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MARTIN MARIETTA

Replacement Cost Integration Program (Reserve Replacement Version)

User's Guide

J. R. Einstein
L. D. Trowbridge

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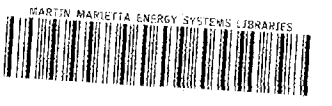

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ABSTRACT

RCIP, the Replacement Cost Integration Program, was developed for the Department of Energy's Office of Planning and Environment within the Office of Fossil Energy. It is a PC-based tool designed to aid the study of the replacement of domestic oil reserves by new discoveries. Its function is primarily to translate regional supply functions (replacement cost/quantity functions) for undiscovered oil into a projection of future reserve additions.

The primary data input to RCIP takes the form of undiscovered resource bases broken down by region and production cost. Other assumptions address demand for domestic oil, resource availability as a function of time (leasing and technology constraints), and availability of enhanced oil recovery (EOR) production . A series of menus allows the user to control many of these data elements to create a wide range of scenarios of future oil discoveries. Projections of reserve additions are made by selecting demanded quantities by a series of simplified priority schemes, the most important of which is that the least costly resources will be discovered first.

The user's guide for RCIP contains detailed directions for operation of the RCIP system of programs, as well as a description of the program logic, assumptions, and data sources.

INTRODUCTION

RCIP, the Replacement Cost Integration Program, is a tool designed to aid the study of the replacement of domestic oil reserves by new discoveries. The basic premise of the model is that the nation will attempt to hold reserves of oil constant - that is, that production from domestic reserves will be balanced by new discoveries.

The primary data input to RCIP takes the form of oil demand schedules and undiscovered resource bases broken down by region and production cost. Other parameters address resource availability as a function of time (leasing and technology constraints), and availability of enhanced oil recovery production (EOR). The user has control over many of these parameters in the form of choices among pre-established estimates. There is also a more limited capability for direct input of parameter values.

The basic logic of RCIP is fairly straightforward. The user-controlled and intrinsic data sets are processed to create a large table of resources "available for discovery". This table is subdivided into resource regions and cost-of-production brackets. During each 5-year time period, RCIP attempts to replace that period's oil production by selecting available resources from this table. Resources are selected in a priority order until either the production quota has been met, or available resources have been exhausted. The priority for selection is primarily by cost (inexpensive resources being selected first) and then by a predetermined regional priority scheme (in general, resources are selected first in those areas where oil production has a significant history, and latest in those areas requiring novel technologies or that are remote from existing processing infrastructure). Each period, the resource availability table is updated by addition of resources previously unavailable due to technological or leasing constraints.

The calculation outlined above is repeated for each period (1983 through 2005) and the results are retained internally. Four results for each region and period may be output: the average cost of the new reserves, the range of costs, the quantities added to reserves, and the

average lead time for actual production from the new reserves. For each of these elements, a table can be generated either to the screen or to a printer.

Once created, the input parameter selections and calculated results for a given scenario can be stored onto a disk file. Previously stored scenarios may be recalled later for examination, and it is possible to simultaneously retain in memory and directly compare two scenarios.

The above description is an overview of RCIP. More detailed instructions and descriptions of the above features will be covered below.

USING RCIP

RCIP is designed to estimate the production cost of new oil discoveries under the assumption that production from known reserves will be balanced by new discoveries. The primary data requirements are estimates of:

(1) Future domestic oil production

(2) Cost/resource functions for each potential discovery region

(3) Timing parameters for new technology availability and leasing and land set-aside constraints.

The user has control over many of these parameters either in the form of selections from a range of pre-defined values or by direct input of parameter values.

The program is driven by a series of interconnected menus, employs extensive prompts to aid the proper use of the model, and is well-protected against improper data entry. Should an unrecoverable error occur and terminate the program, a message similar to the following will appear:

```
Run-time error 02, PC=2867
Program aborted
```

The authors of the program should be notified of such an occurrence. To aid in correcting the error, please make a note of the entire message, and the conditions under which it occurred.

Loading and Running RCIP

RCIP is designed to run under PC-DOS on an IBM PC, PC-XT or PC-AT with 2 disk drives (one floppy disk drive and one hard disk or two

floppy disk drives). RCIP contains 5 program files (RCIP.COM, MENU.CHN, SCREENS.CHN, UTIL.CHN, and OUT.CHN) and two data files (RCIP.INP and PQ1.DAT). These files must reside in the same directory either on a diskette or on a hard disk. In addition to the above files, a separate diskette for storing scenario files may optionally be used.

To start RCIP, two steps are required:

(1) Change the default directory to that directory containing the RCIP program and data files. For example, if these files resided on a directory named "MODELS" you would type:

CHDIR MODELS

(2) To activate the model, type: RCIP

Once RCIP has been activated, the user is guided through operations by an extensive series of interconnected menu-driven screen displays. Descriptions of these screens and their associated operations are presented below, and images of the screens and related output are presented in Figures 1 through 17 on pages 15 through 23.

Figure 1. Main Menu Screen

A number of options are presented to the user, as shown in Fig. 1. These include retrieving and saving scenario parameters to disk files, editing program parameters, running the program, and selection of output for viewing or printing. More specifically:

EDIT Option

The edit option on the main menu permits the user to choose values for program parameters such as resource size, oil demand, and others. Selection of this option calls a series of seven parameter input screens. Use of these screens will be described in the EDIT SUBSYSTEM, below.

