

DEFINITIONS OF OIL AND GAS RESOURCES AND RESERVES

CSA Staff Notice 51-324 - Glossary to NI 51-101 *Standards of Disclosure for Oil and Gas Activities* sets out the reserves and resources definitions derived from Section 5 of volume 1 of the Canadian Oil and Gas Evaluation Handbook (COGEH).

To further assist users of NI 51-101, an updated version of Section 5 of volume 1 of the COGEH, "Definitions of Resources and Reserves", is attached. (The copyright holders of COGEH have given the Alberta Securities Commission, and users of NI 51-101, authority to reproduce Section 5 of volume 1 of COGEH.) This version reflects updated resource classification and terminology that is provided in the recently published second edition of COGEH.

The COGEH itself can be obtained from the Petroleum Society of the Canadian Institute of Mining, Metallurgy and Petroleum, Calgary Chapter at www.petsoc.org.

SECTION 5
DEFINITIONS OF RESOURCES AND RESERVES

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5.1 Preface

5.1.1 Background

The Petroleum Society of CIM (Petroleum Society) Standing Committee on Reserves Definitions (Standing Committee) released revised *Definitions and Guidelines For Estimating and Classifying Oil and Gas Reserves* in January 2002. Later in 2002 these reserves definitions were adopted as the foundation for reserves estimation in the Canadian Oil and Gas Evaluation Handbook (COGEH).

The authors of COGEH and the Standing Committee each developed separate definitions of resources, incorporating terminology and concepts published in February 2000 by the Society of Petroleum Engineers (SPE), the World Petroleum Council (WPC), and the American Association of Petroleum Geologists (AAPG) (hereafter referred to as the 2000 SPE Resources Definitions). The COGEH version was published in COGEH in 2002, with the Standing Committee version being published in the second edition of the Petroleum Society's Monograph No. 1, *Determination of Oil and Gas Reserves*, in 2004.

The Standing Committee has now reviewed its definitions for both resources and reserves. Simultaneously, the Society of Petroleum Engineers (SPE), the World Petroleum Council (WPC), the American Association of Petroleum Geologists (AAPG), and the Society of Petroleum Evaluation Engineers (SPEE) reviewed the 2000 SPE Resources Definitions and released revised definitions in April 2007 in its *Petroleum Resources Management System* (SPE-PRMS) document. This revision to COGEH has given due consideration to the SPE-PRMS and has resulted in notable changes to resources definitions, with only minor editorial changes to the previous reserves definitions and guidance.

There is now a broad alignment between the COGEH and SPE-PRMS definitions and guidelines, but some minor differences remain. Currently neither the sponsors of COGEH nor those of SPE-PRMS have fully endorsed all aspects of the other party's definitions, nor has such endorsement been requested.

5.1.2 Introduction

Petroleum is defined as a naturally occurring mixture consisting predominantly of hydrocarbons in the gaseous, liquid, or solid phase. The term "resources" encompasses all petroleum quantities that originally existed on or within the earth's crust in naturally occurring accumulations, including discovered and undiscovered (recoverable and unrecoverable) plus quantities already produced. Accordingly, total resources is equivalent to total Petroleum Initially-In-Place (PIIP). It is recommended

that the term “total PIIP” be used rather than “total resources” in order to avoid any confusion that may result from the mixed historical usage of the term “resources” to mean the recoverable portion of PIIP or total PIIP.

The concept that a recovery or development *project* is required in order to recover resources from a petroleum accumulation is fundamental to the SPE-PRMS. One or more exploration, delineation, or development projects may be applied to an accumulation, and each project will provide additional technical data and/or recover an estimated portion of the PIIP. In the early stage of exploration or development, project definition will not be of the detail expected in later stages of maturity. For the purposes of government/regulatory resource management or for basin potential studies, projects will typically be defined with lesser precision. Regardless of the end use of estimates, a basic requirement for the assignment of recoverable resources in any category is that it must be possible to define a technically feasible recovery project.

Figure 5-1, taken from the SPE-PRMS, illustrates the main resources classification system. Additional operational subcategories may also be optionally used (see Section 5.3.4 a).

The vertical axis of Figure 5-1 represents the chance of commerciality. The key vertical categories relate to the quantities that are estimated to be remaining and recoverable; that is

- reserves, which are discovered and commercially recoverable;
- contingent resources, which are discovered and potentially recoverable but sub-commercial;
- prospective resources, which are undiscovered and potentially recoverable.

The range of uncertainty indicated on the horizontal axis of Figure 5-1 reflects that remaining recoverable quantities can only be estimated, not measured. Three uncertainty categories, or scenarios, are identified for estimates of recoverable resources — low estimate, best estimate, and high estimate (abbreviations for contingent resources are 1C, 2C, and 3C, respectively) — with the corresponding reserves categories of proved (1P), proved + probable (2P), and proved + probable + possible (3P).

Formal definitions for each element of Figure 5-1 are provided in Section 5.2.

