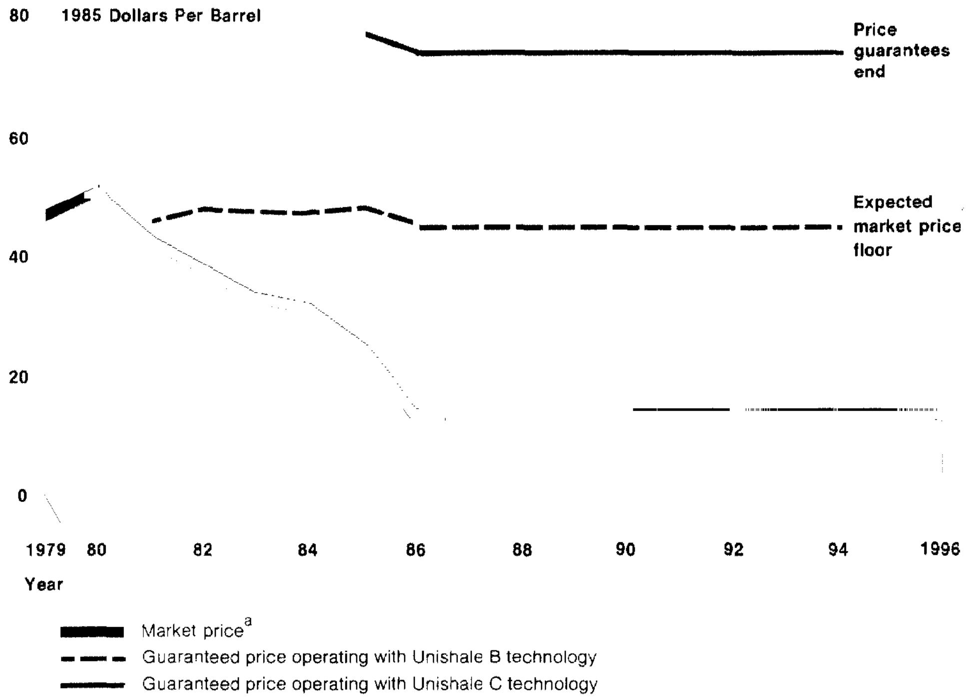
Original Phase I Technology

The phase I facilities consist of

- an underground mine capable of producing 13,800 tons a day of raw oil shale (see fig. 2.3);
- a large complex of equipment for heating the shale and designed to extract 10,000 barrels a day of shale oil (see figs. 2.3 and 2.4);
- an upgrading facility for converting the shale oil into a high-grade synthetic crude oil at a rate of 10,400 barrels a day; and
- a solid waste disposal site for the spent shale.

The phase I Unishale B technology is depicted in the schematic diagram shown in figure 2.5. The principal piece of equipment is called a retort, which circulates crushed shale with gases heated to 1,000° Fahrenheit (F). The shale is first passed through a crusher that reduces it to less

Figure 2.2: Union's Market and Guaranteed Price Comparison (Constant 1985 Dollars Per Barrel)



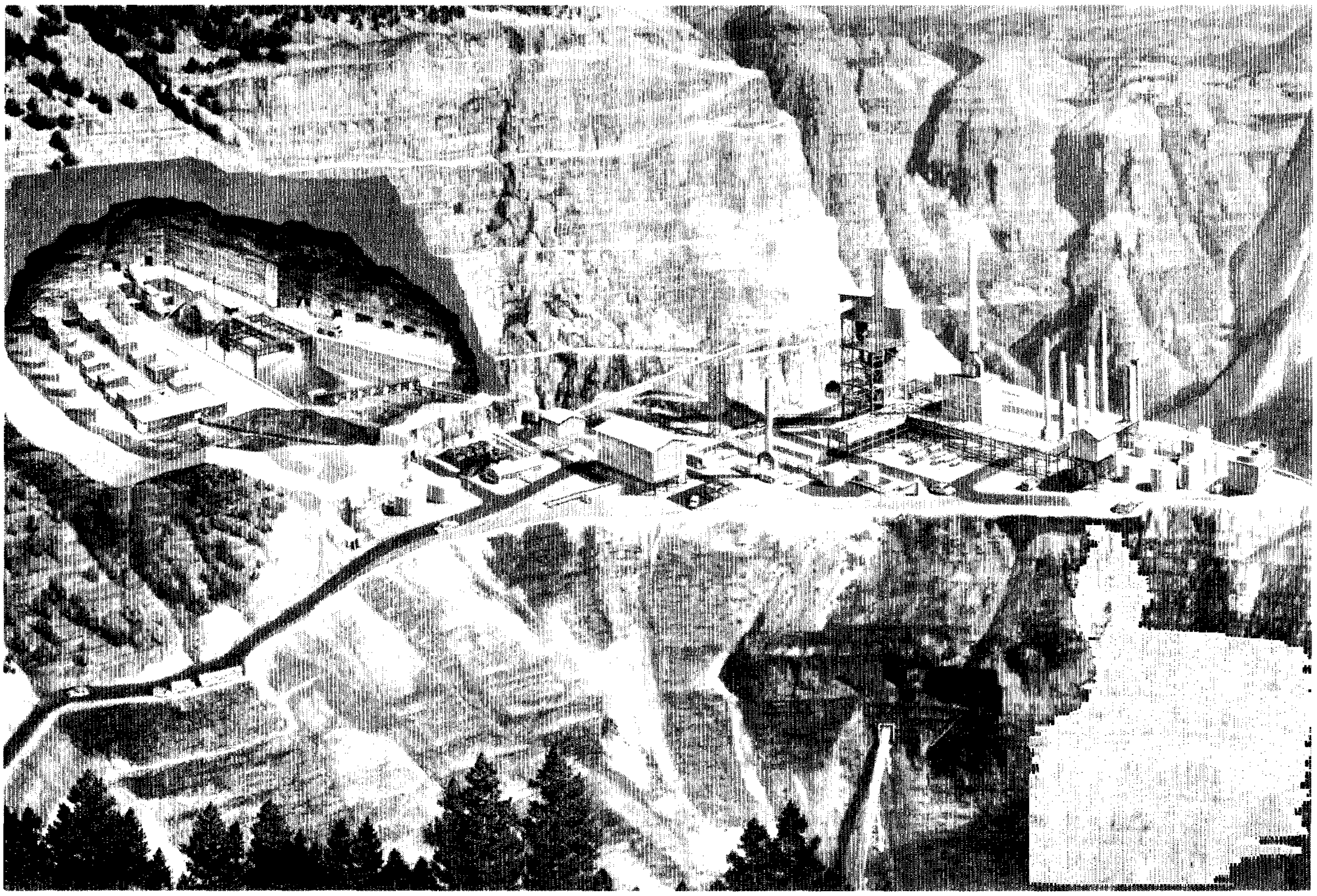
[a]Actual prices until 1986; projected prices afterwards.

Source: Produced from Unocal Corporation November 1986 data.

than 2-inch size pieces and then is passed over a screen that removes the very small particles. The crushed shale is then fed upward into the retort vessel by a piston, and the heated gas is introduced at the top. In the retort, the kerogen is liberated from the shale and decomposes into a raw oil. The oil is recovered from the retort and piped to the upgrading facility, where further processing converts the shale oil into a high-grade crude oil.

The spent shale is funneled into a pair of vertical cooling shafts, where it is cooled from 920° F to 250° F, and then transported by a system of chutes and conveyers down through a mountain to trucks that haul it to the disposal site. Approximately 4 percent, by weight, of the spent shale is carbon, which represents about 15 percent of the initial energy content of the raw shale. This residual carbon content is important in the proposed more efficient Unishale C technology.

Figure 2.3: Artist's Conception of the Parachute Creek Project Mine and Retort Facilities



Source: Unocal Corporation.

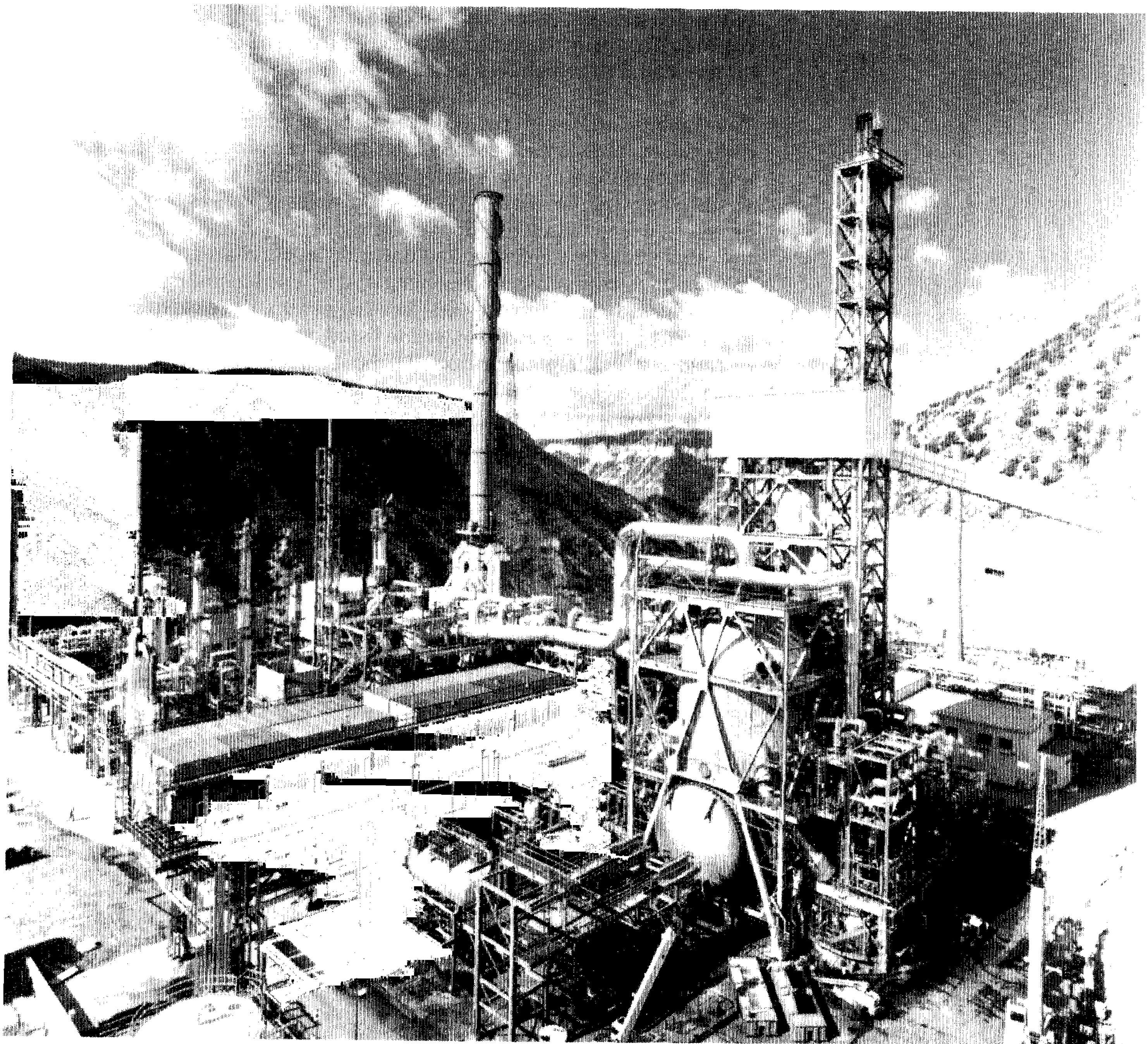
Modified Phase I Technology

The Unishale C technology initially planned for phase II is the basis of the phase I modifications and is depicted in figure 2.6. This operation is similar to the Unishale B operation until the spent shale is passed from the retort. Instead of being passed into a cooling shaft and removed to a disposal site, the spent shale is crushed into a finer size and fed to a device called a fluidized bed combustor.

