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FUEL QUALITY/PROCESSING STUDY

VOLUME I - OVERVIEW & RESULTS

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Gulf Research & Development Company

May 1982

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewis Research Center
Under Contract DEN3-175

for
U.S.DEPARTMENT OF ENERGY
Energy Technology
Fossil Fuel Utilization Division

National Aeronautics and
Space Administration

Lewis Research Center
Cleveland, Ohio
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NASA

Reply to Attn of: 4521

August 10, 1982

Distribution:

Enclosed, per your request, is a copy of the Gulf Research & Development Company Volume I Summary Report for the Fuel Processing Quality Study.

Sincerely,

John W. Dunning

John W. Dunning, Jr.
FP/Q Project Manager

Enclosure

FUELS QUALITY/PROCESSING STUDY

GULF RESEARCH & DEVELOPMENT COMPANY - FINAL REPORT

DOE/NASA/DEN 175-1

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MAY 1982

VOLUME I

OVERVIEW AND RESULTS

Prepared For

National Aeronautics and Space Administration
Lewis Research Center
2100 Brookpark Road
Cleveland, Ohio 44135

Under Contract No. DEN 3-175

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U.S. Department of Energy
Energy Technology
Fossil Fuel Utilization Division
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16. Abstract

The final report for this study consists of four volumes. This volume, Volume I, Overview & Results, outlines the methods whereby the intermediate results were obtained, and presents the conclusions the study obtained from its evaluation of the feasible paths from liquid fossil fuel sources to generated electricity. The segments from which these paths were built are the results from the fuel upgrading schemes, on-site treatments, and exhaust gas treatments detailed in the subsequent volumes. Volume I also includes the salient cost and quality parameters generated by the study. Volume II is a literature survey. Volume III contains processing details and economics for upgrading fuels for use in industrial gas turbines. Volume IV contains processing details and economics for on-site fuel treatments and for exhaust gas purifications.

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I. OVERVIEW AND RESULTS

Introduction

Industrial gas turbines can more effectively be used for electrical power generation if an appropriate balance can be found between turbine improvements, fuel choices, fuel upgrading, on-site fuel processing, and exhaust gas treatment. This study provides information that can facilitate finding that balance. Furthermore, because the study examined paths starting with raw liquid fuel sources and leading to the generation of electical power and acceptable exhaust gasses, the study reveals interactions between the turbine operation cycle and the cost effectiveness of fuel upgrading vs on-site processing options.

Variations in turbine design were, as directed, excluded from this study. Upgrading schemes were limited to those expected to be commercially available in the next few years. Nevertheless the cost/quality relationships and tradeoffs developed in this study should help guide both future turbine design as well as the selection of raw materials, their upgrading schemes, and the on-site fuel or exhaust gas processing options.

Data Analysis Approach

The various combinations amoung raw materials, processing schemes, on-site upgrading choices, turbine cycle types and turbine duty cycles provided about 600 feasible paths from fossil fuel sources to electical power and acceptable exhaust gas.

Because available fuel upgrading schemes simultaneously alter several attributes of the fuel being upgraded, the study has not produced "one quality at a time" upgrading information. Instead, the study did develop comprehensive cost/quality tradeoffs by comparisons among the several hundred feasible paths.

Highlights of Results

From the path comparisons these conclusions become apparent:

- Upgrading costs for a turbine fuel are frequently reduced because high quality blending components can be diverted from the turbine fuel thus increasing the amounts of more valuable products available for sale.

- The least cost paths for a given raw material usually have the highest thermal efficiency.

- Fuel costs represent about 85 to 90% of the generated electricity cost.

- Upgrading either a petroleum based or a shale oil based fuel in a modified existing refinery resulted in lower costs for generating electricity than upgrading in a new facility.

- It does not make sense to upgrade a coal liquid in modified existing refinery.

- The best fuel upgrading strategy varied with raw material. One strategy used direct impurity removal while the other upgraded indirectly by altering the boiling point range.

- For upgrading fuels from shale oils altering the boiling range was best.

- For upgrading fuels from crude petroleums direct impurity removal was best.

- For coal liquids only impurity removal was possible, there being no high boiling fraction into which the impurities might be concentrated.

- An intermediate level of on-site fuel washing was more economical than either a low or a high level for a simple cycle 1500 hr/yr peaking application with a 30 MW output.

- In contrast a high level of on-site fuel washing gave better economics for the larger combined cycle turbines.

- Simple cycle operation requires a lower level of fuel nitrogen at this time than does a combined cycle operation.

- Simple cycle operation requires a lower level of fuel sulfur at this time than does a combined cycle operation.

- Credible exhaust gas treatment systems require some exhaust gas cooling before treatment. This is not an economically attractive addition for a simple cycle but is an inherent aspect of a combined cycle.

Description of Path Concept

The results from the upgrading studies (reported in Volume III) are summarized in the appended Tables 1 and 2. These two tables give the calculated selling prices for the industrial turbine fuels produced by those fuel upgrading studies.

The results from on-site options studies (reported in Volume IV) were combined with the upgrading results to generate the paths from raw liquids to generated electical power. Table 3 shows these paths for four studies using augmented existing refineries. Table 4 shows these paths for four studies using new facilities.

The several paths associated with a given upgrading scheme represent the feasible on-site processing options appropriate for the turbine cycles (one simple and three combined) by which electrical power was generated.

Similar groups of paths were generated for all upgrading studies. An evaluation of this collection of paths produced the results reported in this volume. Additional tables and charts included in this volume provide more quantitative information. The methods used for the evaluation and the results produced are presented in more detail in this volume.

II. BACKGROUND AND SCOPE

The more efficient generation of electricity from liquid fuels could be a significant factor in alleviating future effects of a world petroleum shortage on the United States.

For stationary gas turbines, the issue of fuel availability becomes crucially important. Natural gas is unlikely to be available in sufficient quantities toward the end of the century to allow its use in stationary turbines. The premium fuels derived from petroleum may go to the transportation and home-heating markets and be largely unavailable for turbine use. Thus, development of gas turbines able to use either synthetic fuels or the less desirable fuels from petroleum should place them in a desirable position insofar as fuel availability is concerned.

This study addresses the cost and energy efficiency of achieving various fuel characteristics and purity levels in residual oils, coal-derived liquids, and shale oils. The study develops the costs associated with using on-site fuel treatment, blending, additives, and exhaust gas cleaning to allow the turbine user to tolerate poorer quality fuels. Then the study examines the trade-offs between these options and the fuel processing options. Minimum cost paths are identified from consideration of the above trade-offs.

A major difficulty for a study such as this is the number of possible options which appear to be available. The literature survey (Volume II) led to some valid simplifications. Two residual oils, two coal liquids, and one oil shale provide an adequate resource data base. The only coal liquefaction processes likely to be commercialized in the time frame of interest are the SRC-II, Exxon Donor Solvent (EDS) and H Coal processes. An additional simplification is that for a given coal, each process yields a roughly similar product.

Indirect liquefaction processes are excluded from the study. The products of such processes are premium products. It is unlikely that they would be available at a competitive price for use in future stationary gas turbines.

Only two generic types of shale oil were considered in this study. One shale oil came from surface retorting and the other from modified in situ retorting. True in situ is excluded on the basis that methods for creating the necessary permeability in the oil shale formation are not likely to be developed in the time frame of interest.

For the purpose of the present study, conventional refining refers to the application of proven petroleum refining concepts to the particular problems of synthetic fuels and residual oils, where changes to existing domestic refineries could be made to accomplish this. In contrast, New Refining Concepts will be used to refer to grassroots designs, specifically intended for handling such feedstocks.

The various combinations among raw materials, processing schemes, on-site upgrading choices, turbine cycle types, and turbine duty cycles provided about 600 feasible paths from the fossil fuel liquids to electricity and acceptable exhaust gas by way of industrial gas turbines. Despite their number, the processing schemes could not represent one quality at a time upgrading of a fuel. This study, therefore, developed the cost/quality trade-offs by exhaustive comparison among the almost 600 feasible paths.

III. REPORT ORGANIZATION

The final report for this study consists of four volumes. This volume, Volume I, SUMMARY REPORT, represents an overview of the entire study. This overview outlines the methods whereby the intermediate results were obtained. This volume presents the conclusions the study obtained from its evaluation of the feasible paths from liquid fossil fuel sources to generated electricity. The segments from which these paths were built are the results from the fuel upgrading schemes, on-site treatments, and exhaust gas treatments detailed in the subsequent volumes. Volume I also includes the salient cost and quality parameters which were generated by the study and are needed to identify and define the paths whereby the cost/quality trade-offs were investigated. Volume I presents these results in a number of tables. Some of these tables serve to quantitatively support the conclusions of the study. Other tables included in Volume I provide the interested investigator with results of this structure to facilitate making additional comparisons.

Volume II, LITERATURE SURVEY, generally confirms the validity of our initial assumptions about raw material choices and relevant upgrading processing options. The literature survey also serves to define the on-site (at the turbine location) options for fuel treatment and exhaust gas treatment. The literature survey also contains a substantial compilation of specification and physical property information about liquid fuel products relevant to industrial gas turbines.

Volume III, FUEL UPGRADING STUDIES, describes the methods used to calculate the refinery selling prices for the turbine fuels of low quality. Also included in Volume III are detailed descriptions of the upgrading schemes. These descriptions include flow diagrams showing the interconnection between processes and the stream flows involved. Each scheme is in fact a complete, integrated, stand-alone facility. Except for the purchase of electricity and water, each scheme provides its own fuel and manufactures, when appropriate, its own hydrogen. Volume III also presents the economic summaries for each scheme.

Volume IV presents the results of the study related to treating the fuel at the turbine and processing the turbine exhaust gas at the turbine site. Fuel treatments are used to protect the turbine from contaminants or impurities either in the upgrading fuel as-produced or picked up by the fuel during normal transportation. Exhaust gas treatments provided for the reduction of NO_x and SO_x to environmentally acceptable levels. Volume IV results also permitted the study to consider the impact of fuel quality upon turbine maintenance and deterioration. This was achieved by including on-site base cases wherein a premium fuel was used. On-site costs reported in Volume IV include not only the fuel treatment costs as such, but also incremental components representing an estimated typical cost penalty incurred by the turbine operator if a turbine fuel of low quality is not acceptably upgraded.

IV. BASIS OF COSTS FOR UPGRADING

In this study the product of interest, a turbine fuel of low quality, is not yet an item of commerce. In some instances the raw material (e.g., coal liquids or shale oils) is also not items of commerce. For these materials the study must provide itself with consistent prices. Fortunately the other raw materials (high- and low-sulfur crudes), as well as all the other products, are items of commerce. For those raw materials and products which are items of commerce, the study uses nonproprietary price forecasts.

The raw materials used in the upgrading studies were all liquid hydrocarbons.

Two petroleums were used. One, a South Louisiana crude, is a low-sulfur, low-metals crude produced and refined in the United States in large volumes. The other crude, Ceuta crude oil, contains high concentrations of both metals and sulfur. It is processed in the United States to make residual fuel products. These two petroleum crudes assure a wide range in turbine fuel upgrading costs. The low sulfur crude contained 3.1 ppm nickel, 0.7 ppm vanadium, 0.31 wt% sulfur, and had a density of 32.3° API. The high sulfur crude contained 20 ppm nickel, 133 ppm vanadium, 1.32 wt% sulfur, and had a density of 30.8° API.

Two shale oils were used. The first was intended to be representative of a shale oil produced by surface retorting. It was similar to shale oil produced by the Paraho process. It contained 0.2 ppm of vanadium, 0.66 wt% sulfur, 2.18 wt% nitrogen, 1.16 wt% oxygen, and had a density of 20.2° API. The second shale oil was intended to be representative of a shale oil produced by modified in situ retorting. It had a similar vanadium content, 0.5 wt% sulfur, 1.4 wt% nitrogen, 1.00 wt% oxygen, and had a density of 20.3° API.

Two coal liquids were used: one from Eastern Coal (an SRC-II liquid) and the other from Western coal (Wyodak H-Coal). The liquid from Eastern coal had 0.27 wt% sulfur, 1.0 wt% nitrogen, 3.0 wt% oxygen, and had a density of 14.2° API gravity. The liquid from Western coal contained 0.04 wt% sulfur, 0.17 wt% nitrogen, 0.85 wt% oxygen, and had a density of 35.1° API.

Additional information about these raw materials is to be found in Volume III of this report.

The results of the study are clearly influenced by the methods used to arrive at costs for the shale oils and coal liquids. The unknown prices for shale oils were estimated in the following manner. A refinery scheme producing products having forecast prices from a crude oil having a forecast price was established as a base case. The base-case scheme was then altered so that some of the original raw material could be replaced by a specific shale oil. Neither the kinds of products nor their qualities were permitted to change, although the relative amounts of these products could, of course, shift slightly.

The price of the shale oil raw material was calculated to provide this altered scheme with (1) the same profit as was produced in its base case, and (2) an appropriate return on any additional investment required for altering the scheme used in the base case. This methodology was quite satisfactory for shale oils because these raw materials could sensibly be processed within the context of a modified existing petroleum refinery.

For coal liquids, a somewhat different approach was needed because these raw materials are not sensibly processed in the context of a modified existing refinery. Therefore, a base case was established involving a scheme whereby the coal liquid was processed to produce products which, as items of commerce, had available forecast prices. The cost of the coal liquid was adjusted so that this base case could produce an acceptable rate of return on the investment required for such a new facility. The coal liquids fed into these schemes were of a quality such as might usually be produced from a coal liquefaction plant. The upgrading processing schemes were independent, stand-alone facilities.

It is worth noting that these raw material costing schemes were substantially self-contained. We did not need to assume transfer costs for intermediate streams nor estimate internal costs of the various appropriate utility streams.

Once raw material prices were developed on this consistent basis, the study addressed the costs of manufacturing turbine fuel of low quality from each raw material.

For petroleums, the product slate was altered to produce a low-quality turbine fuel. The base-case refinery scheme was also altered to produce a variety of upgrading schemes. The cost of the turbine fuel of low quality was calculated to provide the scheme in question with: (1) the same profit as was produced in the base case, and (2) an appropriate return on any additional investment required for altering the scheme used in the base case. This was appropriate for both the existing refinery and the new refinery situations involving petroleum.

For coal liquids, an analogous method was appropriate. As already mentioned, these raw materials could not sensibly be processed as adjuncts to petroleum in an existing refinery. Therefore, new processing schemes were defined for upgrading coal liquids with the product slates altered to also produce turbine fuel of low quality. The turbine fuel price was calculated to produce, for the scheme in question: (1) the same profit as was produced in the base case, and (2) an appropriate return on any additional investment required for altering the scheme used in the base case.

For each feasible raw material-operating facility combination, a base case existed. Each such base case produced conventional products for which price forecasts were available. The economics of these cases were thereby established. Now these schemes and their product slates were altered to produce turbine fuels of low quality. In each such instance the selling price of the turbine fuel of low quality was calculated to provide the altered scheme with: (1) the same profit as was produced in the base case, and (2) an appropriate return on any additional investment required for altering the scheme used in the base case.

Some of these schemes involved processing that emphasized direct removal of impurities. The other schemes involved processing intended to upgrade by altering boiling ranges.

V. BASIS FOR ON-SITE OPTIONS COSTS

Costs have been generated for fuel washing/treatment operations and exhaust gas $DeNO_x$ for selected cases. These costs are presented as incremental costs over a base case.

1. The base case for cost estimating purposes for the combined cycle is as follows:

   - Combined-cycle power plant
   - Nominal 400 MW plant output
   - Maximum fuel flow 400 gpm
   - Distillate fuel
     - no fuel treatment system required
     - exhaust gas $DeNO_x$ not required.

2. The base case for the simple cycle is as follows:

   - Simple-cycle power plant
   - 30 MW plant output
   - Maximum fuel treatment system fuel flow is 33 gpm
   - Distillate fuel
     - no fuel treatment system required.

As noted above, the base case combined cycle operates on distillate fuel. Consequently, all costs (capital, operating, and maintenance) associated with installation and operation of a fuel treatment system and the exhaust gas $DeNo_x$ system are, by definition, incremental over the base case. Similarly, costs for installation and operation of a fuel treatment system are incremental for the simple-cycle case. No costs have been generated for exhaust gas $DeNo_x$ for the simple-cycle case since this technology is not applicable at simple cycle exhaust gas temperatures.

Costs are presented for the following items:

1. Power plant operating and maintenance costs (including hot gas path parts replacement costs, turbine cleaning costs)

   - simple- and combined-cycle cases, distillate and ash-forming residual fuels with as-burned fuel alkali levels of 0.5, 1.0, and 2.0 ppm sodium.

2. Fuel treatment system capital, operating, and maintenance costs for the combined cycle and simple-cycle case

   - for 50 ppm alkali residual fuel supplied to the power plant site,
   - as-burned fuel alkali levels of 0.5, 1.0, 2.0 ppm sodium,
   - provision for other sodium levels in the fuel supplied to the power plant site.

3. Exhaust gas $DeNO_x$ system capital, operating, and maintenance costs for the combined cycle case.

   - for 50 ppm NO_x level exhaust gas (corresponds to the maximum NO_x expected at 2.0% nitrogen in the fuel),
   - 90% effectiveness, i.e., NO_x reduction from 450 ppm to 45 ppm in the stack effluent.

The data in this report includes a complete cost estimate case for high-nitrogen, ash-forming fuel in simple-cycle and combined-cycle applications.