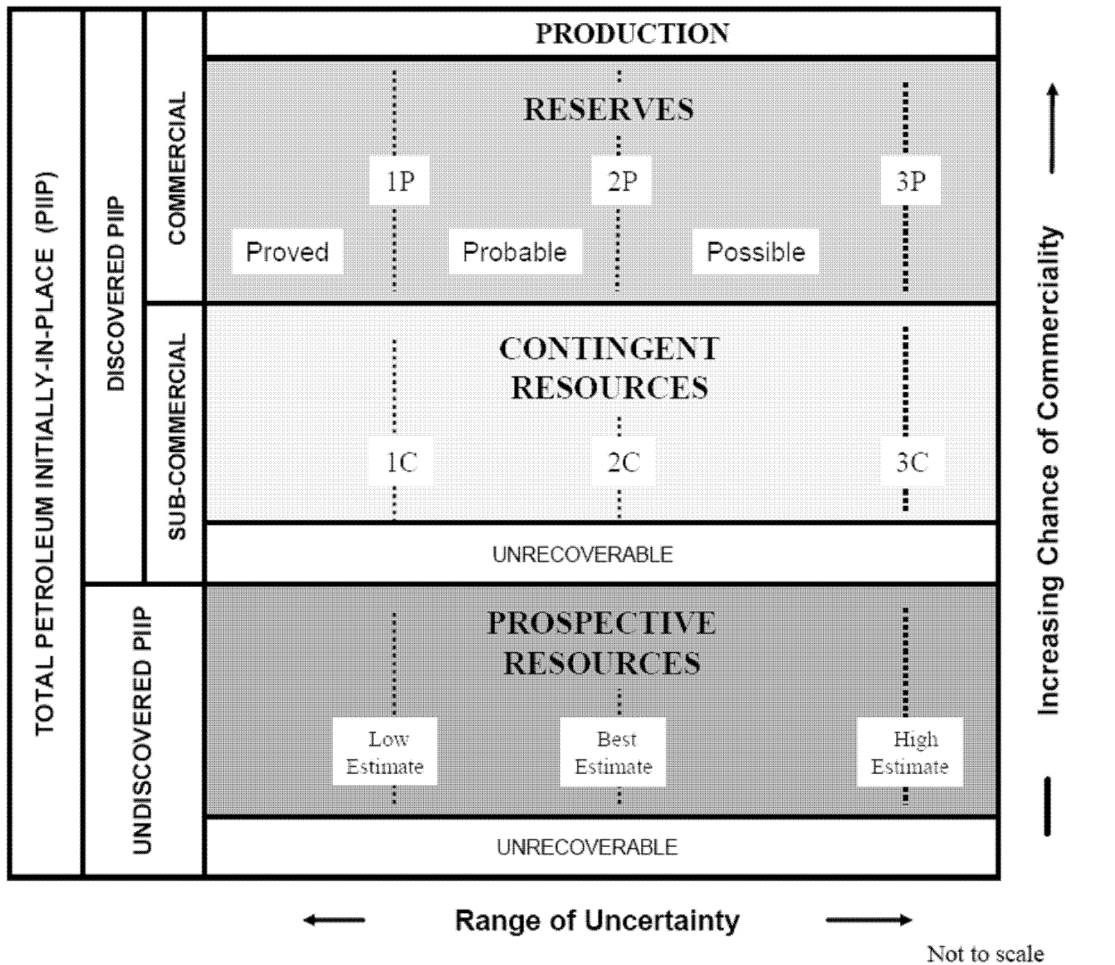


Figure 5-1 Resources classification framework (SPE-PRMS, Figure 1.1).

5.2 Definitions of Resources

The following definitions relate to the subdivisions in the resources classification framework of Figure 5-1 and use the primary nomenclature and concepts contained in the 2007 SPE-PRMS, with direct excerpts shown in italics.

Total Petroleum Initially-In-Place (PIIP) is that quantity of petroleum that is estimated to exist originally in naturally occurring accumulations. It includes that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations, prior to production, plus those estimated quantities in accumulations yet to be discovered (equivalent to “total resources”).

Discovered Petroleum Initially-In-Place (equivalent to discovered resources) is that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations prior to production. The recoverable portion of discovered petroleum

initially in place includes production, reserves, and contingent resources; the remainder is unrecoverable.

Production is the cumulative quantity of petroleum that has been recovered at a given date.

Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, as of a given date, based on the analysis of drilling, geological, geophysical, and engineering data; the use of established technology; and specified economic conditions, which are generally accepted as being reasonable. Reserves are further classified according to the level of certainty associated with the estimates and may be subclassified based on development and production status. Refer to the full definitions of reserves in Section 5.4.

Contingent Resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations using established technology or technology under development, but which are not currently considered to be commercially recoverable due to one or more contingencies. Contingencies may include factors such as economic, legal, environmental, political, and regulatory matters, or a lack of markets. It is also appropriate to classify as contingent resources the estimated discovered recoverable quantities associated with a project in the early evaluation stage. Contingent Resources are further classified in accordance with the level of certainty associated with the estimates and may be subclassified based on project maturity and/or characterized by their economic status.

Unrecoverable is that portion of Discovered or Undiscovered PIIP quantities which is estimated, as of a given date, not to be recoverable by future development projects. A portion of these quantities may become recoverable in the future as commercial circumstances change or technological developments occur; the remaining portion may never be recovered due to the physical/chemical constraints represented by subsurface interaction of fluids and reservoir rocks.