A fluidized bed combustor burns fine particles of fuels, such as coal or oil shale, by moving them through a set of burners in an air stream. The air is injected through a bed of fuel particles, causing them to move in the combustion chamber. This process allows an efficient combustion of the fuel. The term "fluidized bed" comes from the idea that the fuel-and-air stream mixture behaves as a fluid.

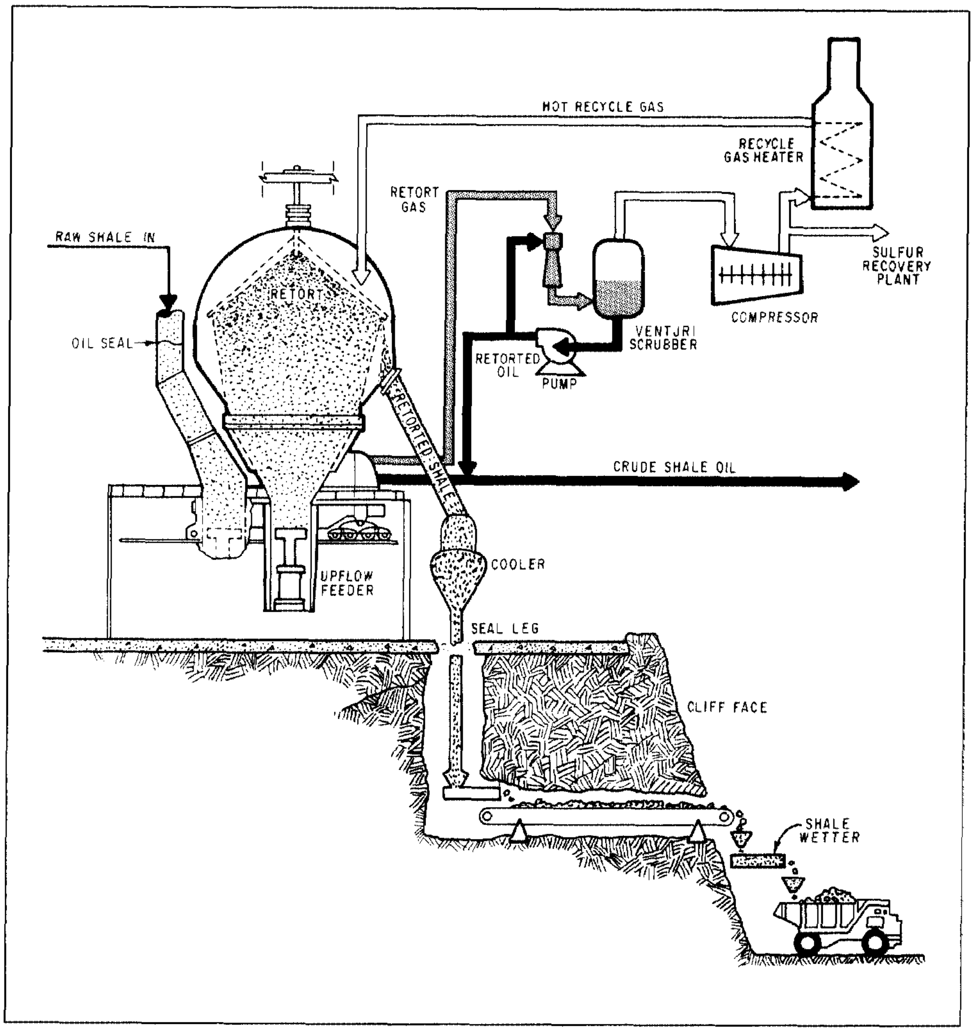
The combustion heat in the fluidized bed combustor will be used to produce steam for electricity production and other plant uses. Hence, the technology allows unused energy content in the shale to be used that would otherwise be discarded in the Unishale B process. This process increases overall plant efficiency and reduces operating costs by reducing or eliminating electricity and natural gas purchases. Fluidized bed combustors are starting to becoming widely used in industrial and commercial coal-fired electricity and heating plants. For example, the February 1985 edition of Power magazine listed, worldwide, 52 manufacturers of fluidized bed combustors and 233 boiler plants with or scheduled to have fluidized bed combustors installed. However, none have been developed on a commercial scale to burn oil shale.

Figure 2.4: Parachute Creek Retort



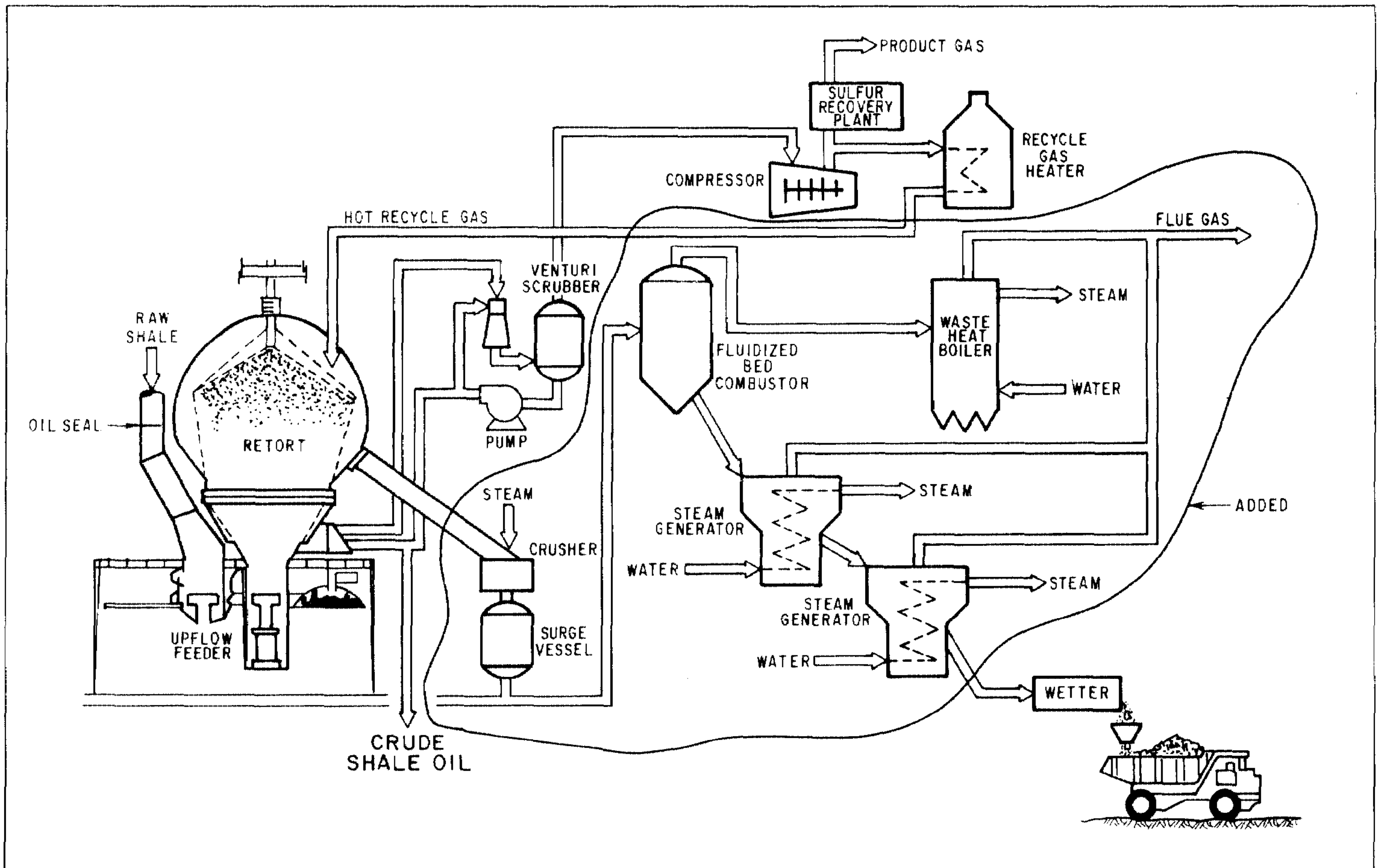
Source: Unocal Corporation.

Figure 2.5: Schematic Diagram of the Unishale B Shale Oil Process



Source: Unocal Corporation.

Figure 2.6: Schematic Diagram of the Unishale C Shale Oil Process



Source: Unocal Corporation.

Project's Economic Outlook Depends on Future Oil Prices

When DOE awarded Union $400 million in price guarantee assistance in 1981 for phase I of the project, it guaranteed Union $42.50 a barrel for the project's synthetic crude oil. SFC assumed responsibility for the project in 1982 and in October 1985 amended the phase I agreement to provide an additional $500 million in price and loan guarantee assistance for retrofitting the project with a fluidized bed combustor (Unishale C technology). Under the amended agreement, SFC was committed to paying Union the difference between a guaranteed price adjusted for inflation (about $45 a barrel in January 1987) and the oil's market price, if lower, for production with Unishale B technology. It was also committed to paying Union an additional $30 a barrel, adjusted for inflation, for production with Unishale C technology (a total guaranteed price of about $75 a barrel as of January 1987).

Several methods can be used to determine the economic viability of an investment. For example, these include calculating the rate of return on the investment, the time required to recoup the investment, and the net present value of future returns. (See ch. 4.) Nearly all methods involve projecting investment-related future cash flows. Critical to the economic success of the Parachute Creek shale oil project is its after-tax cash flow,[1] which depends heavily on the future prices of oil. We examined the project's after-tax cash flows as a general indicator of its economic viability (whether project operations are likely to be continued based on the project's economic outlook). It should be noted that the projection of negative cash flows does not necessarily indicate that the project should cease operations, nor does the projection of positive cash flows necessarily indicate viability and project continuation. The magnitude of the cash flows would be a very important factor in a decision whether to continue the project, as would many other factors, such as tax considerations, abandonment costs, and developmental value for future operations.

In October 1985, SFC prepared after-tax cash-flow projections for the project operating with each technology under the amended agreement terms. These were the latest projections that SFC made prior to the October 1985 agreement. SFC projected that without the Unishale C technology, the project's after-tax cash flows would generally be positive before the $400 million in price guarantee supports are exhausted,

[1] After-tax cash-flow calculations take into account all the various elements affecting revenues, operating and maintenance costs, net tax liability including tax credits, principal and interest payments on project-related debt, changes in working capital, profit sharing, and capital expenditures.

which it projected to occur in 1995, but would be predominantly negative afterwards. On the basis of these projections, SFC concluded that Union would abandon the project in 1995. SFC projected that with Unishale C technology, the project would have positive after-tax cash flows and be viable throughout the project's useful economic life after the $900 million in price supports is exhausted in 1995.

Union also prepared after-tax cash flows for the project under the amended terms in October 1985. It projected that with Unishale C technology, the project's total after-tax cash flow from 1985 through 2012 would be positive. However, it also projected that the project would have marginal or negative after-tax cash flows from 1995, when the $900 million in price guarantee supports is exhausted, to 2012, the end of its analysis period. Union did not indicate in the analysis it submitted to SFC how long it would operate the project based on these projections, but SFC concluded that on the basis of this analysis, Union would discontinue operations in 2000.

To examine the project's economic viability with Unishale C technology, we tested the sensitivity of SFC's after-tax cash-flow projections to crude oil prices and inflation. We did this by (1) substituting crude oil price and inflation forecasts by Chase Econometrics, Inc., and Wharton Econometric Forecasting Associates, that were available at a comparable time to SFC's projections, in an SFC computer model of the project's economics and (2) recalculating the project's after-tax cash flows.[2] On the basis of these calculations for SFC's preagreement projections, the project with Unishale C technology may experience negative after-tax cash flows after the $900 million in price supports is exhausted in 1994 through at least 2005 and, therefore, may not be economically viable after price supports are exhausted.