Retrieve Scenario From Disk

Selection of the "Retrieve" option in the menu screen allows you to use a previously defined scenario's parameters as those to be edited with the "Edit" option, or its results to be used for output. On first selecting "Retrieve", the following display will appear:

```
                    RETRIEVE SCENARIO FROM DISK

    No scenario disk is loaded.
    Choose option:  load disk  -or-  abort  (l,a)
```

Entering "a" will return you to the main menu. Choosing "l" will result in the further question:

```
    Which drive is used for Scenario (data) diskette?  (a,b):
```

The user should answer this question appropriately, the following prompt appears (illustrated for the case of drive a):

```
    Place Scenario Disk in drive a:
    When ready, press  Esc
```

The user should insert a previously created scenario diskette into the appropriate drive and push the "Esc" key. Creation of such scenario diskettes is covered under the "Utilities" option, below. RCIP will confirm that the data disk is a valid scenario disk. If it is, the user will be shown the disk title and asked to confirm that this is indeed the disk desired:

```
    Loaded disk has title: Test RCIP Data - start 1/10/86
    Is this the correct disk to use for the present purpose?
       (y: yes;   n: no;   a: abort menu selection)
```

If the user answers "n", the program asks for a new scenario disk. If the answer is "y", the table of contents for the scenario disk is shown. For example:

SELECTION OF SCENARIO FOR RETRIEVAL

Scenario disk: Test RCIP Data - start 1/10/86 Pg 1 of 1

0001<---->Baseline scenario
0002 Pessimistic : Low supply; high demand

A scenario is selected by moving the arrow to the desired entry line using the Up and Down Arrow keys, then pushing the F1 key.

Print Parameter Summary

The "Print parameter summary" selection lists the titles of the parameter sets defined by each screen in the "Edit" process. Fig. 9 is an example of such a summary.

Store Scenario From Memory to Disk

This option allows you to store the results of the scenario to the scenario diskette. As with the retrieve option, the user will be prompted to load the disk if this has not previously been done. The user will be asked for a 4 digit number (actually, letters will be accepted as well) and a title to identify the scenario. Selection of a duplicate identification number results in a request for a new number; old scenario information will not be destroyed through inadvertant overwriting. A sample "Store" sequence is shown below:

STORE SCENARIO TO DISK

Enter scenario number for directory (4 digits) : 0002
This scenario number is already in this directory. Choose another.

Enter scenario number for directory (4 digits) : 0003

Enter scenario title for directory (up to 70 characters)

Duplicate Baseline scenario 1/25/86

Are scenario number and title OK? (y,n):

Once the indicated scenario is loaded, the program returns to the main menu.

Calculate Results

The "Calculate" option processes the scenario data to create four data sets which represent the output of RCIP. These data sets are accessed via the "Output Menu" option.

Before the calculation commences, the user is given the option of choosing a printed summary of the output. If a printed summary is selected, a page similar to that shown in Fig. 10 is printed. This summary page will identify the scenario, indicate whether the production in each period was equalled by reserve additions, list the scenario's economic benefit values, and give a list of the data output for each region and period of time. Regions are identified by their ID number, for which a key is listed at the bottom of the summary page. Data elements displayed are quantity of reserves selected; the minimum, maximum, and average marginal production costs; the average lead time before production begins. At the right of this table, regional totals are given for resource selection during all periods; at the bottom of the table, period summaries are listed covering all regions.

If the user chooses not to generate the printed summary, a more abbreviated running commentary of the calculation is displayed to the screen, as shown in Fig. 11.

Once the scenario is calculated, more detailed output may be obtained using the "Output Menu" selection.

Go to Utilities Menu

At present, the Utilities Menu contains only one operation: Creation of a new scenario diskette. Upon selection of this operation, the user will be prompted to select a drive (A: or B:), insert a disk, and enter a disk title. The diskette used will be reformatted, destroying any data already present on the diskette; the user is warned of this.

Go to Output Menu

This selection transfers control to the Output Menu subprogram described below. An error message results if the scenario has not been calculated yet. Should this occur, simply push the "Esc" key, select the "Calculate" option, then return to the "Output" menu.

Exit from RCIP

This selection ends RCIP and returns control to DOS.

EDIT SUBSYSTEM

As described above, on selection of "Edit" in the main menu, the user enters the Edit Subsystem. In this system, the user is presented with a series of seven screens, each allowing selection a set of parameters. In all cases one or more default parameter sets is available to the user. In some cases, more detailed editing of individual parameters is permitted. In each case, the bottom line of the screen will show valid entries. In most cases, the F1 and F2 keys (i.e. Function Keys 1 and 2) permit selection among pre-defined data sets or values, the F5 key will allow more detailed editing of parameters, the F10 key advances the program to the next screen, and the F9 key returns to the previous screen. To exit the EDIT routine, the user must choose F10 in the last screen (advanced EOR technology date selection). A description of each screen within the EDIT routine follows:

Figure 2. Demand Track

The demand track is the estimate used by the program of the schedule of reserve additions to be achieved through new discoveries. This is implicitly treated as equivalent to domestic oil production. RCIP will attempt to replace reserves by means of new discoveries in the amounts shown here. Three selections are presented for complete demand tracks, one from Lewin & Assoc., the second from DOE/OPPA, and the third from DOE/EIA. Alternatively, the user may enter individual numbers for each of the periods.

Figure 3. Size and Distribution of Domestic Resource

The second edit screen is devoted to selection of the size of the ultimately recoverable resource. Estimates of undiscovered oil resources are selected for each of 20 regions. Three standard data sets are available based on the low, mean, and high USGS Circular 860 estimates for all regions. In addition, the user may create custom data sets by selecting a mixture of low, mean and high estimates on a region-by-region basis. It should be noted that resource values have been corrected for discoveries made between publication of USGS Circ. 860 and the beginning of the model and also that regional "low" and "high" estimates have been scaled such that the sum of the regional estimates will equal the appropriate USGS estimate for the total USA.