Undiscovered Petroleum Initially-In-Place (equivalent to undiscovered resources) is that quantity of petroleum that is estimated, on a given date, to be contained in accumulations yet to be discovered. The recoverable portion of undiscovered petroleum initially in place is referred to as “prospective resources,” the remainder as “unrecoverable.”

Prospective Resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from undiscovered accumulations by application of future development projects. Prospective resources have both an associated chance of discovery and a chance of development. Prospective Resources are further subdivided in accordance with the level of certainty associated with recoverable estimates assuming their discovery and development and may be subclassified based on project maturity.

Unrecoverable: see above.

Reserves, contingent resources, and prospective resources should not be combined without recognition of the significant differences in the criteria associated with their classification. However, in some instances (e.g., basin potential studies) it may be desirable to refer to certain subsets of the total PIIP. For such purposes the term “resources” should include clarifying adjectives “remaining” and “recoverable,” as appropriate. For example, the sum of reserves, contingent resources, and prospective resources may be referred to as “remaining recoverable resources.” However, contingent and prospective resources estimates involve additional risks, specifically the risk of not achieving commerciality and exploration risk, respectively, not applicable to reserves estimates. Therefore, when resources categories are combined, it is important that each component of the summation also be provided, and it should be made clear whether and how the components in the summation were adjusted for risk.

5.3 Classification of Resources

For petroleum quantities associated with simple conventional reservoirs, the divisions between the resources categories defined in Section 5.2 may be quite clear, and in such instances the basic definitions alone may suffice for differentiation between categories. For example, the drilling and testing of a well in a simple structural accumulation may be sufficient to allow classification of the entire estimated recoverable quantity as contingent resources or reserves. However, as the industry trends toward the exploitation of more complex and costly petroleum sources, the divisions between resources categories are less distinct, and accumulations may have several categories of resources simultaneously. For example, in extensive “basin-center” low-permeability gas plays, the division between all categories of remaining recoverable quantities, i.e., reserves, contingent resources, and prospective resources, may be highly interpretive. Consequently, additional guidance is necessary to promote consistency in classifying resources. The following provides some

clarification of the key criteria that delineate resources categories. Subsequent volumes of COGEH provide additional guidance.

5.3.1 Discovery Status

As shown in Figure 5-1, the total petroleum initially in place is first subdivided based on the discovery status of a petroleum accumulation. Discovered PIIP, production, reserves, and contingent resources are associated with known accumulations. Recognition as a known accumulation requires that the accumulation be penetrated by a well and have evidence of the existence of petroleum. COGEH Volume 2, Sections 5.3 and 5.4, provides additional clarification regarding drilling and testing requirements relating to recognition of known accumulations.

5.3.2 Commercial Status

Commercial status differentiates reserves from contingent resources. The following outlines the criteria that should be considered in determining commerciality:

- economic viability of the related development project;
- a reasonable expectation that there will be a market for the expected sales quantities of production required to justify development;
- evidence that the necessary production and transportation facilities are available or can be made available;
- evidence that legal, contractual, environmental, governmental, and other social and economic concerns will allow for the actual implementation of the recovery project being evaluated;
- a reasonable expectation that all required internal and external approvals will be forthcoming. Evidence of this may include items such as signed contracts, budget approvals, and approvals for expenditures, etc.;
- evidence to support a reasonable timetable for development. A reasonable time frame for the initiation of development depends on the specific circumstances and varies according to the scope of the project. While five years is recommended as a maximum time frame for classification of a project as commercial, a longer time frame could be applied where, for example, development of economic projects are deferred at the option of the producer for, among other things, market-related reasons or to meet contractual or strategic objectives.

COGEH Volume 2, Sections 5.5 to 5.8, provides additional details relating to the foregoing aspects of commerciality relating to classification as reserves versus contingent resources.

5.3.3 Commercial Risk

In order to assign recoverable resources of any category, a development plan consisting of one or more projects needs to be defined. In-place quantities for which a feasible project cannot be defined using established technology or technology under development are classified as unrecoverable. In this context “technology under development” refers to technology that has been developed and verified by testing as feasible for future commercial applications to the subject reservoir. In the early stage of exploration or development, project definition will not be of the detail expected in later stages of maturity. In most cases recovery efficiency will be largely based on analogous projects.

Estimates of recoverable quantities are stated in terms of the sales products derived from a development program, assuming commercial development. It must be recognized that reserves, contingent resources, and prospective resources involve different risks associated with achieving commerciality. The likelihood that a project will achieve commerciality is referred to as the “chance of commerciality.” The chance of commerciality varies in different categories of recoverable resources as follows:

- **Reserves:** To be classified as reserves, estimated recoverable quantities must be associated with a project(s) that has demonstrated commercial viability. Under the fiscal conditions applied in the estimation of reserves, the chance of commerciality is effectively 100 percent.
- **Contingent Resources:** Not all technically feasible development plans will be commercial. The commercial viability of a development project is dependent on the forecast of fiscal conditions over the life of the project. For contingent resources the risk component relating to the likelihood that an accumulation will be commercially developed is referred to as the “chance of development.” For contingent resources the chance of commerciality is equal to the chance of development.
- **Prospective Resources:** Not all exploration projects will result in discoveries. The chance that an exploration project will result in the discovery of petroleum is referred to as the “chance of discovery.” Thus, for an undiscovered accumulation the chance of commerciality is the product of

two risk components — the chance of discovery and the chance of development.