World oil prices have been volatile on several occasions in recent years and began another volatile period shortly after the October 1985 assistance award. After a period of relative stability in 1985, prices began falling sharply in December 1985 after an Organization of Petroleum Exporting Countries (OPEC) production quota agreement collapsed. For example, DOE's Weekly Petroleum Status Report reported that the spot market price of United Kingdom Brent crude oil fell from $28.25 a barrel in the week ending December 13, 1985, to $18.55 in the week ending January 24, 1986. World crude oil prices spiraled further downward

[2]Crude oil price and inflation forecasts refer to forecasted refiners' acquisition costs for imported crude oil and Producer Price Indexes.

during 1986, approaching $10 a barrel, and were generally about $16 a barrel on March 1, 1987.

In a first quarter 1986 revised analysis of the project, its last before it terminated, SFC lowered its future oil price assumptions an average of 6 percent from its October 1985 assumptions.[3] In its analysis for the project operating with Unishale C technology, SFC continued to project positive after-tax cash flows for each year of the project's economic life after the $900 million in price supports is exhausted in 1995. However, our analysis using Chase and Wharton price and inflation forecasts (which also reflected lower oil prices than their third quarter 1985 forecasts) indicated that the project would have predominantly negative after-tax cash flows from then through 2005.

In September 1986, Union revised its economic assessment of the project. On the basis of this analysis, Union told Treasury officials that if the existing plant can produce more than 5,000 barrels a day, which it considered likely, the economic attractiveness of adding the combustor is reduced. Union also stated that because of projected negative cash flows if it adds the combustor, it may cease operations in 1995 after the $900 million in price guarantee supports is exhausted, unless future oil prices rise significantly above current forecasts.

Tax credits are available to producers of fuels from nonconventional sources and are influential in determining a synthetic fuels project's economic viability. Union is eligible to receive such credits for production from the Parachute Creek project. If the credits are abolished before 1994, when they are projected to take effect for the project, the project's total after-tax cash flow between 1994 and 2005, operating with Unishale C technology, could be reduced by between $90 million and $134 million, depending on which price and inflation assumptions are used in SFC's economic model.

[3] According to former SFC officials, however, the lowered prices did not take into account the effect of the recent oil market volatility on the outlook for future oil prices. (See p. 36.)

SFC's October 1985 Projections for Unishale B Operations

In its October 1985 projections, the economic and operating assumptions SFC used for Unishale B operations were the same as those it used for the project operated with Unishale C technology, with three notable exceptions:

- SFC assumed a plant production rate of 5,200 barrels a day instead of 8,000 barrels a day because SFC engineers believed it to be the most likely rate that could be sustained if the Unishale B technology could be made to work.
- SFC assumed that production would begin in 1986 rather than 1989.
- The project's economic useful life would end in 2012 instead of 2019.

According to SFC's projection, the project would have predominantly positive after-tax cash flows while the $400 million in price guarantee payments are being received, but would have predominantly negative after-tax cash flows after the price support payments are exhausted, which was projected to occur in 1995.

SFC also analyzed the project's after-tax cash flows under the terms of the original 1981 agreement if it were to remain in effect. Under the 1981 agreement, price guarantee payments were restricted to a 7-year period beginning in 1983. For this case, SFC projected that price guarantee assistance would have ended in 1990 after payment of only $239 million. SFC concluded from its analysis that under both the original and amended agreements, Union would likely discontinue operating the project after price guarantees are no longer available.

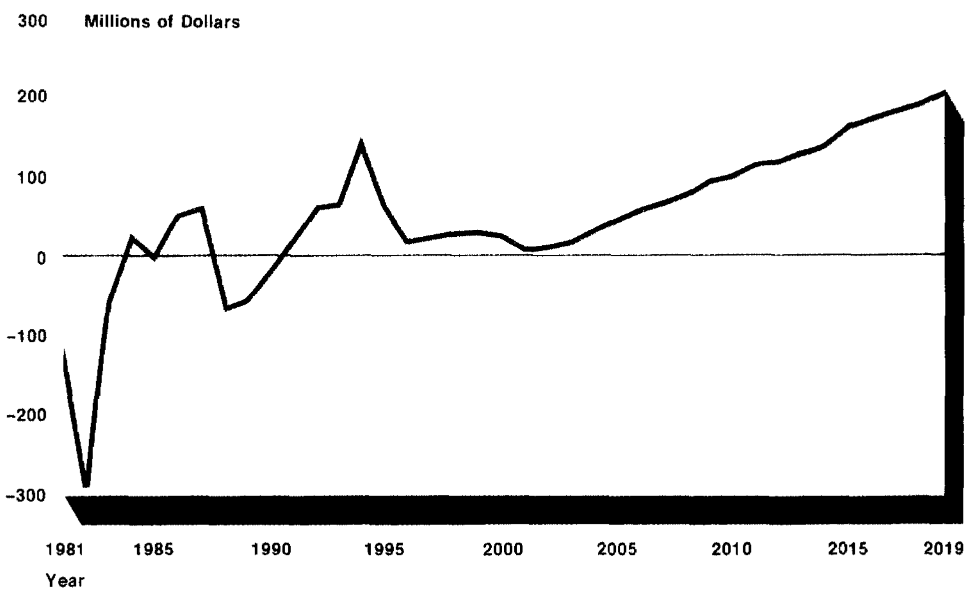
SFC's October 1985 Projections for Unishale C Operations

SFC developed after-tax cash-flow projections for the modified project using its estimate of most likely economic and operating conditions (called the median case). According to former SFC officials, the future oil price assumptions SFC used for its October 1985 analysis were based on a composite of oil price projections from more than 30 forecasting sources, including econometric forecasting firms, consultants, oil companies, and DOE. To determine how economic performance varied using different assumptions, SFC also developed cash-flow projections using the economic and operating assumptions Union submitted to it in October 1985 (called the base case). Both SFC and Union estimated that the plant's production would reach about 8,000 barrels a day, for 330 days a year, in the year 1991.

SFC's projection is shown in figure 3.1. Assuming production would begin on schedule in 1989, SFC projected that

- Union would receive the $900 million in price guarantee supports between 1989 and 1996;
- yearly after-tax cash flows from 1991, when maximum sustained production is achieved, through 2019 would be positive;
- the total after-tax cash flow generated from sustained maximum production in 1991 until 2019 would be about $2.3 billion; and
- Union would return about $62 million in profit-sharing payments to the federal government over the project's life.

Figure 3.1: SFC's Oct. 1985 After-Tax Cash-Flow Projections for Unishale C Operations



Source: Produced from SFC's Oct. 1985 data.

SFC's projection using Union's assumptions indicated that

- Union would receive the $900 million in price guarantee supports between 1989 and 1995;
- yearly after-tax cash flows would be negative from 1995 through 2012, the last year of Union's analysis period;
- the total after-tax cash flow from 1985 through 2012 would be a negative $111 million;

- the total after-tax cash flow from 1995, when price supports are exhausted, until 2012 would be a negative $352 million compared with a positive $893 million under SFC's assumptions for the same period; and
- no profit-sharing payments would be paid to the government.

On the basis of these results, SFC concluded that Union would discontinue operating the project in the year 2000, 5 years after the $900 million in price guarantee supports are paid.

The differences in the financial outcomes projected using SFC's and Union's assumptions primarily resulted from the use of different crude oil price forecasts. SFC's projected crude oil prices exceeded Union's projected prices by an average of 66 percent.

Union's October 1985 Projection For Unishale C Operations

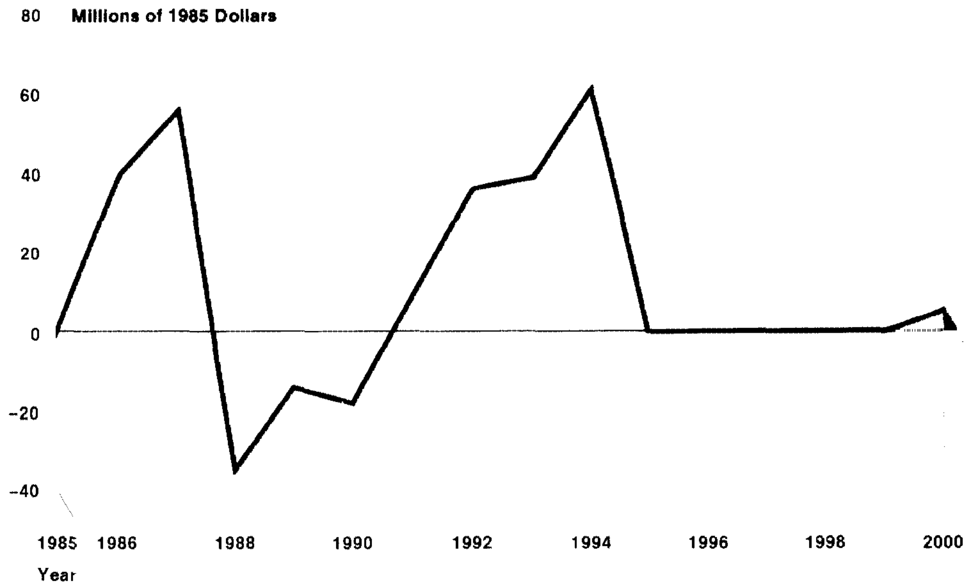
Union's base-case financial analysis submitted to SFC in October 1985 was expressed in constant 1985 dollars. SFC's projections and our calculations are expressed in current dollars. Current dollars take into account the effects of anticipated future inflation while constant dollars do not. Union used constant dollars because it believed that evaluating the project in constant dollar terms would provide an analysis undistorted by potentially inaccurate inflation forecasts.

Union's analysis indicated that with Unishale C technology, the $900 million price guarantee supports would be exhausted in 1994 and the project's total after-tax cash flow from 1985 through 2012 would be positive. However, it projected that the project would have only a marginal total after-tax cash flow from 1995 through 2000 and a negative total after-tax cash flow from 2001 through 2012, the end of its analysis period. In the analysis that it submitted to SFC, Union did not indicate how long it would operate the project based on these projections, but SFC concluded that on the basis of this analysis, Union would discontinue operations in 2000. Union's projection is shown in figure 3.2. The positive cash flows projected for 1986 and 1987 stem from tax benefits and loan receipts. The projections in figure 3.2 end in 2000 because Union did not specify the yearly cash flows beyond that year.

Our After-Tax Cash-Flow Calculations for Unishale C Operations

At the request of the Chairman's office, we examined the sensitivity of SFC's projections to future crude oil price assumptions by substituting only alternative price forecasts by several economic forecasting authorities in SFC's economic model of the project. To do this, we substituted crude oil price projections developed by Chase Econometrics, Inc., and Wharton Econometric Forecasting Associates, Inc., for the third quarter

Figure 3.2: Union Oil Company's After-Tax Cash-Flow Projections for Unishale C Operations (1985 Constant Dollars)



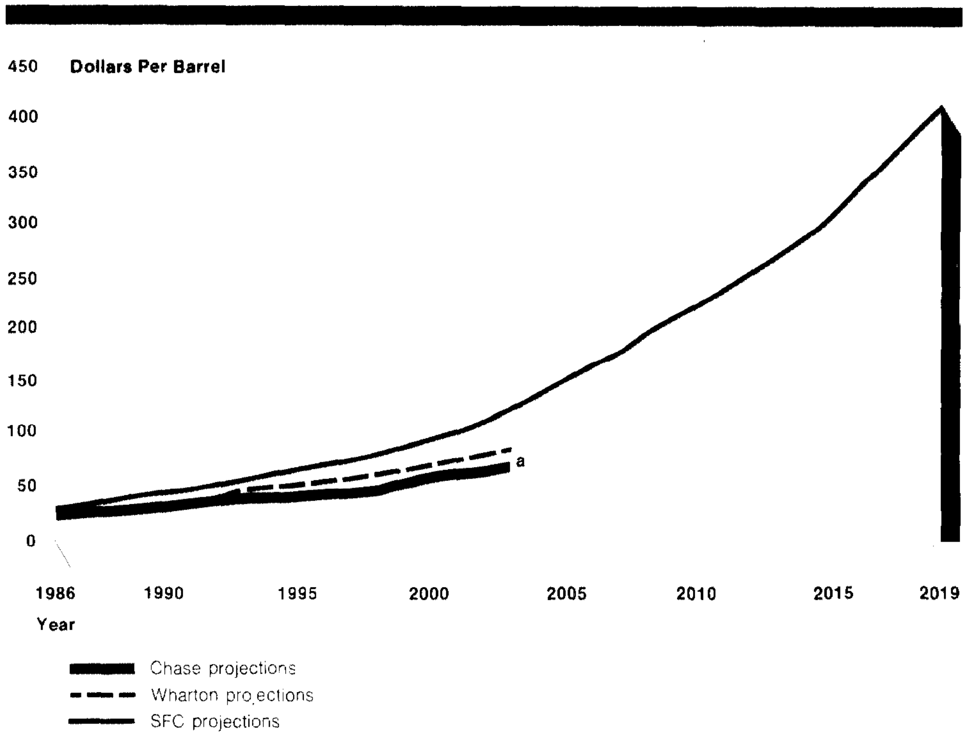
Source: Produced from Union Oil Company's Oct. 1985 data.

of 1985 into SFC's monitoring model to generate alternative cash-flow projections for the project operating with Unishale C. Since SFC's models escalated project operating expenses based on projected increases to the Producer Price Index, we also substituted both the forecasters' corresponding inflation projections and their price forecasts in the SFC monitoring model.