Fuel treatment costs are presented for petroleum residual fuel. Coal-derived liquids and shale oils are not expected to require on-site treatment since CDL's are expected to be commercially available as essentially ash-free distillates; whereas shale oils produced by above ground retort will be upgraded at the conversion facility to reduce gums and meet transportation requirements. The upgrading is expected to reduce trace element constituents, e.g., arsenic (whose corrosive effects are not known), nickel, vanadium, etc., to levels tolerable by today's gas turbines.

NO_x reduction by exhaust gas treatment (catalytic $DeNO_x$) is treated generically as a function of nitrogen content and $DeNO_x$ effectiveness. Costs at effectiveness levels of 77.5%, 85%, and 90% are presented in this report.

SO_x reduction by exhaust gas treatment by three processes (lime/limestone, Wellman-Lord, and Shell-UOP) has been evaluated. Economics are expressed in $/kW·h cost for sulfur removal levels consistent with fuel sulfur levels from 0.8 to 2.5 wt% sulfur in the fuel.

VI. DATA ANALYSIS

Summary

This work collects the costs and energy efficiencies of various processing steps to produce and treat a residual or synthetic-based gas turbine fuel for use in 1985 power plants. The processing steps include: production of gas turbine fuels in refineries; followed by power plant on-site fuel treatment; and then followed by turbine exhaust gas cleanup. This work also examines the trade-offs between the above processing steps in order to develop minimum total cost-paths.

The total costs of producing and treating (from raw material to exhaust stack) have been calculated, in the 1985 time frame, for a wide range of turbine fuel qualities. This range resulted from the following variations in fuel processing:

1. Variations in refinery processing to upgrade residual or synthetic oil to gas turbine fuel
   - 19 existing refinery processing schemes
   - 26 grassroots refinery processing schemes.

2. Variations in power plant on-site fuel treatment costs
   - three output sodium levels
   - a range of input vanadium levels
   - two different size power plants (simple-cycle and combined-cycle)
   - three utilization levels for the combined cycle plant.

3. Variations in exhaust gas NO_x reduction costs; three utilization levels for the combined cycle case.

4. Variations in exhaust gas SO_x reduction costs; three SO_x removal processes.

These variations have generated several hundred total cost paths for the production and treating processes required in order to utilize gas turbine fuel. These paths have been studied to determine minimum cost paths.

In addition, energy consumptions and thermal efficiences have also been examined for the various paths.

Illustrative examples for total costs of producing and treating refinery turbine fuel for use in 30 MW and 400 MW power plants are given in Tables 3 and 4. All upgrading cases were developed to this level.

These tables also show the effect of various processing conditions on the total cost of gas turbine fuel. Power plant on-site fuel treatment costs are calculated for a range of output sodium levels, input vanadium levels, and various service factors (utilization levels) for the simple-cycle and combined-cycle power plants. Exhaust gas NO_x reduction costs have also been calculated for a range of utilization levels for the combined-cycle case. Although not detailed in this table, exhaust gas SO_x removal costs, discussed later, are calculated for three SO_x removal processes.

It is important to note that the total cost of gas turbine fuels is sensitive to the refinery feedstock price. For feedstocks based on synthetic crudes, a calculated market value of the feedstock is used in determining the price of the refinery gas turbine fuel. If the refinery feedstock market value changes, possibly because of feedstock availability or higher transportation costs, the results be greatly affected.

Results

The ultimate total cost of gas turbine fuel will be heavily dependent on the refinery feedstock selected. However, it is important to note that the selection of the best feedstock is determined partly from its market value at the time of processing. These selections should be re-evaluated in light of new feedstock price data.

In evaluating the minimum cost paths for a particular feedstock, it is clear that the refinery processing step is the critical path in achieving the lowest total cost gas turbine fuel. In many cases, it is more economical to reduce the severity of refinery operations, thereby producing a lower-quality and lower-priced refinery gas turbine fuel, and increase costs at the power plant fuel treatment site. The fuel cost savings thereby realized have more than offset increased on-site processing cost.

Properties and selling prices of gas turbine fuels produced by the upgrading cases detailed in Volume III are summarized in Tables 1 and 2. Fuel distillate category is specified by gravity. The prices of these turbine fuels are prices needed in order to obtain an acceptable profit plus an acceptable return on new investments.

Gas turbine fuel properties listed in these tables include quantity of impurities (vanadium, nitrogen, and sulfur), viscosity, and carbon/hydrogen ratio.

Energy consumption and thermal efficiency for upgrading are also summarized in Tables 1 and 2. Thermal efficiency is the percent quotient of heating value of all products divided by the heating value of the liquid feed to the upgrading facility.

Low thermal efficiency usually results in higher fuel selling costs because energy consumed by upgrading reduces the output of saleable products. The losses are charged against all the products.

A major part of the on-site energy consumption is concentrated in the fuel treatment process. Energy consumption for the exhaust gas treatment is reportedly minimal in comparison. The following tabulation summarizes energy costs for the on-site fuel treatment of refinery gas turbine fuel.

Energy Costs for On-Site Fuel Treating

	Mills/kW·h	
	Simple Cycle	Combined Cycle
Fuel Heating	0.17	0.07
Electricity	0.13	0.07
Water	0.01	0.009

In this study , vanadium levels in the refinery gas turbine fuels range from 0.0 to 50.4 ppm of vanadium. In general, fuel treatment cost for vanadium inhibitor is 0.016 mills/kW·h/ppm of vanadium. Thus, for vanadium levels less than 5 ppm, vanadium inhibitor cost is minimal and does not greatly affect total gas turbine fuel cost.

Cases 2.31-2.33 (in Table 3) and Cases 6010-6030 (in Table 4) illustrate the small effect of vanadium level on vanadium inhibitor cost. In Cases 2.31-2.33 the vanadium level of the refinery gas turbine fuel decreases from 50.4 ppm to 10.9 ppm as the severity of hydrotreating increases. On-site fuel treatment cost decrease by about 0.7 mills/kW·h for the combined-cycle case. The refinery gas turbine fuel price, meanwhile, has increased from 80.7 to 82.5 mills/kW·h.

The same result is illustrated in Cases 6010-6030 where sour resid is hydrotreated at three severities resulting in a reduction of vanadium from 49 ppm to 11 ppm. The cost of refinery gas turbine fuel increases by about 2.3 mills/kW·h with increasing hydrotreating severity. However, the fuel treatment cost decreases by only 0.6 mills/kW·h. In both instances it is more economical to increase the power plant fuel treatment cost and reduce the initial upgrading metals removal.

Nitrogen levels for the refinery gas turbine fuels range from 0.02-0.70 wt% nitrogen. Exhaust gas $DeNO_x$ removal costs are included only for the combined-cycle case, since simple-cycle $DeNO_x$ removal is not feasible.

In general, it is more economical to produce a lower quality refinery gas turbine fuel (with a higher nitrogen level) and increase $DeNO_x$ exhaust gas treatment costs at the power plant than to produce a higher quality gas turbine fuel at the refinery. This result is illustrated in Cases 2.31-2.33 (sour rosid hydrotreating) where refinery turbine fuel nitrogen is decreased from 0.36 to 0.30% nitrogen, resulting in a refinery gas turbine increase from 80.7 to 82.5 mills/kW•h, but resulting in a decrease of $DeNO_x$ exhaust gas clean-up cost of only 0.1 mills/kW•h.

The same result is more pronounced in Cases 1010-1030 (eastern coal liquid hydrotreating). In these cases, nitrogen level is reduced from 0.70 to 0.30%, with a resulting increase in refinery fuel price from 73.4 to 84.6 mills/kW•h, but only a 0.8 mills/kW•h decrease in $DeNO_x$ costs at the power plant. Thus, it is more economical to produce a lower quality refinery gas turbine fuel (with a higher nitrogen content) and increase exhaust gas treatment costs at the power plant.

It is difficult to draw any conclusions about the effect of decreasing fuel sulfur at the refinery site since $DeSO_x$ exhaust gas treatment is not required for the majority of the gas turbine fuels produced at the refinery. $DeSO_x$ exhaust gas treatment is required only for fuel sulfur levels greater than 0.8 wt% sulfur, and only one case, 1.10, with a sulfur level of 0.83% sulfur may require $DeSO_x$ exhaust gas treatment.

$DeSO_x$ removal costs are high in comparison to possible hydrotreating costs required to remove sulfur from the fuel. For a fuel sulfur of 2.5%, the following exhaust gas SO_x removal costs have been calculated to be:

	SO_x Removal Process		
	Lime/ Limestone	Wellman/ Lord	Shell/ UOP
Cost, mills/kW•h	11.0	30.0	8.0

Fortunately, it has been demonstrated that residual fuel sulfur, with a minimum of refinery processing, should be decreased to the safe level of 0.8%. However, further processing to reduce sulfur level results in a higher gas turbine fuel price. For example, in Cases 1010-1030, gas turbine fuel sulfur is reduced from 0.13 to 0.07 with a resulting increase in fuel price from 73.4 to 84.6 mills/kW•h (combined cycle).

The carbon/hydrogen ratio of the refinery turbine fuel does not affect downstream power plant fuel treatment and exhaust gas treatment costs; however, the C/H ratio is reflected in refinery gas turbine fuel price. As C/H ratio is decreased, as a result of increasing hydrogenation from hydrotreating, the refinery fuel price increases. Impacts of C/H ratio upon turbine cost was outside the scope of this study.

Table 5 summarizes upgrading cases which provide a basis for demonstrating the impact of reducing the carbon to hydrogen ratio on the fuel cost component in the generated electrical power. A decrease of 0.1 in C/H ratio costs about 5 mills/kW•h.

The effect of increasing fuel viscosity at the refinery has a minimal impact on downstream power plant fuel treatment costs. The capital cost of the fuel treatment plant is affected only when the viscosity of the fuel is greater than 900 cSt, and the effect on capital cost when this occurs is only .1-1 mills/kW•h. For many of the turbine fuels developed in the upgrading studies fuel viscosity is in the 0.0 to 35.0 cSt range. However, fuels produced by refinery hydrotreating are blended to 1100 cSt which is the maximum viscosity allowed for fuel transportation (based on No. 6 fuel). Thus, in these cases, it is either unfeasible to increase refinery fuel viscosity or increasing viscosity in the low viscosity range (0-900 cSt) has no effect on the cost of gas turbine fuel.

Certain useful conclusions can also be established by examination of plots related to the sulfur content of the upgraded turbine fuels. In all of the attached graphs, the best paths for both the high duty combined cycle turbine and for the simple cycle turbine have been included. By including only the best paths, the plots are not cluttered with results from using less attractive on-site processing options. However by including information about all feasible raw material - plant - processing combinations, the graphs show some significant interactions between upgrading with respect to sulfur and overall economics.

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The first figure "TOTAL POWER COST VS FUEL SULFUR CONTENT, USES COMBINED CYCLE TURBINE" suggests a very minor effect of fuel sulfur content upon power cost over a sulfur concentration range from 0.2 to 0.9 wt% sulfur. However below 0.2 wt% sulfur power cost rises rapidly as fuel sulfur content is reduced.

This first figure also shows a rather unusual trend. For turbine fuels made by upgrading a low sulfur crude (the LOWS points) total power cost decreases as fuel sulfur content decreases from about 0.8 to about 0.2 wt% sulfur. This occurs because the available upgrading processes simultaneously improve several attributes, one of which is viscosity. As a result of this viscosity reduction, other low viscosity streams may be released from the turbine fuel and blended into more valuable refinery products.

The second figure "TOTAL POWER COST VS FUEL SULFUR CONTENT, USES SIMPLE CYCLE TURBINE" confirms the power cost vs sulfur in fuel trend. In addition this figure also reveals that turbine fuel from an Eastern coal is not a feasible raw material for a simple-cycle turbine. As mentioned elsewhere in this report, this turbine fuel's nitrogen content requires exhaust gas treatment. Unfortunately present exhaust gas treatments are not compatible with the high temperatures of the exhaust gas from a simple-cycle turbine system.

The third figure "FUEL PRICE vs THERMAL EFFICIENCY" relates to a trend in the upgrading information. The Turbine Fuel Selling Price is the price at which the operator of an upgrading facility would wish to sell a turbine fuel in order to realize an acceptable profit from his operation. Thermal Efficiency indicates how much of the heating value in the feed to the upgrading facility is available as heating value in the products from the upgrading facility. The points in the figure are labeled to indicate the raw material used to generate the fuel. In general, low thermal efficiency accompanies high fuel selling price. The fourth and fifth figures segregate the data of the third figure according to type of facility. In these last two figures the relation between selling price and thermal efficiency is even more apparent. For a given raw material in a given type of facility, fuel selling price declines as the thermal efficiency of the upgrading improves. This clearly indicates that a major component of upgrading costs is the value of the fuel consumed , upgrading.

General Comments on Upgrading

The refinery processing step is the critical path in achieving the lowest total cost of using gas turbine fuel in power plants. Since the price of gas turbine fuel produced from the refinery is approximately 85% of the total cost of using turbine fuel in the power plant, the refinery gas turbine fuel price overshadows any further plant on-site fuel treatment costs. For this reason, it is important to optimize the refinery processing step in order to produce a minimum-cost turbine fuel.

This study also demonstrates that, in many cases, it is more economical to produce a lower quality refinery gas turbine fuel (thereby reducing the refinery turbine fuel price) and invest in fuel treatment equipment at the turbine site, rather than produce a higher quality fuel at the refinery in order to reduce treating costs at the power plant.

Gas turbine fuel prices exceeding distillate price occurs in one-third of the processing schemes studied. In the remaining two-thirds of the 30 cases, only four refinery schemes produce a gas turbine fuel which, after power plant on-site fuel treatment, costs less than distillate fuel. Three of these schemes are based on refining Eastern coal liquid, which has a relatively low market value in comparison to other refinery feedstocks. Thus, for all cases studied, the cost differential between total gas turbine fuel cost (including treatment costs) and distillate cost, although dependent on refinery feedstock cost, is usually adverse. This adverse picture for two turbine fuels of low quality may reflect our choice of cost estimating methods. We did charge the new product for any new equipment required and for any loss in productivity of existing equipment.

Path Evaluations

The various combinations among raw materials, processing schemes, on-site upgrading choices, turbine cycle types, and turbine duty cycles provided about 600 feasible paths from fossil fuel sources to electricity and acceptable exhaust gas by way of industrial gas turbines. Despite their number, the upgrading schemes could not represent one quality at a time upgrading of a fuel. This study therefore developed the cost/quality trade-offs by exhaustive comparison among the almost 600 feasible paths.

From the path comparisons, these conclusions became apparent.

The least cost paths for a given raw material usually have the highest thermal efficiency.

Fuel costs represent about 85 to 90% of the generated electricity cost.

For both the petroleum-based, as well as the shale oil-based fuels, upgrading in a modified existing facility resulted in lower total costs for generating electricity. Except for the low-sulfur petroleum-based turbine fuels, the modified existing facility paths had about a 5% cost advantage. Even in the case of the low sulfur-based, petroleum-based turbine fuels, the modified existing facility had a 1% advantage. In the case of coal liquids, no such comparison can be made because it does not make sense to upgrade a coal liquid in a modified existing petroleum refinery.

The least cost paths for a combined-cycle turbine operation were unaltered over the operating cycle range (7000 to 3000 hr/yr at a 400 MW capacity) investigated. Therefore, the bulk of the path analysis was conducted using only the 7000 hr/yr combined-cycle operation. Paths for the other two duty cycles were always the same as the paths for the 7000 hr/yr duty cycle paths. Cost of generated electricity was, of course, somewhat higher because shorter duty cycles increased the capital charges allocated to a unit of produced electrical energy.

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There are some significant path differences between the combined-cycle operating paths and the simple-cycle operating paths. The best level of washing was one such difference. For the simple-cycle (a peaking application operating 1500 hr/yr with a 30 MW output), an intermediate level of on-site fuel washing was more economical than either a low-level or a high-level of on-site fuel washing. In contrast, the combined-cycle operating paths using the highest level of on-site fuel washing gave better economics than corresponding paths at levels of site fuel washing. In the simple-cycle cases, the cost savings from turbine deterioration and maintenance could only justify the costs of the intermediate level of fuel washing. The savings at issue were but a fraction of a cent per kW. Nevertheless, our method of analysis thus demonstrated responsiveness to these kinds of economic issues.

Simple-cycle operation requires a lower level of fuel nitrogen at this time than does a combined-cycle operation. A credible exhaust gas NO_x removal process requires that the exhaust gas be cooled extensively before the exhaust gas is treated. If the costs of equipment required for such cooling are recovered, then the simple-cycle installation has for all practical purposes been converted into a combined-cycle operation. The scale of operation is deemed to be too low to make sense as a combined cycle. Although outside the scope of this study, the unforeseen development of a high temperature NO_x exhaust gas treatment process would provide a simple-cycle turbine with greater tolerance to nitrogen in its fuel.

For similar reasons, simple-cycle turbines are less tolerant of sulfur in their fuels. Credible SO_x exhaust gas treatment systems also require that the exhaust gas be cooled before it is processed.

At this time the exhaust gas cooling inherent in a combined-cycle operation permits exhaust gas treatment for a combined-cycle operation. Therefore, a combined-cycle operation can process less fully upgraded fuels.