Figure 4. Alternative Lease Schedule and Land Setaside Scenario

This screen permits selection of the scheduling of resource availability due to lease and land setaside constraints. RCIP assumes that for each region, a certain fraction of the recoverable resource is available for discovery before a specified date, and that a further fraction becomes available after that date. The user can control both fractions and the availability date. This may be done on three levels of detail. The least detailed is the selection of one of three predefined estimates for all regions, one being a best-guess current projection of availability and date, and the other two being accelerated and delayed availability projections. The second level of detail is to select among these three projections individually for each region, and the third level allows the user to define all the parameters as desired.

Figure 5. Timing of Advanced Technology for Offshore Alaska

This screen allows the user to select the timing and effectiveness of advanced offshore technology in the Arctic. The parameters controlled are the fraction of resource available without advanced technology, the fraction available with advanced technology, and the date of introduction of that technology. These parameters may be controlled either by selection of predefined data sets or by explicit user specification of each parameter. The predefined parameter sets are estimates for scenarios in which advanced technology is developed according to optimistic, pessimistic, and best-guess schedules.

Figure 6. Baseline EOR

The Baseline EOR screen allows the user to select cost/supply parameters for EOR. Two pre-defined tables are provided, one based on estimates of Lewin & Assoc. and the other on estimates published by the NPC.[2] The user may choose to specify other values.

Figure 7. EOR: Constraints on Production

This screen establishes a schedule of limits on EOR production for each time period. A predefined estimate by Lewin & Assoc. is provided, and the user has the option of specifying alternate limits.

Figure 8. Introduction of Advanced EOR Technology

This screen allows the user to select the date of introduction of advanced technology for EOR. After the date selected, EOR becomes 50% more effective.

At the completion of this last screen, the parameters for a scenario have been defined, and the results may be calculated.

OUTPUT MENU

The output menu display is shown in Fig. 12. The operations are grouped into two categories: Setup and Action. In general, the user may want to select several setup options before generating output with one of the "Action" options.

"Setup" operations are concerned with selecting the type of data to output, the regions or aggregate regions from which to list data, and the output device to be used. The default condition is: "output oil supply for all of the default aggregate regions to the screen".

Aggregation Scheme

This option allows the user to set up an aggregation scheme for output listings. Fig. 13 shows the default scheme that will appear upon first loading RCIP. A series of questions will be asked:

Want to change aggregation scheme ? (y,n):

If the answer is yes, then the user will have the opportunity to enter new aggregate numbers for each region. This aggregation number defines the group to which a region belongs. Each region must be a member of any one such group, and no aggregation number may be skipped (i.e. if some region belongs to group "6", then there must be at least one region in each of groups "1" through "5"). There is no other restriction on grouping. If RCIP is not satisfied with the user's numbering system, then an error message will be displayed and an opportunity will be given to correct the numbering scheme. While entering numbers, the following rules apply:

{Return} results in no change to a region's group number

Single digit integers are entered followed by {Return}

Double digit integers: enter the two digits,
NOT followed by a {Return}.

When all regions have been numbered, the following question is asked:

Is this aggregation scheme OK ? (y,n):

An answer of "n" recycles the user through the numbering again; if the numbering is satisfactory to the user, the appropriate answer is "y". At this point the question will be asked:

Wish to edit aggregate names ? (y,n):

An answer of "y" permits alteration of the aggregate names. As before, the user is given an opportunity to correct errors before finishing.

Note that the "Aggregation scheme" option deals only with defining the membership in aggregate groups. The "Select Regions for Output" option must be used to set up output from these aggregates.

Retrieve Second Scenario for Comparison

This option allows the user to select a previously calculated and stored scenario. The results from this second scenario will be displayed along with those of the scenario currently resident in memory. The aggregation schemes and output selections will be those of the current session.

Select Regions for Output

This section defines the regions to be output. The first question asked is:

Want selection among individual (i) subregions or
aggregate (a) regions ?

An answer of "i" presents the list of supply regions. The "Up Arrow" and "Down Arrow" keys move a cursor from one region to another; a region will be included in output if the user pushes "F1"; it can be excluded by pushing the "Del" key. The "F10" key completes the selection process.

Regions selected for output will be indicated by an asterisk. Answering the above question with "a" presents the current list of aggregate names. Selection of aggregate regions is done similarly to selection of individual regions.

Choose Result to Output

This setup parameter defines the variable to be used in subsequent output operations. The choices given are:

Supply
Minimum-maximum prices
Average Price
Average Leadtime

"Supply" output will present quantities of oil reserves (in units of million barrels) added in each selected region and in each time period. "Minimum-maximum prices" output will contain the lowest and highest cost brackets selected. "Average price" will produce output containing weighted averages of costs. "Average Leadtime" will give a weighted average leadtime required for the first actual production from a particular resource addition.

Direct Output to Printer
and
Direct Output to Display

These options direct subsequently generated output to the device indicated. The default choice is the display screen; the default will be set each time the Output Menu is re-entered.

Output Table (Figs. 14 through 17)

This option selects and generates tabular output of one of the four results listed above. Appropriate results will be displayed for each region or aggregate area selected for output. At the right of the table, a column of regional summaries is displayed covering all periods. At the bottom appears a row of period summaries for all regions (including those not selected for display). If the setup has not been adequately defined, a warning is issued. For example, if no regions have been selected for output, the following appears:

No regions have been selected. Press Esc to return to menu.

This rarely occurs, as a default selection is automatically loaded when the program begins. The appropriate action to take, however, is indicated by the prompt: Push "Esc", then use the "Select Regions" setup option.

Output Graph

Graphical output is not yet implemented. A message to this effect is given when this option is selected. It is contemplated this option will allow the creation of output files compatible with the Microsoft "Chart" graphics package.

Return to Main Menu

This option returns control to the main menu.