SFC's median-case projections, made with its Synfuels Project Analysis Network (SPAN) model (see app. I), covered the period from 1986 to 2019. Our analysis covers the period from 1990, when price support payments were projected to first become material to the project's cash flow, to 2005. Our analysis ends in 2005 because the SFC monitoring computer model and the forecast data we used did not extend beyond that date. Because of SFC's abolishment, the SPAN model was not available at the time of our analysis.

SFC's October 1985 crude oil price assumptions exceeded Chase's and Wharton's third quarter 1985 projections for comparable periods by an average of 60 and 44 percent, respectively. For example, SFC projected crude oil prices to be about $69 a barrel during 1996, the year it projected that price guarantees would run out, while Chase and Wharton forecasted prices of about $40 and $47 a barrel for the same year. SFC's inflation indexes were also higher. Figure 3.3 shows the respective oil price projections.

Figure 3.3: Comparison of SFC's Oct. 1985 and Chase's and Wharton's Third Quarter 1985 Crude Oil Price Projections



[a]200' through 2005 data extrapolated by GAO.

Sources: SFC data; SFC's Oct. 1985 analysis (refiner acquisition cost).

Chase data; Energy Analysis Quarterly, Third-quarter 1985, Chase Econometrics, Inc. (refiner acquisition cost).

Wharton data: Long-Term Alternative Scenarios and 20-Year Extension, Aug. 1985, Wharton Econometric Forecasting Associates, Inc. (refiner acquisition cost).

Figure 3.4 shows the results from substituting Chase and Wharton price and inflation forecasts into SFC's model and also shows SFC's projections for the same period. Table 3.1 compares the after-tax cash flows for the period after price supports are exhausted. The differences in SFC's and our calculations resulted primarily from the differences in SFC's price assumptions and Chase's and Wharton's price forecasts.

Figure 3.4: Comparison of GAO's After-Tax Cash-Flow Calculations for Unishale C Operations With SFC's Oct. 1985 Projections

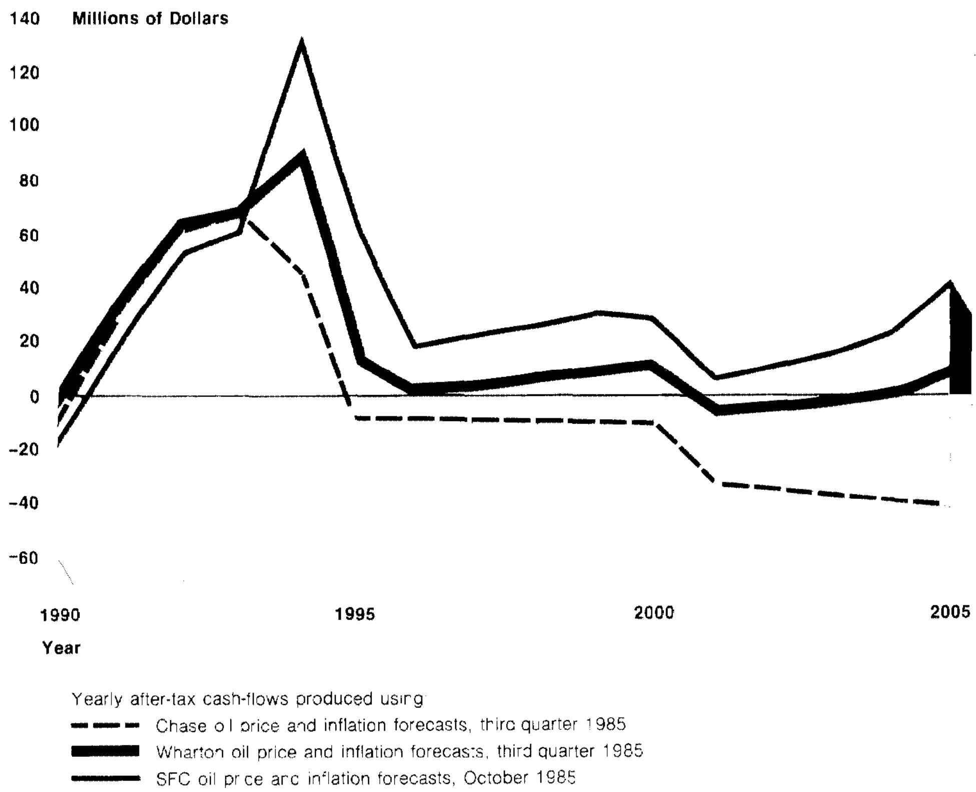


Table 3.1: Summary of GAO's After-Tax Cash-Flow Calculations and SFC's Oct. 1985 Projections for Unishale C Operations

Calculation/projection	Yearly after-tax cash flows, 1995-2005	Total after-tax cash flow, 1995-2005
GAO's with Chase oil price and inflation forecasts	Negative each year	Negative $247 million
GAO's with Wharton oil price and inflation forecasts	Positive 8 of 11 years	Positive $40 million
GAO's with Chase oil price forecasts only	Negative each year	Negative $419 million
GAO's with Wharton oil price forecasts only	Negative 10 of 11 years	Negative $216 million
SFC's with SFC oil price and inflation assumptions	Positive each year	Positive $271 million

SFC's First Quarter 1986 Projections and Our After-Tax Cash-Flow Calculations for Unishale C Operations

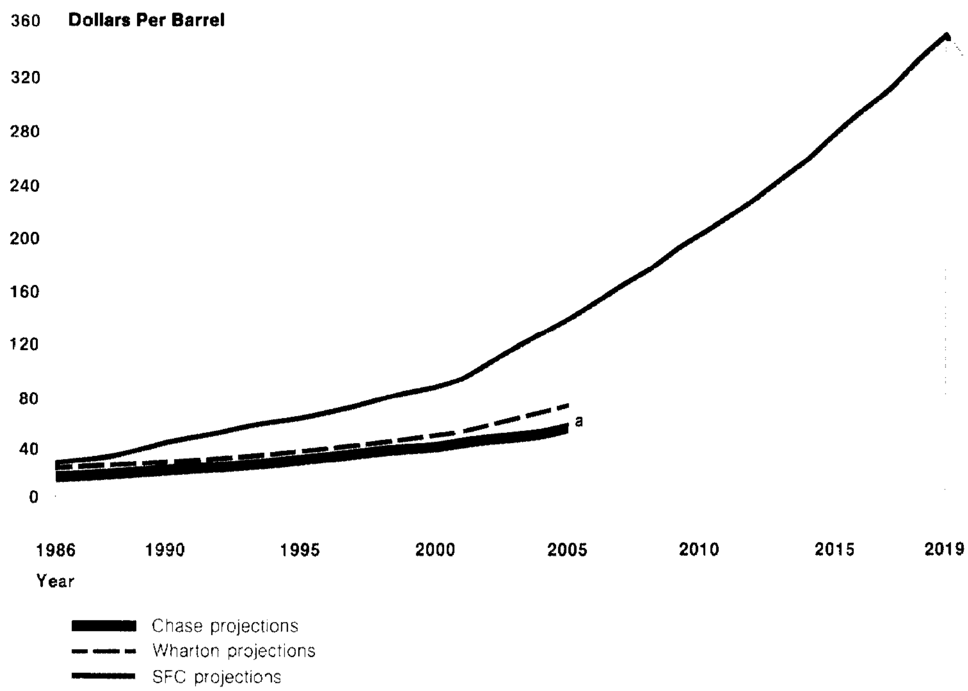
To assess the impact of the oil market decline on the project's economic outlook, we substituted Chase's and Wharton's first quarter 1986 oil price and inflation forecasts in SFC's revised first quarter 1986 median-case analysis. Chase's and Wharton's first quarter 1986 crude oil price forecasts were lower than their third quarter 1985 forecasts by an average of 27 and 20 percent, respectively, and their inflation forecasts were also lower.

In SFC's revised analysis, future oil price assumptions were lower than its October 1985 assumptions by an average of 6 percent. Its inflation index assumptions were also lower. According to former SFC officials, however, these lowered price assumptions did not include effects on future oil prices of the declining oil prices that were occurring at the time of the analysis revision.

SFC's revised price assumptions were higher than Chase's and Wharton's new forecasts for comparable periods by an average of 95 and 66 percent, respectively. For example, SFC projected crude oil prices to be about $67 a barrel in 1996, while Chase and Wharton forecasted prices to be about $32 and $38 a barrel for the same year. Figure 3.5 shows the respective oil price projections.

SFC's analysis showed increased positive after-tax cash flows as a result of the revisions, while our calculations with Chase and Wharton price and inflation forecasts showed predominantly greater negative after-tax cash flows. Our calculations also continued to indicate that price guarantees would be expended in 1994, compared with 1995 under SFC's assumptions.

Figure 3.5: Comparison of SFC's, Chase's, and Wharton's First Quarter 1986 Crude Oil Price Projections



[a]2001 through 2005 data extrapolated by GAO.

Sources: SFC data; SFC's first quarter 1986 analysis (refiner acquisition cost).

Chase data; Energy Analysis Quarterly, First-quarter 1986, Chase Econometrics, Inc. (refiner acquisition cost).

Wharton data; Long-Term Alternative Scenarios and 20-Year Extension, Feb. 1986, Wharton Econometric Forecasting Associates, Inc. (refiner acquisition cost).

Figure 3.6 shows the results from substituting Chase and Wharton price and inflation forecasts into SFC's model and also shows SFC's projections for the period 1995 through 2005. After-tax cash flows were significantly lower as a result of the substitutions. Table 3.2 compares the after-tax cash flows for the period after price supports are exhausted.

