An automated system for the appraisal of hydrocarbon producing properties

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PURPOSE OF PAPER

This paper is presented for the following reasons:

(1) To inform petroleum engineers that there does exist an automated system for the appraisal of hydrocarbon producing properties.
(2) To inform the public that one more application of computers to an area that has traditionally been the domain of human decision has been accomplished.
(3) To inform the computer industry of another market (i.e., petroleum producers) for software and hardware.
(4) Stimulating further research in the area of hydrocarbon production prediction and hydrocarbon property appraisal.

CONCERNS OF THE DEPARTMENT OF INTERCOUNTY EQUALIZATION

A major element of the California State Board of Equalization, Property Tax Department Intercounty Equalization program is the completion of approximately 5500 property appraisals per year. Because all locally assessable property is not reappraised annually by county assessors' staffs and because the appraisals that are made by them are not always made to uniform standards, there is disparity among the counties in the relationship of county-appraised to true, current full cash value.

For use in supplying equalization aid to school districts, providing for school construction loan repayments, County Medical Contribution, and other purposes for which equalized assessed values constitute the primary test of ability to raise revenue locally, it is essential that an unbiased state agency measure the assessment level of each county each year. In general this is done (1) by selecting and appraising samples of locally assessable properties and estimating the aggregate full value of the universe of such properties as of the preceding lien date* in each of 19 or 20 counties each year, (2) trending each of these aggregate forward to the succeeding years' lien dates until they are replaced with new ones, and (3) comparing each county's current total locally assessed value with the aggregate full cash value for the corresponding lien date.

The properties identified in the samples are inspected, analyzed, and appraised by the Intercounty Equalization Division's appraisal staff, using accepted professional appraisal procedures. The sample results are then ascribed to the universe of locally assessable property to produce, at three-year intervals, an estimate of the full cash value of all locally assessable property in each county.

The types of property appraised include residences, vacant lots, farms and ranches, commercial and industrial enterprises, oil and gas fields, and timber holdings, as well as unsecured personal property. The properties chosen for appraisal constitute a randomly selected sample within assessed-value strata, except for those developed petroleum and water rights which are a significant part of a county's economy. All or substantially all developed hydrocarbon mineral rights in the counties where they are deemed to be a significant part of the economy are appraised in every three-year cycle, and their values are trended between appraisal years separately from the trending of other property values. Appraising all these properties in a county (and designating this group as Stratum 10), instead of a random sample is considered more reliable than appraising only a sample because an oil and gas field can be appraised more accurately as a unit then as a group of separate wells and undeveloped well sites.

One part of the Intercounty Equalization Divisions program is to determine the value of all hydrocarbon producing properties in those counties where the value of such properties is greater than 3 percent of the total county roll. Originally, 2 percent was recognized as the statistically significant limit for sampling purposes (12 of California's 58 counties were in this category). In succeeding years, the number of fields and secondary recovery projects have increased, with a corresponding increase in the appraisal workload. In June 1969, the statistical limit was raised to 3 percent of the county roll to compen-
The Hydrocarbon Property Appraisal System (HAS) described in the remainder of the paper allows the Intercounty Equalization Division to maintain acceptable appraisal quality standards and remain within the present budget limitations. Moreover, the system's ability to handle a greater volume of current data will allow for a more accurate and flexible value-trending program in succeeding years. The program creates a high level of confidence within the counties that the petroleum property appraisals are well documented and professionally done.

The Board of Equalization is making this system available to counties with the hopes that it will result in an increase in the market value of several counties is expected to occur when HAS is used to value the petroleum mineral rights in the counties. The program reduces the time needed to appraise petroleum mineral rights so the Senior Petroleum and Mining Engineer can devote more time to other tasks (i.e. appraising other types of mineral rights).
improved property tax equalization and greater appraisal standardization for oil and gas producing properties.

The remainder of the paper is devoted to describing the traditional method of hydrocarbon property appraisal, how the traditional method was automated, short comings in the present automated system, and overall system improvements to be made in the future.

MANUAL METHOD

Producing hydrocarbon properties to be appraised in the triennial survey are selected by two methods. First, as previously stated, all hydrocarbon producing properties are appraised in each county where these properties exceed 3 percent of the county assessor’s roll. Second, in those counties where the value of such properties is less than 3 percent of the county assessor’s roll, the hydrocar-

7. Review items 2 through 6 and select the appropriate operating costs and capital expenditures for the reserves and production rates selected in step 6.
8. Determine future net income by multiplying the estimate future production rate by the price of oil and subtracting the estimated future costs.
9. Capitalize the net income to a present worth indication at the appropriate interest rate to derive a market value indicator. Separate studies are required to identify an appropriate rate of capitalization. (See Appendix A).