5.3.4 Economic Status, Development, and Production Subcategories

a. Economic Status

By definition, reserves are commercially (and hence economically) recoverable. A portion of contingent resources may also be associated with projects that are economically viable but have not yet satisfied all requirements of commerciality. Accordingly, it may be a desirable option to subclassify contingent resources by economic status:

Economic Contingent Resources are those contingent resources that are currently economically recoverable.

Sub-Economic Contingent Resources are those contingent resources that are not currently economically recoverable.

Where evaluations are incomplete such that it is premature to identify the economic viability of a project, it is acceptable to note that project economic status is “undetermined” (i.e., “contingent resources – economic status undetermined”).

In examining economic viability, the same fiscal conditions should be applied as in the estimation of reserves, i.e., specified economic conditions, which are generally accepted as being reasonable (refer to COGEH Volume 2, Section 5.8).

b. Development and Production Status

Resources may be further subclassified based on development and production status. For reserves, the terms “developed” and “undeveloped” are used to express the status of development of associated recovery projects, and “producing” and “non-producing” indicate whether or not reserves are actually on production (see Section 5.4.2).

Similarly, project maturity subcategories can be identified for contingent and prospective resources; the SPE-PRMS (Section 2.1.3.1) provides examples of subcategories that could be identified. For example, the SPE-PRMS identifies the highest project maturity subcategory as “development pending,” defined as “a discovered accumulation where project activities are ongoing to justify commercial development in the foreseeable future.”

5.3.5 Uncertainty Categories

Estimates of resources always involve uncertainty, and the degree of uncertainty can vary widely between accumulations/projects and over the life of a project. Consequently, estimates of resources should generally be quoted as a range according to the level of confidence associated with the estimates. An understanding of statistical concepts and terminology is essential to understanding the confidence associated with resources definitions and categories. These concepts, which apply to all categories of resources, are outlined in Sections 5.5.1 to 5.5.3.

The range of uncertainty of estimated recoverable volumes may be represented by either deterministic scenarios or by a probability distribution. Resources should be provided as low, best, and high estimates as follows:

- **Low Estimate:** This is considered to be a conservative estimate of the quantity that will actually be recovered. It is likely that the actual remaining quantities recovered will exceed the low estimate. If probabilistic methods are used, there should be at least a 90 percent probability (P_{90}) that the quantities actually recovered will equal or exceed the low estimate.
- **Best Estimate:** This is considered to be the best estimate of the quantity that will actually be recovered. It is equally likely that the actual remaining quantities recovered will be greater or less than the best estimate. If probabilistic methods are used, there should be at least a 50 percent probability (P_{50}) that the quantities actually recovered will equal or exceed the best estimate.
- **High Estimate:** This is considered to be an optimistic estimate of the quantity that will actually be recovered. It is unlikely that the actual remaining quantities recovered will exceed the high estimate. If probabilistic methods are used, there should be at least a 10 percent probability (P_{10}) that the quantities actually recovered will equal or exceed the high estimate.

This approach to describing uncertainty may be applied to reserves, contingent resources, and prospective resources. There may be significant risk that sub-commercial and undiscovered accumulations will not achieve commercial production. However, it is useful to consider and identify the range of potentially recoverable quantities independently of such risk.

5.4 Definitions of Reserves

The following reserves definitions and guidelines are designed to assist evaluators in making reserves estimates on a reasonably consistent basis, and assist users of evaluation reports in understanding what such reports contain and, if necessary, in judging whether evaluators have followed generally accepted standards.

The guidelines outline

- general criteria for classifying reserves,
- procedures and methods for estimating reserves,
- confidence levels of individual entity and aggregate reserves estimates,
- verification and testing of reserves estimates.

The determination of oil and gas reserves involves the preparation of estimates that have an inherent degree of associated uncertainty. Categories of proved, probable, and possible reserves have been established to reflect the level of these uncertainties and to provide an indication of the probability of recovery.

The estimation and classification of reserves requires the application of professional judgement combined with geological and engineering knowledge to assess whether or not specific reserves classification criteria have been satisfied. Knowledge of concepts including uncertainty and risk, probability and statistics, and deterministic and probabilistic estimation methods is required to properly use and apply reserves definitions. These concepts are presented and discussed in greater detail within the guidelines in Section 5.5.

The following definitions apply to both estimates of individual reserves entities and the aggregate of reserves for multiple entities.

5.4.1 Reserves Categories

Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, as of a given date, based on

- analysis of drilling, geological, geophysical, and engineering data;
- the use of established technology;

- specified economic conditions, which are generally accepted as being reasonable, and shall be disclosed.

