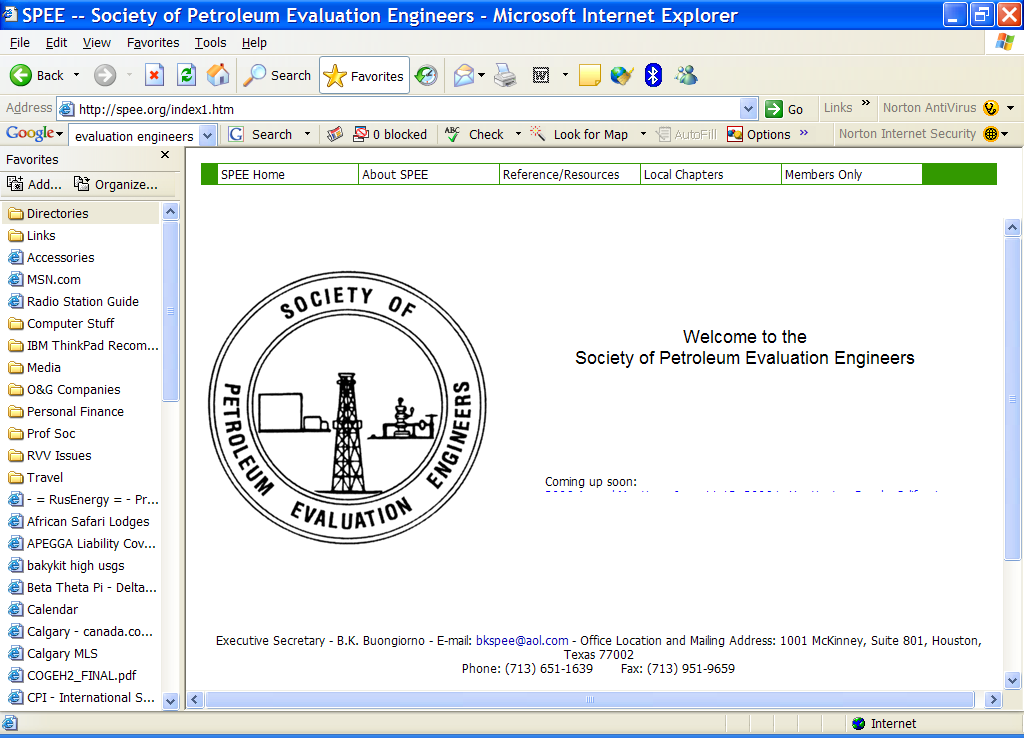
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**World Petroleum Council**

CO2 Storage

Resources Management System

Sponsored by:

Society of Petroleum Engineers (SPE)

American Association of Petroleum Geologists (AAPG)

World Petroleum Council (WPC)

Society of Petroleum Evaluation Engineers (SPEE)

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**CO2 Storage Resources Management System**

**Preamble**

CO2 storage (or storage) resources are the estimated quantities of pore volume in a geologic formation naturally occurring within the Earth’s crust that have the potential use for storage. Resource assessments estimate total storage quantities in known and yet-to-be-discovered (identified) geologic formations; resource evaluations are focused on those quantities that can potentially be used for commercial storages. A storage resources management system provides a consistent approach to estimating storage quantities, evaluating development projects, and presenting results within a comprehensive classification framework.

It has been recognized for several years that quantitative estimates of CO2 storage need to be better described in terms of data availability and certainty of the estimate as well as the status of a related injection project.

Over the past decade a number of methods to describe and systematically estimate storage resources have been proposed by authors around the world; however, none of these have gained global acceptance. A summary of proposed classification systems was presented in 2014 by Liu et.al [International Journal of Greenhouse Gas Control 22 (2014) 244–255, Modified classification system for estimating the CO2 storage capacity of saline formations].

A number of authors and institutes have recommended systems based on the SPE Petroleum Resources Management System (SPE-PRMS). These include the CO2CRC (Kaldi & Gibson-Poole, 2008), IEAGHG (Gorecki et.al, 2009), Frailey and Finley (2009), Allinson et.al (2010), Rodosta et al. (2011) and Liu et.al (2014). The Carbon Sequestration Leadership Forum (CSLF) has adopted a techno-economic resource pyramid approach [Phase II Final Report from the Task Force for Review and Identification of Standards for CO2 Storage Capacity Estimation] published in 2007.

The United Nations Economic Commission for Europe (UNECE) has an overarching classification system for fossil energy and mineral reserves and resources (UNFC-2009) and is looking to apply this system to injection projects that includes geological storage of CO2. The final Specifications for the Application of the UNFC-2009 to Injection Projects for the purpose of geological storage can be found at [<http://www.unece.org/energy/se/reserves.html>. The UNFC-2009 as applied to petroleum resources has been mapped to the SPE/WPC/AAPG/SPEE Petroleum Resources Management System (PRMS) using a bridging document. The SPE taskforce is working with the UNECE to apply the same approach to the CO2 Storage Resources Management System in order to maintain the consistency of both systems.

This multiplicity of similar but different systems has a remarkable parallel with the situation in the petroleum industry prior to the coordinated efforts of a number of societies at the beginning of the 21st century. Drawing upon this experience, this document outlines a system based on the SPE/WPC/AAPG/SPEE PRMS, which has a well-established usage and acceptance by many organization and was used very closely in the development to of this document. The PRMS definitions and the related classification system are now in common use internationally within the petroleum industry. The CO2 Storage Resources Management System is being developed to create a consistent set of definition and classification system for international usage. The SRMS will also provide a measure of comparability and reduce the subjective nature of resources estimation. As technologies employed for CO2 storage continue to evolve and improve, the CO2 Storage Resources Management System sub-committee will work closely with other organizations to maintain the definitions and issues periodic revisions to keep current with evolving technologies and changing commercial opportunities.

The established usage and acceptance of the PRMS provided the initial template for adaption to this Storage Resources Management System document. The PRMS classification concerns the commercial viability of hydrocarbon accumulations. The basis of the SRMS classification scheme is the accessible pore volume in a geologic formation in which CO2 could be stored (i.e. storable quantities).

These definitions and guidelines are designed to provide a common reference for the international storage industry, including national reporting and regulatory disclosure agencies, and to support storage project and portfolio management requirements. They are intended to improve clarity in global communications regarding storage resources. It is expected that this document will be supplemented with industry education programs and application guides addressing their implementation in a wide spectrum of technical and/or commercial settings.

It is understood that these definitions and guidelines allow flexibility for users and agencies to tailor application for their particular needs; however, any modifications to the guidance contained herein should be clearly identified. The definitions and guidelines contained in this document must not be construed as modifying the interpretation or application of any existing regulatory reporting requirements.

This SPE Storage Resources Management System document, including its Appendix, may be referred to by the abbreviated term “SPE-SRMS”.

**1.0 Basic Principles and Definitions**

The estimation of storage resource quantities involves the interpretation of the subsurface that has an inherent degree of uncertainty. These quantities are associated with development projects at various stages of design and implementation. Use of a consistent classification system enhances comparisons between projects, groups of projects, and storage efficiency**.** Such a system must consider both technical and commercial factors that impact the project’s economic feasibility, its productive life, and its related cash flows.

## 1.1 Storage Resources Classification Framework

The term “resources” as used herein is intended to encompass all quantities of pore volume potentially suitable for storage naturally occurring within the Earth’s crust, discovered and undiscovered (accessible and inaccessible), plus those quantities already used for storage (stored). Further, it includes all types of storage whether currently considered “conventional” or “unconventional.”

Figure 1-1 is a graphical representation of the SPE/WPC/AAPG/SPEE Storage resources classification system.The system defines the major storage resources classes: Stored, Capacity, Contingent Storage Resources, and Prospective Storage Resources, as well as Unexploitable Storage Resources.



Figure 1-1: Resources Classification Framework.

The “Range of Uncertainty” reflects a range of storable quantities, i.e. pore volume potentially accessible within a geologic formation by a project, while the vertical axis represents the “Chance of Commerciality”, that is, the chance that the project will be developed and reach commercial storage status. The following definitions apply to the major subdivisions within the resources classification:

**TOTAL STORAGE RESOURCES** is that quantity of storage estimated to exist in geologic formations. It includes that quantity of storage estimated, as of a given date, to be possible in known and characterized geologic formations prior to injection plus those estimated quantities in undiscovered or uncharacterized geologic formations. (Total Storage Resources is the sum of Discovered and Undiscovered Storage Resources.)

**DISCOVERED STORAGE RESOURCES** is the estimated quantity of Total Storage Resources, as of a given date, where the potential for storage has been ascertained within an assessed geologic formation.

**STORED** is the cumulative quantity of Discovered Storage Resources that have been previously exploited by a given date: this equates to the quantity of CO2 injected and stored. While all Storage Resources are estimated, and Stored is measured in terms of CO2 metering specifications, the total injection quantities (CO2 plus associated injectants) are also measured as required in support of engineering analyses.

Multiple development projects may be applied to each known geologic formation, and each project will use a portion of the storable quantities estimated for the geologic formation. The projects shall be subdivided into Commercial and Sub-Commercial, with the estimated storable quantities being classified as Capacity and Contingent Storage Resources respectively, as defined below.

**CAPACITY** are those quantities of Total Storage Resources anticipated to be commercially exploitable in the target geologic formation by application of development projects to known geologic formations from a given date forward under defined conditions. Commercial Storage Resources must further satisfy five criteria: the target geologic formation must be discovered, it must be possible to inject at the required rates, the development project must be commercial, the project permitted, and the storage resource must be remaining (as of the evaluation date) based on the development project(s) applied. Commercial Storage Resources are further categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by development and injection status.

**CONTINGENT RESOURCES** are those quantities of Total Storage Resources estimated, as of a given date, to be potentially exploitable in known geologic formations, but the applied project(s) are not yet considered mature enough for commercial development due to one or more contingencies. Contingent Storage Resources must be discovered (characterized) and may include, for example, projects for which there are currently no viable CO2 sources, project value is insufficient to support development, permitting is still incomplete, commercial storage is dependent on technology under development, management is not committed or evaluation of the geologic formation is insufficient to clearly assess commerciality. Contingent Storage Resources are further categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by their economic status and permitting/stakeholder status.

**UNDISCOVERED STORAGE RESOURCES** are the estimated quantity of Total Storage Resources, as of a given date, where the suitability for storage has not been ascertained within the target geologic formation.

**PROSPECTIVE RESOURCES** are the quantity of Undiscovered Storage Resources estimated, as of a given date, to be potentially exploitable within undiscovered geologic formations or uncharacterized parts of discovered geologic formations by application of future exploration/development projects. Prospective Storage Resources have both an associated chance of discovery and a chance of development. Prospective Storage Resources are further subdivided in accordance with the level of certainty associated with exploitable estimates assuming their discovery and development and may be sub-classified based on project maturity.

**UNEXPLOITABLE STORAGE RESOURCES** are the portion of Discovered or Undiscovered Storage Resources, which are estimated, as of a given date, not usable by future storage development projects. A portion of these Unexploitable Storage Resources may be used for storage in the future as commercial or regulatory circumstances change or technological developments occur; the remaining portion may never be used for storage due to physical/societal constraints of the storage location, both surface and subsurface.

Estimated Ultimate Storage (EUS) is not a resources category, but a term that may be applied to any geologic formation (discovered or undiscovered) to define those quantities of CO2 estimated, as of a given date, to be potentially stored under defined technical and commercial conditions plus those quantities already injected and stored.

The sum of Capacity, Contingent Resources, and Prospective Resources may be referred to as “remaining Storage Resources.” When such terms are used, it is important that each classification component of the summation also be provided. Moreover, these quantities should not be aggregated without due consideration of the varying degrees of technical and commercial risk involved with their classification.

## Project-Based Resources Evaluations

The resources evaluation process consists of identifying a storage project, or projects, associated with a geologic formation(s), estimating the storable quantities, estimating the portion of those storable quantities that can be used by each project, and classifying the project(s) based on its maturity status or chance of commerciality.

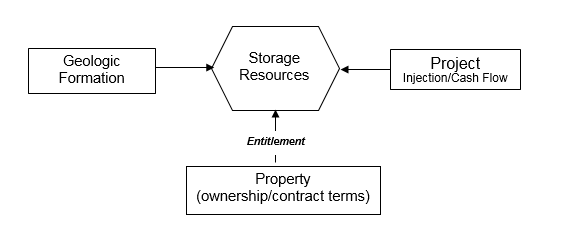
This concept of a project-based classification system is further clarified by examining the primary data sources contributing to an evaluation of storage resources (see Figure 1-2) that may be described as follows:

Figure 1-2: Resources Evaluation Data Sources.

* The Geologic Formation: Key attributes include the storable quantities and the fluid and rock properties that affect CO2 storage.
* The Project: Each project applied to a specific geologic formation development generates a unique injection and cash flow schedule. The time integration of these schedules taken to the project’s technical, economic, or contractual limit defines the estimated storage resources and associated future net cash flow projections for each project. The ratio of EUS to Total Storage Resources defines the ultimate storage efficiency for the development project(s). A project may be defined at various levels and stages of maturity; it may include one or many wells and associated injection and processing facilities. One project may develop many geologic formations, or many projects may be applied to one geologic formation.
* The Property (lease or license area): Each property may have unique associated contractual rights and obligations including the fiscal terms. Such information allows definition of each participant’s share of storable quantities (entitlement) and share of investments, expenses, and revenues for each storage project and the geologic formation to which it is applied. One property may encompass many geologic formations, or one geologic formations may span several different properties. A property may contain both discovered and undiscovered geologic formations.

In context of this data relationship, “project” is the primary element considered in this resources classification, and net storage resources are the incremental storable quantities used by each project. Projects represents the link between the geologic formation and the decision-making process. A project may, for example, constitute the development of a storable quantities in single geologic formation or multiple geologic formations, or an incremental development for a geologic formation, or the integrated development of several geologic formations and associated facilities with a common ownership. In general, an individual project will represent the level at which a decision is made whether or not to proceed (i.e., spend more money) and there should be an associated range of estimated storable quantities for that project.

Storage or potential storage of CO2 may be subject to several separate and distinct projects that are at different stages of exploration or development. Thus, a geologic formation may have storable quantities in several resource classes simultaneously.