The fuel upgrading schemes involve one of two upgrading approaches. One approach removes impurities as a result of boiling point modification. The other approach directly removes impurities. Coking is an example of boiling range modification. Direct impurity removal involves two alternatives. A variety of processes hydrogenate the fuel. Although most such processes add hydrogen to the fuel hydrocarbons, some such processes selectively react with the non-hydrocarbon elements to produce chemical substances readily separated from the hydrocarbons of the fuel. Another form of direct impurity removal occurs because of the selective affinity between some non-organic impurities and the catalyst substances used to facilitate hydrocarbon fuel processing. Much of the present fuel upgrading with respect to metals contact involves the use of spent catalysts for just such purposes.

This study provides a basis for comparing the two different upgrading approaches. This could be done for all the feed materials except coal liquids. Coal liquids are not amenable to the boiling range approach because the coal liquids have no inherently very high boiling ends into which impurities can be concentrated. For the shale oils (both surface retorted and modified in situ retorted), the boiling range approach provided a 5% advantage on total cost of producing electricity. For both high- and low-sulfur petroleums, the impurity removal approach was better. For the high-sulfur petroleum, a 7% advantage could be realized for the impurity removal approach. For the low-sulfur petroleum, the impurity removal approach had a 2% advantage. The best approach did vary with raw material and, for a given raw material, the cost difference between approaches appeared to be consistent, even as the schemes varied in detail.

Description of Path Tables

This study generated and compared feasible paths from liquid raw materials for turbine fuels to generated electrical power. Tables 6 through 13 contain subsets of these paths. The higher numbered tables contain fewer paths and thus highlight the better alternative paths.

Each row in any one of these tables represents a path from a liquid raw material to electrical power. A unique combination of raw material, plant type, upgrading process, on-site processing, and turbine cycle is involved in any row. Some of the columns in these tables contain code names whereby the nature of the path can be determined. Other columns in these tables present cost or quality information. Although some of these tables include table of nomenclature, two "nomenclature tables" are included for the reader's convenience. Table 14 defines the column names used in the earlier tables, and Table 15 defines the abbreviated upgrading process descriptions used in the earlier tables.

Tables 1 and 2 contain path information unique to the fuel upgrading studies, details of which appear in Volume III.

Tables 3 and 4, on the other hand contain path information relevant to both upgrading, on-site processing, and turbine cycle.

Table 5 depicts information from Tables 1 and 2 organized so as to highlight one particular upgrading phenomena.

Tables 3 and 4 contain paths for four turbine cycles (HIGH, MED, LOW, and SIMP). As discussed in the DATA ANALYSIS section, the HIGH, MED, and LOW are merely different duty cycles for a combined cycle operation.

Tables 6 through 13 include only HIGH (7000 hr) combined-cycle paths. They do not include any of the paths involving the 3000 or 5000 hr cycles because the nature and ranking of the paths is the same for all three duty cycles in the combined-cycle cases. The paths in Tables 6 through 13 contain the information essential to the overall cost path trade-off assessments for this study.

The paths in Table 6 have been placed in a particular sequence.

- All paths related to a given CASE are contiguous.
- Within each case, the combined cycle paths (CYCLE = HIGH) are segregated from the simple cycle cases (CYCLE = SIMP)
- Within each CASE - CYCLE combination the paths are sorted by total cost of generated electricity (TOTCST, mills/kW•h). For

each CASE - CYCLE combination there are three paths. These three paths represent three different levels of sodium removal (NA = 0.5, 1.0, 2.0 ppm of sodium).

With this ordering of the paths in Table 6 one can immediately identify the best on-site fuel treatment options for each CASE - CYCLE combination.

The First Path of each CASE - CYCLE combination in Table 6 has the best on-site fuel treatment option for that combination because it has the least "TOTCOST" for that combination.

Table 7 contains these best on-site fuel treatment paths disclosed by the path ordering of Table 6. Table 7 is retained and its genesis has been described to provide an insight into the "best path" selection process used in this study. By examining a sorted table one can detect patterns, make comparisons and draw conclusions. The row sorting done to organize and cull Tables 6 through 13 always involves sorting on the total cost of generating electricity. This provides us with a simple bases upon which to eliminate less attractive alternatives. The procedure was rendered less tedious, less costly, and less error prone by using machine data processing techniques.

Table 8 contains exactly the same paths as does Table 7. However by placing the paths in a different sequence some useful patterns become apparent. In Table 8 combined cycle (HIGH) paths are segregated from simple cycle (SIMP) paths. Furthermore within each type of cycle the paths using upgrading in a grass roots facility (PLANT=NEW) are segregated from paths using upgrading in a modified existing facility (PLANT=OLD). Within each CYCLE - PLANT combination paths are sorted by cost of generated electricity. Some patterns with respect to cost of produced electricity cost vs raw material appear. More importantly, it is readily apparent that the more intensive upgrading schemes are often less attractive than their less intensive equivalents.

Table 8 helps one decide the best paths for a given CYCLE - PLANT combination. For example:

The least cost combined-cycle operation using a new upgrading facility involves a coal liquid from Eastern Coal upgraded by moderate hydrotreating.

The least cost combined cycle operation using a modified existing facility involves a low sulfur crude upgraded by intermediate hydrodesulfurization.

Table 9 also contains the same paths as do Tables 7 and 8. However, Table 9 is sorted by cycle, raw material, and total cost. Table 9 shows that (when the option is available for a fuel source) electicity costs are less when the upgrading facility is a modified petroleum refinery than when it is a grass roots facility. Table 9 also shows that, except for the shale oils, impurity removal (MODE=IMP) is generally more economically attractive than boiling range alteration (MODE=BOIL).

Table 10 has fewer paths than do Tables 7, 8, and 9. Only the best upgrading option for each raw material, given a particular cycle-plant combination appears in Table 10. Note that Eastern coal is the best choice if one wishes to use a grass roots upgraded fuel in a combined-cycle operation. However, an Eastern coal liquid cannot be used in a simple cycle. The nitrogen content of this liquid fuel is too great because the simple-cycle turbine exhaust gas is too hot for exhaust gas treatment.

For a given cycle-plant combination, Table 10 orders the feasible raw material-cycle-plant combinations according to total power cost. For any raw material-cycle-plant combination, Table 10 includes only the best processing option for that particular combination. Table 10 shows the best raw material for a given cycle-plant combination.

Table 11 has the same paths as Table 10, but they are arranged to highlight a different issue. Table 11 shows the best plant type for a given raw material-cycle combination.

Table 12 retains the most attractive plant type option for each raw material-cycle option that appeared in Tables 10 or 11. Table 12 is ordered to indicate preference for a given turbine cycle.

Table 13 has the same paths as Table 12. Table 13 displays its paths to show preferences for a given plant type.

To recapitulate the path tables:

- Tables 1 and 2 depict upgrading information for all paths.
- Tables 3 and 4 depict both upgrading and onsite processing information for several representative raw material-plant-upgrading options.
- Table 6 retains all simple cycle and all the high duty combined-cycle paths.
- Tables 7, 8, and 9 retain all the best paths with repect to on-site processing options.
- Tables 10 and 11 retain all the best paths with repect to both upgrading and on-site processing options.
- Tables 12 and 13 retain all the best paths with repect to both plant choice and upgrading and on-site processing options.
- Tables 14 and 15 define terms.

Table 12 eliminates the less attractive of the plant type options if (for a given raw material-turbine cycle combination) more than one plant option is available. The grass roots facility is used only if a modified existing facility cannot adequately upgrade a fuel. The distinctive differences between the fuel qualities for the combined- and simple-cycle fuels relate to nitrogen content (must be lower for the simple cycle) and carbon-to-hydrogen ratio (more hydrogen in the simple-cycle fuel). The two are related because denitrification of the fuel is accompanied by more extensive hydrogenation of the fuel.

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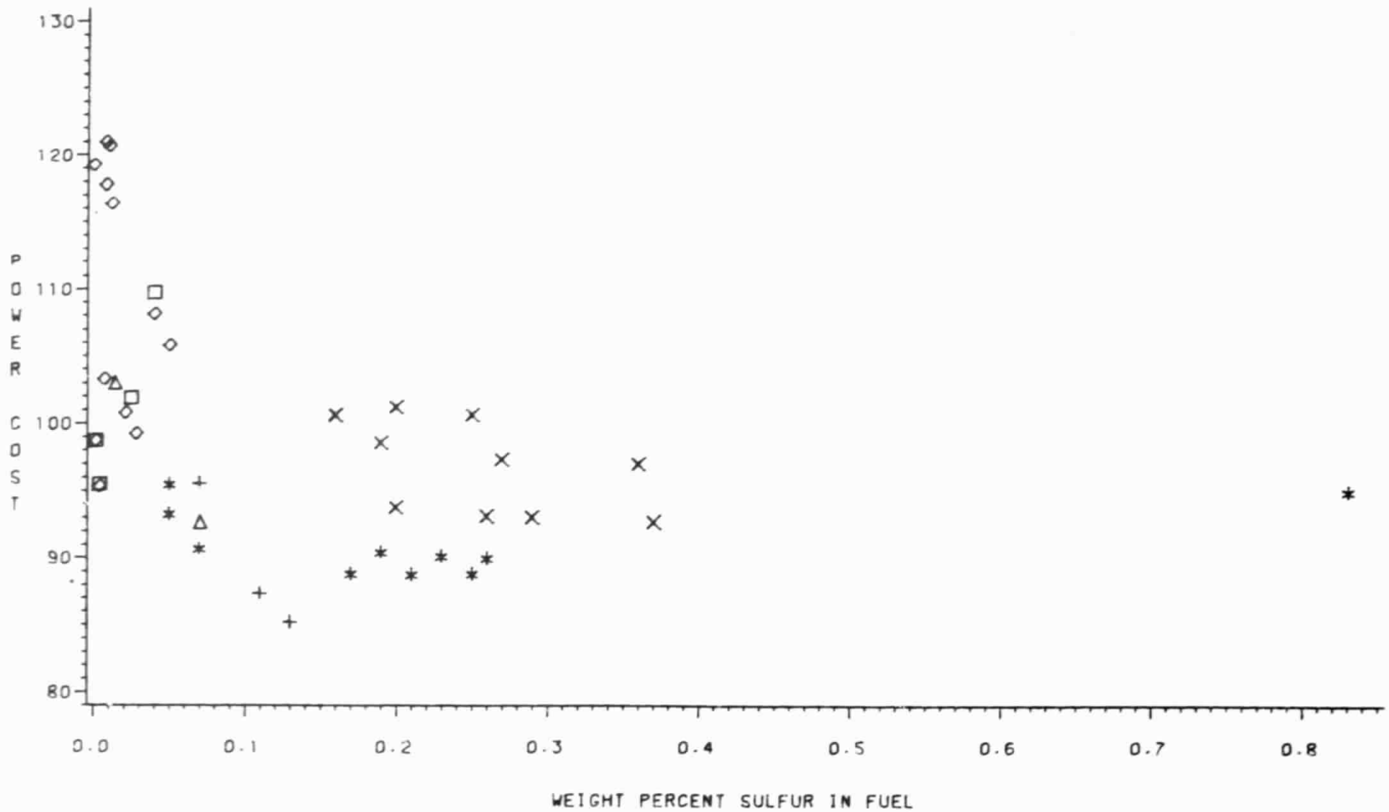
APPENDIX I

FIGURES 1 THROUGH 5

Fig. 1

TOTAL POWER COST VS FUEL SULFUR CONTENT

USES COMBINED CYCLE TURBINE



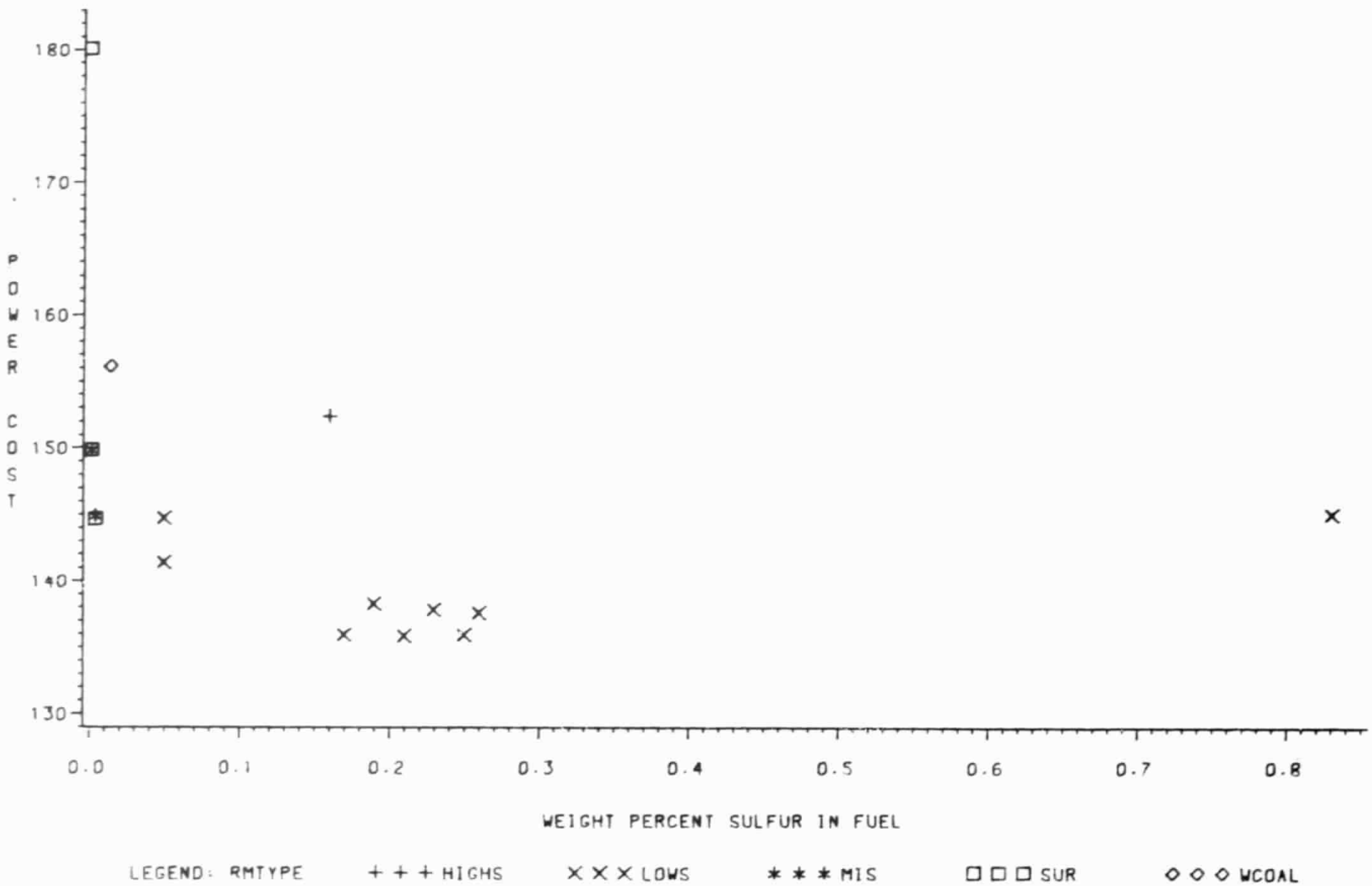
LEGEND: RMTYPE + + + ECOAL × × × HIGHS * * * LOWS □ □ □ MIS ◇ ◇ ◇ SUR △ △ △ WCOAL

