ETHERINGTON, JOHN, PRA International Ltd, Calgary, Canada.

Laying the Foundations for Hydrocarbon Resource Management

Introduction

Resource management includes but is much more than conventional portfolio management! It begins with a systematic assessment of estimated in-place petroleum volumes and the value derived through implementing exploration and development projects. Each project has unique technical and commercial risks and uncertainties. Using a comprehensive logical model, a resource management system can be designed that supports internal resource tracking, regulatory reserves disclosures, and long-range portfolio planning from a single database of exploration, development and producing projects.

Scope of Portfolio

Hydrocarbon assets include all those oil and gas accumulations, or potential accumulations, in whose development your company may decide to invest, now or in the future. Some properties have existing discoveries under development, some have identified prospects, and others may have potential that is not yet fully defined. Some discoveries may be "not-yet-commercial" awaiting future infrastructure or technology development; yet these assets have value today based on that projection. Both conventional and unconventional reservoirs are included. Project participation may be in diverse forms and subject to complex fiscal terms. In some cases there is no current ownership but projects depend on predicted acquisitions. We call this collection of entities a hydrocarbon resource inventory.

Structured Approach

Companies require an organized, consistent, and systematic approach to manage projects that span maturity from early exploration to late stage production.

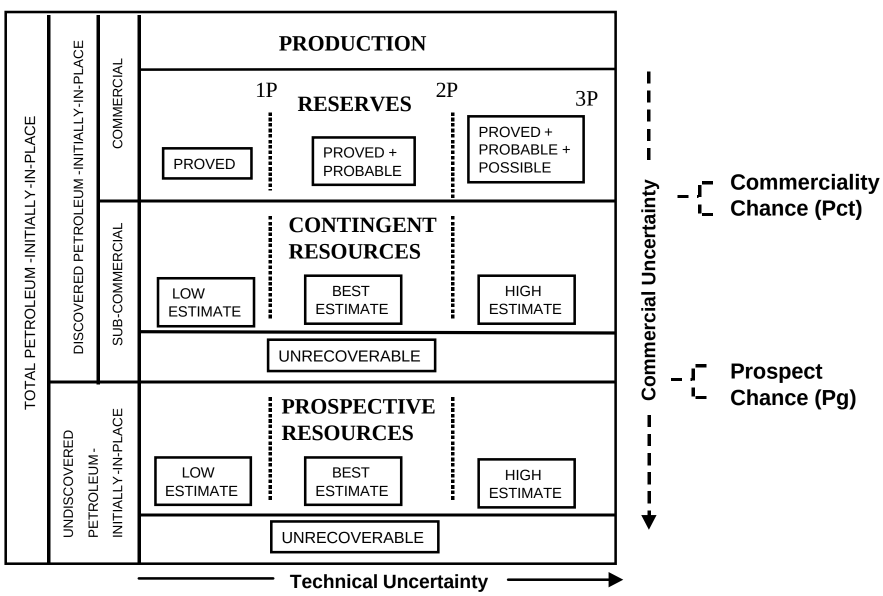

Figure 1: SPE/WPC/AAPG 2000 Resource Classification

The recommended approach builds on the classification system jointly published in 2000 by the Society of Petroleum Engineers (SPE), the World Petroleum Congress (WPC) and the American Association of Petroleum Geologists (AAPG)[1]. As originally presented the horizontal axis represents recoverable volumes (technical) uncertainty and the vertical axis addresses commercial uncertainty. In this case, the model has been modified (figure 1) such that the commerciality axis is not a continuous uncertainty distribution but is a series of risk, or chance, nodes. Chance of Commerciality (Pct) is the probability that the contingency will be overcome within a reasonable time –frame (e.g. 5 years) and is treated similarly to the standard exploration chance of discovery (Pg). The model requires clear separation of risk and uncertainty. Another key risk factor is the chance of capture (Pcp) of a property not yet owned. The risk factors are combined as appropriate; for example, the prospects contained in an upcoming exploration license offering would be discounted for both chance of discovery and a chance of acquisition.