Figure 3.6: Comparison of GAO's After-Tax Cash-Flow Calculations for Unishale C Operations With SFC's First Quarter 1986 Projections

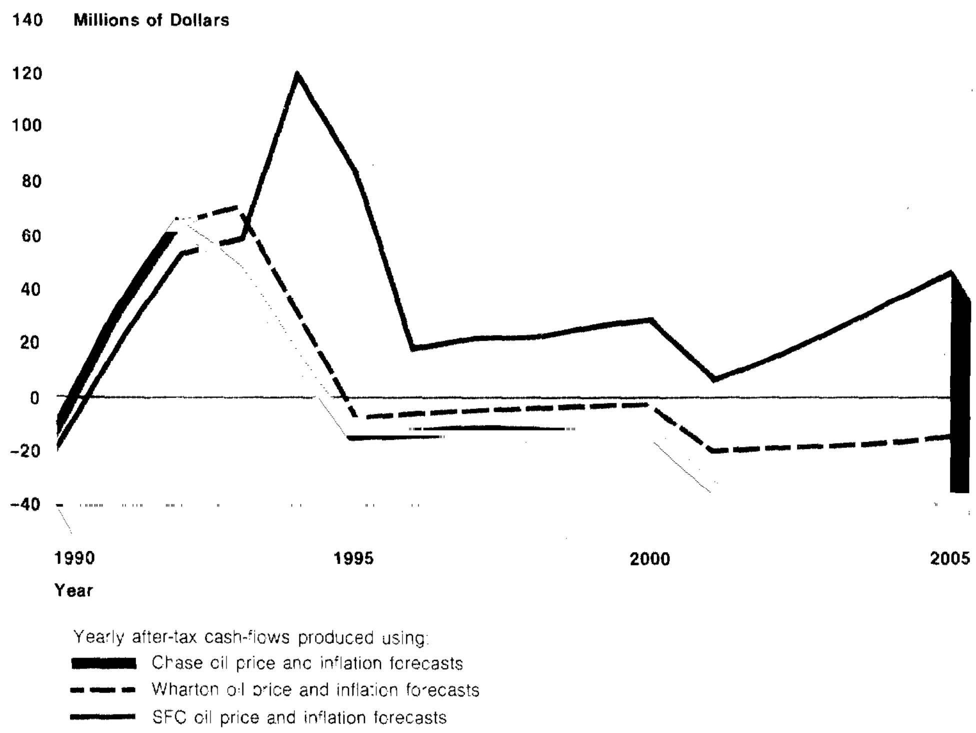


Table 3.2: Summary of GAO's After-Tax Cash-Flow Calculations and SFC's First Quarter 1986 Projections for Unishale C Operations

Calculation/projection	Yearly after-tax cash flows, 1995-2005	Total after-tax cash flow, 1995-2005
GAO's with Chase oil price and inflation forecasts	Negative each year	Negative $286 million
GAO's with Wharton oil price and inflation forecasts	Negative each year	Negative $127 million
GAO's with Chase oil price forecast only	Negative each year	Negative $513 million
GAO's with Wharton oil price forecast only	Negative each year	Negative $376 million
SFC's with SFC oil price and inflation assumptions	Positive each year	Positive $327 million

SFC's first quarter 1986 projection for the modified project indicated that after price guarantees run out, the project would generate about $56 million more in total after-tax cash flow through 2005 than it would for the same period in its October 1985 projection. This increase occurred because disproportional declines in operating expenses resulting from the downward inflation projections more than offset projected revenue losses.

As indicated in figure 3.5, crude oil prices would have to be about $67 in 1996, after price supports would be exhausted, for the project to achieve the level of after-tax cash flows that SFC projected for that year. We compared this price with the prices that would be required, in the same year, after price supports are exhausted, for the project to achieve the same level of after-tax cash flows without specialized production tax credits. (See p. 42.) We calculated, using SFC's first quarter projections, that crude oil prices would have to average about $78 a barrel in 1996 for the project to generate the same after-tax cash flows that SFC projected for that year. We also calculated, on the basis of SFC's first quarter 1986 projections, that crude oil prices would have to average about $66 a barrel in 1996 for the project to achieve a zero (break even) after-tax cash flow without production tax credits.

Union's September 1986 Financial Projections

In a September 1986 update of its financial projections for the project operated with Unishale C, Union revised its forecast of the project's crude oil market price downward from its October 1985 projections, across the board, by about 71 percent. Encouraged by results of plant tests from July to September 1986, it also assumed that the sustained plant output would reach 10,000 barrels a day for 300 days a year in 1991 and that the project would operate at 5,000 barrels a day with Unishale B technology until the Unishale C modification is made.

According to Union officials, despite positive cash flows projected during the guarantee period, Union will fall $272 million short, in constant 1985 dollars, of recovering its investment in the project when price guarantees are used up. At that point, if its price forecast holds true, Union officials said the project's cash flow is expected to turn negative and that it may be necessary to discontinue operating the plant. Union officials also told the Department of the Treasury in September 1986 that the incremental attractiveness of installing the fluidized bed combustor is reduced if Union can establish production at more than 5,000 barrels a day without the combustor.

Impact of Eliminating Production Tax Credits

We demonstrated in previous reports[4] that tax credits are influential in determining a synthetic fuels project's economic viability. We were asked to determine the impact that elimination of production tax credits in the future would have on

- SFC's first quarter 1986 projections for the modified project,
- SFC's October 1985 projections for the modified project using Union's August 1985 assumptions, and
- our after-tax cash-flow calculations using first quarter 1986 Chase and Wharton price and inflation forecasts.

Production tax credits are credits allowed for fuels production from nonconventional sources: A tax credit of $3 per 5.8 million British thermal units (Btu's) of energy (the approximate energy content of a barrel of crude oil) is provided for the domestic production and sale of qualified fuels. The Parachute Creek project qualifies to receive such credits from shale oil produced and sold before January 1, 2001, from facilities placed in service before January 1, 1990. While these tax credits were considered for repeal during congressional debate on the Tax Reform Act of 1986, they were not repealed.

According to SFC's first quarter 1986 median-case projection, Union would receive production tax credits from 1994 through 2000 if they remain available. To calculate the effect of production tax credit elimination, we deleted the credits from each of the projections and recalculated the after-tax cash flows. As a result, if the credits are eliminated before 1994, total after-tax cash flows from 1994 through 2000 would be reduced by between $90 million and $134 million. The specific amount depends on which scenario is considered. Table 3.3 shows the specific impact on the modified project's after-tax cash flows if production tax credits are not available.

Table 3.3: Impact of Eliminating Production Tax Credits

Projection/calculation	Change in after-tax cash flow, 1994-2000
SFC's, first quarter 1986	Positive $319 million reduced $134 million to $185 million
SFC's, first quarter 1986, using Union's Oct. 1985 base-case assumptions	Positive $98 million reduced $121 million to a negative $23 million
GAO's, using first quarter 1986 Chase forecasts	Negative $56 million reduced $93 million to a negative $149 million
GAO's, using first quarter 1986 Wharton forecasts	Positive $21 million reduced $90 million to a negative $71 million

[4]See GAO/RCED-83-210 (Aug. 24, 1983) and GAO/RCED-85-140 (July 10, 1985).

Conclusions

The project's economic outlook depends heavily on what assumptions about future oil prices are considered. SFC's assumptions about future crude oil prices appear optimistic compared with price forecasts by Union, Chase Econometrics, and Wharton Econometric Forecasting Associates made at comparable times to SFC's analyses. However, since oil markets can be volatile, it would be difficult to conclude which forecasts will turn out to be more accurate. The project's actual economic viability will be determined in the future largely by the prices that prevail after price supports are exhausted.

If Union does not install the Unishale C technology, SFC's negative after-tax cash-flow projections after price guarantee payments are exhausted indicate that Union would likely cease operating the project. Since Union's, Chase's, and Wharton's price forecasts were much lower than SFC's price assumptions, unless oil prices increase above SFC's price assumptions, it appears Union would not have an economic incentive to continue the project's operation after it exhausts the $400 million price guarantee support.

If Union successfully installs the Unishale C technology, the project may be profitable to operate throughout its expected useful life if SFC's assumptions hold true. It may not be profitable after price guarantee support runs out if prices turn out to be more in line with the other forecasts we considered, particularly those for the first quarter of 1986. On this basis, application of prudent business practice may lead Union to discontinue operations when the support is exhausted, and Union officials have said they would consider doing so under these circumstances.

In the scenarios for which we analyzed the impact of production tax credit elimination, the elimination of the credits would decrease the after-tax cash flows between 1994 and 2000. For SFC's first quarter 1986 projection, the cash-flow reduction is material but, in our opinion, would likely not cause cessation of operations since the cash flows remain positive. For SFC's projection using Union's assumptions, if Union would cease operations in 2000 with the credits, as SFC had concluded, it may cease operations earlier without them, when the after-tax cash flow for the period 1994 through 2000 begins to turn negative. For our calculations using Chase and Wharton forecasts, the decrease in after-tax cash flows would cause the project's economic viability after price supports end to be even more tenuous.

For our analyses, we and SFC assumed that the fluidized bed combustor installation would be accomplished without major technical problems or schedule delays. However, as discussed in chapter 5, technical problems and delays are likely to occur. Consequently, if Union elects to install the combustor and such problems do occur, construction and start-up cost overruns are also likely, and the project's cash flows will be decreased. The impact on the project's viability, should these problems occur, will depend on the extent of the problems and delays and the magnitude of the overruns.

The Government Could Provide Up to $1.5 Billion in Financial Assistance to Union

The net financial assistance the government could provide to Union Oil Company for the Parachute Creek project—price guarantee payments combined with net federal corporate income tax proceeds—depends on which technology Union uses and how long it operates the project. On the basis of SFC's first quarter 1986 median-case analysis, Union could receive net assistance of between $968 million and $1.51 billion.

Because money received today is worth more than money received in the future, taking the time value of money under consideration—discounted-present value analysis—provides a more germane perspective on Union's net assistance from the government. In January 1986 discounted-present value terms, Union could receive net assistance of between $937 million and $1.22 billion.

Undiscounted Assistance

We computed the potential net assistance from the government on the basis of SFC's first quarter 1986 projections. We used SFC's projections because they extend over the project's estimated useful life. We used the first quarter 1986 projection because it was SFC's most recent projection. Generally, if future oil prices turn out to be lower than SFC projected, the project should make less profit after price supports are exhausted and the government's assistance will be increased because less corporate tax payments will be made.

We computed the assistance by combining projected federal tax proceeds with projected federal price guarantee outlays.[1] Federal tax proceeds are the combination of project-related corporate income tax payments and tax benefits. Tax benefits include the effects of investment, energy, and nonconventional fuels production tax credits, depreciation, and oil depletion allowances. Union can use tax credits to reduce tax liabilities accruing from project income or from income earned in other corporate business.

Union received energy and investment tax credits of $55 million and $63 million, respectively, between 1981 and 1986. The energy tax credits were all that were available for the project and investment tax credits were repealed by the Tax Reform Act of 1986 for facilities placed in service after December 31, 1985; therefore Union will not receive any more of these credits. SFC projected that if Union operates the project

[1]Our analysis assumes that this project will not displace any other economic activity that generates federal corporate tax revenues.

with Unishale C technology, it will receive production tax credits of $31 million through 1995, when price supports are exhausted, and $134 million through the end of the project's useful life (2019). SFC also projected that if Union operates with Unishale B technology, it would receive $40 million in production tax credits through 1995, when price supports are exhausted, and $113 million through the end of the project's useful life (2012).

Union could receive about $964 million in depreciation tax benefits and $1.1 billion in oil depletion allowances if it operates the project with Unishale C technology for its useful life, resulting in tax savings of about $758 million. Union received about $444 million in net tax benefits between 1981 and 1986 for project construction.

Table 4.1 shows the net financial assistance that Union could receive operating with each technology at two points in time—at the end of the project's useful life, if it were operated until then, and when price guarantee supports are projected to run out.

Table 4.1: Undiscounted Net Federal Assistance Resulting From the Parachute Creek Project

Dollars in millions

	Operating with Unishale C technology	
	Assistance as of the end of the project's useful life (2019)	**Assistance as of when price supports end (1995)**
Income tax payments	$660	$87
Tax benefits	(816)	(693)
Net tax proceeds	**(156)**	**(606)**
Price guarantee payments	(900)	(900)
Total net assistance	**$(1,056)**	**$(1,506)**
	Operating with Unishale B technology	
	Assistance as of the end of the project's useful life (2012)	**Assistance as of when price supports end (1995**
Income tax payments	$44	$11
Tax benefits	(740)	(579
Net tax proceeds	**(696)**	**(568)**
Price guarantee payments	(400)	(400)
Total net assistance	**$(1,096)**	**$(968)**

Note: Based on SFC's first quarter 1986 projections.