Reserves are classified according to the degree of certainty associated with the estimates.

a. Proved Reserves

Proved reserves are those reserves that can be estimated with a high degree of certainty to be recoverable. It is likely that the actual remaining quantities recovered will exceed the estimated proved reserves.

b. Probable Reserves

Probable reserves are those additional reserves that are less certain to be recovered than proved reserves. It is equally likely that the actual remaining quantities recovered will be greater or less than the sum of the estimated proved + probable reserves.

c. Possible Reserves

Possible reserves are those additional reserves that are less certain to be recovered than probable reserves. It is unlikely that the actual remaining quantities recovered will exceed the sum of the estimated proved + probable + possible reserves.

Other criteria that must also be met for the classification of reserves are provided in Section 5.5.4.

5.4.2 Development and Production Status

Each of the reserves categories (proved, probable, and possible) may be divided into developed and undeveloped categories.

a. Developed Reserves

Developed reserves are those reserves that are expected to be recovered from existing wells and installed facilities or, if facilities have not been installed, that would involve a low expenditure (e.g., when compared to the cost of drilling a well) to put the reserves on production. The developed category may be subdivided into producing and non-producing.

Developed producing reserves are those reserves that are expected to be recovered from completion intervals open at the time of the estimate. These reserves may be

currently producing or, if shut in, they must have previously been on production, and the date of resumption of production must be known with reasonable certainty.

Developed non-producing reserves are those reserves that either have not been on production, or have previously been on production but are shut in and the date of resumption of production is unknown.

b. Undeveloped Reserves

Undeveloped reserves are those reserves expected to be recovered from known accumulations where a significant expenditure (e.g., when compared to the cost of drilling a well) is required to render them capable of production. They must fully meet the requirements of the reserves category (proved, probable, possible) to which they are assigned.

In multi-well pools, it may be appropriate to allocate total pool reserves between the developed and undeveloped categories or to subdivide the developed reserves for the pool between developed producing and developed non-producing. This allocation should be based on the estimator's assessment as to the reserves that will be recovered from specific wells, facilities, and completion intervals in the pool and their respective development and production status.

5.4.3 Levels of Certainty for Reported Reserves

The qualitative certainty levels contained in the definitions in Section 5.4.1 are applicable to “individual reserves entities,” which refers to the lowest level at which reserves calculations are performed, and to “reported reserves,” which refers to the highest level sum of individual entity estimates for which reserves estimates are presented. Reported reserves should target the following levels of certainty under a specific set of economic conditions:

- at least a 90 percent probability that the quantities actually recovered will equal or exceed the estimated proved reserves,
- at least a 50 percent probability that the quantities actually recovered will equal or exceed the sum of the estimated proved + probable reserves,
- at least a 10 percent probability that the quantities actually recovered will equal or exceed the sum of the estimated proved + probable + possible reserves.

A quantitative measure of the certainty levels pertaining to estimates prepared for the various reserves categories is desirable to provide a clearer understanding of the associated risks and uncertainties. However, the majority of reserves estimates are prepared using deterministic methods that do not provide a mathematically derived quantitative measure of probability. In principle, there should be no difference between estimates prepared using probabilistic or deterministic methods.

Additional clarification of certainty levels associated with reserves estimates and the effect of aggregation is provided in Section 5.5.3.

5.5 General Guidelines for Estimation of Reserves

The following is a summary of fundamental guidelines that should be followed by reserves evaluators. These general guidelines provide guidance that should aid in improving consistency in reserves reporting, but provide only a brief summary of the issues that may arise in applying the reserves definitions. It must be recognized that reserves definitions and associated guidelines cannot address all possible scenarios, nor can they remove the conditions of uncertainty that are inherent in all reserves estimates. It is the responsibility of the reserves evaluator to exercise sound professional judgement and apply these guidelines appropriately and objectively.

5.5.1 Uncertainty in Reserves Estimation

Reserves estimation has characteristics that are common to any measurement process that uses uncertain data. An understanding of statistical concepts and the associated terminology is essential to understanding the confidence associated with reserves definitions and categories.

Uncertainty in a reserves estimate arises from a combination of error and bias:

- Error is inherent in the data that are used to estimate reserves. Note that the term “error” refers to limitations in the input data, not to a mistake in interpretation or application of the data. The procedures and concepts dealing with error lie within the realm of statistics and are well established.
- Bias, which is a predisposition of the evaluator, has various sources that are not necessarily conscious or intentional.

In the absence of bias, different qualified evaluators using the same information at the same time should produce reserves estimates that will not be significantly different, particularly for the aggregate of a large number of estimates. The range

within which these estimates should reasonably fall depends on the quantity and quality of the basic information and the extent of analysis of the data.