Recognition of a structured relationship between the resource and business entities (figure 2) must be imbedded in the underlying database to allow effective management. Note that the resource entity is an intersection of geotechnical (zone) and ownership (lease) entities. In the production phase lease-zone volumes may be allocated to individual well completions.

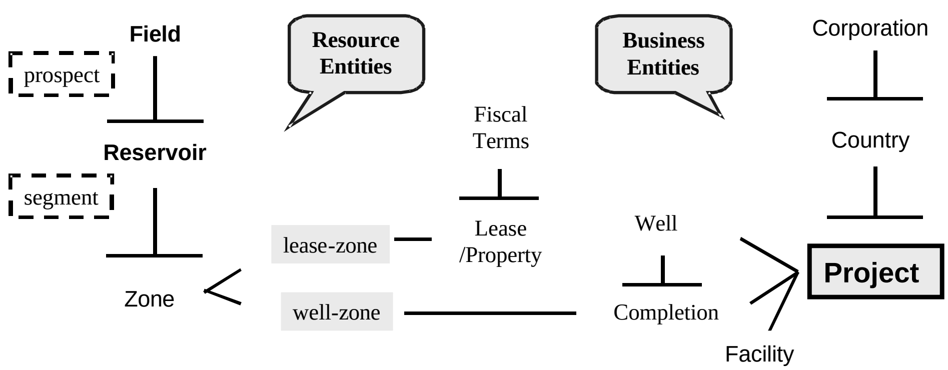

Figure 2: Assessment Entity Relationships

Project represents the link between the petroleum accumulation and the business processes; an individual project represents the level at which a decision is made whether or not to proceed (i.e. spend money)[1,2]. Projects may include a complex mixture of wells, leases and related facilities and are the key building block of portfolio management.

Integrating Deterministic and Probabilistic Assessments

Most exploration and producing companies utilize a mixture of deterministic and probabilistic assessment methods. Producing properties typically use three deterministic scenarios tied to specific guidelines to define estimates of remaining recoverable volumes as 1P (proved), 2P (proved plus probable) and 3P (proved plus probable plus possible). In the case of contingent resources, the equivalent scenarios are the low, best and high estimates. Exploration prospect success cases are typically represented using the full probabilistic volume distributions derived from Monte Carlo simulations.

Regulatory reserves disclosures require a deterministic case and in many jurisdictions the corporate aggregate proved volumes are mandated to be the simple arithmetic sum of field proved. However, portfolio analysis utilizes probabilistic aggregation. Risk management through portfolio optimization requires the avoidance of positive correlation and the exploitation of negative correlation among the individual assets in the portfolio[3]. Projects interact to yield a unique composite suite of performance metrics that are not governed by simple arithmetic summation.

Thus resource management requires a hybrid approach to uncertainty characterization. An Integrated Deterministic/Probabilistic method (herein denoted by the acronym "IDP") was develop by Mobil Oil[4,5] in the late 1980's as an internal quality assurance process applied to major discoveries. At least three major U.S. multinational companies and one foreign national company now use some variation of this method. The process starts with a classical deterministic scenario assessment of 1P and 2P volumes using a combination of regulatory and internal guidelines. Thereafter, staff perform a full probabilistic analysis by applying Monte Carlo simulation using the same underlying geologic models and engineering assumptions expressed as distributions. The two models are then integrated such that the "area under the cumulative probability curve" associated with the deterministic estimate is the probability-weighted volume and when divided by the raw estimate yields an associated "confidence factor" (figure 3). In the Mobil approach, 3P is defined as the P10 volume from probabilistic analyses. The result of this mathematical process is that the sum of the confidence factor-weighted scenario estimates is the mean of the probabilistic distribution. Note that these confidence factors are not probability tree weightings – they do not add to 1.0; they are discount factors to normalize raw volumes such that the sum is the statistical mean volume.