In order to assign resources of any class, a development plan needs to be defined consisting of one or more projects. Even for Prospective Resources, the estimates of storable quantities must be stated in terms of the injected CO2 derived from a development program assuming successful discovery and commercial development. Given the major uncertainties involved at this early stage, the development program will not be of the detail expected in later stages of maturity. In most cases, storage efficiency may be largely based on analogous projects. Storable quantities for which a feasible project cannot be defined using current, or reasonably forecast improvements in, technology are classified as Unexploitable Storage Resources.

Not all technically feasible development plans will be commercial. The commercial viability of a development project is dependent on a forecast of the conditions that will exist during the time period encompassed by the project’s activities (see Commercial Evaluations, section 3.1). “Conditions” include technological, economic, legal, environmental, social, and governmental factors. While economic factors can be summarized as forecast costs , the underlying influences include, but are not limited to, market conditions, transportation and processing infrastructure, fiscal terms, and taxes.

The storable quantities being estimated are those volumes (or mass) that can be stored from a project as measured according to delivery specifications at the point of sale or custody transfer (see Reference Point, section 3.2.1). The cumulative injection from the evaluation date forward to cessation of injection is the remaining storage quantity. The sum of the associated annual net cash flows yields the estimated future net revenue. When the cash flows are discounted according to a defined discount rate and time period, the summation of the discounted cash flows is termed net present value (NPV) of the project (see Evaluation and Reporting Guidelines, section 3.0).

The supporting data, analytical processes, and assumptions used in an evaluation should be documented in sufficient detail to allow an independent evaluator or auditor to clearly understand the basis for estimation and categorization of storable quantities and their classification.

1. **Classification and Categorization Guidelines**

To consistently characterize CO2 storage projects, evaluations of all resources should be conducted in the context of the full classification system as shown in Figure 1-1. These guidelines reference this classification system and support an evaluation in which projects are “classified” based on their chance of commerciality (the vertical axis) and estimates of storable volumes associated with each project are “categorized” to reflect uncertainty (the horizontal axis). The actual workflow of classification vs. categorization varies with individual projects and is often an iterative analytical process leading to a final report. “Report,” as used herein, refers to the presentation of evaluation results within the entity conducting the assessment and should not be construed as replacing guidelines for public disclosures under processes established by regulatory and/or other government agencies.

## Resources Classification

The basic classification requires establishment of criteria for a CO2 storage volume discovery and thereafter the distinction between commercial and sub-commercial projects in known geologic formations (and hence between Capacity and Contingent Storage Resources).

2.1.1 Determination of Discovery Status

A discovery is one geologic formation, or several geologic formations collectively, for which one or several wells have established through testing, sampling, and/or logging the existence of a significant quantity of potential CO2 storage. For a geologic formation to be deemed to have potential for CO2 storage (i.e. storable quantities) it must be assessed as having both accessible pore volume and being suited to containment of the injected CO2 over a significant time period.

In this context, “significant quantity” implies that there is evidence of a sufficient quantity of Total Storage Resources to justify estimating the volume (or mass) demonstrated by the well(s) and for evaluating the potential for economic storage.  Estimated storable quantities within such a discovered (known) geologic formation(s) shall initially be classified as Contingent Storage Resources pending definition of projects with sufficient chance of commercial development to reclassify all, or a portion, as Capacity. Where Total Storage Resources is identified but is not considered currently storable, such quantities may be classified as Unexploitable Storage Resources, if considered appropriate for resource management purposes; a portion of this quantity may become exploitable Storage Resources in the future as commercial circumstances change or technological developments occur.

2.1.2 Determination of Commerciality

Discovered Storage Resources may be considered commercial, and thus be classified as Capacity, if the entity claiming commerciality has demonstrated firm intention to proceed with development and such intention is based upon all of the following criteria:

* Evidence to support a reasonable timetable for development.
* A reasonable assessment of the future economics of such development projects meeting defined investment and operating criteria;
* A reasonable expectation that there will be sustained demand (i.e. market) for storage from this development project and the expected stored quantities required to justify development.
* Evidence that the necessary injection facilities are available or can be made available:
* Evidence that legal, regulatory, contractual, environmental and other social and economic concerns will allow for the actual implementation of the storage project being evaluated.

To be included in the Capacity class, a project must be sufficiently defined to establish its commercial viability. There must be a reasonable expectation that all required internal and external approvals will be forthcoming, and there is evidence of firm intention to proceed with development within a reasonable time frame. 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 (5) years is recommended as a benchmark, a longer time frame could be applied where, for example, development of economic projects are deferred at the option of the developer for, among other things, market-related reasons, or to meet contractual or strategic objectives. In all cases, the justification for classification as Capacity should be clearly documented.

To be included in the Capacity class, there must be a high confidence in the commercial injectability of the geologic formation as supported by actual injection or formation tests, and confidence in the containment assessment. In certain cases, Capacity may be assigned on the basis of well logs and/or core analysis that indicate that the subject geologic formation is capable of injectivity and containment, and is analogous to geologic formations in the same area that are injecting or have demonstrated the ability to inject on formation tests.

**2.1.3 Project Status and Commercial Risk**

Evaluators have the option to establish a more detailed resources classification reporting system that can also provide the basis for portfolio management by subdividing the chance of commerciality axis according to project maturity. Such sub-classes may be characterized by standard project maturity level descriptions (qualitative) and/or by their associated chance of reaching injection status (quantitative).

As a project moves to a higher level of maturity, there will be an increasing chance that the storage resources will be commercially developed. For Contingent and Prospective Storage Resources, this can further be expressed as a quantitative chance estimate that incorporates two key underlying risk components:

* The chance that the geologic formation will result in the discovery of storable quantities. This is referred to as the “chance of discovery.”
* Once discovered, the chance that the storable quantities will be commercial is referred to as the “chance of development.”

Thus, for an undiscovered storage resources, the “chance of commerciality” is the product of these two risk components. For a discovered injectable geologic formation where the “chance of discovery” is 100%, the “chance of commerciality” becomes equivalent to the “chance of development.”

* + - 1. **Project Maturity Sub-Classes**

As illustrated in Figure 2-1, development projects (and their associated storable quantities) may be sub-classified according to project maturity levels and the associated actions (business decisions) required to move a project toward commercial injection.



Figure 2-1: Sub-classes based on Project Maturity.

Detailed definitions and guidelines for each Project Maturity sub-class are provided in Table I. This approach supports managing portfolios of opportunities at various stages of exploration and development and may be supplemented by associated quantitative estimates of chance of commerciality. The boundaries between different levels of project maturity may be referred to as “decision gates.”

Decisions within the Capacity class are based on those actions that progress a project through final approvals to implementation and initiation of injection. For Contingent Storage Resources, supporting analysis should focus on gathering data and performing analyses to clarify and then mitigate those key conditions, or contingencies, which prevent commercial development.

For Prospective Storage Resources, these potential storable quantities are evaluated according to their chance of discovery and, assuming a discovery, the estimated quantities that would be storable under appropriate development projects. The decision at each phase is to undertake further data acquisition and/or studies designed to move the project to a level of technical and commercial maturity where a decision can be made to proceed with exploration drilling.

Evaluators may adopt alternative sub-classes and project maturity modifiers, but the concept of increasing chance of commerciality should be a key enabler in applying the overall classification system and supporting portfolio management.

* + - 1. **Capacity Status**

Once projects satisfy chance of commerciality criteria, the associated storage quantities are classified as Capacity. These storage quantities may be allocated to the following subdivisions based on the funding and operational status of wells and associated facilities within the development plan (detailed definitions and guidelines are provided in Table 2):

* Developed Capacity is the expected quantity that can be storable leveraging existing wells and facilities.
  + **Developed Injection Capacity** is expected to be storable from completion intervals that are open and injecting at the time of the estimate.
  + Developed Non-Injecting Capacity includes shut-in and behind-pipe Capacity.
* Undeveloped Capacity is the expected quantity to be storable through future investments**.**

Where Capacity remains undeveloped beyond a reasonable timeframe, or have remained undeveloped due to repeated postponements, evaluations should be critically reviewed to document reasons for the delay in initiating injection and justify retaining these quantities within the Capacity class. While there are specific circumstances where a longer delay (see Determination of Commerciality, section 2.1.2) is justified, a reasonable time frame is generally considered to be less than five (5) years.

Development and injection status are of significant importance for project management. While Capacity Status has been applied to Proved Capacity, the same concept of Developed and Undeveloped Status based on the funding and operational status of wells and injection facilities within the development project are applicable throughout the full range of Capacity uncertainty categories (Proved, Probable and Possible).

Quantities may be subdivided by Capacity Status independent of sub-classification by Project Maturity. If applied in combination, Developed and/or Undeveloped Capacity quantities may be identified separately within each Capacity sub-class (On Injection, Approved for Development, and Justified for Development).

* + - 1. **Economic Status**

Projects may be further characterized by their Economic Status. All projects classified as Capacity must be economic under defined conditions (see Commercial Evaluations, section 3.1). Based on assumptions regarding future conditions and their impact on ultimate economic viability, projects currently classified as Contingent Storage Resources may be broadly divided into two groups:

* Economically Viable Contingent Storage Resources are those quantities associated with technically feasible projects that are either currently economic or projected to be economic under reasonably forecasted improvements in commercial conditions but are not committed for development because of one or more contingencies.
* Economically Not Viable Contingent Storage Resources are those quantities for which development projects are not economically injectable or not expected to be economically injectable, even considering reasonable improvements in conditions.

Where evaluations are incomplete such that it is premature to clearly define ultimate chance of commerciality, it is acceptable to note that project economic status is “undetermined.” Those discovered Total Storage Resource quantities for which a feasible development project cannot be defined using current, or reasonably forecast improvements in, technology are classified as Unexploitable.

Economic Status may be identified independently of, or applied in combination with, Project Maturity sub-classification to more completely describe the project and its associated resources*.*

## 2.2 Resources Categorization

The horizontal axis in the Resources Classification (Figure 1.1) defines the range of uncertainty in estimates of the storage quantities associated with a project. These estimates include both technical and commercial uncertainty components as follows:

* The total storable quantities remaining within geologic formations.
* That portion of the storable quantities that can be used by a defined development project or projects.

The uncertainty in storable quantities is assessed separately from project classification. The assumed commercial conditions are associated with resource classes or sub-classes and not with the resource categories. For example the injectable CO2 price assumptions are those assumed when classifying projects as Capacity, and there would not be a different price used for assessing Proved versus Probable Capacity as defined below. Use of different commercial assumptions for categorizing storable quantities is referred to as “split conditions”, which are to be avoided.

Moreover, a single project should be uniquely assigned to a sub-class along with its uncertainty range. For example, a single project cannot have quantities categorized in both Contingent Storage Resource and Capacity as 1C, 2P and 3P. This is referred to as “split classification”.

# 2.2.1 Range of Uncertainty

When uncertainty is such that the range needs to be investigated storable and/or potentially storable quantities may be represented by either deterministic scenarios or by a probability distribution (see Deterministic and Probabilistic Methods, section 4.2).

When the range of uncertainty is represented by a probability distribution, a low, best, and high estimate shall be provided such that:

* There should be at least a 90% probability (P90) that the quantities actually stored will equal or exceed the low estimate.
* There should be at least a 50% probability (P50) that the quantities actually stored will equal or exceed the best estimate.
* There should be at least a 10% probability (P10) that the quantities actually stored will equal or exceed the high estimate.

When using the deterministic scenario method, low, best, and high estimates, may be based on qualitative assessments of relative uncertainty using consistent interpretation guidelines. Under the deterministic incremental approach, quantities for each confidence segment are estimated discretely and separately (see Category Definitions and Guidelines, section 2.2.2).

Resources are initially estimated using the above uncertainty range forecasts by applying technical constraints related to wells and facilities. These technical forecasts then have the additional criteria applied (i.e. economics, license cutoffs are the most common) to determine the entitled storable quantities attributed to resource classes: Capacity, Contingent Resources, and Prospective Resources.

While there may be significant likelihood that sub-commercial and undiscovered porous and permeable geologic formations will not achieve commercial injection, it useful to consider the range of potentially storable quantities independently of such a likelihood or consideration of the resource class to which the quantities will be assigned.

# 2.2.2 Category Definitions and Guidelines

Evaluators may assess storable quantities and categorize results by uncertainty using the deterministic incremental approach, the deterministic scenario (cumulative) approach, or probabilistic methods. (See “5Resource Assessment Methods, Section XXX)). In many cases, a combination of approaches is used.

Use of consistent terminology (Figure 1.1) promotes clarity in communication of evaluation results. For Capacity, the general cumulative terms low/best/high estimates are denoted as 1P/2P/3P, respectively. The associated incremental quantities are termed Proved (P1), Probable (P2) and Possible (P3). Capacity is a subset of, and must be viewed within context of, the complete resources classification system. While the categorization criteria are proposed specifically for Capacity, in most cases, they can be equally applied to Contingent and Prospective Storage Resources conditional upon their satisfying the criteria for discovery and/or development.

For Contingent Storage Resources, the general cumulative terms low/best/high estimates are used to determine the resulting 1C/2C/3C respectively. The terms C1, C2 and C3 are defined for incremental quantities of Contingent Resources.

For Prospective Storage Resources, the general cumulative terms low/best/high estimates also apply and are used to determine the resulting 1U/2U/3U still apply. No specific terms are defined for incremental quantities within Prospective Storage Resources.

Quantities between classes and sub-classes should not be aggregated without considering the varying degrees of technical uncertainty and commercial likelihood involved with their classification(s).

Without new technical information, there should be no change in the distribution of technically storable quantities and their categorization boundaries when conditions are satisfied sufficiently to reclassify a project from Contingent Storage Resources to Capacity. All evaluations require application of a consistent set of forecast conditions, including assumed future costs and prices, for both classification of projects and categorization of estimated quantities stored by each project (see Commercial Evaluations, section 3.1).

Table 3 presents category definitions and provides guidelines designed to promote consistency in resource assessments. The following summarizes the definitions for each Capacity category in terms of both the deterministic incremental approach and scenario approach and also provides the probability criteria if probabilistic methods are applied. For all methods (incremental, scenario, or probabilistic), a Low, Best and High Estimate technical forecast may be prepared and then tested against the following criteria for assignment to appropriate PRMS categories.