5.5.2 Deterministic and Probabilistic Methods

Reserves estimates may be prepared using either deterministic or probabilistic methods.

a. Deterministic Method

The deterministic approach, which is the one most commonly employed worldwide, involves the selection of a single value for each parameter in the reserves calculation. The discrete value for each parameter is selected based on the estimator's determination of the value that is most appropriate for the corresponding reserves category.

b. Probabilistic Method

Probabilistic analysis involves describing a range of possible values for each unknown parameter. This approach typically consists of employing computer software to perform repetitive calculations (e.g., Monte Carlo simulation) to generate the full range of possible outcomes and their associated probability of occurrence.

c. Comparison of Deterministic and Probabilistic Estimates

Deterministic and probabilistic methods are not distinct and separate. A deterministic estimate is a single value within a range of outcomes that could be derived by a probabilistic analysis. There should be no significant difference between reported reserves estimates prepared using deterministic and probabilistic methods.

d. Application of Guidelines to the Probabilistic Method

The following guidelines include criteria that provide specific limits to parameters for proved reserves estimates. For example, volumetric estimates are restricted by the lowest known hydrocarbon (LKH). Inclusion of such specific limits may conflict with standard probabilistic procedures, which require that input parameters honour the range of potential values.

Nonetheless, it is required that the guidelines be met regardless of analysis method. Accordingly, when probabilistic methods are used, constraints on input parameters may be required in certain instances. Alternatively, a deterministic check may be made in such instances to ensure that aggregate estimates prepared using probabilistic

methods do not exceed those prepared using a deterministic approach including all appropriate constraints.

5.5.3 Aggregation of Reserves Estimates

Reported reserves typically comprise the aggregate of estimates prepared for a number of individual wells, reservoirs, and/or properties/fields.

When deterministic methods are used, reported reserves will be the simple arithmetic sum of all estimates within each reserves category. Evaluators and users of reserves information must understand the effect of summation on the confidence level of estimates. The confidence level associated with the arithmetic sum for a number of individual estimates may be different from that of each of the individual estimates. Arithmetic summation of independent high-probability estimates will result in a total with a higher confidence level; arithmetic summation of low-probability estimates will yield a total with a lower confidence level.

Because the definitions and guidelines require a conservative approach in the estimation of proved reserves, the minimum probability target for proved reported reserves will be satisfied with a deterministic approach as long as there are enough independent entity estimates in the aggregate. Where a very small number of entities dominate in the reported reserves, a specific effort to meet the probability criteria may be required in preparing deterministic estimates of proved reserves. Since proved + probable reserves prepared by deterministic methods will approximate mean values, the probability associated with the estimates will essentially be unaffected by aggregation.

When probabilistic techniques are used in reserves estimation, statistically based mathematical aggregation is performed within the probabilistic model. It is critical that such models appropriately include all dependencies between variables and components within the aggregation. Where dependencies and specific criteria contained in the guidelines have been treated appropriately, reserves for the various categories would be defined by the minimum probability requirements contained in Section 5.4.3, subject to the following considerations.

Reported reserves for a company will typically not be the aggregate results from a single probabilistic model, since reserves estimates are used for a variety of purposes, including planning, reserves reconciliation, accounting, securities disclosure, and asset transactions. These uses will generally necessitate tabulations of reserves estimates at lower aggregation levels than the total reported reserves. For these reasons and due to the lack of general acceptance of probabilistic aggregation up to

the company level, reserves should not be aggregated probabilistically beyond the field (or property) level.

Statistical aggregation of a tabulation of values, which does not result in a straightforward arithmetic addition, is not accepted for most reporting purposes. Consequently, discrete estimates for each reserves category resulting from separate probabilistic analyses, which may, as appropriate, include aggregation up to the field or property level, should be summed arithmetically. As a result, reported reserves will meet the probability requirements in Section 5.4.3 regardless of dependencies between separate probabilistic analyses and may be summed with deterministic estimates within each reserves category.

It is recognized that the foregoing approach imposes an additional measure of conservatism when proved reserves are derived from a number of mathematically independent probabilistic analyses, because the sum of independent 90 percent confidence level estimates has an associated confidence level of greater than 90 percent. Nonetheless, this is considered to be an acceptable consequence given the need for a discrete accounting of component proved reserves estimates.

Conversely, this approach will cause the sum of proved + probable + possible reserves derived from a number of probabilistic analyses to fail to meet the 10 percent minimum confidence level requirement. Given the limited application for proved + probable + possible reported reserves, this is also considered to be an acceptable consequence.

5.5.4 General Requirements for Classification of Reserves

The following general conditions must be satisfied in the estimation and classification of reserves. More detailed guidance can be found in Chapter 5 of COGEH Volume 2.

a. Ownership Considerations

Assigning reserves to a company requires the company to own the subsurface mineral rights or have the contractual right to exploit and produce. This may be ascertained by reviewing land records and verified in financial records.

Internationally, in Production Sharing Contracts, the company will not usually own the mineral rights, but reserves may be assigned if the company has the right to extract the oil or gas. Further qualifications are

- the right to take volumes in kind,

- exposure to market and technical risk,
- the opportunity for reward through participation in producing activities.

Reserves would not be booked for companies participating in projects where their rights are limited to purchasing volumes or service agreements that do not contain aspects of technical and price risk and reward. Pure service contracts are an example of this type.

Company gross reserves are the working interest share of reserves prior to deduction of payments to others such as royalties (burdens).

Company royalty interest reserves are the net reserves received as a result of a royalty or carried interest.

Company interest reserves are the sum of company gross plus company royalty interest reserves. To avoid double accounting of reserves reported by a company, company royalty interest reserves must include only royalty volumes derived from non-related working interest owners.

