ROUTLEDGE REVIVALS

Methods of Estimating Reserves of Crude Oil, Natural Gas, and Natural Gas Liquids

Wallace F. Lovejoy and
Paul T. Homan

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Methods of Estimating Reserves of Crude Oil, Natural Gas, and Natural Gas Liquids, first published in 1965, aims to throw new light on a field of knowledge vital to consideration of problems of public policy regarding future sources of energy. This book will be of interest to students of environmental studies.

Methods of Estimating Reserves of Crude Oil, Natural Gas, and Natural Gas Liquids

by

WALLACE F. LOVEJOY

and

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This book is one of RFF's studies in energy and mineral resources, which are directed by Sam H. Schurr. The research was supported by a grant to Southern Methodist University. Wallace F. Lovejoy is professor of economics, and Paul T. Homan research associate and former director of graduate studies, Department of Economics, at the University. The manusacript was edited by Doris L. Morton.

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Foreword

The concepts and approaches employed in estimating the future availability of petroleum have led to considerable misunderstanding. They have also left substantial gaps in the quantitative information. In sponsoring the present study, Resources for the Future hoped that it would throw new light on a field of knowledge vital to consideration of problems of public policy regarding future sources of energy.

Professor Lovejoy and Professor Homan have written a deceptively simple book on the subject. Only those who have themselves been forced to labor through the raw information will recognize how much effort and hard thought have gone into this lucid account of the different reserves estimates and the approaches underlying them. Beginning with the concepts and procedures used by the American Petroleum Institute in producing its estimates of proved oil reserves (which are, in a sense, the "official" figures on the subject), the authors lead us through a number of other significant approaches which have been utilized, or suggested, to measure the nation's position in natural resources of crude oil, natural gas, and natural gas liquids.

The past instances in which the available statistics on oil and gas reserves have apparently yielded "wrong" answers on questions of the future adequacy of resources are so numerous that much skepticism now exists concerning the real worth of existing information. To a degree, as the authors point out, the improper application of reserves figures to deal with questions for which they were never intended has been the source of much of the difficulty.

Nevertheless, even when the underlying concepts and methods are fully understood, serious deficiencies still exist, because the statistics now being compiled are inadequate for dealing with important questions affecting the public interest. Consequently, at various points in the study, but mainly in the last chapter, the authors discuss the types of improvements

in the figures which are needed and which appear to be within reach as a logical extension of the present programs of data collection and analysis.

It is our hope that the publication of this study will help to minimize the future misuse of reserves statistics, and that it will also call attention to the possibilities that exist for making improvements in the statistics. The attention of the petroleum industry, government agencies and the interested public is directed to both of these objectives.

SAM H. SCHURR
Director, Energy and
Mineral Resources Program,
Resources for the Future, Inc.

Preface

The present study is the lineal offspring of an earlier effort by the same authors. To establish the origin and purpose of the present study, we quote from the Preface of the earlier one.

> In the spring of 1961, Resources for the Future, Inc. made a grant to the Department of Economics and the School of Law at Southern Methodist University to hold a seminar on economic and legal aspects of the petroleum industry. A central purpose of the project was to bring face to face around the conference table, for discussion of some fundamental topic, people from within the industry, academic personnel engaged in research upon the industry, and other persons who in a consulting or regulatory capacity were concerned with the problems of the industry. The initial project was conceived of as possibly the opening step in a series of studies in petroleum economics and law; and it was felt that the establishment of direct lines of communication between the various types of personnel concerned with the problems of the industry would be valuable.
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> It was decided, for purposes of this experiment, to choose a topic of limited scope and technical character. This limitation excluded consideration of, and argument about, controversial questions of policy. Following this principle, the subject chosen was "Oil and Gas Finding, Development, and Producing Costs." Within this limited scope, the orientation was not toward the specific costing problems of individual companies, but rather toward questions of whether meaningful cost studies could be made, whether existing cost concepts and methods of analysis are correct and useful, and whether cost data are essential information in evaluating the future availability of petroleum supplies.

The seminar met at Southern Methodist University in five sessions over a period of two and a half days, March 22 to 24, 1962. In preparation for

the seminar the present authors prepared a background paper which was distributed in advance and served as the point of departure for the seminar discussions. This paper was revised and published, together with a summary account of the discussions.[1] Since circumstances did not permit original empirical research into actual cost figures, the study primarily centered around (1) the conceptual basis of cost analysis, (2) a review of earlier cost and availability studies, and (3) the bearing of costs upon regulatory activities and policy making.

In the course of the seminar, an extended discussion of the concept of "replacement cost" took place. This necessarily led into the methods of estimating reserves and the meaning of the estimates, since the replacement cost of oil, as usually calculated, relates finding and development costs to the proved reserve added annually, as estimated by the Committee on Petroleum Reserves of the American Petroleum Institute. Readers who wish to follow the whole discussion will have to consult the original, but the following passage from the *Summary*[2] is especially pertinent:

> As the preceding part of this report has shown, the discussion of replacement costs necessarily included some discussion of petroleum reserve data—how these data are collected, aggregated, reported, and transmuted into a cost context. The significance of reserves is evident when it is recalled that finding costs per barrel and development costs per barrel are computed by dividing annual expenditures on finding and development by the barrels of additional reserves "proved up" during that year. Even if economic cost concepts (or some variation of these) are used, it is necessary to have a denominator for the fraction to obtain a cost *per barrel* of reserves. The discussion with respect to reserves was interspersed in the general discussion on costs; it is dealt with separately at this point in order to emphasize some of the unique aspects of reserve estimation. Three principal questions were as follows. How are reserve data collected? Are the data reliable and adequate for the uses to which they are put? Can reserve data be broken down by functional stages—e.g., discoveries, extensions, revisions—in a meaningful way?
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> The discussion brought out the procedures used by the American Petroleum Institute, the American Gas Association and the National Petroleum Council to collect and report reserve data. Most participants indicated that the annual breakdown between additions to reserves from discoveries on the one hand and from extensions and

[1] Wallace F. Lovejoy and Paul T. Homan, with Charles O. Galvin, *Cost Analysis in the Petroleum Industry* (Dallas: Southern Methodist University Press, 1964).