The total net assistance to Union for the Unishale C case is greater if Union decides to discontinue operations immediately after exhausting price guarantees in 1995 rather than if it continues operating. This is because most tax benefits to Union are expected to accrue during the price guarantee payment period, 1989 through 1995, while the major portion of project-related income tax payments—about $567 million out of $660 million, or 86 percent—are expected to accrue after 2000.

In the case of operating with Unishale B technology, the project would experience negative cash flows under SFC's projections after price supports are exhausted. The government's net assistance would be greater if Union operates the project through its useful life than if it ceases operations in 1995. This would occur because of the project's continuing negative tax positions that would result from the negative cash flows. However, SFC concluded that Union would likely terminate operations after expending price guarantees.

January 1986 Discounted-Present Value of the Assistance

Since money has earning power over time from investment, money received today is worth more than the same amount received in the future. A future cash flow's value at any prior point in time can be estimated by selecting a reasonable expected earnings rate and calculating the amount that would have to be invested at that rate at the beginning of the period to receive the future cash flow, the reverse procedure of compounding interest. This value is called the discounted-present value because the future cash flow is discounted back to the present or point in time considered. A reverse process can be used to convert past cash flows to later values.

We used the 30-year Treasury bond rate for January 1986 (9.40 percent) to calculate the January 1986 discounted-present value of future project cash flows and federal assistance to Union. We used the January 1981 30-year Treasury bond rate (12.14 percent) to calculate the January 1986 values of project cash flows and federal assistance associated with the project that occurred prior to January 1986. (See app. I for additional details.) Table 4.2 shows the results presented in table 4.1 in January 1986 discounted-present value terms.

Table 4.2: January 1986 Discounted-Present Value of the Net Federal Assistance Resulting From the Parachute Creek Project

Dollars in millions

	Operating with Unishale C technology	
	Assistance as of the end of the project's useful life (2019)	**Assistance as of when price supports end (1995)**
Income tax payments	$97	$42
Tax benefits	(854)	(786)
Net tax proceeds	**(757)**	**(744)**
Price guarantee payments	(460)	(460)
Total net assistance	**$(1,216)[a]**	**$(1,204**

	Operating with Unishale B technology	
	Assistance as of the end of the project's useful life (2012)	**Assistance as of when price supports end (1995**
Income tax payments	$10	$7
Tax benefits	(745)	(698
Net tax proceeds	**(735)**	**(691**
Price guarantee payments	(246)	(246
Total net assistance	**$(980)[a]**	**$(937**

Note: Based on SFC's first quarter 1986 projections.

[a]Does not add because of rounding.

Technical Viability of the Project Is Not Certain

Major technical problems have prevented the Parachute Creek project from achieving sustained operations since it was first constructed. Union Oil Company has made progress toward solving these problems. Recent plant testing and operations with Unishale B technology at up to 45 percent of design production capacity through January 1987 have encouraged Union and Treasury officials about the project's technical viability. However, during these operations, the project continued to experience unscheduled shutdowns because of technical problems, and the plant's reliability and ultimate sustainable capacity have not been determined. Consequently, the project's technical viability for long-term commercial operation with Unishale B technology, although more encouraging than it was in October 1985, is uncertain.

Because adding a shale-burning fluidized bed combustor (Unishale C technology) involves developing and installing pioneer technology, additional technical problems could be expected to occur if it is installed. The extent to which such new problems will occur and delay future operations cannot be predicted with certainty, although Union has anticipated certain problems and believes they can be overcome. Consequently, in our opinion, the Unishale C's technical viability will depend on the extent to which problems occur and Union's willingness to invest time and additional money to solve them if they do occur. It will also depend on the reliability that can be established for the equipment common to the Unishale B and Unishale C technologies.

Technical Problems Experienced

The Parachute Creek shale oil project is a heavy industrial, solid materials process operation with complex technology that had not previously been developed on a commercial scale. According to a 1981 Rand Corporation study prepared for DOE,[1] errors, unforeseen problems, schedule delays, and large cost overruns can generally be expected in pioneering large-scale, state-of-the-art materials processing technology. The Parachute Creek project has been no exception to such expectations.

Union has been developing shale oil technology for over 40 years, conducting numerous laboratory and scaled simulations of the process to convert oil shale to shale oil. In spite of these years of testing and preparation, Union has been unable to avoid extensive technical problems in getting the Parachute Creek plant to operate on a sustained basis and has had to make many engineering modifications. For nearly 3 years

[1]See Edward W. Merrow, et al., Understanding Cost Growth and Performance Shortfalls in Pioneer Process Plants, September 1981, The Rand Corporation.

after construction was completed in 1983, Union attempted to operate the plant more than 40 times but could not establish sustained operations because of technical malfunctions in numerous plant components. Union officials told us that during this time, Union's investment in the project rose from an originally budgeted $472 million to over $926 million through 1985. However, during this period Union demonstrated that the mining and upgrading plant equipment could be operated successfully and that the retort process was basically operable.

Most of the problems involved unpredicted behavior of the shale material at various processing stages and machinery that failed because of it. These problems occurred even though equipment designs were based on test results from preliminary, smaller-scale simulations. According to SFC's former Vice President for Technology and Engineering, materials with irregular shapes and consistency, like crushed oil shale, can behave differently in large-scale processing than smaller-scale simulations would indicate. This is because the interaction of forces and materials is not quite the same on the two scales and because the models, while generally useful for indicating feasibility, cannot precisely predict larger-scale behavior.

Major Modifications Made

In an October 1985 informational report to SFC, Union described the engineering problems it encountered from 1983 until then, including 15 problems which it considered to have required major modifications. These include increasing motor and rock crusher capacities and redesigning or adding major pieces of equipment. Several of the problems and modifications involved the system to cool and remove the spent shale. Appendix II summarizes other specific major problems that were experienced and the modifications that were made through October 1985.

The Spent-Shale Cooling Problem Has Not Been Completely Solved

Perhaps the most difficult problem Union experienced, which was unsolved at the time of the October 1985 price and loan guarantee award, was in the spent-shale cooling and removal system. The system is supposed to depressurize and cool the 920° F shale while it is passed from the retort exit through a cooling shaft, called a shaft cooler. It is also supposed to strip the hydrocarbons from the shale. The cooled spent shale is dumped from the cooling system into trucks, which haul the spent shale to a solid waste disposal site. The problem Union encountered was in obtaining even cooling of the retorted shale after it left the shale oil extraction equipment (retort) and controlling the flow of the shale through the system.

The initial cooling configuration involved spraying water on the shale at the top of the shaft and passing it down through various stages maintained at successively lower pressures. However, because of the compactness of the shale and steam generation, the shale was cooled unevenly, thus causing pressure surges, jamming, and general loss of control. A number of modifications have been made, including distribution cones with water injection nozzles, larger and differently shaped discharge sections, temperature monitoring, and water piping. But these measures did not bring the problem under control.

In August 1985, Union shut down the Parachute Creek plant to develop other solutions and make major modifications to the cooling system. Several solutions were considered or tried without success. The latest attempted solution uses a series of mixers to control the flow of spent shale in the cooling shaft and produce more even cooling. Union reported that with this configuration, it was able to achieve limited continuous plant operations, at production rates exceeding 3,000 barrels a day, during a testing period from July to September 1986. (See ch. 2.)

Union resumed plant operations in November 1986 with the objective of establishing sustained continuous operations and determining maximum sustainable production rates. Through January 1987, it had operated the plant for limited continuous periods at oil production rates of up to 4,500 barrels a day. During these operations, Union continued to experience unscheduled shutdowns because of the cooling system and other technical problems. Nevertheless, it began selling synthetic crude oil produced by the project in December 1986 and began receiving price guarantee payments in April 1987. (See ch. 2.) In February 1987, Treasury officials said they were encouraged about the project's technical viability as a result of the operations, but they also said that because of the limited nature of the operations, the project's viability was still not certain.

On June 8, 1987, a Treasury official told us that Union had made further progress in stabilizing the project's operation, but that the plant's operational reliability and production capacity had still not been proven. He said the project had been shut down in March and April 1987 for about 6 weeks to make additional technical modifications and had been operated since mid-April 1987 with only occasional shutdowns of several hours duration at rates of up to 5,000 barrels a day. He also said that during this time, Union was experimenting with different grades of shale and feed rates and had further technical modifications scheduled for July 1987.

Potential Technology Modification Problems

In the October 1985 documents it submitted to SFC in support of its proposal to modify the project to Unishale C technology, Union recognized and described a number of potential equipment or operating problems that might occur but that it believed could be surmounted. Union also said, however, that there can be no assurance that the modified project will work completely or, if it does work, that it will operate at or close to design rates. As with many of the Unishale B problems, the potential problems with the Unishale C equipment that Union described relate to the somewhat unpredictable behavior and characteristics of the retorted shale and processing equipment in a full-scale commercial operation.

Unishale B Equipment

Additional technical problems with the Unishale B equipment that will be used in the Unishale C plant may be encountered. Union described the following potential problems with the retort and oil upgrading equipment.

The Retort

Although Union has demonstrated that the retort will produce shale oil, it does not know at what sustained capacity or reliability the machinery can be operated until it operates for longer periods. In the reports submitted to SFC, Union characterized the risk to the modification project as significant if sustained operation of the phase I facility cannot be achieved before beginning the modification construction.

According to Union's assessment, the major risk factors include: shale feeder system wear and reliability; maintaining retort pressure; sustaining proper gas and shale velocities in the retort; and maintaining sustained performance and reliability of the recycled gas heater and scrubbers (filtering machinery), the deasher (which removes residual solids, or ash, from the crude shale oil), and the sulfur removal equipment.

We discussed the project's technology with shale oil program officials at DOE's Morgantown (W.Va.) Energy Technology Center. They agreed with Union's assessment and believed that prudent managers should want the basic retort system's production rate and reliability proven before committing large amounts of money to the modifications. They said that the retort should be operated continuously for at least 3 to 4 months to demonstrate the components' reliability and that 6 months to a year of operation would be desirable. They also stated that any problems that may occur with either Unishale B or Unishale C technology could probably be solved if Union is willing to commit sufficient time and money.

In addition, the DOE officials told us that the average production rate that can be expected may be lower than the design rate of 10,000 barrels per day because a leaner shale than that considered in the plant design rating may have to be used to solve some of the technical problems. For example, the plant was designed and rated assuming that a shale yielding 34 gallons of oil per ton of ore would be used. However, by using a shale of lower organic content—30 to 31 gallons per ton—material flow problems may be diminished sufficiently to allow sustained operations. They estimated that the average achievable production could reach between 7,000 and 8,000 barrels per day. These figures are consistent with assumptions SFC made in its median-case projections of the project's economic performance.

Unocal's Vice President for Oil Shale Operations agreed that daily production rates could possibly be limited because of the grade of shale used but observed that, on the basis of retort tests from July to September 1986, it appears the retort will operate satisfactorily with the design higher-grade shale. He also told us that, on the basis of this conclusion, he believes the daily 10,000-barrels-a-day design production rate and an average annual production rate of 8,000 barrels a day (allowing for scheduled maintenance and other down time) appears possible to achieve, and that an average 5,000-barrels-a-day rate should be easily attained.

Ash/Scale Removal

Additional ash needs to be removed from the crude oil after the oil passes from the retort area. The technique used to do this, which has only been demonstrated in smaller-scale pilot plants, involves filtering the oil through beds of inert material. The risk in this process centered on unknown ash buildup and crusting rates in the full-size filtering beds. If the buildup and crusting occur unevenly and too rapidly, operations may have to be suspended to produce and install additional beds for rotation with the ones currently planned. According to a Treasury official who is monitoring the project, this equipment has operated well through February 1987 and appears to no longer be a potential problem.