* Proved Capacity is those storable quantities, which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially storable, from a given date forward, from known geologic formations and under defined economic conditions, operating methods, and government regulations. If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be stored. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually stored will equal or exceed the estimate.
* Probable Capacity is those additional storable quantities which analysis of geoscience and engineering data indicate are less likely to be stored than Proved Capacity but more certain to be stored than Possible Capacity. It is equally likely that actual remaining quantities stored will be greater than or less than the sum of the estimated Proved plus Probable Capacity (2P). In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual stored quantities will equal or exceed the 2P estimate.
* Possible Capacity is those additional storable quantities which analysis of geoscience and engineering data suggest are less likely to be storable than Probable Capacity. The total ultimately stored quantities from the project have a low probability to exceed the sum of Proved plus Probable plus Possible (3P) Capacity, which is equivalent to the high estimate scenario. In this context, when probabilistic methods are used, there should be at least a 10% probability that the actual quantities stored will equal or exceed the 3P estimate.

Based on additional data and updated interpretations that indicate increased certainty, portions of Possible and Probable Capacity may be re-categorized as Probable and Proved Capacity.

Uncertainty in resource estimates is best communicated by reporting a range of potential results. However, if it is required to report a single representative result, the “best estimate” is considered the most realistic assessment of storable quantities. It is generally considered to represent the sum of Proved and Probable estimates (2P) when using the deterministic scenario or the probabilistic assessment methods. It should be noted that under the deterministic incremental (risk-based) approach, discrete estimates are made for each category, and they should not be aggregated without due consideration of their associated chance (see “2001 Supplemental Guidelines,” Chapter 2.5).

2.3 Incremental Projects

The initial resource assessment is based on application of a defined initial development project. Incremental projects are designed to increase storage efficiency and/or to accelerate injection through making changes to existing projects. Such projects should be classified according to the same criteria as initial projects. Related incremental quantities are similarly categorized on certainty of storage capacity. The projected increased storage can be included in estimated Capacity if the degree of commitment is such that the project will be developed and placed on injection within a reasonable timeframe.

Circumstances where development will be significantly delayed should be clearly documented. If the likelihood of project execution is not reasonably expected, then the forecast incremental storage should be classified as Contingent Storage Resources (see Determination of Commerciality, section 2.1.2).

## 

## Evaluation and Reporting Guidelines

The following guidelines are provided to promote consistency in project evaluations and reporting. “Reporting” refers to the presentation of evaluation results within the business entity conducting the evaluation and should not be construed as replacing guidelines for subsequent public disclosures under guidelines established by regulatory and/or other government agencies, or any current or future associated accounting standards.

## 3.1 Commercial Evaluations

Investment decisions are based on the entity’s view of future commercial conditions that may impact the development feasibility (commitment to develop) and injection/cash flow schedule of storage projects. Commercial conditions include, but are not limited to, assumptions of financial conditions (costs, prices, fiscal terms, taxes, credits and subsidies), marketing, legal, environmental, social, and governmental factors. Project value may be assessed in several ways (e.g., historical costs, comparative market values); the guidelines herein apply only to evaluations based on cash flow analysis. Moreover, modifying factors such as contractual or political risks that may additionally influence investment decisions are not addressed. (Additional detail on commercial issues can be found in the “2001 Supplemental Guidelines,” Chapter 4.)

3.1.1 Cash-Flow-Based Resources Evaluations

Resource evaluations are based on estimates of future injection and the associated cash flow schedules for each development project or related project wherein credits for said injection are being used. The sum of the associated annual net cash flows yields the estimated future net revenue.

Where the storage project revenue is from the sale of ‘storage’ of CO2 that has been generated and transferred from a separate project or entity (e.g. an industrial plant, power generation or a hydrocarbon producing project), the cash flow should be evaluated for the storage project alone on the basis of the forecasted CO2 supply and agreed fiscal terms as laid out in the storage contract.

Where the storage project is developed (or retrofitted) in direct combination with a larger revenue generating and CO2 generating project; then the revenue and net cash flows should be evaluated at a combined project level (going forward from the date of evaluation), such that the storage costs are treated as additional CAPEX and OPEX to the revenue generating project.

When the cash flows are discounted according to a defined discount rate and time period, the summation of the discounted cash flows is termed net present value (NPV) of the project. The calculation shall reflect:

* The expected quantities of storage projected over identified time periods.
* The estimated costs associated with the project to develop, inject and use the quantities of storage resources as measured at the defined Reference Point (see section 3.2.1), including environmental, abandonment, post-closure monitoring, and reclamation costs charged to the project, based on the evaluator’s view of the costs expected to apply in future periods.
* The estimated revenues from the quantities of injection, based on the evaluator’s view of the prices, subsidies and/or tax credits expected to apply to the CO2 injected in future periods including that portion of the costs and revenues accruing to the entity.
* Future projected storage and revenue related taxes and royalties expected to be paid by the entity.
* A project life that is limited to the period of entitlement or reasonable expectation thereof.
* The application of an appropriate discount rate that reasonably reflects the weighted average cost of capital or the minimum acceptable rate of return applicable to the entity at the time of the evaluation.

While each organization may define specific investment criteria, a project is generally considered to be “economic” if its “best estimate” case has a positive net present value under the organization’s standard discount rate, or if at least has a positive undiscounted cash flow.

3.1.2 Economic Criteria

Evaluators must clearly identify the assumptions on commercial conditions used in the evaluation and must document the basis for these assumptions.

The economic evaluation underlying the investment decision is based on the entity’s reasonable forecast of future conditions, including costs, prices, subsidies and tax credits of the project or related project (e.g. an industrial plant, power generation or a hydrocarbon producing project), which will exist during the life of the project (forecast case). Such forecasts are based on projected changes to current conditions; SPE defines current conditions as the average of those existing during the previous 12 months.

Alternative economic scenarios are considered in the decision process and, in some cases, to supplement reporting requirements. Evaluators may examine a case in which current conditions are held constant (no inflation or deflation) throughout the project life (constant case).

Evaluations may be modified to accommodate criteria imposed by regulatory agencies regarding external disclosures. For example, these criteria may include a specific requirement that, if the storage resources were confined to the technically Proved Capacity estimate, the constant case should still generate a positive cash flow. External reporting requirements may also specify alternative guidance on current conditions (for example, year-end costs and prices)*.*

There may be circumstances in which the project meets criteria to be classified as Capacity using the forecast case but does not meet the external criteria for Proved Capacity. In these specific circumstances, the entity may record 2P and 3P estimates without separately recording Proved. As costs are incurred and development proceeds, the low estimate may eventually satisfy external requirements, and Proved Capacity can then be assigned.

While SPE guidelines do not require that project financing be confirmed prior to classifying projects as Capacity, this may be another external requirement. In many cases, loans are conditional upon the same criteria as above; that is, the project (or combined CO2 generating and storage project) must be economic based on Proved Capacity only. In general, if there is not a reasonable expectation that loans or other forms of financing (e.g., farm-outs) can be arranged such that the development will be initiated within a reasonable timeframe, then the project should be classified as Contingent Resources. If financing is reasonably expected but not yet confirmed, the project may be classified as Capacity, but no Proved Capacity may be reported as above.

3.1.3 Economic Limit

Economic limit is defined as the injection rate beyond which the net operating cash flows from a project, which may be an individual well, lease, entire storage site, or related project (e.g. an industrial plant, power generation or a hydrocarbon producing project), are negative, a point in time that defines the project’s economic life. Operating costs should be based on the same type of projections as used in price forecasting. Operating costs should include only those costs that are incremental to the project for which the economic limit is being calculated (i.e., only those cash costs that will actually be eliminated if project injection ceases should be considered in the calculation of economic limit). Operating costs should include fixed property-specific overhead charges if these are actual incremental costs attributable to the project and any injection and property taxes but, for purposes of calculating economic limit, should exclude depreciation, abandonment and reclamation costs, and income tax, as well as any overhead above that required to operate the subject property itself. Operating costs may be reduced, and thus project life extended, by various cost-reduction and revenue-enhancement approaches, such as sharing of injection facilities, pooling or maintenance contracts.

Interim negative project net cash flows may be accommodated in short periods of low prices, tax credits or major operational problems, provided that the longer-term forecasts must still indicate positive economics.

## 3.2 Injection Measurement

In general, the CO2 stored, as measured according to injection specifications at a defined Reference Point, provides the basis for injection quantities and resources estimates. The following operational issues should be considered in defining and measuring injection. While referenced specifically to Capacity, the same logic would be applied to projects forecast to develop Contingent and Prospective Resources conditional on discovery and development. (Additional detail on operational issues that impact resources estimation can be found in the “2001 Supplemental Guidelines,” Chapter 3.)

If reporting storage quantities (stored or storable) in units of volume, a standard pressure and temperature should be used and clearly stated with the volumetric estimate of CO2 storage.

3.2.1 Reference Point

Reference Point is a defined location(s) where the injected quantities are measured (metered) or assessed. The Reference Point is typically the point of transfer from a CO2 generator to either a third party storage project, or to the CO2 generator’s storage operations. Metered injection and estimated Capacity are normally measured and reported in terms of quantities crossing this point over the period of interest. Furthermore, the CO2 injection stream should be predominantly CO2.

The Reference Point may be defined by relevant accounting regulations in order to ensure that the Reference Point is the same for both the measurement of reported storage quantities and for the accounting treatment of storage revenues. This ensures that storage quantities are stated according to their delivery specifications at a defined price. In integrated projects, the appropriate price at the Reference Point may need to be determined using a netback calculation.

To reduce risk of accounting for any CO2 losses between the reference point and the injection well (downstream of the meter), placing the Reference Point near the injection well head is recommended.

#### **3.2.2 Processing Losses**

Any losses occurring between the reference point (meter) and the injection well head are not included in stored quantities.

3.2.3 Injection Balancing

Capacity estimates must be adjusted for stored quantities.This may be a complex accounting process when the allocation of injection among project participants is not aligned with their entitlement to Capacity. Stored overage or underage can occur in CO2 injection records because of the necessity for participants to use their storage resources at an injection rate to suit the CO2 generator as agreed among the parties. Similarly, an imbalance in CO2 injection can result from the participants having different operating or marketing arrangements that prevent storage capacity usage from being equal to entitlement share within a given time period.

Based on storage resource matching the internal accounts, annual injection should generally be equal to the quantities stored by the participant and not on the stored entitlement for the year. However, actual injection and entitlements must be reconciled in Capacity assessments. Resulting imbalances must be monitored over time and eventually resolved before project abandonment.

## Resources Entitlement and Recognition

While assessments are conducted to establish estimates of the Total Storage Resources and that portion used by defined projects, the allocation of storable quantities, costs, and revenues impacts the project economics and commerciality. This allocation is governed by the applicable contracts between the pore space owners (lessors) and contractors (lessees) and is generally referred to as “entitlement.” For publicly traded companies, securities regulators may set criteria regarding the classes and categories that can be “recognized” in external disclosures.

Entitlements must ensure that the storage resources claimed/reported by individual stakeholders sum to the total storage resources; that is, there are none missing or duplicated in the allocation process. (The “2001 Supplemental Guidelines,” Chapter 9, addresses issues of Reserves recognition under production-sharing and non-traditional agreements.)

* + 1. Royalty

Royalty refers to payments that are due to the host government or storage resource owner (lessor) in return for use of the storage resources by the operator (lessee/contractor) having access to the storage resources.

Many agreements allow for the lessee/contractor to use the royalty stored quantities and monetize it on behalf of, and pay the proceeds to, the royalty owner/lessor. Some agreements provide for the royalty to be taken only in-kind by the royalty owner. In either case, royalty stored quantities must be deducted from the lessee’s entitlement to resources. In some agreements, royalties owned by the host government are actually treated as taxes to be paid in cash. In such cases, the equivalent royalty stored quantities are controlled by the contractor who may (subject to regulatory guidance) elect to report these stored quantities as Capacity and/or Contingent Resources with appropriate offsets (increase in operating expense) to recognize the financial liability of the royalty obligation.

Conversely, if a company owns a royalty or equivalent interest of any type in a project, the related quantities can be included in Resources entitlements.

* + 1. Injection-Sharing Contract Capacity

Injection-Sharing Contracts (ISCs) of various types may replace conventional tax-royalty systems in many countries. Under the ISC terms, the operators has an entitlement to a portion of the stored quantities. This entitlement, often referred to as “net entitlement” or “net economic interest,” is estimated using a formula based on the contract terms incorporating project costs and project profits.

Although ownership of the stored quantities invariably remains with the government authority up to the export point of the project, the operators may take title to their share of the net entitlement at that point and may claim that share as their Capacity.

Risked-Service Contracts (RSCs) are similar to ISCs, but in this case, the operators are paid in cash rather than in stored quantities. As with ISCs, the Capacity claimed are based on the parties’ net economic interest. Care needs to be taken to distinguish between an RSC and a “Pure Service Contract.” Capacity can be claimed in an RSC on the basis that the operators are exposed to capital at risk, whereas no Capacity can be claimed for Pure Service Contracts because there are no market risks and the operators act as contractors.

Unlike traditional royalty-lease agreements, the cost recovery system in stored quantities sharing, risk-service, and other related contracts typically reduce the stored quantity share and hence Capacity obtained by the operator in periods of high value / low costs and increase volumes in periods of low value / high costs. While this ensures cost recovery, it introduces a significant price-related volatility in annual Capacity estimates under cases using “current” economic conditions. Under a defined “forecast conditions case,” the future relationship of price (subsidies or tax credits) to Capacity entitlement is known.

The treatment of taxes and the accounting procedures used can also have a significant impact on the Capacity recognized and stored quantities reported from these contracts.

* + 1. Contract Extensions or Renewals

As injection-sharing or other types of agreements approach maturity, they can be extended by negotiation for contract extensions, by the exercise of options to extend, or by other means.

Capacity should not be claimed for those resource quantities that will be used beyond the ending date of the current agreement unless there is reasonable expectation that an extension, a renewal, or a new contract will be granted. Such reasonable expectation may be based on the historical treatment of similar agreements by the license-issuing jurisdiction. Otherwise, forecast of storage resource usage beyond the contract term should be classified as Contingent Resources with an associated reduced chance of commercialization. Moreover, it may not be reasonable to assume that the fiscal terms in a negotiated extension will be similar to existing terms.