Company net reserves are the working interest reserves after payment of burdens. Received royalty interests and carried interests are included in net reserves. Internationally, net reserves are after payments to governments. Depending on the PSC, they may be before or after payment of income tax.

b. Drilling Requirements

Proved, probable, or possible reserves may be assigned only to known accumulations that have been penetrated by a wellbore. Potential hydrocarbon accumulations that have not been penetrated by a wellbore may be assigned to prospective resources.

c. Testing Requirements

Confirmation of commercial productivity of an accumulation by production or a formation test is required for classification of reserves as proved. In the absence of production or formation testing, probable and/or possible reserves may be assigned to an accumulation on the basis of well logs and/or core analysis that indicates that the zone is hydrocarbon bearing and is analogous to other reservoirs in the immediate area that have demonstrated commercial productivity by actual production or formation testing.

d. Regulatory Considerations

In general, proved, probable, or possible reserves may be assigned only in instances where production or development of those reserves is not prohibited by governmental regulation. This provision could, for instance, preclude the assignment of reserves in designated environmentally sensitive areas. Reserves may be assigned in instances where regulatory restraints may be removed subject to satisfaction of minor conditions. In such cases the classification of reserves as proved, probable, or possible should be made with consideration given to the risk associated with project approval.

e. Infrastructure and Market Considerations

In order to assign reserves there should be an identifiable transportation infrastructure and a market to sell the oil or gas. The market requirement could vary from highly transparent spot markets such as exist in North America or the UK to long-term contracts in more remote areas of the world. If there is no existing market, the evaluator has to assess the level of confidence that one will be available within a reasonable time frame.

If there is no infrastructure in place, or the company has no ownership in nearby infrastructure, the evaluator has to assess the level of confidence that access to suitable infrastructure will be available within a reasonable time frame.

f. Timing of Production and Development

Non-producing reserves should be planned to be developed within a reasonable time frame. For projects requiring minor capital expenditures, two years is a recommended guideline unless the non-producing reserves are awaiting depletion of another producing zone or production levels are constrained by facility or market limitations. For larger capital expenditures, three years is a recommended guideline for assigning proved reserves and five years for assigning probable reserves. Exceptions to these guidelines are possible but should be clearly documented.

For producing reserves, extrapolating reserves over very long periods should take into account the uncertainties in forecasting volumes, fiscal terms, market factors, and infrastructure. It is recommended that reserves be limited to less than a 50-year forecast period unless there are clear reasons to extend beyond this.

g. Economic Requirements

Proved, probable, or possible reserves may be assigned only to those volumes that are economically recoverable. The fiscal conditions under which reserves estimates are prepared should generally be those considered to be a reasonable outlook on the future. Securities regulators or other agencies may require that constant or other prices and costs be used in the estimation of reserves and value. In such instances the estimated reserves quantities must be recoverable under those conditions and should also be recoverable under fiscal conditions considered to be a reasonable outlook on the future. In any event, the fiscal assumptions used in the preparation of reserves estimates must be disclosed.

Undeveloped recoverable volumes must have a sufficient return on investment to justify the associated capital expenditure in order to be classified as reserves as opposed to contingent resources.

5.5.5 Procedures for Estimation and Classification of Reserves

The process of reserves estimation falls into three broad categories: volumetric, material balance, and decline analysis. Selection of the most appropriate reserves estimation procedures depends on the information that is available. Generally, the range of uncertainty associated with an estimate decreases and confidence level increases as more information becomes available and when the estimate is supported by more than one estimation method. Regardless of the estimation method(s) employed, the resulting reserves estimate should meet the certainty criteria in Section 5.4.

a. Volumetric Methods

Volumetric methods involve the calculation of reservoir rock volume, the hydrocarbons in place in that rock volume, and the estimation of the portion of the hydrocarbons in place that ultimately will be recovered. For various reservoir types at varied stages of development and depletion, the key unknown in volumetric reserves determinations may be rock volume, effective porosity, fluid saturation, or recovery factor. Important considerations affecting a volumetric reserves estimate are outlined below:

- **Rock Volume:** Rock volume may simply be determined as the product of a single well drainage area and wellbore net pay or by more complex geological mapping. Estimates must take into account geological characteristics, reservoir fluid properties, and the drainage area that could be expected for the well or wells. Consideration must be given to any limitations

indicated by geological and geophysical data or interpretations, as well as pressure depletion or boundary conditions exhibited by test data.

- **Elevation of Fluid Contacts:** In the absence of data that clearly define fluid contacts, the structural interval for volumetric calculations of proved reserves should be restricted by the lowest known structural elevation of occurrence of hydrocarbons (LKH) as defined by well logs, core analyses, or formation testing.
- **Effective Porosity, Fluid Saturation, and Other Reservoir Parameters:** These are determined from logs and core and well test data.
- **Recovery Factor:** Recovery factor is based on analysis of production behaviour from the subject reservoir, by analogy with other producing reservoirs, and/or by engineering analysis. In estimating recovery factors the evaluator must consider factors that influence recoveries, such as rock and fluid properties, PIIP, drilling density, future changes in operating conditions, depletion mechanisms, and economic factors.

b. Material Balance Methods

Material balance methods of reserves estimation involve the analysis of pressure behaviour as reservoir fluids are withdrawn, and they generally result in more reliable reserves estimates than volumetric estimates. Reserves may be based on material balance calculations when sufficient production and pressure data are available. Confident application of material balance methods requires knowledge of rock and fluid properties, aquifer characteristics, and accurate average reservoir pressures. In complex situations, such as those involving water influx, multi-phase behaviour, multi-layered or low-permeability reservoirs, material balance estimates alone may provide erroneous results.