Arsenic Removal

Raw shale oil contains arsenic compounds that decompose and diminish catalytic activity during the process to upgrade the oil to a refining quality. According to Union's assessment, some uncertainty existed as to whether a set of reactors used at the upgrading plant to remove the arsenic compounds would work as demonstrated in pilot plant operations. However, Union considered the risks associated with this operation to be very low. Treasury officials said that this equipment has also been operating well and no longer appears to be a potential problem.

Modification Equipment

Union described the following potential problems in October 1985 and told us that the primary areas of risks are with the transport of the shale from the pressurized retort into the nonpressurized fluidized bed combustor and the attainment of proper sizing to achieve proper fluidization of the shale in the fluidized bed combustor.

Shale Crushers and Transport

The shape and consistency of the crushed, retorted shale are critical to the operation of the lift leg (part of the shale feeder), fluidized bed combustor, and dust-handling equipment. To achieve the 1/4-inch size needed, the 920° F retorted shale will be fed to four two-stage crushers consisting of rollers to break the particles and hammer mills to crush them to the required size. From the crusher, the retorted shale will be transported in a sealed pneumatic conveyer system to the fluidized bed combustor. If the size of the shale has to be reduced further to achieve proper fluidization in the combustor, operating at higher temperatures and pressure may be necessary. The pressure (20 pounds per square inch above atmospheric pressure of 14.7 pounds per square inch) will be reduced in stages in the conveyer system to atmospheric pressure at the combustor.

The retorted shale at the transport temperature is combustible and must be kept from exposure to oxygen. Union is concerned with the integrity of the shaft seals in the hot, dusty environment and the ability of the equipment to produce sufficient size consistency. Long, continuous runs are not expected so spare crushing systems are planned. The high temperature and erosive environment may also cause high wear and short life.

Fluidized Bed Combustor

Fluidized bed combustors of the size planned for the technology modification (46-foot diameter) are in operation in industry, but this would be the first of its kind on a commercial scale to use oil shale. It differs from those using coal because the feed stock has lower energy content than coal and, therefore, requires a higher mass flow to produce equivalent heat. Also, unlike the others, the feed is pressurized and hot. Consequently, problems may be experienced in obtaining the proper fluidization patterns in the full-size combustor and in wear and corrosion of the equipment. Union said in its reports to SFC that, even though more studies and pilot tests will have been conducted before it decides whether to proceed with construction, it will not know for sure before beginning construction whether the fluidized bed combustor operation can be sustained over the long term.

Other Equipment

Much of the rest of the equipment will also be first of a kind, especially for use with shale oil. Consequently, it also presents additional potential technical problems that cannot be predicted in less-than-full-scale models. For example, the extent or rate of corrosion, wear, and equipment jamming that may occur in many pieces of equipment from the behavior or properties of the shale is not known. This equipment includes several types of valves; ceramic linings in the feed systems; the flue gas waste heat boiler (produces steam using the waste heat from the combustor's flue gas, which contains about 50 percent of the decarbonized shale leaving the combustor); steam generators; a "baghouse" dust collector (removes particulate matter before gases are discharged into the atmosphere); and conveyers, most of which could prevent operations should they fail to work. In addition, wet, decarbonized shale may have cement-like properties and be hard to handle when wetted for the final cooling and disposal process.

Recent Tests

Union planned to conduct additional studies and pilot tests and more detailed design of the Unishale C equipment before it decides whether to proceed with the plant modification. In the reports submitted to SFC in support of the modification project, Union said that the results of these efforts will reduce any new risks associated with the additional equipment, but it also recognized that technical problems may still arise. In February 1987, Treasury officials told us that Union had selected a design contractor and that the contractor conducted pilot tests in October 1986. The Treasury officials said these tests identified several technical problems that would have to be solved but that appeared solvable. These problems involved excessive production of exhausted nitrogen oxides, heat exchanger fouling from fine particles, and reduction of net combustion heat from certain chemical reactions during the combustion process. Through May 1987, Union was continuing to design the combustor and evaluate its viability.

Additional SFC Opinions and Observations

In an October 1985 report to SFC's board of directors, SFC engineers stated that in their opinion, the modification project is a technically sound undertaking despite the problems that have been experienced and the additional risks of installing more prototype equipment. In supporting their opinion, they cited the extensive development work on which Union's retort and upgrading designs are based, the advanced status of phase I, and Union's planned activities to develop the Unishale C technology. They believed the planned development activities should adequately address the risks associated with installing prototype equipment.

In October 1985, SFC officials also believed there was a low probability—as little as 10 percent—that Union would be able to find a satisfactory solution to the cooling system problem. Hence, they believed the installation of the fluidized bed combustor would be the best opportunity to get the plant into production because it would replace the shale cooling system. Further, SFC officials believed that development of the more efficient fluidized bed combustor technology would make the development of future shale oil plants more economically attractive.

SFC engineers initially regarded the fluidized bed combustor technology as more complicated and a higher risk than the Unishale B technology. However, according to them, as they became more familiar with the technology over the last several years and as Union conducted more pilot plant testing of the concept, they became more confident of the concept and regarded the chances for its success as very good by the time of the October 1985 assistance award to Union. Although they expected additional technical problems to occur, they believed Union would be able to solve them.

Nevertheless, according to SFC's Vice President for Technology and Engineering, installing the fluidized bed combustor is still risky. He said that although the basic technology has been around in the coal industry for years, feedstock materials of such fine size, which present potentially more material handling problems such as jamming or cementing, have never been used.

Conclusions

On the basis of Union's most recent testing and operations, it appears that Union has made progress in solving the spent-shale cooling problem and that the viability of the Unishale B technology is more encouraging than when the October 1985 agreement was made. However, because the equipment reliability and the achievable production rate are still undetermined, the project's technical viability for long-term commercial operations is uncertain. Further, Union could experience additional technical problems if it proceeds with installing the fluidized bed combustor.

The project's technical viability using fluidized bed combustor technology will depend on the nature and seriousness of the problems encountered and the degree of time, money, and commitment Union is willing to continue investing to solve them, particularly in view of the project's economic outlook presented in chapter 3. It appears that the Unishale C technology could be viable if Union is willing to contend with the uncertainties that exist and that may cause problems. However, the viability cannot be predicted with certainty because of the unknown factors involved in pioneering process technology.

The Unishale C's viability will also depend on the extent that the viability and reliability of the equipment common to the two technologies can be established. If Union is not able to prove the retort's reliability before dismantling the shaft cooler and beginning modification construction, the project's technical viability outlook with Unishale C technology is diminished.

Installing Unishale C Technology Questionable

This chapter highlights key facts, results, and conclusions concerning the installation of the Unishale C technology and makes recommendations to the Secretary of the Treasury. The chapter includes

- the reasons SFC provided the additional $500 million in assistance,
- the terms of the assistance agreement that allow the Unishale C installation and the additional $500 million in assistance to be terminated,
- several factors that question the reasonableness of providing the additional assistance to install the Unishale C technology,
- our conclusion that it would not be in the government's best interest to expend an additional $500 million in assistance to install the Unishale C technology, and
- our recommendations to the Secretary of the Treasury to terminate the additional assistance if possible or explore ways to minimize the government's outlays for the project.

Operational Problems Led to Additional SFC Assistance

In 1981, under provisions of the Energy Security Act, Union was awarded $400 million in price guarantees to construct the Parachute Creek shale oil project in Colorado, which was designed to produce 10,400 barrels a day of synthetic crude oil with Unishale B technology. Since project construction was completed in 1983, Union has not been able to establish sustained, continuous operations because of numerous technical malfunctions. The most serious problem has been with the system for cooling and removing the spent shale from the shale oil production equipment.

Union and SFC explored the possibility of replacing the cooling system with a fluidized bed combustor, which would burn the spent shale instead of cooling it and produce energy to run the plant. SFC and Union decided that adding the combustor might be the only way to establish sustained plant operations. SFC also believed that, because the combustor would produce energy for plant operations and reduce operating costs, investors would be more likely to build other commercial shale oil plants using the Unishale C technology. In October 1985, SFC awarded Union additional loan and price guarantees of up to $500 million if it installs a fluidized bed combustor (Unishale C technology).

Union has made a number of modifications to the cooling system of the Unishale B technology and, through January 1987, was able to operate the plant for limited continuous periods at production rates of up to 4,500 barrels of shale oil a day. Through December 1986, Union had spent about $961 million on the project. It also started selling the project's oil in December 1986 and began receiving price guarantee support payments from the initial $400 million in assistance in April 1987.

Terms of the Unishale C Agreement

Under the terms of the agreement for the additional $500 million in assistance, Union has the option of not installing the Unishale C technology whenever certain criteria related to Union's calculations of the real rate of return from adding the Unishale C technology, cost to construct the Unishale C technology, and after-tax cash flow are not met. For example, Union can terminate the Unishale C installation program before it submits a detailed cost estimate, financial projections, and a project master schedule to Treasury for installing the Unishale C technology if construction cost estimates exceed $286 million in 1985 constant dollars or the real rate of return of the incremental after-tax cash flow from installing the Unishale C technology is estimated to be less than 18 percent. The rate of return and construction cost criteria change slightly after these estimates are submitted and at subsequent milestones.

Under the terms of the agreement, Treasury is obligated to provide the additional $500 million in assistance as long as Union does not terminate the Unishale C program and meets the terms of the agreement. The agreement allows Treasury the option to rescind the additional financial assistance if, for example, Union terminates the Unishale C installation program; defaults on the federally guaranteed loan; or does not formally submit a detailed construction cost estimate, financial projections, and a master schedule for the Unishale C installation by June 30, 1987.

Factors Affecting the Project's Future

We have identified the following factors that could have a bearing on the project's future:

- At the time of the 1985 agreement, a principal reason SFC agreed to provide the additional assistance was to allow the project to become operable and commercially produce shale oil on a sustained, continuous basis. Union has made progress since the October 1985 agreement in operating with Unishale B technology. Consequently, if the improved Unishale B technology can be made to achieve sustained, continuous production at a reasonable rate, SFC's objective of establishing a technology to commercially produce shale oil will have been met and the Unishale C technology will not be needed for this purpose.

- Fluidized bed combustors have been developed to produce energy from coal and other fuels, but not from spent oil shale. Because of this and because oil shale has proven to be a difficult material to process, the project could experience operational problems with the combustor and require additional investments to make it operable.
- We substituted crude oil price and inflation forecasts from Chase Econometrics and Wharton Econometric Forecasting Associates in SFC's economic model of the project and calculated the project's after-tax cash flow. Using first quarter 1986 forecasts, we calculated that with Unishale C technology the project's after-tax cash flow from 1995 through 2005 would be either a negative $286 million or a negative $127 million, depending on which forecasts were substituted. Also, Union indicated to Treasury in September 1986 that if it installs the Unishale C technology and its revised crude oil price forecasts hold true, it may have to cease project operations after the $900 million in assistance is exhausted. In view of these factors, Union may abandon the project in 1994 after the $900 million in price guarantees is exhausted. Consequently, it would be unlikely for the Unishale C technology to be commercially replicated by investors in other shale oil projects.
- In June 1986, several Members of Congress and the Friends of the Earth, an environmental advocacy group, filed a lawsuit in the U.S. District Court for the District of Columbia seeking to invalidate the October 1985 agreement between SFC and Union. The litigation, which was still pending as of May 1, 1987, was based on several issues, including whether SFC had the budget authority to obligate the funds and whether SFC followed a requirement of the Energy Security Act to consult the Secretary of the Treasury on the impact of the assistance on financial markets. If Union begins installing the combustor and the agreement is subsequently found invalid, further legal complications and expense to the government may ensue.

Conclusions

The Parachute Creek shale oil project has experienced serious operational problems. Union has made progress in solving these problems, and is attempting to operate the plant on a sustained, continuous basis. Should Union succeed in operating the plant with the improved Unishale B technology at reasonable production rates, then the need for the Unishale C technology is questionable.