[2] *Ibid.*, pp. 110-12.

revisions on the other hand was not reliable enough for purposes of cost analysis. Dividing total development costs by extensions and revisions to get a development cost per barrel was not justified, as there is no established relationship between the two. The same general comment applies to finding costs and new reserves from discoveries. It applies also if combined finding and development costs are related to total additions to reserves.

The question was raised as to what extent there is a bias in the official A.P.I. and A.G.A. reserve data. It was recognized that they are, by their very definition, conservative, representing a working inventory concept and not a prediction of probable or possible recovery from known reservoirs. Companies customarily make further estimates of probable reserves, although these figures contain a large judgment factor and are apt to diverge widely even within a company among different people. Some in the group advocated that companies pool the estimates on the probable reserves or that the A.P.I. and A.G.A. report both "proved" and "probable" reserves by whatever methods are available to them. The group seemed to agree that A.P.I.-A.G.A. estimates of reserves added by discoveries for single years do not present a time series of much use for charting the time trend of discovery.

Some members of the group emphasized a need for greater detail in the reporting of reserves, especially in differentiating revisions and extensions. This led to the further suggestion that it would be valuable if specific additions to reserves could be attributed to specific factors, such as changes in information, further drilling or recompleting, introduction of secondary recovery operations, technological innovations or applications, and changes in underlying economic conditions. Such information would record reserve changes over a time path, pin-pointed to show certain events or factors responsible for the changes. Conceptually, it was agreed, such a breakdown would be helpful in cost analysis, since cause and effect could be more clearly discussed in the relations between outlay and results. Some in the group felt that such detailed reporting would not only be excessively costly, but also difficult to make internally consistent, given the large degree of judgment which would have to be exercised by the reporting sources. The discussion ended on the note of practicability—to what extent such reporting may be feasible. This, it was agreed, was a matter for further investigation.

In the course of the discussion, some members of the group voiced the need for reporting reserves by reservoir as well as by geographic region. This additional detail, they felt, could be fairly easily obtained and would assist in the more detailed forms of cost analysis. It was

assumed that the API reporting procedures were built up from a base of reservoir information. An objection was raised that reporting on this basis would not only be difficult and costly, but that companies would refuse to cooperate in compiling such information, since it would prejudice their position in negotiating with landowners.

The matter of "dating back" reserves to the year of discovery of their fields was a thorny question. Some participants felt strongly that such action was required for determining (1) trends in additions to the physical availablity of oil and (2) trends in discovery outlay associated with this physical availability. They felt that cost analysis required additions to a known reserve to be credited back to the earlier costs of finding and developing reserves in order to get a meaningful unit cost having trend significance.

Others in the group emphasized the extreme difficulty of attempting to date back existing reserves in the absence of a suitable technique, beyond what has already been attempted by the National Petroleum Council. Although they conceded the difficulty of such reporting retrospectively, some participants insisted on the desirability of initiating this type of reporting from now forward, with respect to newly discovered fields, crediting later revisions and extensions back to the year of discovery. The consensus was that the feasibility of such reporting should be investigated.

In this matter, as in others, there sometimes appeared a difference of outlook or emphasis as between industry participants and those with an academic status. Two different kinds of tests could be applied to various proposals for improvements in data and extensions of analysis. One was whether they were significant for management in decision-making with respect to profitability. The other was whether they would serve some useful purpose in relation to questions of public policy. And in either case, are the changes worth the toil, trouble and expense involved? Everyone recognized that these questions were appropriate, so that the differences were only in the weighting of judgment.

Although the participants in the seminar were all acquainted with the conventional estimates of reserves published by the American Petroleum Institute and the American Gas Association, the discussion revealed that they felt their knowledge to be inadequate on three points: (1) the technical methods of estimating reserves, (2) the valid uses and limitations of the estimates, and (3) alternative or supplementary methods of estimating reserves which could throw additional light on future availability of petroleum. There was a general feeling that the present "official" estimates

are less than sufficient to meet certain informational needs, and that, such as they are, they are commonly misinterpreted and put to invalid uses. Out of these feelings arose the suggestion that a technical study of methods of estimating reserves would serve a useful purpose. The suggestion was received with favor by Resources for the Future, Inc., which then provided a grant to support the research out of which the present study has developed.

A considerable portion of the study is devoted simply to a review of the methods used by the American Petroleum Institute and the American Gas Association in estimating reserves of crude oil, natural gas, and natural gas liquids, and to examining the uses and limitations of the estimates. Beyond that, other methods for extending the boundaries of knowledge concerning future availability of petroleum are reviewed, and various suggestions for improving the state of knowledge are examined.

The study has had the benefit of critical comment by a number of experts from both inside and outside the petroleum industry. To them we express our thanks collectively, since not all of them might care to be mentioned by name.

WALLACE F. LOVEJOY
PAUL T. HOMAN

August 1965

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