POWER COST UNITS ARE MILLS PER KILOWATT HOUR

Fig. 2

TOTAL POWER COST VS FUEL SULFUR CONTENT

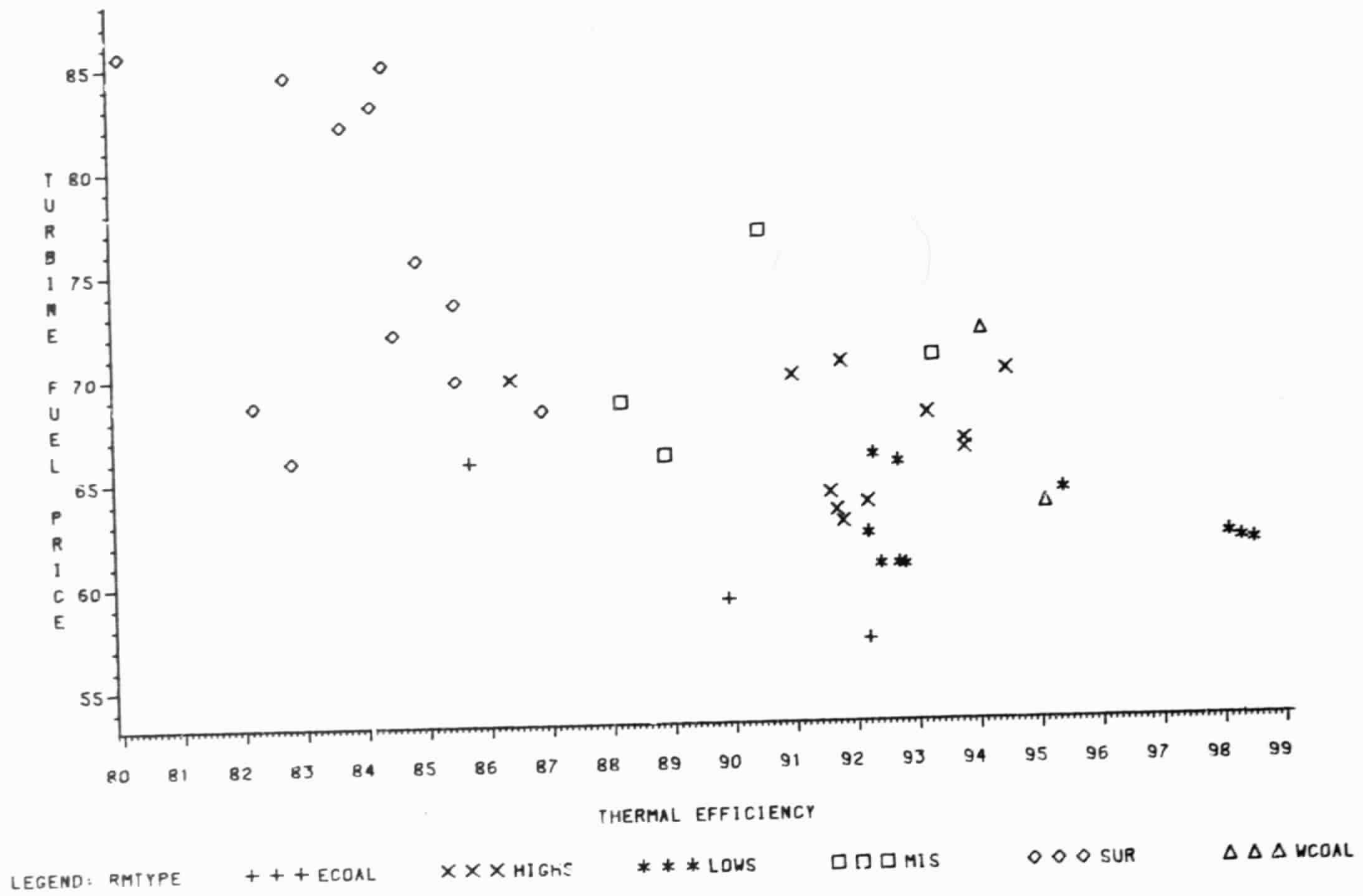
USES SIMPLE CYCLE TURBINE



POWER COST UNITS ARE MILLS PER KILOWATT HOUR

Fig. 3

FUEL PRICE VS THERMAL EFFICIENCY

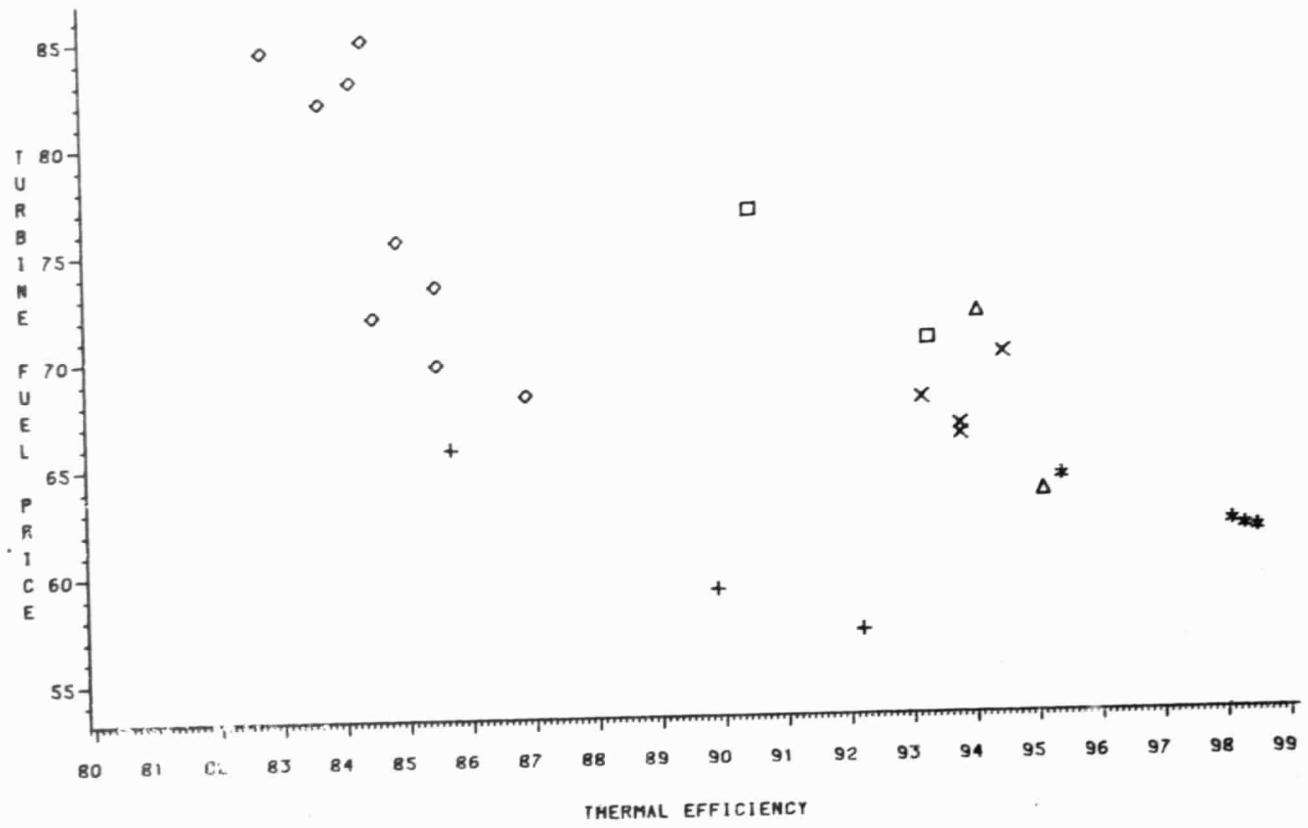


TURBINE FUEL PRICE IS $ PER BBL

Fig. 4

FUEL PRICE VS THERMAL EFFICIENCY

FOR UPGRADING IN NEW FACILITIES



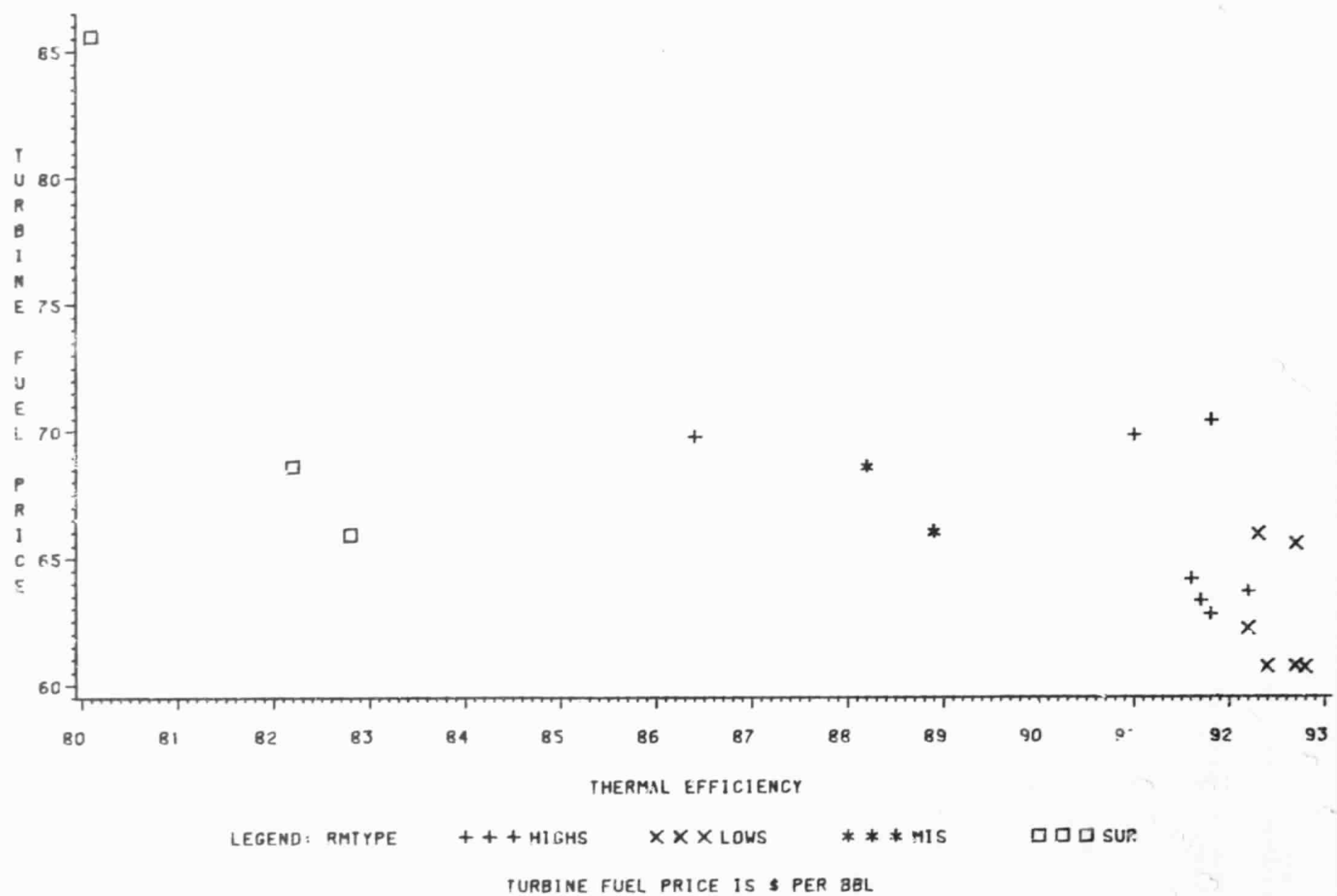
LEGEND: RMTYPE + + + ECOAL × × × HIGHS * * * LOWS □ □ □ MIS ◇ ◇ ◇ SUR Δ Δ Δ WCOAL

TURBINE FUEL PRICE IS $ PER BBL

Fig. 5

FUEL PRICE VS THERMAL EFFICIENCY

FOR UPGRADING IN MODIFIED EXISTING FACILITIES



APPENDIX II

TABLES 1 THROUGH 15

TABLE 1
SUMMARY OF UPGRADING SCHEMES
FOR AUGMENTED EXISTING FACILITIES

CASE	PLANT	RMTYPE	MODE	PROCESS	RMCOST	METALS	API	CTOH	N	S	VIS	FRMTL	EELEC	EWAT	TH_EFF	FUELPR
1.10	OLD	LOWS	BOIL	DECARB	62.00	0.2	17.4	8.25	0.100	0.8300	1100.00	0.92	0.029	0.0005	92.7	65.58
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	62.00	0.0	37.7	6.63	0.090	0.0500	1.00	0.90	0.033	0.0005	92.3	65.95
1.22	OLD	LOWS	BOIL	COKE_HYD375+	62.00	0.0	31.0	6.85	0.110	0.0700	5.00	0.92	0.033	0.0006	92.2	62.21
1.31	OLD	LOWS	IMP	HDS_MOD	62.00	1.3	22.9	7.37	0.090	0.2500	1100.00	0.84	0.032	0.0006	92.7	60.72
1.32	OLD	LOWS	IMP	HDS_INTER	62.00	0.6	23.1	7.36	0.090	0.2100	1100.00	0.84	0.032	0.0006	92.8	60.67
1.33	OLD	LOWS	IMP	HDS_HIGH	62.00	0.1	24.4	7.33	0.070	0.1700	1100.00	0.89	0.032	0.0006	92.4	60.71
2.10	OLD	HIGHS	BOIL	DECARB	59.00	11.6	21.7	7.55	0.270	0.2600	1130.00	0.87	0.034	0.0005	92.2	63.63
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	59.00	0.0	37.7	6.65	0.190	0.1600	1.00	1.67	0.044	0.0006	86.4	69.79
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	59.00	0.0	31.5	6.83	0.110	0.2000	5.00	0.92	0.042	0.0006	91.8	70.45
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	59.00	0.0	22.3	7.45	0.170	0.2500	26.50	1.03	0.041	0.0006	91.0	69.85
2.31	OLD	HIGHS	IMP	HDS_MOD	59.00	50.4	23.0	7.36	0.360	0.3700	1130.00	0.90	0.045	0.0006	91.8	62.76
2.32	OLD	HIGHS	IMP	HDS_INTER	59.00	31.0	23.2	7.35	0.360	0.2900	1130.00	0.91	0.046	0.0006	91.7	63.31
2.33	OLD	HIGHS	IMP	HDS_HIGH	59.00	10.9	23.4	7.33	0.300	0.2000	1130.00	0.92	0.047	0.0006	91.6	64.16
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	50.86	0.2	38.0	6.60	0.019	0.0015	2.35	1.80	0.092	0.0016	82.2	68.63
3.20	OLD	SUR	BOIL	HYDRO_HIGH	50.86	0.2	37.5	6.65	0.050	0.0040	2.35	1.74	0.080	0.0016	82.8	65.93
3.30	OLD	SUR	BOIL	COKE_HYDC5+	50.86	0.0	39.0	6.55	0.300	0.0080	2.40	1.93	0.074	0.0010	80.1	85.58
4.10	OLD	MIS	BOIL	1STAGE_HYDRO	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	1.19	0.078	0.0014	88.2	68.63
4.20	OLD	MIS	BOIL	HYDRO_HIGH	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	1.12	0.064	0.0013	88.9	66.04

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
PROCESS	An abbreviated description of the upgrading scheme

PROPERTIES OF PRODUCED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 deg.

UPGRADING SCHEME COST PARAMETERS

Name	Definition
EPMTL	Cost of fuel for processing, $ per mm BTU of products
EELECT	Cost of electricity for processing, $ per mm BTU of products
EWAT	Cost of water for processing, $ per mm BTU of products
FUELPR	Turbine fuel selling price for scheme, $ per BBL
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal effeciency (energy in products/ energy in fuel)

TABLE 7
SUMMARY OF UPGRADING SCHEMES
FOR GRASSROOTS FACILITIES

CASE	PLANT	RMTYPE	MODE	PROCESS	RMCOST	METALS	API	CTOH	N	S	VIS	ERMTL	EELEC	EWAT	TH_EFF	FUELPR
1010	NEW	ECOAL	IMP	HYDRO_MOD	51.66	0.00	13.4	9.10	0.7000	0.130	3.60	0.70	0.030	0.0003	92.2	57.09
1020	NEW	ECOAL	IMP	HYDRO_INTER	51.66	0.00	14.1	9.00	0.5000	0.110	2.90	0.93	0.037	0.0004	89.9	59.10
1030	NEW	ECOAL	IMP	HYDRO_HIGH	51.66	0.00	14.8	8.90	0.3000	0.070	2.45	1.37	0.064	0.0008	85.7	65.79
2010	NEW	WCOAL	IMP	HYDRO_NAPH	62.71	0.00	27.0	7.05	0.2600	0.070	1.70	0.56	0.019	0.0002	95.1	63.52
2070	NEW	WCOAL	IMP	HYDRO_ALL	62.71	0.00	32.3	6.78	0.0001	0.014	1.70	0.66	0.038	0.0005	94.1	71.93
3010	NEW	SUR	IMP	HYD650+_MOD	53.90	0.00	25.0	7.10	0.5000	0.050	.	1.43	0.078	0.0011	85.5	73.46
3020	NEW	SUR	IMP	HYD650+_INTER	53.90	0.00	27.9	6.86	0.3000	0.040	.	1.49	0.084	0.0012	84.9	75.57
3030	NEW	SUR	IMP	HYD650+_HIGH	53.90	0.00	29.0	6.93	0.1900	0.012	.	1.64	0.090	0.0012	83.7	82.07
301A	NEW	SUR	IMP	HYD350+_MOD	53.90	0.00	29.9	6.90	0.5400	0.028	.	1.27	0.063	0.0010	86.9	68.27
302A	NEW	SUR	IMP	HYD350+_INTER	53.90	0.00	32.8	6.80	0.3400	0.021	.	1.41	0.069	0.0011	85.5	69.76
303A	NEW	SUR	IMP	HYD350+_HIGH	53.90	0.00	34.2	6.73	0.1080	0.007	.	1.56	0.075	0.0011	84.5	72.02
3040	NEW	SUR	BOIL	COKE-HYDRO_MOD	53.90	0.00	37.0	6.60	0.5000	0.010	.	1.57	0.072	0.0010	84.4	85.01
3050	NEW	SUR	BOIL	COKE_HYDRO_INT	53.90	0.00	39.0	6.57	0.3000	0.009	.	1.59	0.074	0.0010	84.2	83.06
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	53.90	0.00	40.7	6.50	0.0600	0.000	.	1.75	0.093	0.0012	82.8	84.51
4020	NEW	MIS	IMP	HYD650+_INTER	58.00	0.10	27.0	6.86	0.3000	0.040	.	0.96	0.071	0.0010	90.5	76.81
402A	NEW	MIS	IMP	HYD350+_INTER	58.00	0.10	32.0	6.80	0.3000	0.025	.	0.64	0.056	0.0009	93.3	70.70
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	49.02	1.30	22.4	7.45	0.0900	0.260	1100.00	0.08	0.042	0.0003	98.5	61.59
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	49.02	0.50	22.6	7.45	0.0900	0.230	1100.00	0.09	0.045	0.0003	98.3	61.71
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	49.02	0.05	23.0	7.38	0.0900	0.190	1100.00	0.11	0.047	0.0003	98.1	61.94
5040	NEW	LOWS	BOIL	COKE_HYDC5+	49.02	0.00	37.2	6.64	0.0900	0.050	1.70	0.31	0.064	0.0003	95.4	64.20
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	45.44	49.00	22.9	7.40	0.3500	0.360	1100.00	0.44	0.083	0.0006	93.8	66.19
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	45.44	39.00	23.0	7.37	0.3500	0.270	1100.00	0.43	0.090	0.0006	93.8	66.65
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	45.44	11.00	23.2	7.35	0.2900	0.190	1100.00	0.48	0.093	0.0007	93.2	67.93
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	45.44	0.00	37.7	6.68	0.0900	0.160	1.70	0.36	0.067	0.0004	94.5	69.99

PATH IDENTIFIERS

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-NEW	Upgrading scheme uses a grass roots facility
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PROCESS	An abbreviated description of the upgrading scheme

PROPERTIES OF PRODUCED TURBINE FUEL

Name	Definition
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N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 deg.