REPLACEMENT COST INTEGRATION PROGRAM (v. 1.10) - MAIN MENU

```
                 ------------------------
                |      Parameters     <------- From scenario on disk
Scenario:       |       -------              and/or program options,
                |       Results              with editing if desired.
                 ------------------------
```

Retrieve scenario from disk to memory

Edit parameters in memory (program options available)

Print parameter summary

Calculate results

Store scenario from memory to disk

Go to Output menu

Go to Utilities menu

EXit from RCIP

Fig. 1. Image of "Main Menu" Screen Display

DEMAND TRACK

OPTION: Constant (Lewin)

PERIOD	Average Production Rate (MMB/D)
1983-1984	8.2
1985-1989	8.2
1990-1994	8.2
1995-1999	8.2
2000-2004	8.2
2005-2009	8.2

Fig. 2. Image of "Demand Track" Screen Display

SIZE AND DISTRIBUTION OF DOMESTIC RESOURCE BASE
OPTION: USGS Mean (all regions)
Undiscovered oil (B BBL) (USGS C.860, corrected for discoveries in 1980-1982

Lower-48 Onshore		
West Coast	Mean	4.3
Rocky Mts.	Mean	22.5
Mid-Cont.	Mean	3.9
West Texas	Mean	4.9
Gulf Coast	Mean	5.8
Appalachia	Mean	2.6
Alaska Onshore	Mean	6.9
Gulf Coast Offshore		
Shelf	Mean	2.9
Slope	Mean	2.0
Atlantic Offshore		
N & C Shelf	Mean	1.2
N & C Slope	Mean	3.2
S Slope	Mean	0.9
West Coast Offshore		
S Shelf	Mean	0.7
N Shelf	Mean	0.3
S Slope	Mean	0.9
N Slope	Mean	0.7
Alaska Offshore		
Shelf-LoRisk	Mean	2.4
Shelf-HiRisk	Mean	8.4
Slope-LoRisk	Mean	0.4
Slope-HiRisk	Mean	1.0

Fig. 3. Image of "Site and Distribution of Domestic Resource Base" Screen Display.

ALTERNATIVE LEASE-SCHEDULE AND LAND-SET-ASIDE SCENARIO
OPTION: Current Projection (all regions)
Parameters are percent of resource available, before and after date.

		%	DATE	%
Lower-48 Onshore				
West Coast	CrntProj	98	2000	0
Rocky Mts.	CrntProj	96	2000	0
Mid-Cont.	CrntProj	100	2000	0
West Texas	CrntProj	100	2000	0
Gulf Coast	CrntProj	100	2000	0
Appalachia	CrntProj	100	2000	0
Alaska Onshore				
ANWR	CrntProj	0	2000	100
NPR-A	CrntProj	81	2000	19
Other	CrntProj	100	2000	0
Gulf Coast Offshore				
Shelf	CrntProj	100	2000	0
Slope	CrntProj	100	2000	0
Atlantic Offshore				
N & C Shelf	CrntProj	0	2000	100
N & C Slope	CrntProj	0	2000	100
S Slope	CrntProj	100	2000	0
West Coast Offshore				
S Shelf	CrntProj	0	2000	100
N Shelf	CrntProj	0	2000	100
S Slope	CrntProj	0	2000	100
N Slope	CrntProj	0	2000	100
Alaska Offshore				
Shelf-LoRisk	CrntProj	58	2000	42
Shelf-HiRisk	CrntProj	63	2000	37
Slope-LoRisk	CrntProj	0	2000	100
Slope-HiRisk	CrntProj	0	2000	100

Fig. 4. Image of "Alternative Lease-Schedule and Land-Set-Aside Scenario" Screen Display.

TIMING OF ADVANCED TECHNOLOGY FOR OFFSHORE ALASKA

OPTION: Current projection

	Percent of Resources Recoverable		
	Before	Date	After
Shelf-Low Risk	100	2000	0
Shelf-High Risk	42	2000	58
Slope-Low Risk	100	2000	0
Slope-High Risk	0	2000	100

Fig. 5. Image of "Timing of Advanced Technology for Offshore Alaska" Screen Display.

BASELINE EOR

OPTION:	NPC
Price ($/BBL)	Supply (B BBL)
< 30	14.5
30-40	3.5
40-50	1.5
50-60	0.0
60-80	0.0
80-100	0.0

Fig. 6. Image of "Baseline EOR" Screen Display.

EOR: CONSTRAINTS ON PRODUCTION

OPTION: Lewin

PERIOD	Maximum Production Over Period (B BBL)
1983-1984	0.3
1985-1989	1.6
1990-1994	1.9
1995-1999	2.1
2000-2004	2.1
2005-2009	1.8

Fig. 7. Image of "EOR: Constraints on Production" Screen Display.

INTRODUCTION OF ADVANCED EOR TECHNOLOGY

DATE: 1990

Fig. 8. Image of "Introduction of Advanced EOR Technology" Screen Display.

RCIP SCENARIO No. none

Demand: User-defined

1983-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009
5.2	6.1	5.9	5.9	5.3	5.1

Size and Distribution of Domestic Resource Base: USGS Mean (all regions)

Lease-Schedule and Land-Set-Aside Scenario: Current Projection (all regions)

Timing of Advanced Technology for Offshore Alaska: Current projection

Baseline EOR: NPC

EOR: Constraints on Production: Lewin

Date of Introduction of Advanced EOR Technology: 1990

Fig. 9. Sample Parameter Summary Listing.