Similar logic should be applied where third party CO2 storage agreements (e.g. a power generation plant) are required to generate revenue for the storage project economics. Capacity should not be claimed for those storage resource quantities that will be used beyond those specified in the current agreement or reasonably forecast to be included in future agreements.

Where the risk of cessation of rights to inject or inability to secure CO2 for storage through a storage contracts or continued integration with a CO2 generating project is not considered significant, evaluators may choose to incorporate the uncertainty by categorizing quantities to be stored beyond the current contract as Probable or Possible Capacity.

**4.0**  **Estimating Storable Quantities**

Assuming that projects have been classified according to their project maturity, the estimation of associated storable quantities under a defined project and their assignment to uncertainty categories may be based on one or a combination of analytical procedures. Such procedures may be applied using an incremental (risk-based) and/or scenario approach; moreover, the method of assessing relative uncertainty in these estimates of storable quantities may employ both deterministic and probabilistic methods.

## 4.1 Analytical Procedures

The analytical procedures for estimating storable quantities fall into three broad categories: (a) analogy, (b) volumetric estimates, and (c) performance-based estimates, which include material balance and other injection performance analyses. Reservoir simulation may be used in either volumetric or performance-based analyses. Pre- and early post-discovery assessments are typically made with analog field/project data and volumetric estimation. After injection commences and injection rates and pressure information become available, performance-based methods can be applied with site-specific data to improve the storage quantity estimate.

In each procedural method, results are not a single quantity of remaining storage, but rather a range that reflects the underlying uncertainties in both the storage quantities and the storage efficiency of the applied development project. By applying consistent guidelines (see Resources Categorization, section 2.2.), evaluators can define remaining storable quantities using either the incremental or cumulative scenario approach. The confidence in assessment results generally increases when the estimates are supported by more than one analytical procedure.

4.1.1 Analogs

Analogs are widely used in petroleum resources estimation, particularly in the exploration and early development stages, when direct measurement information is limited. The methodology is based on the assumption that the analogous reservoir is comparable to the subject reservoir regarding reservoir and fluid properties that control ultimate storage of CO2. By selecting appropriate analogs, where performance data based on comparable development plans (including well type, well spacing and stimulation) are available, a similar injection schedule may be forecast. Choice of analogous projects (e.g. CO2 injection or CO2 injection with brine extraction) is also important.

Analogous formations in which CO2 has been stored are defined by features and characteristics including, but not limited to, approximate depth, pressure, temperature, natural drive mechanisms (e.g. closed system and strong aquifer), in situ brine and CO2 stream composition, formation size, gross thickness, net thickness, net-to-gross ratio, lithology, heterogeneity, porosity, permeability, seal structure, presence of existing wells and development plan. Analogous formations in which CO2 has been stored are formed by the same, or very similar, processes with regard to sedimentation, diagenesis, pressure, temperature, chemical and mechanical history, and structural deformation.

Comparison to several analogs may improve the range of uncertainty in estimated storable quantities in the subject formation. While formations with stored CO2 in the same geographic area and of the same age typically provide better analogs, such proximity alone may not be the primary consideration. In all cases, evaluators should document the similarities and differences between the analog and the subject reservoir/seal/project. Review of analog storage project performance is useful in quality assurance of resource assessments at all stages of development.

As there is limited experience in the CO2 storage industry, analogs may not be readily available for a significant number of storage cases. Due to this lack of maturity, storage quantities based on analogs or volumetric methods with storage coefficients based on analog developments may have significant uncertainty and may be classified less mature than methods not based on analog development. However, analogs will become increasingly important as this industry matures and gains a breadth of experience

4.1.2 Volumetric Estimate

This procedure uses rock properties to calculate storable quantities and then estimate that portion that will be available to store CO2 by one or more specific development projects or basin-scale assessment. Key uncertainties affecting storable quantities include:

Formation geometry and thickness that impact gross rock volume.

Geological heterogeneity of the pore volume.

Hydrodynamic and geochemical factors affecting the mobility and fate of the injected CO2.

Extent, and current competence of containment system.

The gross rock volume of interest is that for the total formation. While spatial distribution of porosity and permeability impact storage efficiency, the calculation of storable quantities often uses average net-to-gross ratio and porosity. In more heterogeneous formations, increased well density may be required to confidently assess and categorize resources. (Note: Storage efficiency may be defined on a pore volume (either effective or total) or bulk volume basis and should be clearly stated.)

Given estimates of the storable quantities, that portion that can be stored by a defined set of wells and operating conditions must then be estimated based on analog well performance and/or simulation studies using available geologic information. Key assumptions must be made regarding natural drive mechanisms.

Key parameters include

Permeability

Pore and fluid compressibility (water compressibility for saline aquifer, and an average fluid compressibility for storage in depleted oil and gas reservoirs)

Maximum storage and injection pressures defined not to damage the cap rock

Boundary conditions of the domain, enabling or not some lateral pressure dissipation

Drive mechanism: injection only or injection and water extraction to mitigate pressure build up

The estimates of storable quantities must reflect uncertainty not only in the storable quantities but also in the storage efficiency of the development project(s) applied to a specific geologic formation being studied.

Data permitting, geostatistical methods can be used to preserve spatial distribution information and incorporate it in subsequent storage simulation applications. Such processes may yield improved estimates of the range of storable quantities. Incorporation of seismic analyses typically improves the underlying geologic and flow models and yields more reliable resource estimates. [Refer to the “2001 SPE Supplemental Guidelines” for more detailed discussion of geostatistics (Chapter 7) and seismic applications (Chapter 8)].

4.1.3 Material Balance

Material balance methods to estimate storable quantities involve the analysis of pressure and geochemical behavior as CO2 is injected. In ideal situations, such as injection in homogeneous, high-permeability formations in a closed system (as a reservoir bounded by impermeable faults), and where sufficient and high quality pressure data is available, estimation based on material balance may provide very reliable estimates of ultimate storage at various storage pressures. In complex situations, such as those involving natural water flow, geologic compartmentalization, and multilayered or low-permeability formations, material balance estimates alone may provide erroneous results. Evaluators should take care to accommodate the complexity of the formation and its pressure response to injection when developing uncertainty profiles for the applied storage project.

Computer modeling or simulation can be considered a sophisticated form of material balance analysis. While such modeling can be a reliable predictor of storage behavior under a defined development program, the reliability of input rock properties, formation geometry, pore and fluid compressibility, relative permeability functions, fluid properties, location of fault systems, and acceptable overpressures are critical. Predictive models are most reliable for estimating storable quantities when there is sufficient injection history to validate the model through history matching.

4.1.4 Injection Performance Analysis

Analysis of the changes in injection pressure vs. injection rates, time, and cumulative injection and pressure transients provides valuable information to predict ultimate storable quantities. The bottomhole or injection pressures can be extrapolated to an economic limit condition to estimate storable quantities.

Reliable results require a sufficient period of stable operating conditions after wells in a formation have established their CO2 injectivity. In estimating storable quantities, evaluators must consider complicating factors affecting injection performance behavior, such as variable rock and fluid properties, transient vs. stabilized flow, changes in operating conditions, interference effects, and drive mechanisms. In early stages of injection, there may be significant uncertainty in both the ultimate performance profile and the commercial factors that impact injection rate or project performance. Such uncertainties should be reflected in the resources categorization. For very mature storage projects, the future injection forecast may be sufficiently well defined that the remaining uncertainty in the technical profile is not significant; in such cases, the “best estimate” 2P scenario may also be used for the 1P and 3P injection forecasts.  However, there may still be commercial uncertainties that will impact the abandonment rate/pressure, and these should be accommodated in the resources categorization.

## 4.2 Deterministic and Probabilistic Methods

Regardless of the analytical procedure used, storage estimates may be prepared using either deterministic or probabilistic methods.

In the deterministic method, a discrete value or array of values for each parameter is selected based on the estimator’s choice of the values that are most appropriate for the corresponding resource category. A single outcome of storable quantities is derived for each deterministic increment or scenario.

In the probabilistic method, the estimator defines a distribution representing the full range of possible values for each input parameter. These distributions may be randomly sampled (typically using Monte Carlo simulation software) to compute a full range and distribution of potential outcome of results of storage quantities (see “2001 Supplemental Guidelines,” Chapter 5, for more detailed discussion of probabilistic reserves estimation procedures). This approach is most often applied to volumetric resource calculations in the early phases of an exploitation and development projects. The Resources Categorization guidelines include criteria that provide specific limits to parameters associated with each category. Moreover, the resource analysis must consider commercial uncertainties. Accordingly, when probabilistic methods are used, constraints on parameters may be required to ensure that results are not outside the range imposed by the category deterministic guidelines and commercial uncertainties.

Deterministic volumes are estimated for discrete increments and defined scenarios. While deterministic estimates may have broadly inferred confidence levels, they do not have associated quantitatively defined probabilities. Nevertheless, the ranges of the probability guidelines established for the probabilistic method (see Range of Uncertainty, section 2.2.1) influence the amount of uncertainty generally inferred in the estimate derived from the deterministic method.

Both deterministic and probabilistic methods may be used in combination to ensure that results of either method are reasonable.

* + 1. Aggregation Methods

Storable quantities are generally estimated and categorized according to certainty of storage within individual formations or portions of formations; this is referred to as the “storage formation level” assessment. These estimates are summed to arrive at estimates for fields, properties, and projects. Further summation is applied to yield totals for areas, countries, and companies; these are generally referred to as “resource reporting levels.” The uncertainty distribution of the individual estimates at each of these levels may differ widely, depending on the geological settings and the maturity of the resources. This cumulative summation process is generally referred to as “aggregation.”

Two general methods of aggregation may be applied: arithmetic summation of estimates by category and statistical aggregation of uncertainty distributions. There is typically significant divergence in results from applying these alternative methods. In statistical aggregation, except in the rare situation when all the storable quantities being aggregated are totally dependent, the P90 (high degree of certainty) quantities from the aggregate are always greater than the arithmetic sum of the formation level P90 quantities, and the P10 (low degree of certainty) of the aggregate is always less than the arithmetic sum P10 quantities assessed at the formation level. This “portfolio effect” is the result of the central limit theorem in statistical analysis. Note that the mean (arithmetic average) of the sums is equal to the sum of the means; that is, there is no portfolio effect in aggregating mean values.

In practice, there is likely to be a large degree of interdependence among storable quantities estimated for geologic formations in the same field, and such dependencies must be incorporated in the probabilistic calculation. When dependency is present and not accounted for, probabilistic aggregation will overestimate the low estimate result and underestimate the high estimate result. (Aggregation of Reserves is discussed in Chapter 6 of the “2001 Supplemental Guidelines.”)

The aggregation methods used depends on the business purpose. It is recommended that for reporting purposes, assessment results should not incorporate statistical aggregation beyond the field, property, or project level. Results reporting beyond this level should use arithmetic summation by category but should caution that the aggregate Proved may be a very conservative estimate and aggregate 3P may be very optimistic depending on the number of items in the aggregate. Aggregates of 2P results typically have less portfolio effect that may not be significant in mature properties where the statistical median approaches the mean of the resulting distribution.

Various techniques are available to aggregate deterministic and/or probabilistic field, property, or project assessment results for detailed business unit or corporate portfolio analyses where the results incorporate the benefits of portfolio size and diversification. Again, aggregation should incorporate degree of dependency. Where the underlying analyses are available, comparison of arithmetic and statistical aggregation results may be valuable in assessing impact of the portfolio effect. Whether deterministic or probabilistic methods are used, care should be taken to avoid systematic bias in the estimation process.

It is recognized that the monetary value associated with these storable quantities is dependent on the injection and cash flow schedules for each project; thus, aggregate distributions of storable quantities may not be a direct indication of corresponding uncertainty distributions of aggregate value.

**4.2.1.1 Aggregating Resources Classes**

Storage quantities classified as Capacity, Contingent Resources, or Prospective Resources should not be aggregated with each other without due consideration of the significant differences in the criteria associated with their classification. In particular, there may be a significant risk that accumulations containing Contingent Resources and/ or Prospective Resources will not achieve commercial storage.

Where the associated discovery and commerciality risks have been quantitatively defined, statistical techniques may be applied to incorporate individual project risk estimates in portfolio analysis of volume and value.

**New Definitions to be included in the Glossary:**

Stored quantities: part of estimated Capacity for a geologic formation that has injected CO2 occupying pore volume; can be reported as mass or volume.

Storable quantities: part of an estimated pore volume of a geologic formation that is accessible to CO2 via a CO2 injection well (i.e. a storage project) sometime in the future; can be reported as mass or volume. To be considered a storable quantity, an assessment of the longevity of the stored CO2 is required; i.e. a seal within a structure or regional dip will be part of analyses.

CO2 stream: Fluid injected that is predominantly CO2

Operator: entity that has ownership and responsibility of the storage site and project

Project: CO2 storage project.

CO2 generator: Source of CO2; typically anthropogenic, industrial sites such as a coal fired power plant, cement plant, ethanol plant, and natural gas processing.

Storage Formation (or Formation): geologic interval in which storage quantities are identified.