UPGRADING SCHEME COST PARAMETERS

Name	Definition
ERMTL	Cost of fuel for processing, $ per mm BTU of products
EELECT	Cost of electricity for processing, $ per mm BTU of products
EWAT	Cost of water for processing, $ per mm BTU of products
FUELPR	Turbine fuel selling price for scheme, $ per BBL
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal efficiency (energy in products/ energy in fuel)

TABLE 7 (page 1 of 2)
PATH DETAILS FOR A FEW REPRESENTATIVE CASES
EMPHASIS ON SITE OPTION INFORMATION
ALL COMBINED CYCLE PATHS OF A CASE USE THE SAME WASHING OPTION

PLANT=OLD CASE=1.1C

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
LOWS	BOIL	DECARB	HIGH	0.2	0.1	0.83	1100	0.5	4.6	6.2	10.8	84.317	95.117
LOWS	BOIL	DECARB	HIGH	0.2	0.1	0.83	1100	1.0	5.2	6.2	11.4	84.317	95.717
LOWS	BOIL	DECARB	HIGH	0.2	0.1	0.83	1100	2.0	7.1	6.2	13.3	84.317	97.617
LOWS	BOIL	DECARB	LOW	0.2	0.1	0.83	1100	0.5	5.9	7.7	13.6	84.317	97.917
LOWS	BOIL	DECARB	LOW	0.2	0.1	0.83	1100	1.0	6.2	7.7	13.9	84.317	98.217
LOWS	BOIL	DECARB	LOW	0.2	0.1	0.83	1100	2.0	8.1	7.7	15.8	84.317	100.117
LOWS	BOIL	DECARB	MED	0.2	0.1	0.83	1100	0.5	5.0	6.7	11.7	84.317	96.017
LOWS	BOIL	DECARB	MED	0.2	0.1	0.83	1100	1.0	5.5	6.7	12.2	84.317	96.517
LOWS	BOIL	DECARB	MED	0.2	0.1	0.83	1100	2.0	7.4	6.7	14.1	84.317	98.417
LOWS	BOIL	DECARB	SIMP	0.2	0.1	0.83	1100	1.0	20.3	0.0	20.3	124.914	145.214
LOWS	BOIL	DECARB	SIMP	0.2	0.1	0.83	1100	2.0	20.6	0.0	20.6	124.914	145.514
LOWS	BOIL	DECARB	SIMP	0.2	0.1	0.83	1100	0.5	21.8	0.0	21.8	124.914	146.714

PLANT=OLD CASE=3.1U

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
SUR	BOIL	1STAGE_HYDRO	HIGH	0.2	0.019	0.0015	2.35	0.5	4.5	6.0	10.5	88.238	98.738
SUR	BOIL	1STAGE_HYDRO	HIGH	0.2	0.019	0.0015	2.35	1.0	5.1	6.0	11.1	88.238	99.338
SUR	BOIL	1STAGE_HYDRO	HIGH	0.2	0.019	0.0015	2.35	2.0	7.0	6.0	13.0	88.238	101.238
SUR	BOIL	1STAGE_HYDRO	LOW	0.2	0.019	0.0015	2.35	0.5	5.6	7.5	13.1	88.238	101.338
SUR	BOIL	1STAGE_HYDRO	LOW	0.2	0.019	0.0015	2.35	1.0	6.0	7.5	13.5	88.238	101.738
SUR	BOIL	1STAGE_HYDRO	LOW	0.2	0.019	0.0015	2.35	2.0	7.9	7.5	15.4	88.238	[illegible]
SUR	BOIL	1STAGE_HYDRO	MED	0.2	0.019	0.0015	2.35	0.5	4.8	6.5	11.3	88.238	99.538
SUR	BOIL	1STAGE_HYDRO	MED	0.2	0.019	0.0015	2.35	1.0	5.4	6.5	11.9	88.238	100.138
SUR	BOIL	1STAGE_HYDRO	MED	0.2	0.019	0.0015	2.35	2.0	7.3	6.5	13.8	88.238	102.038
SUR	BOIL	1STAGE_HYDRO	SIMP	0.2	0.019	0.0015	2.35	1.0	19.1	0.0	19.1	130.724	149.824
SUR	BOIL	1STAGE_HYDRO	SIMP	0.2	0.019	0.0015	2.35	2.0	20.1	0.0	20.1	130.724	150.824
SUR	BOIL	1STAGE_HYDRO	SIMP	0.2	0.019	0.0015	2.35	0.5	20.6	0.0	20.6	130.724	151.324

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.5	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
[illegible]	[illegible]

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
NACST	Costs for on site fuel treatment, incremental maintenane, incremental deprec. on turbine
NOXCST	Costs for on site exhaust gas treatment
SITECST	Sum of NACST PLUS NOXCST
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 3 (page 2 of 2)
PATH DETAILS FOR A FEW REPRESENTATIVE CASES
EMPHASIS ON SITE OPTION INFORMATION
ALL COMBINED CYCLE PATHS OF A CASE USE THE SAME WASHING OPTION

PLANT=OLD CASE=2.31

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
HIGHS	IMP	HDS_MOD	HIGH	50.4	0.36	0.37	1130	0.5	5.5	6.6	12.1	80.6912	92.7912
HIGHS	IMP	HDS_MOD	HIGH	50.4	0.36	0.37	1130	1.0	6.1	6.6	12.7	80.6912	93.3912
HIGHS	IMP	HDS_MOD	HIGH	50.4	0.36	0.37	1130	2.0	8.0	6.6	14.6	80.6912	95.2912
HIGHS	IMP	HDS_MOD	LOW	50.4	0.36	0.37	1130	0.5	6.8	8.1	14.9	80.6912	95.5912
HIGHS	IMP	HDS_MOD	LOW	50.4	0.36	0.37	1130	1.0	7.1	8.1	15.2	80.6912	95.8912
HIGHS	IMP	HDS_MOD	LOW	50.4	0.36	0.37	1130	2.0	9.0	8.1	17.1	80.6912	97.7912
HIGHS	IMP	HDS_MOD	MED	50.4	0.36	0.37	1130	0.5	5.9	7.1	13.0	80.6912	93.6912
HIGHS	IMP	HDS_MOD	MED	50.4	0.36	0.37	1130	1.0	6.4	7.1	13.5	80.6912	94.1912
HIGHS	IMP	HDS_MOD	MED	50.4	0.36	0.37	1130	2.0	8.3	7.1	15.4	80.6912	96.0912

PLANT=OLD CASE=2.33

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
HIGHS	IMP	HDS_HIGH	HIGH	10.9	0.3	0.2	1130	0.5	4.8	6.5	11.3	82.4912	93.7912
HIGHS	IMP	HDS_HIGH	HIGH	10.9	0.3	0.2	1130	1.0	5.4	6.5	11.9	82.4912	94.3912
HIGHS	IMP	HDS_HIGH	HIGH	10.9	0.3	0.2	1130	2.0	7.3	6.5	13.8	82.4912	96.2912
HIGHS	IMP	HDS_HIGH	LOW	10.9	0.3	0.2	1130	0.5	6.1	8.0	14.1	82.4912	96.5912
HIGHS	IMP	HDS_HIGH	LOW	10.9	0.3	0.2	1130	1.0	6.4	8.0	14.4	82.4912	96.8912
HIGHS	IMP	HDS_HIGH	LOW	10.9	0.3	0.2	1130	2.0	8.3	8.0	16.3	82.4912	98.7912
HIGHS	IMP	HDS_HIGH	MED	10.9	0.3	0.2	1130	0.5	5.2	7.0	12.2	82.4912	94.6912
HIGHS	IMP	HDS_HIGH	MED	10.9	0.3	0.2	1130	1.0	5.7	7.0	12.7	82.4912	95.1912
HIGHS	IMP	HDS_HIGH	MED	10.9	0.3	0.2	1130	2.0	7.6	7.0	14.6	82.4912	97.0912

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cycle, 1500 hours/year, for power generation
-HIGH	Combined cycle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
NACST	Costs for on site fuel treatment, incremental maintenane, incremental deprec. on turbine
NOXCST	Costs for on site exhaust gas treatment
SITECST	Sum of NACST PLUS NOXCST
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 4 (page 1 of 2)
PATH DETAILS FOR A FEW REPRESENTATIVE CASES
EMPHASIS ON SITE OPTION INFORMATION
ALL COMBINED CYCLE PATHS OF A CASE USE THE SAME WASHING OPTION

PLANT=NEW CASE=1010

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
ECOAL	IMP	HYDRO_MOD	HIGH	0	0.7	0.13	3.6	0.5	4.5	7.3	11.8	73.4012	85.2012
ECOAL	IMP	HYDRO_MOD	HIGH	0	0.7	0.13	3.6	1.0	5.1	7.3	12.4	73.4012	85.8012
ECOAL	IMP	HYDRO_MOD	HIGH	0	0.7	0.13	3.6	2.0	7.0	7.3	14.3	73.4012	87.7012
ECOAL	IMP	HYDRO_MOD	LOW	0	0.7	0.13	3.6	0.5	5.6	8.8	14.4	73.4012	87.8012
ECOAL	IMP	HYDRO_MOD	LOW	0	0.7	0.13	3.6	1.0	6.0	8.8	14.8	73.4012	88.2012
ECOAL	IMP	HYDRO_MOD	LOW	0	0.7	0.13	3.6	2.0	7.9	8.8	16.7	73.4012	90.1012
ECOAL	IMP	HYDRO_MOD	MED	0	0.7	0.13	3.6	0.5	4.8	7.8	12.6	73.4012	86.0012
ECOAL	IMP	HYDRO_MOD	MED	0	0.7	0.13	3.6	1.0	5.4	7.8	13.2	73.4012	86.6012
ECOAL	IMP	HYDRO_MOD	MED	0	0.7	0.13	3.6	2.0	7.3	7.8	15.1	73.4012	88.5012

PLANT=NEW CASE=1030

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
ECOAL	IMP	HYDRO_HIGH	HIGH	0	0.3	0.07	2.45	0.5	4.5	6.5	11.0	84.5869	95.587
ECOAL	IMP	HYDRO_HIGH	HIGH	0	0.3	0.07	2.45	1.0	5.1	6.5	11.6	84.5869	96.187
ECOAL	IMP	HYDRO_HIGH	HIGH	0	0.3	0.07	2.45	2.0	7.0	6.5	13.5	84.5869	98.087
ECOAL	IMP	HYDRO_HIGH	LOW	0	0.3	0.07	2.45	0.5	5.6	8.0	13.6	84.5869	98.187
ECOAL	IMP	HYDRO_HIGH	LOW	0	0.3	0.07	2.45	1.0	6.0	8.0	14.0	84.5869	98.587
ECOAL	IMP	HYDRO_HIGH	LOW	0	0.3	0.07	2.45	2.0	7.9	8.0	15.9	84.5869	100.487
ECOAL	IMP	HYDRO_HIGH	MED	0	0.3	0.07	2.45	0.5	4.8	7.0	11.8	84.5869	96.387
ECOAL	IMP	HYDRO_HIGH	MED	0	0.3	0.07	2.45	1.0	5.4	7.0	12.4	84.5869	96.987
ECOAL	IMP	HYDRO_HIGH	MED	0	0.3	0.07	2.45	2.0	7.3	7.0	14.3	84.5869	98.887

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
NACST	Costs for on site fuel treatment, incremental maintenane, incremental deprec. on turbine
NOXCST	Costs for on site exhaust gas treatment
SITECST	Sum of NACST PLUS NOXCST
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 4 (page 2 of 2)
PATH DETAILS FOR A FEW REPRESENTATIVE CASES
EMPHASIS ON SITE OPTION INFORMATION
ALL COMBINED CYCLE PATHS OF A CASE USE THE SAME WASHING OPTION

PLANT=NEW CASE=6010

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
HIGHS	IMP	HYDRO_VAC_MOD	HIGH	49	0.35	0.36	1100	0.5	5.4	6.6	12.0	85.1011	97.101
HIGHS	IMP	HYDRO_VAC_MOD	HIGH	49	0.35	0.36	1100	1.0	6.0	6.6	12.6	85.1011	97.701
HIGHS	IMP	HYDRO_VAC_MOD	HIGH	49	0.35	0.36	1100	2.0	7.9	6.6	14.5	85.1011	99.601
HIGHS	IMP	HYDRO_VAC_MOD	LOW	49	0.35	0.36	1100	0.5	6.7	8.1	14.8	85.1011	99.901
HIGHS	IMP	HYDRO_VAC_MOD	LOW	49	0.35	0.36	1100	1.0	7.0	8.1	15.1	85.1011	100.201
HIGHS	IMP	HYDRO_VAC_MOD	LOW	49	0.35	0.36	1100	2.0	8.9	8.1	17.0	85.1011	102.101
HIGHS	IMP	HYDRO_VAC_MOD	MED	49	0.35	0.36	1100	0.5	5.8	7.1	12.9	85.1011	98.001
HIGHS	IMP	HYDRO_VAC_MOD	MED	49	0.35	0.36	1100	1.0	6.3	7.1	13.4	85.1011	98.501
HIGHS	IMP	HYDRO_VAC_MOD	MED	49	0.35	0.36	1100	2.0	8.2	7.1	15.3	85.1011	100.401

PLANT=NEW CASE=6030

RMTYPE	MODE	PROCESS	CYCLE	METALS	N	S	VIS	NA	NACST	NOXCST	SITECST	FUELCST	TOTCST
HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	11	0.29	0.19	1100	0.5	4.8	6.5	11.3	87.3383	98.638
HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	11	0.29	0.19	1100	1.0	5.4	6.5	11.9	87.3383	99.238
HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	11	0.29	0.19	1100	2.0	7.3	6.5	13.8	87.3383	101.138
HIGHS	IMP	HYDRO_VAC_HIGH	LOW	11	0.29	0.19	1100	0.5	6.1	8.0	14.1	87.3383	101.438
HIGHS	IMP	HYDRO_VAC_HIGH	LOW	11	0.29	0.19	1100	1.0	6.4	8.0	14.4	87.3383	101.738
HIGHS	IMP	HYDRO_VAC_HIGH	LOW	11	0.29	0.19	1100	2.0	8.3	8.0	16.3	87.3383	103.638
HIGHS	IMP	HYDRO_VAC_HIGH	MED	11	0.29	0.19	1100	0.5	5.2	7.0	12.2	87.3383	99.538
HIGHS	IMP	HYDRO_VAC_HIGH	MED	11	0.29	0.19	1100	1.0	5.7	7.0	12.7	87.3383	100.038
HIGHS	IMP	HYDRO_VAC_HIGH	MED	11	0.29	0.19	1100	2.0	7.6	7.0	14.6	87.3383	101.938

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
NACST	Costs for on site fuel treatment, incremental maintenane, incremental deprec. on turbine
NOXCST	Costs for on site exhaust gas treatment
SITECST	Sum of NACST PLUS NOXCST
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 5
PATH DETAILS TO EXAMINE EFFECT OF C/H RATIO
EMPHASIS ON SITE OPTION INFORMATION

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	METALS	CTOH	FUELCST
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	50.40	7.36	80.691
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	10.90	7.33	82.491
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	HIGH	0.20	6.60	88.239
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	0.20	6.65	84.767
4.10	OLD	MIS	BOIL	1STAGE_HYDRO	HIGH	0.20	6.63	88.238
4.20	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	0.20	6.65	84.908
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.00	9.10	73.401
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	0.00	8.90	84.587
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.00	7.05	81.668
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	0.00	6.78	92.481
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	0.00	7.10	94.449
3030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	0.00	6.93	105.518
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.00	6.90	87.775
303A	NEW	SUR	IMP	HYD350+_HIGH	HIGH	0.00	6.73	92.597
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	1.30	7.45	79.187
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	0.05	7.38	79.637
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	49.00	7.40	85.101
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	11.00	7.35	87.338

A decrease of 0.1 in C/H ratio costs about 5 mills/KWHr

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
PROCESS	An abbreviated description of the upgrading scheme
CYCLE-HIGH	Combined cycle, 7000 hours/year, for power generation

PROPERTIES OF PRODUCED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

PATH COSTS (all mills/KWHr)