SUMMARY OF RESULTS FOR SCENARIO No. none

Quota Track (MMB/PERIOD)

	1983-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009
To be filled:	5986	14965	14965	14965	14965	14965
Final:	0	0	0	0	0	0

Measures of (inverse) economic benefit (Billion $-1983) (1983 $/Bbl)

By methodology of DFI:	388.43	4.81
By methodology of L&A:	2720.51	33.67

REG	1983-1989					1990-1994					1995-1999					2000-2004					2005-2009					Tot Qty
1	2747	30	30	30	3	351	30	35	32	3	590	35	45	40	3	0	-	-	-	-	348	45	55	50	3	4036
2	12775	30	30	30	3	1422	30	35	31	3	4218	33	45	37	3	0	-	-	-	-	2188	45	55	50	3	20603
3	2173	30	30	30	3	572	30	32	31	3	751	33	45	39	3	0	-	-	-	-	268	45	55	50	3	3764
4	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	2797	48	55	52	3	2797
5	3256	30	30	30	3	1185	30	32	31	3	843	33	45	38	3	0	-	-	-	-	398	45	55	49	3	5682
6	0	-	-	-	-	1892	30	32	30	3	385	33	45	38	3	0	-	-	-	-	216	45	55	50	3	2493
7	0	-	-	-	-	2538	30	30	30	3	1336	30	45	35	3	2314	30	37	31	3	656	35	55	46	3	6844
8	0	-	-	-	-	1774	30	30	30	6	999	30	45	35	6	0	-	-	-	-	116	45	55	48	6	2889
9	0	-	-	-	-	973	30	30	30	10	773	30	45	37	10	0	-	-	-	-	208	43	55	48	11	1954
10	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	1195	30	40	30	8	5	40	47	43	5	1200
11	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	2526	30	35	30	13	656	35	55	44	11	3182
12	0	-	-	-	-	702	30	30	30	12	140	30	40	35	13	0	-	-	-	-	43	40	55	46	12	885
13	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	695	30	40	30	6	5	40	47	43	5	700
14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	297	30	40	30	6	3	40	47	44	6	300
15	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	739	30	35	30	8	155	35	55	42	8	894
16	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	424	30	35	31	8	259	35	55	41	8	683
17	0	-	-	-	-	354	30	30	30	7	534	30	40	34	7	507	30	35	31	7	972	35	55	45	7	2367
18	0	-	-	-	-	352	30	30	30	7	1246	30	40	34	7	3118	30	35	31	7	2737	35	52	41	7	7453
19	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	235	40	50	46	9	235
20	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0
21	0	-	-	-	-	2850	30	30	30	3	3150	30	30	30	3	3150	30	30	30	3	2700	30	30	30	3	11850
All	20951	30	30	30	3	14965	30	35	30	4	14965	30	45	35	4	14965	30	40	30	7	14965	30	55	44	5	80811

Regions

ONSHORE	OFFSHORE			
1. West Coast	8. Gulf Coast Shelf	13. West Coast S Shelf	17. Alaska Shelf-LoRisk	21. EOR
2. Rocky Mts.	9. Slope	14. N Shelf	18. Shelf-HiRisk	
3. Mid-Cont.	10. Atlantic N & C Shelf	15. S Slope	19. Slope-LoRisk	
4. West Texas	11. N & C Slope	16. N Slope	20. Slope-HiRisk	
5. Gulf Coast	12. S Slope			
6. Appalachia				

Results for each region and period are:
- Reserves added during period (MM Bbl)
- Minimum marginal cost (1983 $)
- Maximum marginal cost
- Average marginal cost
- Average lead time (yrs)

Fig. 10. Sample Summary Printout.

CALCULATION OF RESULTS FOR THIS SCENARIO

Quota Track (MMB/PERIOD)

	1983-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009
To be filled:	5986	14965	14965	14965	14965	14965
Final:	0	0	0	7398	0	2961

Quota not satisfied!

Measures of (inverse) economic benefit (Billion $-1983) (1983 $/Bbl)

By methodology of DFI:	524.06	6.49
By methodology of L&A:	3187.46	39.44

Press Esc to return to menu.

Fig. 11. Image of "Results Summary" Screen Display.

OUTPUT OF RESULTS OF CALCULATIONS -- MENU

Setup
- Aggregation scheme
- Retrieve Second scenario for comparison in tables and/or graphs
- Select Regions for output
- Choose result to output
- Direct output to Printer
- Direct output to Display

Action
- Output Table
- Output Graph

Return to main Menu

Selection:

Fig. 12. Image of "Output Menu" Screen Display.

SUBREGIONS		AGGREGATION SCHEME		
West Coast Onshore	1	1	48 Onshore	West Coast Onshore
Rocky Mountains	1	.		Rocky Mountains
Mid-Continent	1	.		Mid-Continent
West Texas	1	.		West Texas
Gulf Coast	1	.		Gulf Coast
Appalachia	1	.		Appalachia
Alaska On	2	2	Alaska Onshore	Alaska On
Gulf Coast Shelf	3	3	48 Shelf	Gulf Coast Shelf
Gulf Coast Slope	4	.		Atlantic N&C Shelf
Atlantic N&C Shelf	3	.		West Coast N Shelf
Atlantic N&C Slope	4	.		West Coast S Shelf
Atlantic S Slope	4	4	48 Slope	Gulf Coast Slope
West Coast N Shelf	3	.		Atlantic N&C Slope
West Coast S Shelf	3	.		Atlantic S Slope
West Coast N Slope	4	.		West Coast N Slope
West Coast S Slope	4	.		West Coast S Slope
Alaska Shelf LoRisk	5	5	Alaska Shelf LoRisk	Alaska Shelf LoRisk
Alaska Shelf HiRisk	6	6	Alaska Shelf HiRisk	Alaska Shelf HiRisk
Alaska Slope LoRisk	7	7	Alaska Slope LoRisk	Alaska Slope LoRisk
Alaska Slope HiRisk	8	8	Alaska Slope HiRisk	Alaska Slope HiRisk
EOR	9	9	EOR	EOR

Fig. 13. Image of "Aggregation Scheme" Screen Display.