Table 1: Storage Resources Classes and Sub-Classes

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| --- | --- | --- |
| Class/Sub-Class | **Definition** | Guidelines |
| Capacity | Capacity is the quantity of pore volume anticipated to be commercially accessible by application of development projects to known geologic formations from a given date forward under defined conditions. | Capacity must satisfy four criteria: it must be discovered, commercial, injectable and have containment based on the development project(s) applied. Capacity is further subdivided in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by their development and injection status.  To be included in the Capacity class, a project must be sufficiently defined to establish its commercial viability. There must be a reasonable expectation that all required internal and external approvals will be forthcoming, and there is evidence of firm intention to proceed with development within a reasonable time frame.  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 (5) years is recommended as a benchmark, a longer time frame could be applied where, for example, development of economic projects are deferred at the option of the storage site operator for, among other things, market-related reasons, or to meet contractual or strategic objectives. In all cases, the justification for classification as Capacity should be clearly documented.  To be included in the Capacity class, there must be a high confidence in the commercial storage of the geologic formation as supported by actual injection or formation tests and containment. In certain cases, Capacity may be assigned on the basis of well logs and/or core analysis that indicate that the subject geologic formation has accessible pore volume and is analogous to reservoirs in the same area that are injecting or have demonstrated the ability to inject on formation tests. |
| On Injection | The development project is currently injecting and storing CO2. | The key criterion is that the project is actively injecting CO2, rather than the approved development project necessarily being complete. This is the point at which the project “chance of commerciality” can be said to be 100%.  The project “decision gate” is the decision to initiate commercial injection from the project. |
| Approved for Development | All necessary approvals have been obtained, capital funds have been committed, and implementation of the development project is under way. | At this point, it must be certain that the development project is going ahead. The project must not be subject to any contingencies such as outstanding regulatory approvals or contracts. Forecast capital expenditures should be included in the reporting entity’s current or following year’s approved budget.  The project “decision gate” is the decision to start investing capital in the construction of storage (injection) facilities and/or drilling development wells. |

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| --- | --- | --- |
| Class/Sub-Class | **Definition** | Guidelines |
| Justified for Development | Implementation of the development project is justified on the basis of reasonable forecast commercial conditions at the time of reporting, and there are reasonable expectations that all necessary approvals/contracts will be obtained. | In order to move to this level of project maturity, and hence have Capacity associated with it, the development project must be commercially viable at the time of reporting, based on the reporting entity’s assumptions of future prices, costs, etc. (“forecast case”) and the specific circumstances of the project. Evidence of a firm intention to proceed with development within a reasonable time frame will be sufficient to demonstrate commerciality. There should be a development plan in sufficient detail to support the assessment of commerciality and a reasonable expectation that any regulatory approvals or contracts required prior to project implementation will be forthcoming. Other than such approvals/contracts, there should be no known contingencies that could preclude the development from proceeding within a reasonable timeframe (see Capacity class).  The project “decision gate” is the decision by the reporting entity and its partners, if any, that the project has reached a level of technical and commercial maturity sufficient to justify proceeding with development at that point in time. |
| **Contingent Storage Resources** | Those quantities of pore volume estimated, as of a given date, to be potentially accessible in known geologic formations by application of development projects, but which are not currently considered to be commercially accessible due to one or more contingencies. | Contingent Storage Resources may include, for example, projects for which there are currently no viable markets, or where commercial storage is dependent on technology under development, or where evaluation of the geologic formation is insufficient to clearly assess commerciality, or where there is negative stakeholder or public acceptance. Contingent Storage Resources are further categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by their economic status. |
| Development Pending | A discovered quantity of CO2 storage resource in a geologic formation where project activities are ongoing to justify commercial development in the foreseeable future. | The project is seen to have reasonable potential for eventual commercial development, to the extent that further data acquisition (e.g. drilling, seismic data) and/or evaluations are currently ongoing with a view to confirming that the project is commercially viable and providing the basis for selection of an appropriate development plan. The critical contingencies have been identified and are reasonably expected to be resolved within a reasonable time frame. Note that disappointing appraisal/evaluation results could lead to a re-classification of the project to “On Hold” or “Not Viable” status.  The project “decision gate” is the decision to undertake further data acquisition and/or studies designed to move the project to a level of technical and commercial maturity at which a decision can be made to proceed with development and storage (injection). |

|  |  |  |
| --- | --- | --- |
| Class/Sub-Class | **Definition** | Guidelines |
| Development Unclarified or on Hold | A discovered quantity of accessible pore volume in a geologic formation where project activities are on hold and/or where justification as a commercial development may be subject to significant delay. | The project is seen to have potential for eventual commercial development, but further appraisal/evaluation activities are on hold pending the removal of significant contingencies external to the project, or substantial further appraisal/evaluation activities are required to clarify the potential for eventual commercial development. Development may be subject to a significant time delay. Note that a change in circumstances, such that there is no longer a reasonable expectation that a critical contingency can be removed in the foreseeable future, for example, could lead to a re-classification of the project to “Not Viable” status.  The project “decision gate” is the decision to either proceed with additional evaluation designed to clarify the potential for eventual commercial development or to temporarily suspend or delay further activities pending resolution of external contingencies. |
| Development Not Viable | A discovered quantity of accessible pore volume for which there are no current plans to develop or to acquire additional data at the time due to limited storage potential. | The project is not seen to have potential for eventual commercial development at the time of reporting, but the theoretically accessible pore volume quantities are recorded so that the potential opportunity will be recognized in the event of a major change in technology or commercial conditions.  The project “decision gate” is the decision not to undertake any further data acquisition or studies on the project for the foreseeable future. |
| Prospective Resources | Those quantities of pore volume in a geological formation which are estimated, as of a given date, to be potentially accessible. | Geologic formation is evaluated for potential storage according to its chance of discovery and, assuming a discovery, the estimated accessible pore volume defined by development projects. It is recognized that the development programs will be of significantly less detail and depend more heavily on analog developments in the earlier phases of exploration. |
| Prospect | A project associated with potential storage that is sufficiently well defined to represent a viable drilling target. | Project activities are focused on assessing the chance of discovery and, assuming discovery, the range of potential accessible pore volume quantities under a commercial development program. |
| Lead | A project associated with potential CO2 storage that is currently poorly defined and requires more data acquisition and/or evaluation in order to be classified as a prospect. | Project activities are focused on acquiring additional data and/or undertaking further evaluation designed to confirm whether or not the lead can be matured into a prospect. Such evaluation includes the assessment of the chance of discovery and, assuming discovery, the range of potential storable quantities under feasible development scenarios. |
| Play | A project associated with a prospective trend of potential prospects, but which requires more data acquisition and/or evaluation in order to define specific leads or prospects. | Project activities are focused on acquiring additional data and/or undertaking further evaluation designed to define specific leads or prospects for more detailed analysis of their chance of discovery and, assuming discovery, the range of potential storable quantities under hypothetical development scenarios.  Regional assessments of storable quantities, depending on regional extent compared to data availability, will likely have this “play” classification. |

Table 2: Capacity Status Definitions and Guidelines

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| **Status** | Definition | **Guidelines** |
| **Developed Capacity** | Developed Capacity is expected quantities to be stored from existing wells and facilities. | Capacity is considered developed only after the necessary equipment has been installed, or when the costs to do so are relatively minor compared to the cost of a well. Where required facilities become unavailable, it may be necessary to reclassify Developed Capacity as Undeveloped. Developed Capacity may be further sub-classified as Injecting or Non-Injecting. |
| Developed Injecting Capacity | **Developed Injecting Capacity is** expected to be stored from completion intervals that are open and injecting at the time of the estimate. | Improved storage capacity is classified as “injecting” only after the improved storage project is in operation. s |
| Developed Non-Injecting Capacity | Developed Non-Injecting Capacity include shut-in and behind-pipe Capacity. | Shut-in Capacity is expected to be stored from (1) completion intervals which are open at the time of the estimate but which have not yet started injecting, (2) wells which were shut-in for market conditions or pipeline connections, or (3) wells not capable of injection for mechanical reasons. Behind-pipe Capacity is expected to be stored in geologic formations in existing wells which will require additional completion work or future re-completion prior to start of injection.  In all cases, injection can be initiated or restored with relatively low expenditure compared to the cost of drilling a new well. |
| **Undeveloped Capacity** | Undeveloped Capacity is the quantity expected to be stored through future investments: | (1) from new wells on undrilled acreage in known geologic formations, (2) from deepening existing wells to a different (but known) geologic formations, (3) from infill wells that will increase storage, or (4) where a relatively large expenditure (e.g. when compared to the cost of drilling a new well) is required to (a) recomplete an existing well or (b) install injection or transportation facilities for primary or improved storage projects. |

Table 3: Capacity Category Definitions and Guidelines

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| **Category** | Definition | **Guidelines** |
| **Proved Capacity** | Proved Capacity is the quantity of storage, which by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially used for storage, from a given date forward, from known geologic formations and under defined economic conditions, operating methods, and government regulations. | If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be used for storage. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually stored will equal or exceed the estimate.  The area of the geologic formation considered as Proved includes (1) the area delineated by drilling, and (2) adjacent undrilled portions of the geologic formation that can reasonably be judged as continuous and commercially storable on the basis of available geoscience and engineering data.  Capacity in undeveloped locations may be classified as Proved provided that:   * The locations are in undrilled areas of the geologic formation that can be judged with reasonable certainty to be commercially storable. * Interpretations of available geoscience and engineering data indicate with reasonable certainty that the objective geologic formation is laterally continuous with drilled Proved locations.   For Proved Capacity, the storage efficiency applied to these reservoirs should be defined based on a range of possibilities supported by analogs and sound engineering judgment considering the characteristics of the Proved area and the applied development program. |
| **Probable Capacity** | Probable Capacity is the additional Capacity which analysis of geoscience and engineering data indicate are less likely to be used for storage than Proved Capacity but more certain to be used for storage than Possible Capacity. | It is equally likely that actual remaining quantities stored will be greater than or less than the sum of the estimated Proved plus Probable Capacity (2P). In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities stored will equal or exceed the 2P estimate.  Probable Capacity may be assigned to areas of a geologic formation adjacent to Proved where data control or interpretations of available data are less certain.The interpreted geologic formation continuity may not meet the reasonable certainty criteria.  Probable estimates also include incremental storage associated with project storage efficiency beyond that assumed for Proved. |

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| **Category** | Definition | **Guidelines** |
| **Possible**  **Capacity** | Possible Capacity is the additional Capacity which analysis of geoscience and engineering data indicate are less likely to be used for storage than Probable Capacity. | The total quantities ultimately stored from the project have a low probability to exceed the sum of Proved plus Probable plus Possible (3P), which is equivalent to the high estimate scenario. When probabilistic methods are used, there should be at least a 10% probability that the actual quantities stored will equal or exceed the 3P estimate.  Possible Capacity may be assigned to areas of a geologic formation adjacent to Probable where data control and interpretations of available data are progressively less certain**.** Frequently, this may be in areas where geoscience and engineering data are unable to clearly define the area and vertical limits of commercial storage from the geologic formation by a defined project.  Possible estimates also include incremental quantities associated with project storage efficiency beyond that assumed for Probable. |
| **Probable and Possible**  **Capacity** | (See above for separate criteria for Probable Capacity and Possible Capacity.) | The 2P and 3P estimates may be based on reasonable alternative technical and commercial interpretations within the geologic formation and/or subject project that are clearly documented, including comparisons to results in successful similar projects.  In conventional accumulations, Probable and/or Possible Capacity may be assigned where geoscience and engineering data identify directly adjacent portions of a geologic formation that may be separated from Proved areas by minor faulting or other geological discontinuities and have not been penetrated by a wellbore but are interpreted to be in communication with the known (Proved) geologic formation. In the case of storage in a geologic structure, Probable or Possible Capacity may be assigned to areas that are structurally higher than the Proved area. Possible (and in some cases, Probable) Capacity may be assigned to areas that are structurally lower than the adjacent Proved or 2P area.    Caution should be exercised in assigning Capacity to adjacent reservoirs isolated by major, potentially sealing, faults until this part of the geologic formation is penetrated and evaluated as commercially suitable for storage. Justification for assigning Capacity in such cases should be clearly documented. Capacity should not be assigned to areas that are clearly separated from known storage by known parts of the geologic formation without storage (i.e., absence of porosity and permeability or negative test results); such areas may contain Prospective Resources. |

Appendix A: Glossary of Terms Used in Resources Evaluations

The glossary provides high-level definitions of terms use in resource evaluations. Where appropriate, sections and/or chapters within the 2007 and/or 2001 documents are referenced to best show the use of selected terms in context.

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| **TERM** | **Reference** | **DEFINITION** |
| 1C | 2007 - 2.2.2 | Denotes low estimate scenario of Contingent Resources. |
| 2C | 2007 - 2.2.2 | Denotes best estimate scenario of Contingent Resources. |
| 3C | 2007 - 2.2.2 | Denotes high estimate scenario of Contingent Resources. |
| 1P | 2007 - 2.2.2 | Taken to be equivalent to Proved Capacity; denotes low estimate scenario of Capacity. |
| 2P | 2007 - 2.2.2 | Taken to be equivalent to the sum of Proved plus Probable Capacity; denotes best estimate scenario of Capacity. |
| 3P | 2007 - 2.2.2 | Taken to be equivalent to the sum of Proved plus Probable plus Possible Capacity; denotes high estimate scenario of reserves. |
| Accumulation | 2001 - 2.3 | An individual body of naturally occurring petroleum in a reservoir. |
| Aggregation | 2007 - 3.5.1  2001 - 6 | The process of summing reservoir (or project) level estimates of resource quantities to higher levels or combinations such as field, country or company totals. Arithmetic summation of incremental categories may yield different results from probabilistic aggregation of distributions. |
| Approved for Development | 2007 -  Table I | All necessary approvals have been obtained, capital funds have been committed, and implementation of the development project is underway. |
| Analogous Reservoir | 2007 - 3.4.1 | Analogous reservoirs, as used in resources assessments, have similar rock and fluid properties, reservoir conditions (depth, temperature and pressure) and drive mechanisms, but are typically at a more advanced stage of development than the reservoir of interest and thus may provide concepts to assist in the interpretation of more limited data and estimation of recovery. |
| Assessment | 2007 - 1.2 | See Evaluation. |
| Associated Gas |  | Associated Gas is a natural gas found in contact with or dissolved in crude oil in the reservoir. It can be further categorized as Gas-Cap Gas or Solution Gas. |
| Barrels of Oil Equivalent (BOE) | 2001 - 3.7 | See Crude Oil Equivalent. |
| Basin-Centered Gas | 2007 - 2.4 | An unconventional natural gas accumulation that is regionally pervasive and characterized by low permeability, abnormal pressure, gas saturated reservoirs and lack of a down-dip water leg. |