Name	Definition
FUELCST	Purchased cost of turbine fuel

TABLE 6 (page 1 of 4)
ALL PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1.10	OLD	LOWS	BOIL	DECARB	HIGH	0.5	84.317	10.8	95.117	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	HIGH	1.0	84.317	11.4	95.717	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	HIGH	2.0	84.317	13.3	97.617	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	SIMP	1.0	124.914	20.3	145.214	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	SIMP	2.0	124.914	20.6	145.514	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	SIMP	0.5	124.914	21.8	146.714	62.00	0.2	17.4	8.25	0.10	0.83	1100.00	92.7
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	84.793	10.7	95.493	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	HIGH	1.0	84.793	11.3	96.093	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	HIGH	2.0	84.793	13.2	97.993	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	125.619	19.1	144.719	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	SIMP	2.0	125.619	20.1	145.719	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	SIMP	0.5	125.619	20.6	146.219	62.00	0.0	37.2	6.63	0.09	0.05	1.00	92.3
1.22	OLD	LOWS	BOIL	COKE_HYD375+	HIGH	0.5	79.984	10.7	90.684	62.00	0.0	31.0	6.85	0.11	0.07	5.00	92.2
1.22	OLD	LOWS	BOIL	COKE_HYD375+	HIGH	1.0	79.984	11.3	91.284	62.00	0.0	31.0	6.85	0.11	0.07	5.00	92.2
1.22	OLD	LOWS	BOIL	COKE_HYD375+	HIGH	2.0	79.984	13.2	93.184	62.00	0.0	31.0	6.85	0.11	0.07	5.00	92.2
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	0.5	78.068	10.8	88.868	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	1.0	78.068	11.4	89.468	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	2.0	78.068	13.3	91.368	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	1.0	115.657	20.3	135.957	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	2.0	115.657	20.6	136.257	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	0.5	115.657	21.8	137.457	62.00	1.3	22.9	7.37	0.09	0.25	1100.00	92.7
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	1.0	78.004	11.4	89.404	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	2.0	78.004	13.3	91.304	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	2.0	115.562	20.6	136.162	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	0.5	115.562	21.8	137.362	62.00	0.6	23.1	7.36	0.09	0.21	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	0.5	78.055	10.8	88.855	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	1.0	78.055	11.4	89.455	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	2.0	78.055	13.3	91.355	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	1.0	115.638	20.3	135.938	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	2.0	115.638	20.6	136.238	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	0.5	115.638	21.8	137.438	62.00	0.1	24.4	7.33	0.09	0.17	1100.00	92.4
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.0	13.4	9.10	0.70	0.13	3.60	92.2
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	1.0	73.401	12.4	85.801	51.66	0.0	13.4	9.10	0.70	0.13	3.60	92.2
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	2.0	73.401	14.3	87.701	51.66	0.0	13.4	9.10	0.70	0.13	3.60	92.2
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	0.5	75.985	11.4	87.385	51.66	0.0	14.1	9.00	0.50	0.11	2.90	89.9
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	1.0	75.985	12.0	87.985	51.66	0.0	14.1	9.00	0.50	0.11	2.90	89.9
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	2.0	75.985	13.9	89.885	51.66	0.0	14.1	9.00	0.50	0.11	2.90	89.9
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	0.5	84.587	11.0	95.537	51.66	0.0	14.8	8.90	0.30	0.07	2.45	85.7
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	1.0	84.587	11.6	96.187	51.66	0.0	14.8	8.90	0.30	0.07	2.45	85.7
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	2.0	84.587	13.5	98.087	51.66	0.0	14.8	8.90	0.30	0.07	2.45	85.7
2.10	OLD	HIGHS	BOIL	DECARB	HIGH	0.5	81.874	11.3	93.174	59.00	11.6	21.7	7.55	0.27	0.26	1130.00	92.2
2.10	OLD	HIGHS	BOIL	DECARB	HIGH	1.0	81.874	11.9	93.774	59.00	11.6	21.7	7.55	0.27	0.26	1130.00	92.2
2.10	OLD	HIGHS	BOIL	DECARB	HIGH	2.0	81.874	13.8	95.674	59.00	11.6	21.7	7.55	0.27	0.26	1130.00	92.2

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TABLE 6 (page 2 of 4)
ALL PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCUST	METALS	API	CTOH	N	S	VIS	TH_EFF
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.730	10.9	100.530	59.00	0.0	37.7	6.65	0.1900	0.16[illegible]	[illegible].00	86.4
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	HIGH	1.0	89.730	11.5	101.230	59.00	0.0	37.7	6.65	0.1900	0.1[illegible]	.00	86.4
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	HIGH	2.0	89.730	13.4	103.130	59.00	0.0	37.7	6.65	0.1900	[illegible]	0	86.4
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	HIGH	0.5	90.578	10.7	101.278	59.00	0.0	31.5	6.83	0.110[illegible]	[illegible]	0	91.8
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	HIGH	1.0	90.578	11.3	101.878	59.00	0.0	31.5	6.83	0.110	[illegible]	0	91.8
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	HIGH	2.0	90.578	13.2	103.778	59.00	0.0	31.5	6.83	0.11[illegible]	[illegible]	.00	91.8
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	HIGH	0.5	89.807	10.9	100.707	59.00	0.0	22.3	7.45	0.1	[illegible]	[illegible].50	91.0
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	HIGH	1.0	89.807	11.5	101.307	59.00	0.0	22.3	7.45	0.1	[illegible]	26.50	91.0
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	HIGH	2.0	89.807	13.4	103.207	59.00	0.0	22.3	7.45	0.1[illegible]	[illegible]25[illegible]	26.50	91.0
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.4	23.0	7.36	0.360[illegible]	[illegible]700	1130.00	91.8
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	1.0	80.691	12.7	93.391	59.00	50.4	23.0	7.36	0.3600	0.[illegible]00	1130.00	91.8
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	2.0	80.691	14.6	95.291	59.00	50.4	23.0	7.36	0.3600	0.3700	1130.00	91.8
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	0.5	81.398	11.7	93.098	59.00	31.0	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	1.0	81.398	12.3	93.698	59.00	31.0	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	2.0	81.398	14.2	95.598	59.00	31.0	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	0.5	82.491	11.3	93.791	59.00	10.9	23.4	7.33	0.3000	0.2000	1130.00	91.6
.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	1.0	82.491	11.9	94.391	59.00	10.9	23.4	7.33	0.3000	0.2000	1130.00	91.6
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	2.0	82.491	13.8	96.291	59.00	10.9	23.4	7.33	0.3000	0.2000	1130.00	91.6
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.668	62.71	0.0	27.0	7.05	0.2600	0.0700	1.70	95.1
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	1.0	81.668	11.6	93.268	62.71	0.0	27.0	7.05	0.2600	0.0700	1.70	95.1
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	2.0	81.668	13.5	95.168	62.71	0.0	27.0	7.05	0.2600	0.0700	1.70	95.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	0.5	92.481	10.5	102.981	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	1.0	92.481	11.1	103.581	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	2.0	92.481	13.0	105.481	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	2.0	137.009	20.1	157.109	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	0.5	137.009	20.6	157.609	62.71	0.0	32.3	6.78	0.0001	0.0140	1.70	94.1
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	HIGH	0.5	83.238	10.5	96.738	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	HIGH	1.0	88.238	11.1	99.338	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	HIGH	2.0	88.238	13.0	101.238	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	SIMP	2.0	130.724	20.1	150.824	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	SIMP	0.5	130.724	20.6	151.324	50.86	0.2	38.0	6.60	0.0190	0.0015	2.35	82.2
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	1.0	84.767	11.2	95.967	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	2.0	84.767	13.1	97.867	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	2.0	125.581	20.1	145.681	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	0.5	125.581	20.6	146.181	50.86	0.2	37.5	6.65	0.0500	0.0040	2.35	82.8
3.30	OLD	SUR	BOIL	COKE_HYDC5+	HIGH	0.5	110.031	11.0	121.031	50.86	0.0	39.0	6.55	0.3000	0.0080	2.40	80.1
3.30	OLD	SUR	BOIL	COKE_HYDC5+	HIGH	1.0	110.031	11.6	121.631	50.86	0.0	39.0	6.55	0.3000	0.0080	2.40	80.1
3.30	OLD	SUR	BOIL	COKE_HYDC5+	HIGH	2.0	110.031	13.5	123.531	50.86	0.0	39.0	6.55	0.3000	0.0080	2.40	80.1
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.0	29.9	6.90	0.5400	0.0280	.	86.9
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	1.0	87.775	12.1	99.875	53.90	0.0	29.9	6.90	0.5400	0.0280	.	86.9
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	2.0	87.775	14.0	101.775	53.90	0.0	29.9	6.90	0.5400	0.0280	.	86.9

TABLE 5 (page 3 of 4)
ALL PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	0.5	94.448	11.4	105.848	53.90	0.0	25.0	7.10	0.500	0.0500	.	85.5
3010	NEW	SUP	IMP	HYD650+_MOD	HIGH	1.0	94.448	12.0	106.448	53.90	0.0	25.0	7.10	0.500	0.0500	.	85.5
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	2.0	94.448	13.9	108.348	53.90	0.0	25.0	7.10	0.500	0.0500	.	85.5
302A	NEW	SUR	IMP	HYD350+_INTER	HIGH	0.5	89.691	11.1	100.791	53.90	0.0	32.8	6.80	0.340	0.0210	.	85.5
302A	NEW	SUP	IMP	HYD350+_INTER	HIGH	1.0	89.691	11.7	101.391	53.90	0.0	32.8	6.80	0.340	0.0210	.	85.5
302A	NEW	SUR	IMP	HYD350+_INTER	HIGH	2.0	89.691	13.6	103.291	53.90	0.0	32.8	6.80	0.340	0.0210	.	85.5
3020	NEW	SUP	IMP	HYD650+_INTER	HIGH	0.5	97.161	11.0	108.161	53.90	0.0	27.0	6.86	0.300	0.0400	.	84.9
3020	NEW	SUP	IMP	HYD650+_INTER	HIGH	1.0	97.161	11.6	108.761	53.90	0.0	27.0	6.86	0.300	0.0400	.	84.9
3020	NEW	SUR	IMP	HYD650+_INTER	HIGH	2.0	97.161	13.5	110.661	53.90	0.0	27.0	6.86	0.300	0.0400	.	84.9
303A	NEW	SUP	IMP	HYD350+_HIGH	HIGH	0.5	92.597	10.7	103.297	53.90	0.0	34.2	6.73	0.108	0.0070	.	84.5
303A	NEW	SUP	IMP	HYD350+_HIGH	HIGH	1.0	92.597	11.3	103.897	53.90	0.0	34.2	6.73	0.108	0.0070	.	84.5
303A	NEW	SUR	IMP	HYD350+_HIGH	HIGH	2.0	92.597	13.2	105.797	53.90	0.0	34.2	6.73	0.108	0.0070	.	84.5
3030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	0.5	105.518	10.9	116.418	53.90	0.0	29.0	6.93	0.190	0.0120	.	83.7
3030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	1.0	105.518	11.5	117.018	53.90	0.0	29.0	6.93	0.190	0.0120	.	83.7
3030	NEW	SUP	IMP	HYD650+_HIGH	HIGH	2.0	105.518	13.4	118.918	53.90	0.0	29.0	6.93	0.190	0.0120	.	83.7
3040	NEW	SUR	BOIL	COKE-HYDRO_MOD	HIGH	0.5	109.298	11.4	120.698	53.90	0.0	37.0	6.60	0.500	0.0100	.	84.4
3040	NEW	SUR	BOIL	COKE-HYDRO_MOD	HIGH	1.0	109.298	12.0	121.298	53.90	0.0	37.0	6.60	0.500	0.0100	.	84.4
3040	NEW	SUP	BOIL	COKE-HYDRO_MOD	HIGH	2.0	109.298	13.9	123.198	53.90	0.0	37.0	6.60	0.500	0.0100	.	84.4
3050	NEW	SUP	BOIL	COKE_HYDRO_INT	HIGH	0.5	106.791	11.0	117.791	53.90	0.0	39.0	6.57	0.300	0.0080	.	84.2
3050	NEW	SUP	BOIL	COKE_HYDRO_INT	HIGH	1.0	106.791	11.6	118.391	53.90	0.0	39.0	6.57	0.300	0.0080	.	84.2
3050	NEW	SUP	BOIL	COKE_HYDRO_INT	HIGH	2.0	106.791	13.5	120.291	53.90	0.0	39.0	6.57	0.300	0.0080	.	84.2
3060	NEW	SUP	BOIL	COKE_HYDRO_HIGH	HIGH	0.5	108.655	10.6	119.255	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
3060	NEW	SUP	BOIL	COKE_HYDRO_HIGH	HIGH	1.0	108.655	11.2	119.855	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	HIGH	2.0	108.655	13.1	121.755	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
3050	NEW	SUP	BOIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
3050	NEW	SUP	BOIL	COKE_HYDRO_HIGH	SIMP	2.0	160.971	20.1	181.071	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
3050	NEW	SUR	BOIL	COKE_HYDRO_HIGH	SIMP	0.5	160.971	20.6	181.571	53.90	0.0	40.7	6.50	0.060	0.0000	.	82.8
4010	OLD	MIS	BOIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4010	OLD	MIS	BOIL	1STAGE_HYDRO	HIGH	1.0	88.238	11.1	99.338	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4010	OLD	MIS	BOIL	1STAGE_HYDRO	HIGH	2.0	88.238	13.0	101.238	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4010	OLD	MIS	BOIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4010	OLD	MIS	BOIL	1STAGE_HYDRO	SIMP	2.0	130.724	20.1	150.824	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4010	OLD	MIS	BOIL	1STAGE_HYDRO	SIMP	0.5	130.724	20.6	151.324	53.81	0.2	37.2	6.63	0.019	0.0015	2.35	88.2
4020	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
4020	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	1.0	84.908	11.2	96.108	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
4020	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	2.0	84.908	13.1	98.008	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
4020	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
4020	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	2.0	125.790	20.1	145.890	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
4020	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	0.5	125.790	20.6	146.390	53.81	0.2	36.7	6.65	0.050	0.0040	2.35	88.9
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.1	32.0	6.80	0.300	0.0250	.	93.3
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	1.0	90.900	11.6	102.500	58.00	0.1	32.0	6.80	0.300	0.0250	.	93.3
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	2.0	90.900	13.5	104.400	58.00	0.1	32.0	6.80	0.300	0.0250	.	93.3
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	0.5	98.755	11.0	109.755	58.00	0.1	27.0	6.86	0.300	0.0400	.	90.5
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	1.0	98.755	11.6	110.355	58.00	0.1	27.0	6.86	0.300	0.0400	.	90.5
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	2.0	98.755	13.5	112.255	58.00	0.1	27.0	6.86	0.300	0.0400	.	90.5

TABLE 6 (page 4 of 4)
ALL PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCOST	SITECOST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	1.0	79.187	11.4	90.587	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	2.0	79.187	13.3	92.487	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	2.0	117.314	20.6	137.914	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	0.5	117.314	21.8	139.114	49.02	1.30	22.4	7.45	0.09	0.26	1100.0	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	0.5	79.341	10.8	90.141	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	1.0	79.341	11.4	90.741	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	2.0	79.341	13.3	92.641	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	1.0	117.543	20.3	137.843	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	2.0	117.543	20.6	138.143	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	0.5	117.543	21.8	139.343	49.02	0.50	22.6	7.45	0.09	0.23	1100.0	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	79.637	10.8	90.437	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	1.0	79.637	11.4	91.037	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	2.0	79.637	13.3	92.937	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	1.0	117.981	20.3	138.281	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	2.0	117.981	20.6	138.581	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	0.5	117.981	21.8	139.781	49.02	0.05	23.0	7.38	0.09	0.19	1100.0	98.1
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	82.543	10.7	93.243	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	1.0	82.543	11.3	93.843	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	2.0	82.543	13.2	95.743	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	122.286	19.1	141.386	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	SIMP	2.0	122.286	20.1	142.386	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	SIMP	0.5	122.286	20.5	142.786	49.02	0.00	37.2	6.64	0.09	0.05	1.7	95.4
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.00	22.9	7.40	0.35	0.36	1100.0	93.8
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	1.0	85.101	12.6	97.701	45.44	49.00	22.9	7.40	0.35	0.36	1100.0	93.8
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	2.0	85.101	14.5	99.601	45.44	49.00	22.9	7.40	0.35	0.36	1100.0	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	0.5	85.693	11.7	97.393	45.44	30.00	23.0	7.37	0.35	0.27	1100.0	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	1.0	85.693	12.3	97.993	45.44	30.00	23.0	7.37	0.35	0.27	1100.0	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	2.0	85.693	14.2	99.893	45.44	30.00	23.0	7.37	0.35	0.27	1100.0	93.8
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	87.338	11.3	98.638	45.44	11.00	23.2	7.35	0.29	0.19	1100.0	93.2
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	1.0	87.338	11.9	99.238	45.44	11.00	23.2	7.35	0.29	0.19	1100.0	93.2
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	2.0	87.338	13.8	101.138	45.44	11.00	23.2	7.35	0.29	0.19	1100.0	93.2
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.987	10.7	100.687	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	1.0	89.987	11.3	101.287	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	2.0	89.987	13.2	103.187	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	19.1	152.414	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	2.0	133.314	20.1	153.414	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	0.5	133.314	20.6	153.914	45.44	0.00	37.7	6.68	0.09	0.16	1.7	94.5