Computer reservoir modelling can be considered a sophisticated form of material balance analysis. While modelling can be a reliable predictor of reservoir behaviour, the input rock properties, reservoir geometry, and fluid properties are critical. Evaluators must be aware of the limitations of predictive models when using these results for reserves estimation.

The portion of reserves estimated as proved, probable, or possible should reflect the quantity and quality of the available data and the confidence in the associated estimate.

c. Production Decline Methods

Production decline analysis methods of reserves estimation involve the analysis of production behaviour as reservoir fluids are withdrawn. Confident application of decline analysis methods requires a sufficient period of stable operating conditions after the wells in a reservoir have established drainage areas. In estimating reserves, evaluators must take into consideration factors affecting production decline behaviour, such as reservoir rock and fluid properties, transient versus stabilized flow, changes in operating conditions (both past and future), and depletion mechanism.

Reserves may be assigned based on decline analysis when sufficient production data are available. The decline relationship used in projecting production should be supported by all available data.

The portion of reserves estimated as proved, probable, or possible should reflect the confidence in the associated estimate.

d. Future Drilling and Planned Enhanced Recovery Projects

The foregoing reserves estimation methodologies are applicable to recoveries from existing wells and enhanced recovery projects that have been demonstrated to be economically and technically successful in the subject reservoir by actual performance or a successful pilot. The following criteria should be considered when estimating incremental reserves associated with development drilling or implementation of enhanced recovery projects. In all instances the probability of recovery of the associated reserves must meet the criteria for commerciality (Section 5.3.2), the general requirements (Section 5.5.4), and certainty criteria contained in Section 5.4.

If interpretations are such that no proved or probable reserves are assigned to a development project involving significant future capital expenditures, then the potentially recoverable quantities should be classified as contingent resources rather than stand-alone possible reserves.

i. Additional Reserves Related to Future Drilling

Additional reserves associated with future commercial drilling projects in known accumulations may be assigned where economics support, and regulations do not prohibit, the drilling of the location.

Aside from the criteria stipulated in Section 5.4, factors to be considered in classifying reserves estimates associated with future drilling as proved, probable, or possible include

- whether the proposed location directly offsets existing wells or acreage with proved or probable reserves assigned,
- the expected degree of geological continuity within the reservoir unit containing the reserves,
- the likelihood that the location will be drilled.

In addition, where infill wells will be drilled and placed on production, the evaluator must quantify well interference effects, that portion of recovery that represents accelerated production of developed reserves, and that portion that represents incremental recovery beyond those reserves recognized for the existing reservoir development.

ii. *Reserves Related to Planned Enhanced Recovery Projects*

Reserves that can be economically recovered through the future application of an established enhanced recovery method may be classified as follows.

Proved reserves may be assigned to planned enhanced recovery projects when the following criteria are met:

- Repeated commercial success of the enhanced recovery process has been demonstrated in reservoirs in the area with analogous rock and fluid properties.
- The project is highly likely to be carried out in the near future. This may be demonstrated by factors such as the commitment of project funding.
- Where required, either regulatory approvals have been obtained or no regulatory impediments are expected, as clearly demonstrated by the approval of analogous projects.

Probable reserves may be assigned when a planned enhanced recovery project does not meet the requirements for classification as proved; however, the following criteria are met:

- The project can be shown to be practically and technically reasonable.

- Commercial success of the enhanced recovery process has been demonstrated in reservoirs with analogous rock and fluid properties.
- It is reasonably certain that the project will be implemented.

Additional possible reserves may be assigned in a planned enhanced recovery project considering factors such as greater effective hydrocarbons in place or greater recovery efficiencies than those estimated in the proved + probable reserves scenario. As previously noted, stand-alone possible reserves should not be assigned to a potential future enhanced recovery project where conditions are such that no proved or probable reserves could be assigned. In such cases the potentially recoverable quantities would be classified as contingent resources, with a corresponding low, best, and high estimate.

5.5.6 Validation of Reserves Estimates

A practical method of validating that reserves estimates meet the definitions and guidelines is through periodic reserves reconciliation of both entity and aggregate estimates. The tests described below should be applied to the same entities or groups of entities over time, excluding revisions due to differing economic assumptions:

- Revisions to proved reserves estimates should generally be positive as new information becomes available.
- Revisions to proved + probable reserves estimates should generally be neutral as new information becomes available.
- Revisions to proved + probable + possible reserves estimates should generally be negative as new information becomes available.

These tests can be used to monitor whether procedures and practices employed are achieving results consistent with certainty criteria contained in Section 5.4. In the event that the above tests are not satisfied on a consistent basis, appropriate adjustments should be made to evaluation procedures and practices.