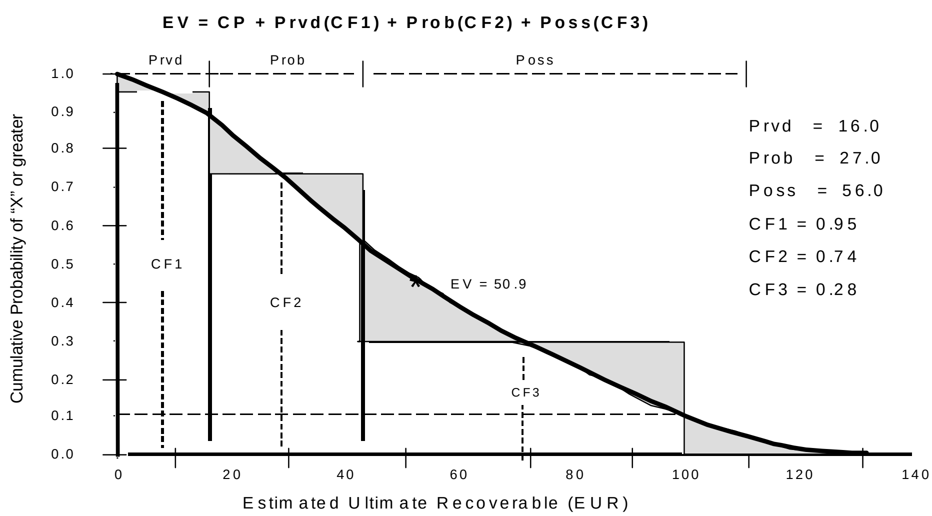

Figure 3: Integrated Deterministic/Probabilistic (IDP) Method

Internal guidelines are set for quality control. For example, the assessed proved volume may not a have a derived confidence factor less than 90% and the curve intercept (so-called "last barrel") may not exceed P85. If these criteria are not met, both deterministic and probabilistic assessments are reviewed for potential amendment. For smaller and more mature properties, a series of default confidence factors may be assigned, e.g.

proved: 100%, probable: 70%, and possible: 30%. By applying these default confidence factors to deterministic estimates, a "pseudo-probabilistic distribution" can be derived. Then either the actual or pseudo-probability volume distribution for each discovered entity may be aggregated probabilistically with exploration prospect potential in a single portfolio.

Synchronizing Volume and Value
Project value depends on many factors including quality of reservoir, drive mechanisms, hydrocarbon type, and the processing and/or transportation costs to deliver a marketable product – and the product price received. In all cases, it depends on an effective project development plan that yields an optimum cost versus revenue schedule. Assuming equal in-place volumes and recovery efficiency, the lower the project cost and the faster reserves are developed and produced, the higher the net present value. The value also depends on fiscal terms; complex profit sharing contacts (psc's) create variable net margins as rates and product prices vary. Software packages are available that link the risk and resource assessment with scheduling, cost and production profile distributions in an integrated Monte Carlo simulation (figure 4). Companies may also use selected deterministic scenarios to evaluate development options in detail.

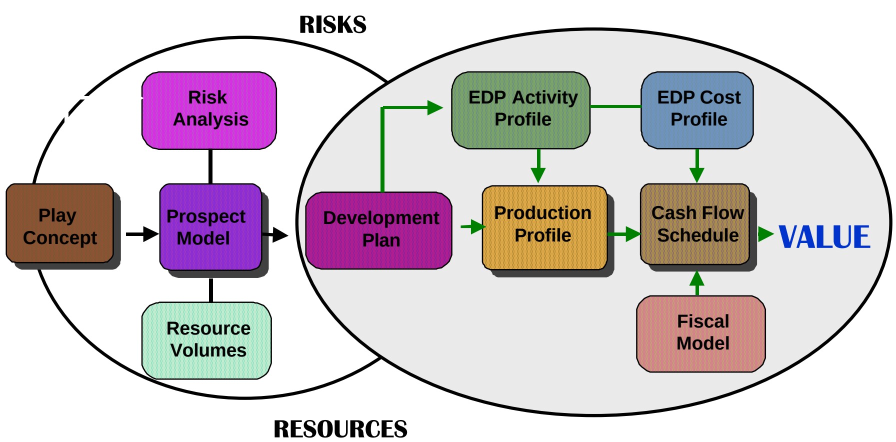

Figure 4: Stochastic Assessment Model

Resource Tracking
Resource assessments are not static; as new information is acquired we continually reassess the technical and commercial risk and uncertainty to revise the volumes allocated to each resource class. (figure 5). From a database/accounting viewpoint, we call this resource transfers. With further development drilling on a discovery, there is a progressive transfer possible to probable to proved undeveloped and ultimately developed reserves. In an ideal world the overall mean reserves would stay constant but there would be changes to the individual class volumes and associated confidence factors. While there may be significant variance in historical mean values in individual projects, overall portfolio variance is more limited.