Fluidized bed combustors have never been used for producing energy from spent shale, and the project could experience additional operational problems if Union proceeds with the Unishale C technology and require additional investments. Further, on the basis of our cash-flow calculations, the project's economic viability with Unishale C technology is uncertain and Union would probably abandon the project in 1994 after the $900 million in price support payments is exhausted. With this outlook, it is unlikely that the Unishale C technology will be commercially replicated if it is installed.

Because of these factors, it would not be in the government's best interest to expend an additional $500 million in assistance to install the Unishale C technology.

Recommendations

In view of the economic and technical issues facing the combustor's installation, the Secretary of the Treasury should rescind the additional $500 million in assistance if the terms of the agreement are not met. If the terms are met and Union elects to proceed with the combustor, the Secretary should use the analysis in this report to critically evaluate Union's proposal and explore the government's options for minimizing additional outlays on this project.

GAO's Economic Analysis Methodology

Determining the Project's Economic Viability

SFC developed two computer models to project economic and financial results for the Parachute Creek project: a mainframe-based Synfuels Project Analysis Network (SPAN) model and a personal computer-based model to allow the Department of the Treasury to monitor the project's viability and performance. We reviewed those portions of SFC's mainframe computer model that calculate revenue and tax effects. We also reviewed the SFC personal computer models of the project for the two cases of operating with phase I technology (Unishale B) and modified phase I technology (Unishale C).

We reviewed SFC's computer models to enhance our understanding of and confidence in the models' outputs. We did not attempt to validate the models because policy-assisting models such as the SFC models cannot, by their very nature, be validated to the extent that their outputs can be relied upon as exact predicters of the future. Instead, we reviewed the assumptions implicit in various input data values, such as inflation rates, plant operating efficiencies, and energy prices. We traced specific model calculations in the selected SPAN components and all calculations in SFC's monitoring models. We also did not validate whether SFC's models were complete and correct with respect to tax considerations, but accepted SFC's treatment of taxes. Within the limits of our review, we observed no major problems with the models. However, this does not attest to the validity of the models.

Future energy price assumptions are critical in determining the economic viability of synthetic fuels projects. Because of the significance of energy price assumptions, we compared SFC's assumptions about future crude oil prices with those projected by Union and two recognized forecasting authorities—Chase Econometrics, Inc., and Wharton Econometric Forecasting Associates, Inc. We substituted these projections into SFC's monitoring model to determine how the project's after-tax cash-flow performance varied under different energy price assumptions. All of SFC's financial projections and our calculations for the project are expressed in current dollars, which reflect the effects of anticipated future inflation.

Union expressed its cash-flow projections in constant dollars, which do not account for inflation, because it believed that inaccurate inflation predictions would distort projections of the project's cash-flow performance. We recognize that each method—projections in current or constant dollars—has inherent advantages and disadvantages. However, for this analysis we believe it is appropriate to incorporate estimates on future inflation levels.

We used SFC's personal computer-based monitoring model because at the time we began our analyses in March 1986, SFC's SPAN model was no longer available because of SFC's impending shutdown. We conducted our sensitivity analyses using the monitoring model for SFC's median-case technology-modification scenario, focusing on variables such as energy prices and inflation indexes. SFC defined its median case as its calculations of the most likely financial performance of the project based on its own estimates of likely energy prices, inflation rates, capital and operating costs, plant output, and tax assumptions.

All of the crude oil price projections used for this report projected prices in annual increments and were also expressed in current-year dollars.

Since SFC's monitoring model escalated project operating expenses based on projected increases to the Producer Price Index, we also substituted the forecasters' corresponding inflation expectations into SFC's computer program. However, at the request of the Chairman's office, we also conducted this analysis using SFC's inflation assumptions—which were higher than the other forecasters'—with the alternative crude oil price projections.

We focused our analyses on the project's after-tax cash flow—which takes into account funds generated from operations, construction costs, and tax effects—accruing between 1990 and 2005. We selected 1990 as the first year of our analysis because significant price guarantee payments are first projected for that year. Our analysis concluded with the year 2005 because SFC's monitoring model did not extend beyond that date. We compared the resulting cash-flow projections with SFC's October 1985 and first quarter 1986 median-case projections and SFC's projections using Union's August 1985 base-case assumptions. Union's base case is its analysis of the plant's most likely performance, based on its assessment of likely economic and operating conditions, that it submitted to SFC in August 1985.

Chase's crude oil price forecasts extended only to the year 2000. Since the forecasts had relatively uniform percentage changes, we extrapolated the forecasts 5 additional years to 2005 by inflating the price forecasted for the year 2000 by the average percentage change rate projected for the years 1995 to 2000.

In conducting our analyses, it would have been ideal to substitute all the economic variables that influence the after-tax cash-flow projections. However, we focused on crude oil price and inflation projections because these variables have the most profound effect on the project's profitability. There are three other variables that, to a lesser extent, also affect the cash-flow projections that we did not substitute into SFC's model:

- Construction cost indexes, used to estimate capital construction cost increases due to inflation.
- Producer Price Indexes excluding food, nonseasonally adjusted, used to escalate the contracted guarantee price.
- Treasury bills, used to estimate Union's interest expense from the loan guarantee.

The forecasters we used for our sensitivity analyses did not generate either of the two inflation indicators. However, based on other inflation forecasts they developed that were comparable to SFC's forecasts, if these indexes had been available, they presumably would have been lower. Therefore, it is probable that the construction cost estimates used in our sensitivity analyses are slightly overstated. However, because the construction schedule is for just 3 years, the distortion does not appear significant. Similarly, we may have overstated the time period for which the project would receive price guarantees by 1 or 2 calendar year quarters.

Although the other forecasting authorities made projections on future Treasury bill yields, the interest expense arising from the loan guarantee does not influence the project's cash flow after price guarantees are projected to end. Also, the interest expense, comprising less than 2 percent of total operating cost, does not appear significant relative to the other project expenses. Therefore, the analyses are not materially distorted by not substituting this variable. Consequently, we did not substitute it in order to simplify our analyses.

Analyzing the Government's Financial Assistance to Union

We used SFC's first quarter 1986 median case to analyze the government's net financial assistance that could accrue to Union for the project under the terms of the amended agreement. We used SFC's projections because they extended to the end of the project's useful life.

In our analysis, we considered the time value of money. We expressed the results of our analysis in both current and January 1986 discounted-present values. The discounted-present value essentially converts the cash outlays and receipts resulting from an investment that occur at different times into comparable form—their discounted-present value equivalents.

In calculating the January 1986 discounted-present values, we used the yield on outstanding Treasury obligations with maturities comparable to the analysis period. In this case, we used the 30-year Treasury bond rate for January 1986 published in the Federal Reserve Bulletin (9.40 percent) as the discount rate. The 1986 Treasury bond compares to the amended agreement's investment period, 33 years (1986 to 2019). The investment period (or the analysis period) begins when Union uses project-related tax credits and/or tax benefits and extends through the project's expected operating life. All relevant outlays and receipts associated with the construction of the phase I project were adjusted by the 30-year Treasury bond rate for January 1981 (12.14 percent)—the rate that prevailed when Union signed the original contract with DOE—to reflect their 1986 values.

Alternate methods exist for calculating discounted-present values. For comparison, we also calculated the discounted-present value using another method. Rather than using a single, long-term rate, we used multiple rates with different maturities. The present value of each past and future cash flow was calculated based on the January 1986 Treasury note or bond yield whose maturity coincided with the particular cash flow. This procedure resulted in about a 15-percent larger net financial assistance in present value terms. The difference occurred because the cash flows in the years closest to 1986 tend to be negative and exert more influence on the result from being discounted by relatively low short-term rates.

In our analysis using first quarter 1986 crude oil price and inflation forecasts, we included the effects of the Tax Reform Act of 1986, which lowered corporate tax rates, repealed investment tax credits, and changed depreciation methods and schedules allowed for many business situations. The act did not change oil depletion allowances and nonconventional fuels production tax credits. As a result of the law, Union will not be eligible to receive investment tax credits associated with construction of the fluidized bed combustor, which were estimated at about $31 million in SFC's projections. According to a Treasury official, any change in the depreciation basis for the Parachute Creek project as a result of the new tax law is not expected to materially affect the project's after-tax cash flows.

Forecast Updates

We also examined Chase's and Wharton's comparable oil price forecasts published in the fourth quarter of 1986 to determine how later forecasts compared to the ones we used in our analysis. On the average, the later forecasts were somewhat lower. Use of lower oil prices in our calculations would result in lower after-tax cash flows after price guarantee supports are exhausted and, consequently, greater amounts of net assistance from the government as a result of correspondingly lower project-related corporate tax liabilities. Use of higher oil prices would have the opposite effect.

Major Modifications Made

In an informational report submitted to SFC in October 1985, Union Oil Company described the following problems with the Parachute Creek shale oil project that it had experienced between 1983 and 1985 and that required what it considered to be major modifications:

Seal screw conveyers. The seal screw conveyers are part of the system that feeds shale to the retort. The initial design caused packing of the material in the screw throat and jamming, which required more drive power than available. Additional motor capacity and baffles to reduce packing tendencies were installed to solve the problem.

Retort scraper. The scraper pushes the retorted shale from a pile inside the retort into the disposal chutes. The pile cone was steeper than anticipated, causing the scraper to dig into the pile instead of pushing it into the chutes. The scraper was redesigned and the problem was solved.

Fines conveying system. Fines (small particles) too small for the retort are screened and conveyed from the retort system. Coarser feed material than originally designed was needed for the retort operation. Consequently, increased fines volume had to be processed by the conveyer system. The system was modified to handle the increased volume.

Retort feed bin. Plates to separate materials at the feed bin inlet and a device to reblend the materials inside the bin had to be installed to redistribute material and improve retort gas flow.

Thermosludge boilers. The plant's water balance could not be maintained while it was in a nonoperational status. Three "thermosludge" boilers were installed to evaporate waste water until the retort becomes continuously operational.

Pug mill wetter. In order to prevent plugging of the conveyer system during emergency shutdowns and to allow the pug mill to restart, a bottom dump system, automatic diverter gate, and new drive motor were installed.

Scrubber separators. Higher than expected fines concentration and water/oil emulsions were experienced, requiring several modifications to the retort shaft cooler scrubber separators to improve solids separations and emulsion handling. These included new nozzles, piping, and devices to improve control of the material.

Shale chute. A carbon steel shale chute, 375 feet long and 2 feet in diameter, failed from localized erosion, requiring the design, fabrication, and installation of an improved chute.

Retort scraper. A variable-speed drive and chutes to remove material from the retort immediately after scraping across the retorted shale bed were installed because the scraper was causing material degradation, leading to pressure drops and retort control problems.

Delumper (crushers). The size and number of shale rocks in certain areas of the feeder system were excessive, requiring design and installation of an 8-inch-in-diameter crusher, which proved inadequate, followed by a 12-inch crusher, greater oil circulation rates, pump modifications, and larger piping.

Water injection isolation valves. Automatic shutoff valves were installed in the shaft cooler water lines to minimize the amount of water injected into the shaft cooler and control steam generation during shale wetting.

Belt dust collection and cleaning. Dust collection and cleaning systems on two belts were inadequate, requiring new cleaners and enclosures for one belt and new dust collectors and cyclones for another.

Intermediate pressure letdown. Additional modifications were made to the shaft cooler and disengaging vessel to reduce pressure and improve control.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.

Flora H. Milans, Associate Director, (202) 275-8545
John W. Sprague, Associate Director
Roy J. Kirk, Group Director
Marcus R. Clark, Jr., Assignment Manager
Charles R. Climpson, Evaluator-in-Charge
Wayne B. Upshaw, Evaluator
Paul K. Marchetti, Economist
Judy K. Pagano, Operations Research Analyst
Helen C. Smith, Typist

*U.S. G.P.O. 1987-181-235:60044

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100