TABLE 7 (page 1 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1.10	OLD	LOWS	BOIL	DECARB	HIGH	0.5	94.317	10.8	95.117	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
1.10	OLD	LOWS	BOIL	DECARB	SIMP	1.0	124.914	20.3	145.214	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	84.793	10.7	95.493	62.00	0.00	37.2	6.63	0.0900	0.0500	1.00	92.3
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	125.619	19.1	144.719	62.00	0.00	37.2	6.63	0.0900	0.0500	1.00	92.3
1.22	OLD	LOWS	BOIL	COKE_HYD375+	HIGH	0.5	79.984	10.7	90.684	62.00	0.00	31.0	6.85	0.1100	0.0700	5.00	92.2
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	0.5	78.068	10.8	88.868	62.00	1.30	22.9	7.37	0.0900	0.2500	1100.00	92.7
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	1.0	115.657	20.3	135.957	62.00	1.30	22.9	7.37	0.0900	0.2500	1100.00	92.7
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	0.5	78.055	10.8	88.855	62.00	0.10	24.4	7.33	0.0900	0.1700	1100.00	92.4
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	1.0	115.638	20.3	135.938	62.00	0.10	24.4	7.33	0.0900	0.1700	1100.00	92.4
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.00	13.4	9.10	0.7000	0.1300	3.60	92.2
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	0.5	75.995	11.4	87.385	51.66	0.00	14.1	9.00	0.5000	0.1100	2.90	89.9
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	0.5	84.587	11.0	95.587	51.66	0.00	14.8	8.90	0.3000	0.0700	2.45	85.7
2.10	OLD	HIGHS	BOIL	DECARB	HIGH	0.5	81.874	11.3	93.174	59.00	11.60	21.7	7.55	0.2700	0.2600	1130.00	92.2
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.730	10.9	100.630	59.00	0.00	37.7	6.65	0.1900	0.1600	1.00	86.4
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	HIGH	0.5	90.578	10.7	101.278	59.00	0.00	31.5	6.83	0.1100	0.2000	5.00	91.8
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	HIGH	0.5	89.807	10.9	100.707	59.00	0.00	22.3	7.45	0.1900	0.2500	26.50	91.0
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.40	23.0	7.36	0.3600	0.3700	1130.00	91.8
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	0.5	81.398	11.7	93.098	59.00	31.00	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	0.5	82.491	11.3	93.791	59.00	10.90	23.4	7.33	0.3000	0.2000	1130.00	91.6
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.658	11.0	92.668	62.71	0.00	27.0	7.05	0.2600	0.0700	1.70	95.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	0.5	92.481	10.5	102.981	62.71	0.00	32.3	6.78	0.0001	0.0140	1.70	94.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.00	32.3	6.78	0.0001	0.0140	1.70	94.1

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 7 (page 2 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
3.10	OLD	SUR	BUIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	50.86	0.20	38.0	6.60	0.0190	0.0015	2.35	82.2
3.10	OLD	SUR	BUIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	50.86	0.20	38.0	6.60	0.0190	0.0015	2.35	82.2
3.20	OLD	SUR	BUIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
3.20	OLD	SUR	BUIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
3.30	OLD	SUR	BUIL	COKE_HYDC5+	HIGH	0.5	110.031	11.0	121.031	50.86	0.00	39.0	6.55	0.3000	0.0080	2.40	80.1
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.00	29.9	6.90	0.5400	0.0280	.	85.9
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	0.5	94.448	11.4	105.848	53.90	0.00	25.0	7.10	0.5000	0.0500	.	85.5
302A	NEW	SUR	IMP	HYD350+_INTER	HIGH	0.5	89.691	11.1	100.791	53.90	0.00	32.8	6.80	0.3400	0.0210	.	85.5
3020	NEW	SUR	IMP	HYD650+_INTER	HIGH	0.5	97.161	11.0	108.161	53.90	0.00	27.0	6.86	0.3000	0.0400	.	84.9
303A	NEW	SUR	IMP	HYD350+_HIGH	HIGH	0.5	92.597	10.7	103.297	53.90	0.00	34.2	6.73	0.1080	0.0070	.	84.5
3030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	0.5	105.518	10.9	116.418	53.90	0.00	29.0	6.93	0.1900	0.0120	.	83.7
3040	NEW	SUR	BUIL	COKE-HYDRO_MOD	HIGH	0.5	109.298	11.4	120.698	53.90	0.00	37.0	6.60	0.5000	0.0100	.	84.4
3050	NEW	SUR	BUIL	COKE_HYDRO_INT	HIGH	0.5	106.791	11.0	117.791	53.90	0.00	39.0	6.57	0.3000	0.0080	.	84.2
3060	NEW	SUR	BUIL	COKE_HYDRO_HIGH	HIGH	0.5	108.655	10.6	119.255	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
3060	NEW	SUR	BUIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
4.10	OLD	MIS	BUIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
4.10	OLD	MIS	BUIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
4.20	OLD	MIS	BUIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
4.20	OLD	MIS	BUIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.10	32.0	6.80	0.3000	0.0250	.	93.3
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	0.5	98.755	11.0	109.755	58.00	0.10	27.0	6.86	0.3000	0.0400	.	90.5

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BUIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr t power produced)

Name	Definition
SITECST	Costs for on site fuel treatment, incremental maint. and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCS.

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TABLE 7 (page 3 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	0.5	79.341	10.8	90.141	49.02	0.50	22.6	7.45	0.0900	0.2300	1100.00	98.3
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	1.0	117.543	20.3	137.843	49.02	0.50	22.6	7.45	0.0900	0.2300	1100.00	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	79.637	10.8	90.437	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	1.0	117.981	20.3	138.281	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	82.543	10.7	93.243	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
5040	NEW	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	122.286	19.1	141.386	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.00	22.9	7.40	0.3500	0.3600	1100.00	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	0.5	85.693	11.7	97.393	45.44	30.00	23.0	7.37	0.3500	0.2700	1100.00	93.8
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	87.338	11.3	98.638	45.44	11.00	23.2	7.35	0.2900	0.1900	1100.00	93.2
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.997	10.7	100.687	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	19.1	152.414	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 9 (page 1 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-PLANT) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.00	13.4	9.10	0.7000	0.1300	3.60	92.2
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	0.5	75.985	11.4	87.385	51.66	0.00	14.1	9.00	0.5000	0.1100	2.90	89.9
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	0.5	79.341	10.8	90.141	49.02	0.50	22.6	7.45	0.0900	0.2300	1100.00	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	79.637	10.8	90.437	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.668	62.71	0.00	27.0	7.05	0.2500	0.0700	1.70	95.1
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	82.543	10.7	93.243	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	0.5	84.587	11.0	95.587	51.66	0.00	14.8	8.90	0.3000	0.0700	2.45	85.7
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.00	22.9	7.40	0.3500	0.3600	1100.00	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	0.5	85.693	11.7	97.393	45.44	30.00	23.0	7.37	0.3500	0.2700	1100.00	93.8
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	87.338	11.3	98.638	45.44	11.00	23.2	7.35	0.2900	0.1900	1100.00	93.2
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.00	29.9	6.90	0.5400	0.0280	.	86.9
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.987	10.7	100.687	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5
302A	NEW	SUR	IMP	HYD350+_INTER	HIGH	0.5	89.691	11.1	100.791	53.90	0.00	32.8	6.80	0.3400	0.0210	.	85.5
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.10	32.0	6.80	0.3000	0.0250	.	93.3
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	0.5	92.481	10.5	102.981	62.71	0.00	32.3	6.78	0.0001	0.0140	1.70	94.1
303A	NEW	SUR	IMP	HYD350+_HIGH	HIGH	0.5	92.597	10.7	103.297	53.90	0.00	34.2	6.73	0.1080	0.0070	.	84.5
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	0.5	94.448	11.4	105.848	53.90	0.00	25.0	7.10	0.5000	0.0500	.	85.5
3020	NEW	SUR	IMP	HYD650+_INTER	HIGH	0.5	97.161	11.0	108.161	53.90	0.00	27.0	6.86	0.3000	0.0400	.	84.9
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	0.5	98.755	11.0	109.755	58.00	0.10	27.0	6.86	0.3000	0.0400	.	90.5
2030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	0.5	105.518	10.9	116.418	53.90	0.00	29.0	6.93	0.1900	0.0120	.	83.7
30[illegible]	NEW	SUR	BOIL	COKE_HYDRO_INT	HIGH	0.5	106.791	11.0	117.791	53.90	0.00	39.0	6.57	0.3000	0.0080	.	84.2
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	HIGH	0.5	108.655	10.6	119.255	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
3040	NEW	SUR	BOIL	COKE-HYDRO_MOD	HIGH	0.5	109.298	11.4	120.698	53.90	0.00	37.0	6.60	0.5000	0.0100	.	84.4

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
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RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
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-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 1.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 9 (page 2 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-PLANT) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	0.5	78.055	10.8	88.855	62.00	0.10	24.4	7.33	0.0900	0.1790	1100.00	92.4
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	0.5	78.068	10.8	88.868	62.00	1.30	22.9	7.37	0.0900	0.2500	1100.00	92.7
1.22	OLD	LOWS	BUIL	COKE_HYD375+	HIGH	0.5	79.984	10.7	90.684	62.00	0.00	31.0	6.85	0.1100	0.0700	5.00	92.2
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.40	23.0	7.36	0.3600	0.3700	1130.00	91.8
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	0.5	81.398	11.7	93.098	59.00	31.00	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.10	OLD	HIGHS	BUIL	DECARB	HIGH	0.5	81.874	11.3	93.174	59.00	11.60	21.7	7.55	0.2700	0.2600	1130.00	92.2
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	0.5	82.491	11.3	93.791	59.00	10.90	23.4	7.33	0.3000	0.2000	1130.00	91.6
1.10	OLD	LOWS	BUIL	DECARB	HIGH	0.5	84.317	10.8	95.117	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
3.20	OLD	SUR	BUIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
1.21	OLD	LOWS	BUIL	COKE_HYDC5+	HIGH	0.5	84.793	10.7	95.493	62.00	0.00	37.2	6.53	0.0900	0.0500	1.00	92.3
4.20	OLD	MIS	BUIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
4.10	OLD	MIS	BUIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
3.10	OLD	SUR	BUIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	50.86	0.20	38.0	6.60	0.0190	0.0015	2.35	82.2
2.21	OLD	HIGHS	BUIL	COKE_HYDC5+	HIGH	0.5	89.730	10.9	100.630	59.00	0.00	37.7	6.65	0.1900	0.1600	1.00	86.4
2.23	OLD	HIGHS	BUIL	COKE_HYD650+	HIGH	0.5	89.807	10.9	100.707	59.00	0.00	22.3	7.45	0.1900	0.2500	26.50	91.0
2.22	OLD	HIGHS	BUIL	COKE_HYD375+	HIGH	0.5	90.578	10.7	101.278	59.00	0.00	31.5	6.83	0.1100	0.2000	5.00	91.8
3.30	OLD	SUR	BUIL	COKE_HYDC5+	HIGH	0.5	110.031	11.0	121.031	50.86	0.00	39.0	6.55	0.3000	0.0090	2.40	80.1

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
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PLANT-OLD	Upgrading scheme uses an augmented existing facility
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-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
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PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
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VIS	viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
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TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (All are mills per KWHr net power produced)

Name	Definition
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FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 8 (page 1 of 3)

PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-PLANT) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	1.0	117.543	20.3	137.843	49.02	0.50	22.6	7.45	0.0900	0.2300	1100.00	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	1.0	117.981	20.3	138.281	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
5040	NEW	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	122.286	19.1	141.386	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	19.1	152.414	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.00	32.3	6.78	0.0001	0.0140	1.70	94.1
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	1.0	115.638	20.3	135.938	62.00	0.10	24.4	7.33	0.0900	0.1700	1100.00	92.4
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	1.0	115.657	20.3	135.957	62.00	1.30	22.9	7.37	0.0900	0.2500	1100.00	92.7
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	SIMP	1.0	125.619	19.1	144.719	62.00	0.00	37.2	6.63	0.0900	0.0500	1.00	92.3
4.20	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
1.10	OLD	LOWS	BOIL	DECARB	SIMP	1.0	124.914	20.3	145.214	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
4.10	OLD	MIS	BOIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	50.86	0.20	33.0	6.60	0.0190	0.0015	2.35	82.2

ATH IDENTIFIERS

Name	Definition
ASE	Identifier for the fuel upgrading scheme
ROCESS	An abbreviated description of the upgrading scheme
LANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
MTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
ODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
YCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
A	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental depreс. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 9 (page 1 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-RMTYPE) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.00	13.4	9.10	0.7000	0.1300	3.60	92.2
1020	NEW	ECOAL	IMP	HYDRO_INTER	HIGH	0.5	75.985	11.4	87.385	51.66	0.00	14.1	9.00	0.5000	0.1100	2.90	89.9
1030	NEW	ECOAL	IMP	HYDRO_HIGH	HIGH	0.5	84.587	11.0	95.587	51.66	0.00	14.8	8.90	0.3000	0.0700	2.45	85.7
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.40	23.0	7.36	0.3600	0.3700	1130.00	91.8
2.32	OLD	HIGHS	IMP	HDS_INTER	HIGH	0.5	81.398	11.7	93.098	59.00	31.00	23.2	7.35	0.3600	0.2900	1130.00	91.7
2.10	OLD	HIGHS	BOIL	DECARB	HIGH	0.5	81.874	11.3	93.174	59.00	11.60	21.7	7.55	0.2700	0.2600	1130.00	92.2
2.33	OLD	HIGHS	IMP	HDS_HIGH	HIGH	0.5	82.491	11.3	93.791	59.00	10.90	23.4	7.33	0.3000	0.2000	1130.00	91.6
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.00	22.9	7.40	0.3500	0.3600	1100.00	93.8
6020	NEW	HIGHS	IMP	HYDRO_VAC_INTER	HIGH	0.5	85.693	11.7	97.393	45.44	30.00	23.0	7.37	0.3500	0.2700	1100.00	93.8
6030	NEW	HIGHS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	87.338	11.3	98.638	45.44	11.00	23.2	7.35	0.2900	0.1900	1100.00	93.2
2.21	OLD	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.730	10.9	100.630	59.00	0.00	37.7	6.65	0.1900	0.1600	1.00	86.4
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	HIGH	0.5	89.987	10.7	100.687	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5
2.23	OLD	HIGHS	BOIL	COKE_HYD650+	HIGH	0.5	89.807	10.9	100.707	59.00	0.00	22.3	7.45	0.1900	0.2500	26.50	91.0
2.22	OLD	HIGHS	BOIL	COKE_HYD375+	HIGH	0.5	90.578	10.7	101.278	59.00	0.00	31.5	6.83	0.1100	0.2000	5.00	91.8
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	HIGH	0.5	78.055	10.8	88.855	62.00	0.10	24.4	7.33	0.0900	0.1700	1100.00	92.4
1.31	OLD	LOWS	IMP	HDS_MOD	HIGH	0.5	78.068	10.8	88.868	62.00	1.30	22.9	7.17	0.0900	0.2500	1100.00	92.7
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	HIGH	0.5	79.341	10.8	90.141	49.02	0.50	22.6	7.45	0.0900	0.2300	1100.00	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	HIGH	0.5	79.637	10.8	90.437	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
1.22	OLD	LOWS	BOIL	COKE_HYD375+	HIGH	0.5	79.984	10.7	90.684	62.00	0.00	31.0	6.85	0.1100	0.0700	5.00	92.2
5040	NEW	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	82.543	10.7	93.243	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
1.10	OLD	LOWS	BOIL	DECARB	HIGH	0.5	84.317	10.8	95.117	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
1.21	OLD	LOWS	BOIL	COKE_HYDC5+	HIGH	0.5	84.793	10.7	95.493	62.00	0.00	37.2	6.63	0.0900	0.0500	1.00	92.3

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment , incremental maint. and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 9 (page 2 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-RMTYPE) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
4.20	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
4.10	OLD	MIS	BOIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.10	32.0	6.80	0.3000	0.0250	.	93.3
4020	NEW	MIS	IMP	HYD650+_INTER	HIGH	0.5	98.755	11.0	109.755	58.00	0.10	27.0	6.86	0.3000	0.0400	.	90.5
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
3.10	OLD	SUR	BOIL	1STAGE_HYDRO	HIGH	0.5	88.238	10.5	98.738	50.86	0.20	38.0	6.60	0.0190	0.0015	2.35	82.2
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.00	29.9	6.90	0.5400	0.0280	.	86.9
302A	NEW	SUR	IMP	HYD350+_INTER	HIGH	0.5	89.691	11.1	100.791	53.90	0.00	32.8	6.80	0.3400	0.0210	.	85.5
303A	NEW	SUR	IMP	HYD350+_HIGH	HIGH	0.5	92.597	10.7	103.297	53.90	0.00	34.2	6.73	0.1080	0.0070	.	84.5
3010	NEW	SUR	IMP	HYD650+_MOD	HIGH	0.5	94.448	11.4	105.848	53.90	0.00	25.0	7.10	0.5000	0.0500	.	85.5
3020	NEW	SUR	IMP	HYD650+_INTER	HIGH	0.5	97.161	11.0	108.161	53.90	0.00	27.0	6.86	0.3000	0.0400	.	84.9
3030	NEW	SUR	IMP	HYD650+_HIGH	HIGH	0.5	105.518	10.9	116.418	53.90	0.00	29.0	6.93	0.1900	0.0120	.	83.7
3050	NEW	SUR	BOIL	COKE_HYDRO_INT	HIGH	0.5	106.791	11.0	117.791	53.90	0.00	39.0	6.57	0.3000	0.0080	.	84.2
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	HIGH	0.5	108.655	10.6	119.255	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
3040	NEW	SUR	BOIL	COKE-HYDRO_MOD	HIGH	0.5	109.298	11.4	120.698	53.90	0.00	37.0	6.60	0.5000	0.0100	.	84.4
3.30	OLD	SUR	BOIL	COKE_HYDC5+	HIGH	0.5	110.031	11.0	121.031	50.86	0.00	39.0	6.55	0.3000	0.0080	2.40	80.1
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.668	62.71	0.00	27.0	7.05	0.2600	0.0700	1.70	95.1
2020	NEW	WCOAL	IMP	HYDRO_ALL	HIGH	0.5	92.481	10.5	102.981	62.71	0.00	32.3	6.78	0.0001	0.0140	1.70	94.1