Exhibit E

- Number of Oil Wells (Actual and Potential)
  - Year

Exhibit F

- Production file of petroleum properties
- Perform Arps' decline curve analysis
- and reserve estimates, plot production curves, print two-year production summary, potential for other methods of extrapolation
- Cost Data Tape contains information on price of oil, price of gas, cost of production, etc.
- Calculation of economic limits, capitalized earning ability based on net cash flow

Exhibit G

- From the collection of the Computer History Museum (www.computerhistory.org)
10. Compare the value indicator derived in step 9 with value indicators derived from sales.
11. Estimate the market value for subject property.

AUTOMATED METHOD

The Hydrocarbon Appraisal System, HAS makes major changes in the above job stream. (See Exhibit F and G). The system can only provide meaningful reserve estimates for those fields that are amenable to ARPS' decline curve analysis. If the appraiser is aware that a specific field is not amenable to decline curve analysis he may, by a control card modification cause the computer to plot a suite of production curves for the field in question. These curves are not as good as an estimate of reserves but they do provide the appraiser information which would otherwise have to be found elsewhere with a resulting large amount of effort expended. These curves are of great importance to the appraiser, who uses them to estimates reserves. Once the reserves are estimated he inputs this information into CFLOW, the cash flow modules.

Although the fields amenable to decline curve analysis contain only about 25 percent of the state's oil and gas reserves they constitute 60 percent of the total number of fields, and therefore 60 percent of the workload. The other 75 percent of the state hydrocarbon reserves may be appraised by use of CFLOW, a subsystem of HAS.

County petroleum production figures, before the advent of PTROL, had been trended manually by estimating reserves and production rates, using over-simplified straight-line extrapolation of the historical production curve manually plotted on semilog paper for each field. The production figures when multiplied by the price of oil would result in the future gross income. The gross income stream thus derived is adjusted to net income using costs collected during the last survey year. Such a method does not respond well to technical innovations, new discoveries, and extensive well repair programs, and therefore, left much to be desired.

The mere extension (by use of a straight-line projection) of past production level into the future until the economic limit of production is reached on a time frame is an expedient method, but in many cases, not viewed by industry, or government as an accurate measurement of future production. One technique generally accepted and used by industry and government is known as the ARPS Decline Curve analysis. Due to human error and time constraints, hand calculation of the curve is impractical in light of the volume and difficulty of calculations required. The practical use of this equation (together with other uses based upon the needs of each user) has been made possible by the advent of automated data processing. The primary objective of PTROL is to plot production curves and use the ARPS Decline Curve analysis in the prediction of future production. The main objective of CFLOW is to extend PTROL by using the predicted production as input for the automation of summary capitalized earning ability that is required to value hydrocarbon producing properties and the printing of a final appraisal report consisting of a summary of value conclusions derived from the entire system.

In order for HAS to be effective, it must have a data base of production history. The Board of Equalization is grateful to the Conservation Committee of California Oil Producers for releasing through the Service Bureau Corporation of Inglewood, California, once a month, a copy of their monthly hydrocarbon production statistics. This tape of production statistics is the heart of the data base as without it none of the system except CFLOW would be able to function. The data base has a capacity of ten years of monthly production data for every field in California. There are approximately 1250 named producing fields in California. The monthly production data consists of oil, gas and water production figures as well as total numbers of wells and total number of fulltime producing wells.

The Board of Equalization originally was able to capture only 3 years of data for the data base. This was not viewed as a serious drawback because the PTROL subsystem which requires the data base will not be needed until next year when four years of data will be available. It is felt that four years at a minimum, of data will suffice for curve plotting purposes. The extrapolation routines in PTROL do not require all ten years of data for accurate fitting. The ten years of data are there primarily for the appraisers benefit so he might have historical information which he can use and override the predicted hydrocarbon production with values of his own before allowing the information into CFLOW.

With the advancements provided by HAS, the job flow is reduced to the following:

1. Identify specific property to be appraised.
2. Collect historical expense or cost data on subject.  (Used in CFLOW)
3. Collect historical capital expenditures on subject. (Used in CFLOW)
4. Input items 1 through 3 into HAS system.
5. Discuss properties operations with company engineering personnel using the PTROL graphs and CFLOW report as an information source.
6. If disputes arise or errors are found in the graphs or the report, correct errors and go to Item 4.

The PTROL subsystem extrapolates the data base explained earlier (i.e., the oil production decline curves) using the method developed by ARPS and later tested on California oil fields by Higgins and Lichtenberg. The extrapolated curve is integrated by year to determine the volume of oil produced for each year in the future.