	SUPPLY (MMB)					
	1983-1989	1990-1994	1995-1999	2000-2004	2005-2009	Summary
48 Onshore	20951	3870	7711	0	5278	37810
Alaska Onshore	0	3108	557	2354	714	6733
48 Shelf	0	2769	110	2771	45	5695
48 Slope	0	1943	873	3007	1219	7042
Alaska Shelf LoRisk	0	425	839	761	372	2397
Alaska Shelf HiRisk	0	0	1725	2855	3725	8305
Alaska Slope LoRisk	0	0	0	67	304	371
Alaska Slope HiRisk	0	0	0	0	608	608
EOR	0	2850	3150	3150	2700	11850
All Regions:	20951	14965	14965	14965	14965	80811

Fig. 14. Sample "Supply (MMB)" Output Table.

	AVERAGE PRICE ($-1983)					
	1983-1989	1990-1994	1995-1999	2000-2004	2005-2009	Summary
48 Onshore	30	32	38	-	52	35
Alaska Onshore	-	30	34	31	47	32
48 Shelf	-	30	33	30	47	30
48 Slope	-	30	33	32	39	33
Alaska Shelf LoRisk	-	30	33	31	42	33
Alaska Shelf HiRisk	-	-	35	33	42	37
Alaska Slope LoRisk	-	-	-	34	40	39
Alaska Slope HiRisk	-	-	-	-	49	49
EOR	-	30	30	30	30	30
All Regions:	30	30	35	31	44	34

Fig. 15. Sample "Average Price" Output Table.

	MINIMUM-MAXIMUM PRICE ($-1983)											
	1983-1989		1990-1994		1995-1999		2000-2004		2005-2009		Summary	
48 Onshore	30	30	30	35	33	45	-	-	43	60	30	60
Alaska Onshore	-	-	30	30	30	40	30	40	40	55	30	55
48 Shelf	-	-	30	30	30	40	30	40	40	55	30	55
48 Slope	-	-	30	30	30	40	30	40	35	55	30	55
Alaska Shelf LoRisk	-	-	30	30	30	40	30	35	35	55	30	55
Alaska Shelf HiRisk	-	-	-	-	30	40	30	35	35	55	30	55
Alaska Slope LoRisk	-	-	-	-	-	-	33	35	35	55	33	55
Alaska Slope HiRisk	-	-	-	-	-	-	-	-	45	55	45	55
EOR	-	-	30	30	30	30	30	30	30	30	30	30
All Regions:	30	30	30	35	30	45	30	40	30	60	30	60

Fig. 16. Sample "Minimum-Maximum Price" Output Table.

	AVERAGE LEAD TIME (Y)					
	1983-1989	1990-1994	1995-1999	2000-2004	2005-2009	Summary
48 Onshore	3	3	3	-	3	3
Alaska Onshore	-	3	3	3	3	3
48 Shelf	-	7	5	8	6	7
48 Slope	-	9	8	10	9	10
Alaska Shelf LoRisk	-	8	7	7	6	7
Alaska Shelf HiRisk	-	-	7	7	6	7
Alaska Slope LoRisk	-	-	-	10	9	9
Alaska Slope HiRisk	-	-	-	-	10	10
EOR	-	3	3	3	3	3
All Regions:	3	5	4	6	5	4

Fig. 17. Sample "Average Lead Time" Output Table.

REFERENCES

1. Dalton, G. L. et al. "Estimates of Undiscovered Recoverable Conventional Resources of Oil and Gas in the United States," USGS, Circ. 860 (1981).

2. Enhanced Oil Recovery, National Petroleum Council (1984).

3. Replacement Costs of Domestic Crude Oil, DOE/FE30014-1 (July 1985).

4. Energy Projections to the Year 2010, DOE-Office of Policy, Planning, and Analysis (October 1983).

APPENDIX A - RCIP CALCULATION LOGIC

The purpose of this appendix is to detail the logic behind RCIP's resource selection scheme. While RCIP contains a number of linked routines, most are devoted to data input, output, and checking, and relatively few to the actual selection and calculation process. Only this last segment is covered here.

Setup

Based on internally specified data and user-specified parameters, a large resource data table is created internally. This table consists of a set of cost/quantity distributions.

Each resource region has associated with it a resource cost/quantity distribution. All of the oil resources potentially available for discovery are allocated among a series of cost slots. The first slot contains the quantity of undiscovered resource costing less than $30/bbl, and the next 40 slots contain quantities available within two and a half dollar increments ranging from $30 to $130 per barrel. (Note that only economically viable increments will actually be selected; the upper limit of $130 provides a more than adequate buffer for price scenarios so far considered). Cost distributions for each resource region are defined in file PQ1.DAT by REPCO,[3] a program which calculates marginal replacement costs for domestic oil. Separate distributions have been defined for each of the high, mean, and low resource-base estimates for each region. The cost distribution imported from REPCO is normalized to assure that the quantities estimated by USGS are economically available. The assumption is made that $60/bbl is equivalent to USGS's term "economically available". On this assumption the normalization is done by scaling the cost distribution so that the total of all resource up to $60/bbl equals the operative USGS estimate. Should there be no resource available under $60, a warning is issued and no scaling takes place for that region.

The internal table of available resources referred to earlier is simply the selected mix (low, mean, and high) of these regional cost distributions.

RCIP Program Logic

In each period, a sequential set of actions is executed by RCIP to determine which resources of those available will be "discovered". This sequence of actions is as follows:

I. Resource Table is updated: additions to the available resource table may occur due to introduction of advanced Arctic offshore technology or to the lifting of leasing constraints.