ATH IDENTIFIERS

Name	Definition
ASE	Identifier for the fuel upgrading scheme
ROCESS	An abbreviated description of the upgrading scheme
LANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
MTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
ODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
YCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
A	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 9 (page 3 of 3)
PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
SHOWS BEST ONSITE OPTION FOR EACH CASE / CYCLE COMBINATION
HIGHLIGHTS COST PROFILES FOR (CYCLE-RMTYPE) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
6040	NEW	HIGHS	BOIL	COKE_HYDCS+	SIMP	1.0	133.314	19.1	152.414	45.44	0.00	37.7	6.68	0.0900	0.1600	1.70	94.5
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.60	23.1	7.36	0.0900	0.2100	1100.00	92.8
1.33	OLD	LOWS	IMP	HDS_HIGH	SIMP	1.0	115.638	20.3	135.938	62.00	0.10	24.4	7.33	0.0900	0.1700	1100.00	92.4
1.31	OLD	LOWS	IMP	HDS_MOD	SIMP	1.0	115.657	20.3	135.957	62.00	1.30	22.9	7.37	0.0900	0.2500	1100.00	92.7
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.30	22.4	7.45	0.0900	0.2600	1100.00	98.5
5020	NEW	LOWS	IMP	HYDRO_VAC_INTER	SIMP	1.0	117.543	20.3	137.843	49.02	0.50	22.5	7.45	0.0900	0.2300	1100.00	98.3
5030	NEW	LOWS	IMP	HYDRO_VAC_HIGH	SIMP	1.0	117.981	20.3	138.281	49.02	0.05	23.0	7.38	0.0900	0.1900	1100.00	98.1
5040	NEW	LOWS	BOIL	COKE_HYDCS+	SIMP	1.0	122.286	19.1	141.386	49.02	0.00	37.2	6.64	0.0900	0.0500	1.70	95.4
1.21	OLD	LOWS	BOIL	COKE_HYDCS+	SIMP	1.0	125.619	19.1	144.719	62.00	0.00	37.2	6.63	0.0900	0.0500	1.00	92.3
1.10	OLD	LOWS	BOIL	DECARB	SIMP	1.0	124.914	20.3	145.214	62.00	0.20	17.4	8.25	0.1000	0.8300	1100.00	92.7
4.20	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.770	19.1	144.870	53.81	0.20	36.7	6.65	0.0500	0.0040	2.35	88.9
4.10	OLD	MIS	BOIL	ISTAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	53.81	0.20	37.2	6.63	0.0190	0.0015	2.35	88.2
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.20	37.5	6.65	0.0500	0.0040	2.35	82.8
3.10	OLD	SUR	BOIL	ISTAGE_HYDRO	SIMP	1.0	130.724	19.1	149.824	50.86	0.20	38.0	6.60	0.0190	0.0015	2.35	82.2
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.00	40.7	6.50	0.0600	0.0000	.	82.8
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.00	32.3	6.79	0.0001	0.0140	1.70	94.1

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium Content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, Centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint. and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 10

PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
BEST ONSITE OPTIONS FOR EACH TURBINE-FUEL/DUTY CYCLE COMBINATION
AND BEST RAW MATERIAL PROCESSING OPTIONS
SHOWS COST PROFILES FOR (CYCLE-PLANT) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.0	13.4	9.10	0.7000	0.130	3.60	92.2
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.3	22.4	7.45	0.0900	0.260	1100.00	98.5
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.669	62.71	0.0	27.0	7.05	0.2600	0.070	1.70	95.1
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.0	22.9	7.40	0.3500	0.360	1100.00	93.8
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.0	29.9	6.90	0.5400	0.028	.	86.9
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.1	32.0	6.80	0.3000	0.025	.	93.3
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.6	23.1	7.36	0.0900	0.210	1100.00	92.8
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.4	23.0	7.36	0.3600	0.370	1130.00	91.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.2	37.5	6.65	0.0500	0.004	2.35	82.8
4.20	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.2	36.7	6.65	0.0500	0.004	2.35	88.9
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.3	22.4	7.45	0.0900	0.260	1100.00	98.5
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	19.1	152.414	45.44	0.0	37.7	6.68	0.0900	0.160	1.70	94.5
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.0	32.3	6.78	0.0001	0.014	1.70	94.1
3050	NEW	SUR	BOIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.0	40.7	6.50	0.0600	0.000	.	82.8
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.6	23.1	7.36	0.0900	0.210	1100.00	92.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.2	37.5	6.65	0.0500	0.004	2.35	82.8
4.20	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.2	36.7	6.65	0.0500	0.004	2.35	88.9

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 11

PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
BEST ONSITE OPTIONS FOR EACH TURBINE-FUEL/DUTY CYCLE COMBINATION
AND BEST RAW MATERIAL PROCESSING OPTIONS
SHOWS COST PROFILES FOR (CYCLE-RMTYPE) COMBINATIONS

CASE	PLANT	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
2.31	OLD	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.4	23.0	7.36	0.3600	0.370	1130.00	91.8
6010	NEW	HIGHS	IMP	HYDRO_VAC_MOD	HIGH	0.5	85.101	12.0	97.101	45.44	49.0	22.9	7.40	0.3500	0.360	1100.00	93.8
1.32	OLD	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.6	23.1	7.36	0.0900	0.210	1100.00	92.8
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	HIGH	0.5	79.187	10.8	89.987	49.02	1.3	22.4	7.45	0.0900	0.260	1100.00	98.5
4.20	OLD	MIS	BOIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.2	36.7	6.65	0.0500	0.004	2.35	88.9
402A	NEW	MIS	IMP	HYD350+_INTER	HIGH	0.5	90.900	11.0	101.900	58.00	0.1	32.0	6.80	0.3000	0.025	.	93.3
3.20	OLD	SUR	BOIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.2	37.5	6.65	0.0500	0.004	2.35	82.8
301A	NEW	SUR	IMP	HYD350+_MOD	HIGH	0.5	87.775	11.5	99.275	53.90	0.0	29.9	6.90	0.5400	0.028	.	86.9
1010	NEW	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0.0	13.4	9.10	0.7000	0.130	3.60	92.2
2010	NEW	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.668	62.71	0.0	27.0	7.05	0.2600	0.070	1.70	95.1
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	[illegible]	152.414	45.44	0.0	37.7	6.68	0.0900	0.160	1.70	94.5
1.32	OLD	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	[illegible]	135.862	62.00	0.6	23.1	7.36	0.0900	0.210	1100.00	92.8
5010	NEW	LOWS	IMP	HYDRO_VAC_MOD	SIMP	1.0	117.314	20.3	137.614	49.02	1.3	22.4	7.45	0.0900	0.260	1100.00	98.5
4.20	OLD	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.2	36.7	6.65	0.0500	0.004	2.35	88.9
3.20	OLD	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.2	37.5	6.65	0.0500	0.004	2.35	82.8
3060	NEW	SUR	BOIL	COKE_HYDRO_HIGH	SIMP	1.0	160.971	19.1	180.071	53.90	0.0	40.7	6.50	0.0600	0.000	.	82.8
2020	NEW	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0.0	32.3	6.78	0.0001	0.014	1.70	94.1

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification capability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS ,

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

TABLE 12

PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
BEST ONSITE OPTIONS FOR EACH TURBINE-FUEL/DUTY CYCLE COMBINATION
AND BEST RAW MATERIAL-PROCESSING-PLANT OPTIONS

CYCLE=HIGH

CASE	PLANT	RMTYPE	MODE	PROCESS	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1010	NEW	ECOAL	IMP	HYDRO_MOD	0.5	73.4012	11.8	85.2012	51.66	0.0	13.4	9.10	0.70	0.130	3.60	92.2
1.32	OLD	LOWS	IMP	HDS_INTER	0.5	78.0040	10.8	88.8040	62.00	0.6	23.1	7.36	0.09	0.210	1100.00	92.8
2010	NEW	WCOAL	IMP	HYDRO_NAPH	0.5	81.6683	11.0	92.6683	62.71	0.0	27.0	7.05	0.26	0.070	1.70	95.1
2.31	OLD	HIGHS	IMP	HDS_MOD	0.5	80.6912	12.1	92.7912	59.00	50.4	23.0	7.36	0.3[illegible]	0.370	1130.00	91.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	0.5	84.7669	10.6	95.3669	50.86	0.2	37.5	6.65	0.05	0.004	2.35	82.8
4.20	OLD	MIS	BOIL	HYDRO_HIGH	0.5	84.9083	10.6	95.5083	53.81	0.2	36.7	6.65	0.05	0.004	2.35	88.9

CYCLE=SIMP

CASE	PLANT	RMTYPE	MODE	PROCESS	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1.32	OLD	LOWS	IMP	HDS_INTER	1	115.562	20.3	135.862	62.00	0.6	23.1	7.36	0.0900	0.210	1100.00	92.8
3.20	OLD	SUR	BOIL	HYDRO_HIGH	1	125.581	19.1	144.681	50.86	0.2	37.5	6.65	0.0500	0.004	2.35	82.8
4.20	OLD	MIS	BOIL	HYDRO_HIGH	1	125.790	19.1	144.890	53.81	0.2	36.7	6.65	0.0500	0.004	2.35	88.9
6040	NEW	HIGHS	BOIL	COKE_HYDC5+	1	133.314	19.1	152.414	45.44	0.0	37.7	6.68	0.0900	0.160	1.70	94.5
2020	NEW	WCOAL	IMP	HYDRO_ALL	1	137.009	19.1	156.109	62.71	0.0	32.3	6.78	0.0001	0.014	1.70	94.1

A row in this table shows the best (least total cost) feasible plant-raw material-upgrading-onsite processing combination for a combined and for a simple turbine cycle

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cycle, 1500 hours/year, for power generation
-HIGH	Combined cycle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 13

PATHS FOR SIMPLE (SIMP) AND HIGH DUTY COMBINED (HIGH) CYCLES
BEST ONSITE OPTIONS FOR EACH TURBINE-FUEL/DUTY CYCLE COMBINATION
AND BEST RAW MATERIAL-PROCESSING-PLANT OPTIONS

PLANT=NEW

CASE	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1010	ECOAL	IMP	HYDRO_MOD	HIGH	0.5	73.401	11.8	85.201	51.66	0	13.4	9.10	0.7000	0.130	3.6	92.2
2010	WCOAL	IMP	HYDRO_NAPH	HIGH	0.5	81.668	11.0	92.668	62.71	0	27.0	7.05	0.2600	0.070	1.7	95.1
6040	HIGHS	BOIL	COKE_HYDC5+	SIMP	1.0	133.314	19.1	152.414	45.44	0	37.7	6.68	0.0900	0.150	1.7	94.5
2020	WCOAL	IMP	HYDRO_ALL	SIMP	1.0	137.009	19.1	156.109	62.71	0	32.3	6.78	0.0001	0.014	1.7	94.1

PLANT=OLD

CASE	RMTYPE	MODE	PROCESS	CYCLE	NA	FUELCST	SITECST	TOTCST	RMCOST	METALS	API	CTOH	N	S	VIS	TH_EFF
1.32	LOWS	IMP	HDS_INTER	HIGH	0.5	78.004	10.8	88.804	62.00	0.6	23.1	7.36	0.09	0.210	1100.00	92.8
2.31	HIGHS	IMP	HDS_MOD	HIGH	0.5	80.691	12.1	92.791	59.00	50.4	23.0	7.36	0.36	0.370	1130.00	91.8
3.20	SUR	BOIL	HYDRO_HIGH	HIGH	0.5	84.767	10.6	95.367	50.86	0.2	37.5	6.65	0.05	0.004	2.35	82.8
4.20	MIS	BOIL	HYDRO_HIGH	HIGH	0.5	84.908	10.6	95.508	53.81	0.2	36.7	6.65	0.05	0.004	2.35	88.9
1.32	LOWS	IMP	HDS_INTER	SIMP	1.0	115.562	20.3	135.862	62.00	0.6	23.1	7.36	0.09	0.210	1100.00	92.8
3.20	SUR	BOIL	HYDRO_HIGH	SIMP	1.0	125.581	19.1	144.681	50.86	0.2	37.5	6.65	0.05	0.004	2.35	82.8
4.20	MIS	BOIL	HYDRO_HIGH	SIMP	1.0	125.790	19.1	144.890	53.81	0.2	36.7	6.65	0.05	0.004	2.35	88.9

A row in this table shows the best (least total cost) feasible cycle-raw material-upgrading-onsite processing combination for a new and for an augmented existing facility.

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PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme
PROCESS	An abbreviated description of the upgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an Western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cyle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity. centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal eff. (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
SITECST	Costs for on site fuel treatment ,incremental maint.and incremental deprec. on turbine and on site exhaust gas treatment
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 14
NOMENCLATURE FOR TABLES

PATH IDENTIFIERS

Name	Definition
CASE	Identifier for the fuel upgrading scheme used on the path
PROCESS	An abbreviated description of the udgrading scheme
PLANT-OLD	Upgrading scheme uses an augmented existing facility
-NEW	Upgrading scheme uses a grass roots facility
RMTYPE-ECOAL	A coal liquid from an Eastern bituminous coal
-WCOAL	A coal liquid from an western bituminous coal
-MIS	A shale oil from a modified insitu retort
-SUR	A shale oil from a surface retort
-LOWS	A low sulfur petroleum crude oil
-HIGHS	A high sulfur petroleum crude oil
MODE-BOIL	Upgrading scheme primarily alters boiling ranges
-IMP	Upgrading scheme primarily removes impurities
CYCLE-SIMP	Simple cyle, 1500 hours/year, for power generation
-HIGH	Combined cycle, 7000 hours/year, for power generation
NA	On site sodium purification cabability
-.05	from 50 ppm to 0.5 ppm NA in washed fuel
-1.0	from 50 ppm to 1.0 ppm NA in washed fuel
-2.0	from 50 ppm to 2.0 ppm NA in washed fuel

PROPERTIES OF CONSUMED TURBINE FUEL

Name	Definition
API	Density, degree API
CTOH	Carbon to Hydrogen weight ratio
METALS	Vanadium content, ppm by weight
N	Nitrogen Content, % by weight
S	Sulfur content, % by weight
VIS	Viscosity, centistoke at 100 degree F

UPGRADING SCHEME COST PARAMETERS

Name	Definition
ERMTL	Cost of fuel for processing, $ per mm BTU of products
EELECT	Cost of electricity for processing, $ per mm BTU of products
EWAT	Cost of water for processing, $ per mm BTU of products
FUELPR	Turbine fuel selling price for scheme, $ per BBL
RMCOST	Raw material purchase cost for scheme, $ per BBL
TH_EFF	Thermal effeciency (energy in products/ energy in fuel)

PATH COSTS (all are mills per KWHr net power produced)

Name	Definition
NACST	Costs for on site fuel treatment plus incremental maintenane and incremental depreciation on turbine
NOXCST	Costs for on site exhaust gas treatment
SITECST	Sum of NACST plus NOXCST
FUELCST	Cost of turbine fuel
TOTCST	Sum of SITECST and FUELCST

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TABLE 15
DEFINITION OF PROCESS NAMES

CASE	PROCESS	ABBREVIATED DESCRIPTION
1.10, 2.10	DECARB	Solvent decarbonization vac bottoms
1.21, 2.21, 3.30 5040, 6040	COKE_HYDC5+	Delayed coking + hydrotreating of naphtha distillate
1.22, 2.22 2.21, 2.22	COKE_HYD375+	Delayed coking + hydrotreating of c5+ to 950 distillate
1.23, 2.23	COKE_HYD650+	Delayed coking + hydrotreating of 650 to 950 distillate
1.31, 2.31	HDS_MOD	Hydrodesulf vac bottoms, mod sever
1.32, 2.32	HDS_INTER	Hydrodesulf vac bottoms, inter sever
1.33, 2.33	HDS_HIGH	Hydrodesulf vac bottoms, high sever
3.10, 4.10	1STAGE_HYDRO	Severe hydrotreating + distillate desulf
3.20, 4.20, 1030	HYDRO_HIGH	Hydrotreating, high severity
1010	HYDRO_MOD	Hydrotreating, moderate severity
1020	HYDRO_INTER	Hydrotreating, intermediate severity
2010	HYDRO_NAPH	Hydrotreating, naphtha only
2020	HYDRO_ALL	Hydrotreating, entire raw feed
301A	HYD350+_MOD	Hydrotreating, mod sever, 350+ dist
3010	HYD650+_MOD	Hydrotreating, mod sever, 650+ dist
302A, 402A	HYD350+_INTER	Hydrotreating, inter sever, 350+ dist
3020, 4020	HYD650+_INTER	Hydrotreating, inter sever, 650+ dist
303A	HYD350+_HIGH	Hydrotreating, high sever, 350+ dist
3030	HYD650+_HIGH	Hydrotreating, high sever, 650+ dist
3040	COKE-HYDRO_MOD	Delayed coking, mod hydrotreat, c5+ dist
3050	COKE_HYDRO_INT	Delayed coking, inter hydrotreat, c5+ dist
3060	COKE_HYDRO_HIGH	Delayed coking, severe hydrotreat, c5+ dist
5010, 6010	HYDRO_VAC_MOD	Hydrotreating vac bottoms, mod severity
5020, 6020	HYDRO_VAC_INTER	Hydrotreating vac bottoms, inter severity
5030, 6030	HYDRO_VAC_HIGH	Hydrotreating vac bottoms, high severity