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| Behind-Pipe Reserves | 2007 - 2.1.3.1 | | | Behind-pipe reserves are expected to be recovered from zones in existing wells, which will require additional completion work or future re-completion prior to the start of production. In all cases, production can be initiated or restored with relatively low expenditure compared to the cost of drilling a new well. |
| Best Estimate | 2007 - 2.2.2  2001 - 2.5 | | | With respect to resource categorization, this is considered to be the best estimate of the quantity that will actually be recovered from the accumulation by the project. It is the most realistic assessment of recoverable quantities if only a single result were reported. If probabilistic methods are used, there should be at least a 50% probability (P50) that the quantities actually recovered will equal or exceed the best estimate. |
| Bitumen | 2007 - 2.4 | | | See Natural Bitumen. |
| Buy Back Agreement | |  | | An agreement between a host government and a contractor under which the host pays the contractor an agreed price for all volumes of hydrocarbons produced by the contractor. Pricing mechanisms typically provide the contractor with an opportunity to recover investment at an agreed level of profit. |
| Carried Interest | | 2001 - 9.6.7 | | A carried interest is an agreement under which one party (the carrying party) agrees to pay for a portion or all of the pre-production costs of another party (the carried party) on a license in which both own a portion of the working interest. |
| Chance | | 2007 - 1.1 | | Chance is 1- Risk. (See Risk) |
| Coalbed Methane (CBM) | | 2007 - 2.4 | | Natural gas contained in coal deposits, whether or not stored in gaseous phase. Coalbed gas, although usually mostly methane, may be produced with variable amounts of inert or even non-inert gases. (Also termed Coal Seam Gas, CSG, or Natural Gas from Coal, NGC) |
| Commercial | | 2007 - 2.1.2 and Table 1 | | When a project is commercial, this implies that the essential social, environmental and economic conditions are met, including political, legal, regulatory and contractual conditions. In addition, a project is commercial if the degree of commitment is such that the accumulation is expected to be developed and placed on production within a reasonable time frame. While 5 years is recommended as a benchmark, 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. In all cases, the justification for classification as Reserves should be clearly documented. |
| Committed  Project | | 2007 - 2.1.2  and Table 1 | | Projects are committed only when it can be demonstrated that there is a firm intention to develop them and bring them to production. Intention may be demonstrated with funding/financial plans and declaration of commerciality based on realistic expectations of regulatory approvals and reasonable satisfaction of other conditions that would otherwise prevent the project from being developed and brought to production. |
| Completion | |  | | Completion of a well. The process by which a well is brought to its final classification—basically dry hole, producer, injector, or monitor well. A dry hole is normally plugged and abandoned. A well deemed to be producible of petroleum, or used as an injector, is completed by establishing a connection between the reservoir(s) and the surface so that fluids can be produced from, or injected into, the reservoir. Various methods are used to establish this connection, but they commonly involve the installation of some combination of borehole equipment, casing and tubing, and surface injection or production facilities. |
| Completion Interval | |  | | The specific reservoir interval(s) that is (are) open to the borehole and connected to the surface facilities for production or injection, or reservoir intervals open to the wellbore and each other for injection purposes. |
| Concession | | 2001 - 9.6.1 | | A grant of access for a defined area and time period that transfers certain entitlements to produced hydrocarbons from the host country to an enterprise. The enterprise is generally responsible for exploration, development, production, and sale of hydrocarbons that may be discovered. Typically granted under a legislated fiscal system where the host country collects taxes, fees, and sometimes royalty on profits earned. |
| Condensate | | 2001 - 3.2 | | Condensates are a mixture of hydrocarbons (mainly pentanes and heavier) that exist in the gaseous phase at original temperature and pressure of the reservoir, but when produced, are in the liquid phase at surface pressure and temperature conditions. Condensate differs from natural gas liquids (NGL) on two respects: (1) NGL is extracted and recovered in gas plants rather than lease separators or other lease facilities; and (2) NGL includes very light hydrocarbons (ethane, propane, butanes) as well as the pentanes-plus that are the main constituents of condensate. |
| Conditions | | 2007 - 3.1 | | The economic, marketing, legal, environmental, social, and governmental factors forecast to exist and impact the project during the time period being evaluated (also termed Contingencies). |
| Constant  Case | | 2007 - 3.1.1 | | Modifier applied to project resources estimates and associated cash flows when such estimates are based on those conditions (including costs and product prices) that are fixed at a defined point in time (or period average) and are applied unchanged throughout the project life, other than those permitted contractually. In other words, no inflation or deflation adjustments are made to costs or revenues over the evaluation period. |
| Contingency | | 2007 - 3.1  and Table 1 | | See Conditions. |
| Contingent  Project | | 2007 - 2.1.2 | | Development and production of recoverable quantities has not been committed due to conditions that may or may not be fulfilled. |
| Contingent Resources | | 2007 - 1.1 and Table 1 | | Those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations by application of development projects but which are not currently considered to be commercially recoverable due to one or more contingencies. Contingent Resources are a class of discovered recoverable resources. |
| Continuous-Type Deposit | | 2007 - 2.4  2001 - 2.3 | | A petroleum accumulation that is pervasive throughout a large area and which is not significantly affected by hydrodynamic influences. Such accumulations are included in Unconventional Resources. Examples of such deposits include “basin-centered” gas, shale gas, gas hydrates, natural bitumen and oil shale accumulations. |
| Conventional Crude Oil | | 2007 - 2.4 | | Crude oil flowing naturally or capable of being pumped without further processing or dilution (see Crude Oil). |
| Conventional Gas | | 2007 - 2.4 | | Conventional Gas is a natural gas occurring in a normal porous and permeable reservoir rock, either in the gaseous phase or dissolved in crude oil, and which technically can be produced by normal production practices. |
| Conventional Resources | | 2007 - 2.4 | | Conventional resources exist in discrete petroleum accumulations related to localized geological structural features and/or stratigraphic conditions, typically with each accumulation bounded by a downdip contact with an aquifer, and which is significantly affected by hydrodynamic influences such as buoyancy of petroleum in water**.** |
| Conveyance | | 2001 - 9.6.9 | | Certain transactions that are in substance borrowings repayable in cash or its equivalent and shall be accounted for as borrowings and may not qualify for the recognition and reporting of oil and gas reserves. |
| Cost Recovery | | 2001 - 9.6.2, 9.7.2 | | Under a typical production-sharing agreement, the contractor is responsible for the field development and all exploration and development expenses. In return, the contractor recovers costs (investments and operating expenses) out of the gross production stream. The contractor normally receives payment in oil production and is exposed to both technical and market risks. |
| Crude Oil | | 2001 - 3.1 | | Crude oil is the portion of petroleum that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric conditions of pressure and temperature. Crude oil may include small amounts of non-hydrocarbons produced with the liquids but does not include liquids obtained from the processing of natural gas. |
| Crude Oil Equivalent | | 2001 - 3.7 | | Converting gas volumes to the oil equivalent is customarily done on the basis of the nominal heating content or calorific value of the fuel. There are a number of methodologies in common use. Before aggregating, the gas volumes first must be converted to the same temperature and pressure. Common industry gas conversion factors usually range between 1 barrel of oil equivalent (BOE) = 5,600 standard cubic feet (scf) of gas to 1 BOE = 6,000 scf. (Many operators use 1 BOE = 5,620 scf derived from the metric unit equivalent 1 m³ crude oil = 1,000 m³ natural gas ). (Also termed Barrels of Oil Equivalent.) |
| Cumulative Production | | 2007 - 1.1 | | The sum of production of oil and gas to date (see also Production). |
| Current Economic Conditions | | | 2007 - 3.1.1 | Establishment of current economic conditions should include relevant historical petroleum prices and associated costs and may involve a defined averaging period. The SPE guidelines recommend that a 1-year historical average of costs and prices should be used as the default basis of “constant case” resources estimates and associated project cash flows. |
| Cushion Gas Volume | | |  | With respect to underground natural gas storage, Cushion Gas Volume (CGV) is the gas volume required in a storage field for reservoir management purposes and to maintain adequate minimum storage pressure for meeting working gas volume delivery with the required withdrawal profile. In caverns, the cushion gas volume is also required for stability reasons. The cushion gas volume may consist of recoverable and non-recoverable in-situ gas volumes and injected gas volumes. |
| Deposit | | | 2007 - 2.4 | Material laid down by a natural process. In resource evaluations, it identifies an accumulation of hydrocarbons in a reservoir (see Accumulation). |
| Deterministic Estimate | | | 2007 - 3.5 | The method of estimation of Reserves or Resources is called deterministic if a discrete estimate(s) is made based on known geoscience, engineering, and economic data. |
| Developed Reserves | | | 2007 - 2.1.3.2 and Table 2 | Developed Reserves are expected to be recovered from existing wells including reserves behind pipe. Improved recovery reserves are considered “developed” only after the necessary equipment has been installed, or when the costs to do so are relatively minor compared to the cost of a well. Developed Reserves may be further sub-classified as Producing or Non-Producing. |
| Developed Producing Reserves | | | 2007 - 2.1.3.2 and Table 2 | **Developed Producing Reserves** are expected to be recovered from completion intervals that are open and producing at the time of the estimate. Improved recovery reserves are considered producing only after the improved recovery project is in operation. |
| Developed Non-Producing Reserves | | | 2007 - 2.1.3.2 and Table 2 | Developed Non-Producing Reserves include shut-in and behind-pipe Reserves. Shut-in Reserves are expected to be recovered from (1) completion intervals which are open at the time of the estimate but which have not yet started producing, (2) wells which were shut in for market conditions or pipeline connections, or (3) wells not capable of production for mechanical reasons. Behind-pipe Reserves are also those expected to be recovered from zones in existing wells which will require additional completion work or future re-completion prior to start of production. In all cases, production can be initiated or restored with relatively low expenditure compared to the cost of drilling a new well. |
| Development Not Viable | | | 2007 - 2.1.3.1 and Table 1 | A discovered accumulation for which there are no current plans to develop or to acquire additional data at the time due to limited production potential. A project maturity sub-class that reflects the actions required to move a project towards commercial production. |
| Development Pending | | | 2007 - 2.1.3.1 and Table 1 | A discovered accumulation where project activities are ongoing to justify commercial development in the foreseeable future. A project maturity sub-class that reflects the actions required to move a project towards commercial production. |
| Development Plan | | | 2007 - 1.2 | The design specifications, timing and cost estimates of the development project including, but not limited to, well locations, completion techniques, drilling methods, processing facilities, transportation and marketing. (See also Project.) |
| Development Unclarified or On Hold | | | 2007 - 2.1.3.1 and Table 1 | A discovered accumulation where project activities are on hold and/or where justification as a commercial development may be subject to significant delay. A project maturity sub-class that reflects the actions required to move a project toward commercial production. |
| Discovered | | | 2007 - 2.1.1 | A discovery is one petroleum accumulation, or several petroleum accumulations collectively, for which one or several exploratory wells have established through testing, sampling, and/or logging the existence of a significant quantity of potentially moveable hydrocarbons. In this context, “significant” implies that there is evidence of a sufficient quantity of petroleum to justify estimating the in-place volume demonstrated by the well(s) and for evaluating the potential for economic recovery.  (See also Known Accumulations.) |
| Discovered Petroleum Initially-in-Place | | | 2007 - 1.1 | Discovered Petroleum Initially-in-Placeis that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations prior to production. Discovered Petroleum Initially-in-Place may be subdivided into Commercial, Sub-Commercial, and Unrecoverable, with the estimated commercially recoverable portion being classified as Reserves and the estimated sub-commercial recoverable portion being classified as Contingent Resources. |
| Dry Gas | | | 2001 - 3.2 | Dry Gas is a natural gas remaining after hydrocarbon liquids have been removed prior to the reference point. The dry gas and removed hydrocarbon liquids are accounted for separately in resource assessments. It should be recognized that this is a resource assessment definition and not a phase behavior definition. (Also called Lean Gas.) |
| Dry Hole | | | 2001 - 2.5 | A well found to be incapable of producing either oil or gas in sufficient quantities to justify completion as an oil or gas well. |
| Economic | | | 2007 - 3.1.2  2001 - 4.3 | In relation to petroleum Reserves and Resources, economic refers to the situation where the income from an operation exceeds the expenses involved in, or attributable to, that operation. |
| Economic Interest | | | 2001 - 9.4.1 | An Economic Interest is possessed in every case in which an investor has acquired any Interest in mineral in place and secures, by any form of legal relationship, revenue derived from the extraction of the mineral to which he must look for a return of his capital. |
| Economic Limit | | | 2007 - 3.1.2  2001 - 4.3 | Economic limit is defined as the production rate beyond which the net operating cash flows (after royalties or share of production owing to others) from a project, which may be an individual well, lease, or entire field, are negative. |
| Entitlement | | | 2007 - 3.3 | That portion of future production (and thus resources) legally accruing to a lessee or contractor under the terms of the development and production contract with a lessor. |
| Entity | | | 2007 - 3.0 | Entity is a legal construct capable of bearing legal rights and obligations. In resources evaluations this typically refers to the lessee or contractor, which is some form of legal corporation (or consortium of corporations). In a broader sense, an entity can be an organization of any form and may include governments or their agencies. |
| Estimated Ultimate Recovery (EUR) | | | 2007 - 1.1 | Those quantities of petroleum which are estimated, on a given date, to be potentially recoverable from an accumulation, plus those quantities already produced therefrom. |
| Evaluation | | | 2007- 3.0 | The geosciences, engineering, and associated studies, including economic analyses, conducted on a petroleum exploration, development, or producing project resulting in estimates of the quantities that can be recovered and sold and the associated cash flow under defined forward conditions. Projects are classified and estimates of derived quantities are categorized according to applicable guidelines. (Also termed Assessment.) |