II. Resource selection: resources are selected (i.e. "discovered") from the available resource table until either the period's discoveries equal its "production quota" (also termed "demand track"), or there are no more resources available for selection. During the selection process, the following rules are used in the order of priority listed:

1. No resource is selected if it is in a slot lying above the "cost cap". The cost cap is determined for each region for each period by comparing costs over a representative production history to the 1983 NEPP projection of world oil price.[4] The calculation is done by a program supplemental to REPCO, not within RCIP.

2. No resource will be selected from a higher cost bracket until all lower brackets have been exhausted. A cost bracket is a group of one or more cost slots. Lower brackets contain 4 slots (i.e. they are $10 brackets), while above $60/bbl, brackets contain 8 slots each.

3. Within the limitations of the first two rules, no resource from a low priority region will be selected until higher priority regions have been exhausted.

Priority group membership is defined in Table A-1. Low priority, as used here, means a high group number - i.e. Alaska Onshore, in group 5, is of lower priority than West Texas, in group 1.

4. Within the limitations of the above rules, all lower cost slots will be selected before higher cost slots.

5. Within the above limitations, resources will be selected from regions in the order they are listed in Table A-1.

III. Calculation of Result

During the selection process, running totals are kept of information used to calculate output data (total quantitites selected from each region, weighted average cost, cost range, average leadtimes, and economic benefit). These calculations are completed in this step.

This entire process is repeated for each time period in the model, and the resulting data retained for storage or output.

Economic benefit calculations carried out in RCIP actually address the effective cost to the domestic economy of production (or the import) of that fraction of domestic needs represented by the demand track. This (negative) economic benefit is computed by two distinct methodologies. The first, due to Lewin and Associates, defines economic benefit as the total cost of all oil selected, plus the cost of imports required to fulfill deficits to the selection quota. The second methodology, due to Decision Focus, Inc., is significantly different in two respects. First, all costs are discounted (at 8% per annum) to the beginning year of the model (1983). Second, that fraction of the replacement cost represented by transfer payments within the USA (e.g. taxes, royalties) is not counted. Economic benefit, as calculated by these two methodologies, is displayed on the scenario summary as a total dollar value and on a per barrel basis (Figs. 10 and 11). It is

TABLE A-1. Resource Regions and Priorities

Resource Subregions contained in RCIP are listed below in (A.) in the order they appear in the data displays and (B.) in selection priority order. Next to each region is the selection priority group to which the region belongs.

A. SUBREGIONS (internal order)	Priority Group
West Coast Onshore	1
Rocky Mountains	1
Mid-Continent	1
West Texas	1
Gulf Coast	1
Appalachia	1
Alaska Onshore	5
Gulf Coast Shelf	2
Gulf Coast Slope	7
Atlantic N&C Shelf	4
Atlantic N&C Slope	9
Atlantic S Slope	9
West Coast N Shelf	3
West Coast S Shelf	3
West Coast N Slope	8
West Coast S Slope	8
Alaska Shelf LoRisk	10
Alaska Shelf HiRisk	11
Alaska Slope LoRisk	12
Alaska Slope HiRisk	13
EOR	6

B. SUBREGIONS (by priority)	Priority Group
West Coast Onshore	1
Rocky Mountains	1
Mid-Continent	1
West Texas	1
Gulf Coast	1
Appalachia	1
Gulf Coast Shelf	2
West Coast N Shelf	3
West Coast S Shelf	3
Atlantic N&C Shelf	4
Alaska Onshore	5
EOR	6
Gulf Coast Slope	7
West Coast N Slope	8
West Coast S Slope	8
Atlantic N&C Slope	9
Atlantic S Slope	9
Alaska Shelf LoRisk	10
Alaska Shelf HiRisk	11
Alaska Slope LoRisk	12
Alaska Slope HiRisk	13

recognized that there is a certain inconsistency in the treatment of imports. Properly speaking, imports will eventually be required to replace production shortfalls due to reserve addition shortfalls. Such a production track treatment is beyond the scope of this version of RCIP and will be treated in the Production Schedule version.

APPENDIX B - SOURCES OF COST/RESOURCE DATA FOR RCIP

The cost/resource data input to RCIP were derived from a modified version of the REPCO code, the methodology for which has been described in the report, "Replacement Costs of Domestic Crude Oil".[3] The modifications made at Oak Ridge National Laboratory did not affect the basic methodology, a summary of which is given below.

The "cost" of new domestic crude-oil reserves is defined here as the levelized selling price, over the entire period of production, which will recover the full expenses of exploration, development, production, and an assumed return on capital. Since the exploration costs are included, this is termed a "replacement cost." The discounted cash-flow analysis includes the following items:

- exploration
  - geological and geophysical work
  - dry holes
  - discovery well
- lease bonus
- development
  - drilling and equipment
  - dry holes
  - delineation wells (offshore)
- G&A on investment
- production
  - fuel, power, labor, materials and injectants
  - drilling of injection wells

- injection equipment
- G&A on operations
- royalties
- severance, state and federal income taxes
- windfall-profit taxes (through 1989)
- price adjustments for API gravity and transportation
- revenues from associated gas (except for Alaska)

• escalation with energy cost of costs of drilling, equipment, injection materials

• return on investment.

The analysis utilizes a geographic disaggregation into seven onshore and fourteen offshore regions. Mean, high and low estimates of the quantities of undiscovered recoverable resources of crude oil for each of these regions are taken from U.S. Geological Survey (USGS) Circular 860 (1982), and corrected for discoveries during the years 1980-1982. The USGS high and low resource estimates for the individual regions are also adjusted so that the high estimates sum to the high estimate for the entire USA; likewise, for the low estimates.