The subsystem CFLOW takes as input either manual extrapolations or machine fitting from PTROL. The volume of oil is multiplied by the price of hydrocarbon products to give the gross income per year. The future value of the hydrocarbon products are balanced against the future expenses and costs required to produce them.
The economic life of the field is the number of years required for the expenses to overcome the income earned from production hydrocarbon substances. Given the economic life, the net income is capitalized at five different fixed rates as well as by one rate specified at input. (See Appendix A) Various other value indicators are calculated and printed. These indicators are used to check the value of the property derived by machine.

If errors arise as mentioned in Item 6, above, machine time is not required to extrapolate the future production again. If the appraiser feels the extrapolations are correct he may use these values for input to CFLOW and change only the cost and expense value to correct the errors in Item 6.

The inspiration for CFLOW came after perusing a copy of the Kern County, California appraisal program. Theirs is a modified version of a still older Standard Oil of California Program. After discussions with the Intercounty Equalization Senior Petroleum and Mining Appraisal Engineer we came upon the calculations and format which we thought would express the value of the hydrocarbon mineral rights best. It is embodied in CFLOW.

FUTURE IMPROVEMENTS

Future improvements in the hydrocarbon property appraisal subsystem for cost and expense data, a new system flow when aforementioned subsystem is completed and more methods of predicting future production (i.e. material balance, volumetric, etc.).

A problem encountered during the implementation phase of HAS was the staggering amount of detailed cost data required for the system to function. A manual system was developed to reduce the cost data to a usable form for the machine. This manual process was very slow and due to the turnover of clerks not very accurate. The solution to the manual system of cost data reduction would be to design and implement a cost history system to reduce the data for the appraiser.

A cost history subsystem would consist of a file of cost and expense data and file maintenance system for adding and deleting data. The file for each hydrocarbon producing field would be of sufficient length so that as much as ten years of cost and expense factors could be stored. These could be printed so that the appraiser could review and correct them if necessary before using the factors as input to HAS.

Taking cost history subsystem and integrating it into (HAS) would result in a far more sophisticated appraisal system. Once triggered by the Petroleum Engineer, the automated cost factors produced by the data reduction program would be directly input into HAS. PTROL would then process as it does now.

This improvement would not only allow the Petroleum Engineer to modify the appraisal data and reenter it into the process at any point but would also allow the system to completely appraise a property without appraiser intervention. This would shave the budget even more, because a significant amount of cost is contributed by the hand processing of cost data by the appraiser.

Another improvement would be to allow PTROL more methods of predicting future production. This would require more research into the state of the art of hydrocarbon production prediction. During the research required for PTROL and CFLOW design several sources were found that indicated that methods dealing with volumetric and material balance were already developed. It would not take too much effort to acquire copies of these sources so that evaluation of their methods could be made in the light of information present in the data bases of this hydrocarbon substance appraisal system.

SUMMARY

HAS is an example of a cooperative effort between a system analyst and a technical engineer. The analyst knew nothing about petroleum engineering and the engineer knew nothing about systems. The system was designed so that if any new technical innovations were published they would be incorporated into HAS with a minimum of down time. This flexibility of the system was due to the report established between the analyst and the engineer.

In conclusion the following reasons summarize the arguments and suggestions for the implementation of PTROL and CFLOW.

1. More accurate appraisal of petroleum properties in California.
2. Better standardization and equalization in petroleum counties throughout the state.
3. Greater accuracy and flexibility in trending oil and gas property values.
4. Quality appraisals at a substantial savings to the state.

ACKNOWLEDGMENTS

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REFERENCES ON PETROLEUM FIELD DECLINE CHARACTERISTICS


ADDITIONAL REFERENCES ON PETROLEUM FIELD DECLINE CHARACTERISTICS


APPENDIX A

Capitalization is the process whereby present worth is calculated. The present worth mentioned here is concentrated at midyear. Present worth (P.W.) is defined by the following equation:

\[ \sum_{j=1}^{e} \frac{n(j)}{(1+i)^{2-j/2}} \]

where

- \( e \) — the economic life of the property
- \( n(j) \) — the net profit of the jth year
- \( i \) — the interest rate desired

The value that the above process provides is the amount of money one must pay today for a value described in tomorrow's dollars.

Example: If a property made a net profit of $5 per year for 5 years in an economy that was expanding at 8 percent a year, how much would that property be worth in today's dollars?

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NET PROFIT</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.00</td>
<td>$4.81</td>
</tr>
<tr>
<td>2</td>
<td>5.00</td>
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<td>4.12</td>
</tr>
<tr>
<td>4</td>
<td>5.00</td>
<td>3.82</td>
</tr>
<tr>
<td>5</td>
<td>5.00</td>
<td>3.54</td>
</tr>
</tbody>
</table>

Therefore, in an expanding economy that is expanding at 8 percent the twenty-five dollars in the future will be worth $20.72 in today's dollars.

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