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| Evaluator | | 2007 - 1.2,  2.1.2 | The person or group of persons responsible for performing an evaluation of a project. These may be employees of the entities that have an economic interest in the project or independent consultants contracted for reviews and audits. In all cases, the entity accepting the evaluation takes responsibility for the results, including Reserves and Resources and attributed value estimates. |
| Exploration | |  | Prospecting for undiscovered petroleum. |
| Field | | 2001 - 2.3 | An area consisting of a single reservoir or multiple reservoirs all grouped on, or related to, the same individual geological structural feature and/or stratigraphic condition. There may be two or more reservoirs in a field that are separated vertically by intervening impermeable rock, laterally by local geologic barriers, or both. The term may be defined differently by individual regulatory authorities. |
| Flare Gas | | 2007 - 3.2.2  2001 - 3.1 | Total volume of gas vented or burned as part of production and processing operations. |
| Flow Test | | 2007 - 2.1.1 | An operation on a well designed to demonstrate the existence of moveable petroleum in a reservoir by establishing flow to the surface and/or to provide an indication of the potential productivity of that reservoir (such as a wireline formation test). |
| Fluid Contacts | | 2007 - 2.2.2 | The surface or interface in a reservoir separating two regions characterized by predominant differences in fluid saturations. Because of capillary and other phenomena, fluid saturation change is not necessarily abrupt or complete, nor is the surface necessarily horizontal. |
| Forecast Case | | 2007 - 3.1.1 | Modifier applied to project resources estimates and associated cash flow when such estimates are based on those conditions (including costs and product price schedules) forecast by the evaluator to reasonably exist throughout the life of the project. Inflation or deflation adjustments are made to costs and revenues over the evaluation period. |
| Forward Sales | | 2001 - 9.6.6 | There are a variety of forms of transactions that involve the advance of funds to the owner of an interest in an oil and gas property in exchange for the right to receive the cash proceeds of production, or the production itself, arising from the future operation of the property. In such transactions, the owner almost invariably has a future performance obligation, the outcome of which is uncertain to some degree. Determination as to whether the transaction represents a sale or financing rests on the particular circumstances of each case. |
| Fuel Gas | 2007 - 3.2.2 | | See Lease Fuel. |
| Gas Balance | 2007 - 3.2.7  2001 - 3.10 | | In gas production operations involving multiple working interest owners, an imbalance in gas deliveries can occur. These imbalances must be monitored over time and eventually balanced in accordance with accepted accounting procedures. |

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| Gas Cap Gas | 2001 - 6.2.2 | Gas Cap Gas is a free natural gas which overlies and is in contact with crude oil in the reservoir. It is a subset of Associated Gas. |
| Gas Hydrates | 2007 - 2.4 | Gas hydrates are naturally occurring crystalline substances composed of water and gas, in which a solid water lattice accommodates gas molecules in a cage-like structure, or clathrate. At conditions of standard temperature and pressure (STP), one volume of saturated methane hydrate will contain as much as 164 volumes of methane gas. Because of this large gas-storage capacity, gas hydrates are thought to represent an important future source of natural gas. Gas hydrates are included in unconventional resources, but the technology to support commercial production has yet to be developed. |
| Gas Inventory |  | With respect to underground natural gas storage, “gas inventory” is the sum of Working Gas Volume and Cushion Gas Volume. |
| Gas/Oil Ratio | 2007 - 3.4.4 | Gas to oil ratio in an oil field, calculated using measured natural gas and crude oil volumes at stated conditions. The gas/oil ratio may be the solution gas/oil , symbol *Rs*; produced gas/oil ratio, symbol *Rp*; or another suitably defined ratio of gas production to oil production. |
| Gas Plant Products |  | Gas Plant Products are natural gas liquids (or components) recovered from natural gas in gas processing plants and, in some situations, from field facilities. Gas Plant Products include ethane, propane, butanes, butanes/propane mixtures, natural gasoline and plant condensates, sulfur, carbon dioxide, nitrogen, and helium. |
| Gas-to-Liquids (GTL) Projects |  | Gas-to-Liquids projects use specialized processing (e.g., Fischer-Tropsch synthesis) to convert natural gas into liquid petroleum products. Typically, these projects are applied to large gas accumulations where lack of adequate infrastructure or local markets would make conventional natural gas development projects uneconomic. |
| Geostatistical Methods | 2001 - 7.1 | A variety of mathematical techniques and processes dealing with the collection, methods, analysis, interpretation, and presentation of masses of geoscience and engineering data to (mathematically) describe the variability and uncertainties within any reservoir unit or pool, specifically related here to resources estimates, including the definition of (all) well and reservoir parameters in 1, 2, and 3 dimensions and the resultant modeling and potential prediction of various aspects of performance. |
| High Estimate | 2007 - 2.2.2  2001 - 2.5 | With respect to resource categorization, this is considered to be an optimistic estimate of the quantity that will actually be recovered from an accumulation by a project. If probabilistic methods are used, there should be at least a 10% probability (P10) that the quantities actually recovered will equal or exceed the high estimate. |
| Hydrocarbons | 2007 - 1.1 | Hydrocarbons are chemical compounds consisting wholly of hydrogen and carbon. |

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| Improved Recovery (IR) | 2007 - 2.3.4 | Improved Recovery is the extraction of additional petroleum, beyond Primary Recovery, from naturally occurring reservoirs by supplementing the natural forces in the reservoir. It includes waterflooding and gas injection for pressure maintenance, secondary processes, tertiary processes and any other means of supplementing natural reservoir recovery processes. Improved recovery also includes thermal and chemical processes to improve the in-situ mobility of viscous forms of petroleum. (Also called Enhanced Recovery.) |
| Injection | 2001 - 3.5  2007 - 3.2.5 | The forcing, pumping, or free flow under vacuum, of substances into a porous and permeable subsurface rock formation. Injected substances can include either gases or liquids. |
| Justified for Development | 2007 - 2.1.3.1 and Table 1 | Implementation of the development project is justified on the basis of reasonable forecast commercial conditions at the time of reporting and that there are reasonable expectations that all necessary approvals/contracts will be obtained. A project maturity sub-class that reflects the actions required to move a project toward commercial production. |
| Kerogen |  | The naturally occurring, solid, insoluble organic material that occurs in source rocks and can yield oil upon heating. Kerogen is also defined as the fraction of large chemical aggregates in sedimentary organic matter that is insoluble in solvents (in contrast, the fraction that is soluble in organic solvents is called bitumen). (See also Oil Shales.) |
| Known Accumulation | 2007 - 2.1.1  2001 - 2.2 | An accumulation is an individual body of petroleum-in-place. The key requirement to consider an accumulation as “known,” and hence containing Reserves or Contingent Resources, is that it must have been discovered, that is, penetrated by a well that has established through testing, sampling, or logging the existence of a significant quantity of recoverable hydrocarbons. |
| Lead | 2007 - 2.1.3.1 and Table 1 | A project associated with a potential accumulation that is currently poorly defined and requires more data acquisition and/or evaluation in order to be classified as a prospect. A project maturity sub-class that reflects the actions required to move a project toward commercial production. |
| Lease  Condensate |  | Lease Condensate is condensate recovered from produced natural gas in gas/liquid separators or field facilities. |
| Lease Fuel | 2007 - 3.2.2 | Oil and/or gas used for field and processing plant operations. For consistency, quantities consumed as lease fuel should be treated as shrinkage. However, regulatory guidelines may allow lease fuel to be included in Reserves estimates.Where claimed as Reserves, such fuel quantities should be reported separately from sales, and their value must be included as an operating expense. |
| Lease Plant |  | A general term referring to processing facilities that are dedicated to one or more development projects and the petroleum is processed without prior custody transfer from the owners of the extraction project (for gas projects, also termed “Local Gas Plant”). |
| Liquefied Natural Gas (LNG) Project |  | Liquefied Natural Gas projects use specialized cryogenic processing to convert natural gas into liquid form for tanker transport. LNG is about 1/614 the volume of natural gas at standard temperature and pressure. |
| Loan Agreement | 2001 - 9.6.5 | A loan agreement is typically used by a bank, other investor, or partner to finance all or part of an oil and gas project. Compensation for funds advanced is limited to a specified interest rate. |

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| Low/Best/High Estimates | 2007 - 2.2.1, 2.2.2 | The range of uncertainty reflects a reasonable range of estimated potentially recoverable volumes at varying degrees of uncertainty (using the cumulative scenario approach) for an individual accumulation or a project. |
| Low Estimate | 2007 - 2.2.2  2001 - 2.5 | With respect to resource categorization, this is considered to be a conservative estimate of the quantity that will actually be recovered from the accumulation by a project. If probabilistic methods are used, there should be at least a 90% probability (P90) that the quantities actually recovered will equal or exceed the low estimate. |
| Lowest Known Hydrocarbons | 2007 - 2.2.2. | The deepest occurrence of a producible hydrocarbon accumulation as interpreted from well log, flow test, pressure measurement, or core data. |
| Marginal Contingent Resources | 2007 - 2.1.3.3 | Known (discovered) accumulations for which a development project(s) has been evaluated as economic or reasonably expected to become economic but commitment is withheld because of one or more contingencies (e.g., lack of market and/or infrastructure). |
| Measurement | 2007 - 3.0 | The process of establishing quantity (volume or mass) and quality of petroleum products delivered to a reference point under conditions defined by delivery contract or regulatory authorities. |
| Mineral Interest | 2001 - 9.3 | Mineral Interests in properties including (1) a fee ownership or lease, concession, or other interest representing the right to extract oil or gas subject to such terms as may be imposed by the conveyance of that interest; (2) royalty interests, production payments payable in oil or gas, and other non-operating interests in properties operated by others; and (3) those agreements with foreign governments or authorities under which a reporting entity participates in the operation of the related properties or otherwise serves as producer of the underlying reserves (as opposed to being an independent purchaser, broker, dealer, or importer). |
| Monte Carlo Simulation | 2001 - 5  2007 - 3.5 | A type of stochastic mathematical simulation that randomly and repeatedly samples input distributions (e.g., reservoir properties) to generate a resulting distribution (e.g., recoverable petroleum volumes). |
| Natural Bitumen | 2007 - 2.4 | Natural Bitumen is the portion of petroleum that exists in the semisolid or solid phase in natural deposits. In its natural state, it usually contains sulfur, metals, and other non-hydrocarbons. Natural Bitumen has a viscosity greater than 10,000 milliPascals per second (mPa.s) (or centipoises) measured at original temperature in the deposit and atmospheric pressure, on a gas free basis. In its natural viscous state, it is not normally recoverable at commercial rates through a well and requires the implementation of improved recovery methods such as steam injection. Natural Bitumen generally requires upgrading prior to normal refining. (Also called Crude Bitumen.) |
| Natural Gas | 2007 - 3.2.3  2001 - 6.6, 9.4.4 | Natural Gas is the portion of petroleum that exists either in the gaseous phase or is in solution in crude oil in natural underground reservoirs, and which is gaseous at atmospheric conditions of pressure and temperature. Natural Gas may include some amount of non-hydrocarbons. |