In addition to these capital-related transfers, there are typically production performance-related revisions as the field matures. Further reserve/resource additions may be sourced from new discoveries, removal of constraints associated with contingent resources, and net gains from acquisitions and property sales.

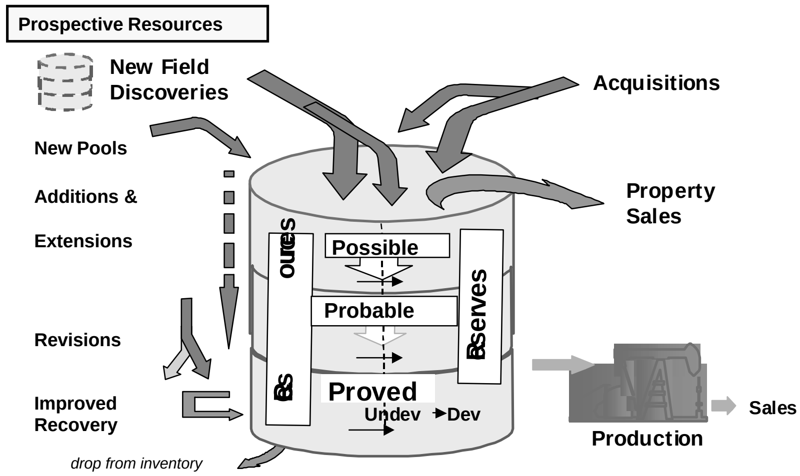

Figure 5: Resource Asset Tracking

Given a rigorous model for transfers related to investment dollars, future year projections of production and remaining volumes by resource classes can be combined with the development economics to derive a full suite of performance indicators such as reserve replacement ratio, cost of finding, and rate of return.

Conclusion

Rigorous process and system design allows companies to achieve consistent risk, volume and value assessments. The resulting project inventory database (figure 6) supports not only current assessment reports including external reserve disclosures but also portfolio planning applications. By storing annual changes in the assessments, a historical database can be referenced to examine predicted versus actual resource estimates and financial performance. Such a resource management system allows integration of exploration, development, and producing projects at all stages of maturity.

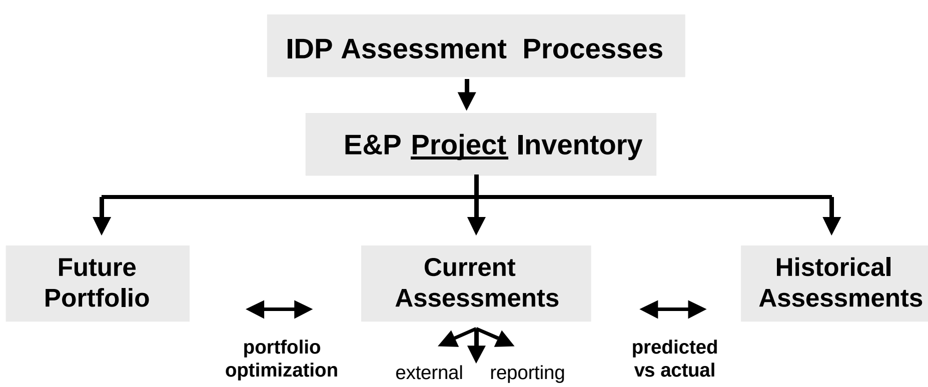

Figure 6: Resource Management Model

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2. Ross, J.G.: "SPE/WPC/AAPG Resource Definitions as a Basis for Portfolio Management", paper SPE 68573, presented at the 2001 SPE Hydrocarbon Economics and Evaluation Symposium, Dallas, Texas, April 2-3.
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