Some of the major points in the analysis are as follows. For a complete account, see the replacement-cost report cited above.

Lower-48 Onshore Model

The analysis employs a finding-rate model based on the assumption of a logistic relationship between exploratory drilling effort (E), total resource (Q_∞), and the hydrocarbons found (Q),

$$Q = Q_\infty \quad [1 - \exp(-bE)] \quad .$$

The parameter b is estimated for each geographic region from the history of drilling and discoveries over several years prior to the start of the model. Use of the relationship allows the estimation of the average

finding rate for each subsequent increment of oil to be discovered. Combining this figure with the average well depth (in recent history) for the region yields the expected ultimate yield per well.

The expected field size (ultimate yield) for an increment of oil in a given region is obtained from the yield per well with the use of a data base of over 5,000 oil fields maintained by Lewin and Associates, Inc., Washington, D.C. Division of the field size by yield-per-well yields the number of production wells. The timing schedule for well drilling is based primarily on a variant of the reserve growth factors initially developed by M. King Hubbert, and elaborated by D. Root in USGS Circular 860.

Costs are taken from data series published by the Energy Information Agency (U.S. Department of Energy), including those for drilling (DOE/EIA-0185(82)) and equipment (DOEEIA-0347(82-83)). The cost analysis is conducted in constant 1983 dollars.

Lower-48 Offshore Model

The Lower-48 offshore model is disaggregated into ten geographic regions and twenty field-size classes. The estimates of undiscovered recoverable resource are derived from USGS Circular 860 regional estimates (with corrections for discoveries during 1980-1982), adjustments of high and low estimates as for the onshore (see above), and from the assumption of lognormal distributions over the field-size classes. The minimum field size for economic recovery was taken from USGS Circular 860. For two regions, Gulf of Mexico Shelf and Pacific Ocean South Shelf, which have been subjected to extensive exploration, the assumed distribution of remaining economically-recoverable undiscovered resource among field-size classes was based partly on the results of exploration and other analyses (see references in the Replacement Cost report cited above). For other regions, the distribution was based on an approximation of the lognormal distribution of economically viable fields.

For each pertinent field-size class in each region, the model calculates the quantity remaining to be found and the replacement cost. For the latter calculation, the field development component first calculates the required wells, platforms, pipeline and equipment according to current offshore design principles, and is dependent on the water depth and drilled depth for the particular region. This component also defines the time sequence of exploration, development and operation phases according to normal engineering practices, and is used to provide the lead-time parameter passed to RCIP via the PQ1.DAT file.

The estimated costs of all items for the Gulf of Mexico are taken from the same sources as for the Lower-48 onshore, plus specialized sources for the offshore: DOE/EIA 0372/2 and USGS Professional Report 1294. Costs for the Atlantic and Pacific regions are derived from Gulf of Mexico costs by application of the "climatic hostility indices" (R. J. Kalter and W. E. Tyner, Atlantic Outer Continental Shelf Energy Resources: An Economic Analyses, Ithaca, NY: DOA Economics, Cornell University, Report AERES 79-17, November 1979, pp. 23-27). Costs are also subjected to escalation with the cost of energy.

Alaska Onshore Model

The models in use for both onshore and offshore Alaska are preliminary ones, to be replaced by improved methodologies from studies currently being carried out by Lewin and Associates, Inc., for the Department of Energy.

For the Alaskan onshore regions, the basic model for Lower-48 onshore regions was utilized with several modifications, as follows. The finding rate values were modified to reflect the uncertainty inherent in the Alaska data. Cost data specific to Alaskan onshore fields were taken from Alaska Hydrocarbon Supply Model, DOE/EIA-80-072, Vol. 3, February 1980. Transportation costs appropriate to Alaska were utilized.

Alaska Offshore Model

The Alaska offshore model was adapted from the Lower-48 offshore model by adjusting both the resource inputs and the cost data to reflect the information provided in U.S. Arctic Oil and Gas, National Petroleum Council, Washington, D.C., December 1981.

Preparation of Cost/Quantity Data for RCIP

The cost/quantity results for each region were smoothed and distributed over the RCIP cost intervals. The lowest interval contains all quantities with costs less than or equal to $30, and succeeding $2.50 intervals continue up to $130. (The $30 minimum was appropriate during the time the analysis was conducted, and will be changed in the next version of RCIP to reflect current realities regarding the price of oil.) The cost/quantity input to RCIP is arranged in three tables, one each for low, mean and high resource estimates. Each table contains data for all twenty RCIP regions. (One REPCO region, Atlantic Offshore South Shelf, was omitted because of the low quantity of its resource.)

COMMENTS

Definitions of Economic Benefit

The program outputs two dollar figures named "Inverse Economic Benefit (DFI)" and "Inverse Economic Benefit (L&A)", where "DFI" and "L&A" stand for Decision Focus, Inc. (Los Altos, CA) and Lewin and Associates Inc. (Washington, D.C.), ORNL's two subcontractors in the RCIP work. These dollar figures are actually costs, defined (in two different ways) so that a decrease in cost represents the relative economic benefit of the scenario, and therefore of the R&D which might make possible, for example, earlier access to advanced technologies.

According to DFI, the only costs which should be considered with relation to economic benefit are those consumed in oil exploration/development/production which would, because of R&D, be freed up for other uses. Therefore, cost is the discounted sum of fixed and variable factor costs and return on equity. This definition excludes taxes and lease acquisition

costs (lease bonus and royalty payments) on the basis that these are transfers within the U.S. economy. The discount factor utilized for this calculation was an average for equity and debt fractions; the figure used was 8% for all regions.

L&A's definition of cost for evaluation of economic benefit is simply the (undiscounted) sum of all costs, including taxes and lease acquisition.

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