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| Natural Gas Inventory |  | With respect to underground natural gas storage operations “inventory” is the total of working and cushion gas volumes. |
| Natural Gas Liquids | 2007 - A13  2001 - 3.2, 9.4.4 | Natural Gas Liquids (NGL) are a mixture of light hydrocarbons that exist in the gaseous phase and are recovered as liquids in gas processing plants. NGL differs from condensate in two principal respects: (1) NGL is extracted and recovered in gas plants rather than lease separators or other lease facilities, and (2) NGL includes very light hydrocarbons (ethane, propane, butanes) as well as the pentanes-plus that are the main constituents of condensates. |
| Natural Gas Liquids to Gas Ratio |  | Natural gas liquids to gas ratio in an oil or gas field, calculated using measured natural gas liquids and gas volumes at stated conditions. |
| Net-Back | 2007 - 3.2.1 | Linkage of input resource to the market price of the refined products. |
| Net Profits Interest | 2001 - 9.4.4 | An interest that receives a portion of the net proceeds from a well, typically after all costs have been paid. |
| Net Working Interest | 2001 - 9.6.1 | A company’s working interest reduced by royalties or share of production owing to others under applicable lease and fiscal terms. (Also called Net Revenue Interest.) |
| Non- Hydrocarbon Gas | 2007 - 3.2.4  2001 - 3.3 | Natural occurring associated gases such as nitrogen, carbon dioxide, hydrogen sulfide, and helium. If non-hydrocarbon gases are present, the reported volumes should reflect the condition of the gas at the point of sale. Correspondingly, the accounts will reflect the value of the gas product at the point of sale. |
| Non-Associated Gas |  | Non-Associated Gas is a natural gas found in a natural reservoir that does not contain crude oil. |
| Normal Production Practices |  | Production practices that involve flow of fluids through wells to surface facilities that involve only physical separation of fluids and, if necessary, solids. Wells can be stimulated, using techniques including, but not limited to, hydraulic fracturing, acidization, various other chemical treatments, and thermal methods, and they can be artificially lifted (e.g., with pumps or gas lift). Transportation methods can include mixing with diluents to enable flow, as well as conventional methods of compression or pumping. Practices that involve chemical reforming of molecules of the produced fluids are considered manufacturing processes. |
| Oil Sands |  | Sand deposits highly saturated with natural bitumen. Also called “Tar Sands.” Note that in deposits such as the western Canada “oil sands,” significant quantities of natural bitumen may be hosted in a range of lithologies including siltstones and carbonates. |
| Oil Shales | 2007 - 2.4 | Shale, siltstone and marl deposits highly saturated with kerogen. Whether extracted by mining or in situ processes, the material must be extensively processed to yield a marketable product (synthetic crude oil). |
| Offset Well Location |  | Potential drill location adjacent to an existing well. The offset distance may be governed by well spacing regulations. In the absence of well spacing regulations, technical analysis of drainage areas may be used to define the spacing. For Proved volumes to be assigned to an offset well location there must be conclusive, unambiguous technical data which supports the reasonable certainty of production of hydrocarbon volumes and sufficient legal acreage to economically justify the development without going below the shallower of the fluid contact or the lowest known hydrocarbon. |
| On Production | 2007 -2.1.3.1 and Table 1 | The development project is currently producing and selling petroleum to market. A project status/maturity sub-class that reflects the actions required to move a project toward commercial production. |
| Operator |  | The company or individual responsible for managing an exploration, development, or production operation. |
| Overlift/Underlift | 2007 - 3.2.7  2001 - 3.9 | Production overlift or underlift can occur in annual records because of the necessity for companies to lift their entitlement in parcel sizes to suit the available shipping schedules as agreed among the parties. At any given financial year-end, a company may be in overlift or underlift. Based on the production matching the company’s accounts, production should be reported in accord with and equal to the liftings actually made by the company during the year, and not on the production entitlement for the year. |
| Penetration | 2007 - 1.2 | The intersection of a wellbore with a reservoir. |
| Petroleum | 2007 - 1.0 | Petroleum is defined as a naturally occurring mixture consisting of hydrocarbons in the gaseous, liquid, or solid phase.Petroleum may also contain non-hydrocarbon compounds, common examples of which are carbon dioxide, nitrogen, hydrogen sulfide, and sulfur. In rare cases, non-hydrocarbon content could be greater than 50%. |
| Petroleum Initially-in-Place | 2007 - 1.1 | Petroleum Initially-in-Place is the total quantity of petroleum that is estimated to exist originally in naturally occurring reservoirs. Crude Oil-in-place, Natural Gas-in-place and Natural Bitumen-in-place are defined in the same manner (see Resources). (Also referred as Total Resource Base or Hydrocarbon Endowment.) |
| Pilot Project | 2007 - 2.3.4, 2.4 | A small-scale test or trial operation that is used to assess the suitability of a method for commercial application. |
| Play | 2007 - 2.1.3.1 and Table 1 | A project associated with a prospective trend of potential prospects, but which requires more data acquisition and/or evaluation in order to define specific leads or prospects. A project maturity sub-class that reflects the actions required to move a project toward commercial production. |
| Pool |  | An individual and separate accumulation of petroleum in a reservoir. |
| Possible Reserves | 2007 - 2.2.2 and Table 3 | An incremental category of estimated recoverable volumes associated with a defined degree of uncertainty. Possible Reserves are those additional reserves which analysis of geoscience and engineering data suggest are less likely to be recoverable than Probable Reserves. The total quantities ultimately recovered from the project have a low probability to exceed the sum of Proved plus Probable plus Possible (3P), which is equivalent to the high estimate scenario. When probabilistic methods are used, there should be at least a 10% probability that the actual quantities recovered will equal or exceed the 3P estimate. |
| Primary Recovery |  | Primary recovery is the extraction of petroleum from reservoirs using only the natural energy available in the reservoirs to move fluids through the reservoir rock to other points of recovery. |
| Probability | 2007 - 2.2.1 | The extent to which an event is likely to occur, measured by the ratio of the favorable cases to the whole number of cases possible. SPE convention is to quote cumulative probability of exceeding or equaling a quantity where P90 is the small estimate and P10 is the large estimate. (See also Uncertainty.) |
| Probabilistic Estimate | 2007 - 3.5 | The method of estimation of Resources is called probabilistic when the known geoscience, engineering, and economic data are used to generate a continuous range of estimates and their associated probabilities. |
| Probable Reserves | 2007 - 2.2.2 and Table 3 | An incremental category of estimated recoverable volumes associated with a defined degree of uncertainty. Probable Reserves are those additional Reserves that are less likely to be recovered than Proved Reserves but more certain to be recovered than Possible Reserves. It is equally likely that actual remaining quantities recovered will be greater than or less than the sum of the estimated Proved plus Probable Reserves (2P). In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the 2P estimate. |
| Production | 2007 - 1.1 | Production is the cumulative quantity of petroleum that has been actually recovered over a defined time period. While all recoverable resource estimates and production are reported in terms of the sales product specifications, raw production quantities (sales and non-sales, including non-hydrocarbons) are also measured to support engineering analyses requiring reservoir voidage calculations. |
| Production- Sharing Contract | 2007 - 3.3.2  2001 - 9.6.2 | In a production-sharing contract between a contractor and a host government, the contractor typically bears all risk and costs for exploration, development, and production. In return, if exploration is successful, the contractor is given the opportunity to recover the incurred investment from production, subject to specific limits and terms. Ownership is retained by the host government; however, the contractor normally receives title to the prescribed share of the volumes as they are produced. |
| Profit Split | 2001 - 9.6.2 | Under a typical production-sharing agreement, the contractor is responsible for the field development and all exploration and development expenses. In return, the contractor is entitled to a share of the remaining profit oil or gas. The contractor receives payment in oil or gas production and is exposed to both technical and market risks. |
| Project | 2007 - 1.2  2001 - 2.3 | Represents the link between the petroleum accumulation and the decision-making process, including budget allocation. A project may, for example, constitute the development of a single reservoir or field, or an incremental development in a producing field, or the integrated development of a group of several fields and associated facilities with a common ownership. In general, an individual project will represent a specific maturity level at which a decision is made on whether or not to proceed (i.e., spend money), and there should be an associated range of estimated recoverable resources for that project. (See also Development Plan.) |
| Property | 2007 - 1.2  2001 - 9.4 | A volume of the Earth’s crust wherein a corporate entity or individual has contractual rights to extract, process, and market a defined portion of specified in-place minerals (including petroleum). Defined in general as an area but may have depth and/or stratigraphic constraints. May also be termed a lease, concession, or license. |
| Prorationing |  | The allocation of production among reservoirs and wells or allocation of pipeline capacity among shippers, etc. |
| Prospect | 2007 - 2.1.3.1 and Table 1 | A project associated with a potential accumulation that is sufficiently well defined to represent a viable drilling target. A project maturity sub-class that reflects the actions required to move a project toward commercial production. |

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| Prospective Resources | 2007 - 1.1 and Table 1 | Those quantities of petroleum which are estimated, as of a given date, to be potentially recoverable from undiscovered accumulations. |
| Proved Economic | 2007 - 3.1.1 | In many cases, external regulatory reporting and/or financing requires that, even if only the Proved Reserves estimate for the project is actually recovered, the project will still meet minimum economic criteria; the project is then termed as “Proved Economic.” |
| Proved Reserves | 2007 - 2.2.2 and Table 3 | An incremental category of estimated recoverable volumes associated with a defined degree of uncertainty Proved Reserves are those quantities of petroleum which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under defined economic conditions, operating methods, and government regulations. If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be recovered. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate. Often referred to as 1P, also as “Proven.” |
| Purchase Contracts | 2001 - 9.6.8 | A contract to purchase oil and gas provides the right to purchase a specified volume of production at an agreed price for a defined term. |
| Pure-Service Contract | 2001 - 9.7.5 | A pure-service contract is an agreement between a contractor and a host government that typically covers a defined technical service to be provided or completed during a specific period of time. The service company investment is typically limited to the value of equipment, tools, and expenses for personnel used to perform the service. In most cases, the service contractor’s reimbursement is fixed by the terms of the contract with little exposure to either project performance or market factors. |
| Range of Uncertainty | 2007 - 2.2  2001 - 2.5 | The range of uncertainty of the recoverable and/or potentially recoverable volumes may be represented by either deterministic scenarios or by a probability distribution. (See Resource Uncertainty Categories.) |
| Raw Natural Gas | 2007 - 3.2.1 | Raw Natural Gas is natural gas as it is produced from the reservoir. It includes water vapor and varying amounts of the heavier hydrocarbons that may liquefy in lease facilities or gas plants and may also contain sulfur compounds such as hydrogen sulfide and other non-hydrocarbon gases such as carbon dioxide, nitrogen, or helium, but which, nevertheless, is exploitable for its hydrocarbon content. Raw Natural Gas is often not suitable for direct usage by most types of consumers. |
| Reasonable Certainty | 2007 - 2.2.2 | If deterministic methods for estimating recoverable resource quantities are used, then reasonable certainty is intended to express a high degree of confidence that the estimated quantities will be recovered. |
| Reasonable Expectation | 2007 - 2.1.2 | Indicates a high degree of confidence (low risk of failure) that the project will proceed with commercial development or the referenced event will occur. |
| Reasonable Forecast | 2007 - 3.1.2 | Indicates a high degree of confidence in predictions of future events and commercial conditions. The basis of such forecasts includes, but is not limited to, analysis of historical records and published global economic models. |
| Recoverable Resources | 2007 - 1.2 | Those quantities of hydrocarbons that are estimated to be producible from discovered or undiscovered accumulations. |

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| Recovery Efficiency | 2007 - 2.2 | A numeric expression of that portion of in-place quantities of petroleum estimated to be recoverable by specific processes or projects, most often represented as a percentage. |
| Reference Point | 2007 - 3.2.1 | A defined location within a petroleum extraction and processing operation where quantities of produced product are measured under defined conditions prior to custody transfer (or consumption). Also called Point of Sale or Custody Transfer Point. |
| Reserves | 2007 - 1.1 | Reserves are those quantities of petroleum anticipated to be commercially recoverable by application of development projects to known accumulations from a given date forward under defined conditions. Reserves must further satisfy four criteria: They must be discovered, recoverable, commercial, and remaining (as of a given date) based on the development project(s) applied. |
| Reservoir | 2001 - 2.3 | A subsurface rock formation containing an individual and separate natural accumulation of moveable petroleum that is confined by impermeable rocks/formations and is characterized by a single-pressure system. |
| Resources | 2007 - 1.1 | The term “resources” as used herein is intended to encompass all quantities of petroleum (recoverable and unrecoverable) naturally occurring on or within the Earth’s crust, discovered and undiscovered, plus those quantities already produced. Further, it includes all types of petroleum whether currently considered “conventional” or “unconventional” (see Total Petroleum Initially-in-Place). (In basin potential studies, it may be referred to as Total Resource Base or Hydrocarbon Endowment.) |
| Resources  Categories | 2007 - 2.2  and Table 3 | Subdivisions of estimates of resources to be recovered by a project(s) to indicate the associated degrees of uncertainty. Categories reflect uncertainties in the total petroleum remaining within the accumulation (in-place resources), that portion of the in-place petroleum that can be recovered by applying a defined development project or projects, and variations in the conditions that may impact commercial development (e.g., market availability, contractual changes) |
| Resources Classes | 2007 - 1.1, 2.1 and Table 1 | Subdivisions of Resources that indicate the relative maturity of the development projects being applied to yield the recoverable quantity estimates. Project maturity may be indicated qualitatively by allocation to classes and sub-classes and/or quantitatively by associating a project’s estimated chance of reaching producing status. |
| Revenue- Sharing Contract | 2001 - 9.6.3 | Revenue-sharing contracts are very similar to the production-sharing contracts described earlier, with the exception of contractor payment. With these contracts, the contractor usually receives a defined share of revenue rather than a share of the production. |
| Reversionary Interest |  | The right of future possession of an interest in a property when a specified condition has been met. |
| Risk | 2001 - 2.5 | The probability of loss or failure. As “risk” is generally associated with the negative outcome, the term “chance” is preferred for general usage to describe the probability of a discrete event occurring. |

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| Risk and Reward | | 2001 - 9.4 | Risk and reward associated with oil and gas production activities stems primarily from the variation in revenues due to technical and economic risks. Technical risk affects a company’s ability to physically extract and recover hydrocarbons and is usually dependent on a number of technical parameters. Economic risk is a function of the success of a project and is critically dependent on cost, price, and political or other economic factors. |
| Risked-Service Contract | | 2007 - 3.3.2  2001 - 9.7.4 | These agreements are very similar to the production-sharing agreements with the exception of contractor payment, but risk is borne by the contractor. With a risked-service contract, the contractor usually receives a defined share of revenue rather than a share of the production. |
| Royalty | | 2007 - 3.3.1  2001 - 3.8 | Royalty refers to payments that are due to the host government or mineral owner (lessor) in return for depletion of the reservoirs and the producer (lessee/contractor) for having access to the petroleum resources.Many agreements allow for the producer to lift the royalty volumes, sell them on behalf of the royalty owner, and pay the proceeds to the owner. Some agreements provide for the royalty to be taken only in kind by the royalty owner. |
| Sales | | 2007 - 3.2 | The quantity of petroleum product delivered at the custody transfer (reference point) with specifications and measurement conditions as defined in the sales contract and/or by regulatory authorities. All recoverable resources are estimated in terms of the product sales quantity measurements. |
| Shut-in Reserves | | 2007 -2.1.3.2 and Table 2 | Shut-in Reserves are expected to be recovered from (1) completion intervals which are open at the time of the estimate, but which have not started producing; (2) wells which were shut-in for market conditions or pipeline connections; or (3) wells not capable of production for mechanical reasons. |
| Solution Gas | |  | Solution Gas is a natural gas which is dissolved in crude oil in the reservoir at the prevailing reservoir conditions of pressure and temperature. It is a subset of Associated Gas. |
| Sour Natural Gas | | 2001 - 3.4 | Sour Natural Gas is a natural gas that contains sulfur, sulfur compounds, and/or carbon dioxide in quantities that may require removal for sales or effective use. |
| Stochastic | | 2001 - 5 | Adjective defining a process involving or containing a random variable or variables or involving chance or probability such as a stochastic stimulation. |
| Sub-Commercial | | 2007 - 2.1.2 | A project is Sub-Commercial if the degree of commitment is such that the accumulation is not expected to be developed and placed on production within a reasonable time frame. While 5 years is recommended as a benchmark, 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. Discovered sub-commercial projects are classified as Contingent Resources. |
| Sub-Marginal Contingent Resources | | 2007 -2.1.3.3 | Known (discovered) accumulations for which evaluation of development project(s) indicated they would not meet economic criteria, even considering reasonably expected improvements in conditions. |
| Sweet Natural Gas | 2001 - 3.3 | | Sweet Natural Gas is a natural gas that contains no sulfur or sulfur compounds at all, or in such small quantities that no processing is necessary for their removal in order that the gas may be sold. |
| Synthetic Crude Oil  (SCO) | 2001 - A12, A13 | | A mixture of hydrocarbons derived by upgrading (i.e., chemically altering) natural bitumen from oil sands, kerogen from oil shales, or processing of other substances such as natural gas or coal. SCO may contain sulfur or other non-hydrocarbon compounds and has many similarities to crude oil. |
| Taxes | 2001 - 9.4.2 | | Obligatory contributions to the public funds, levied on persons, property, or income by governmental authority. |
| Technical Uncertainty | 2007 - 2.2 | | Indication of the varying degrees of uncertainty in estimates of recoverable quantities influenced by range of potential in-place hydrocarbon resources within the reservoir and the range of the recovery efficiency of the recovery project being applied. |
| Total Petroleum Initially-in-Place | 2007 - 1.1 | | Total Petroleum Initially-in-Place is generally accepted to be all those estimated quantities of petroleum contained in the subsurface, as well as those quantities already produced. This was defined previously by the WPC as “Petroleum-in-place” and has been termed “Resource Base” by others. Also termed “Original-in-Place” or “Hydrocarbon Endowment.” |
| Uncertainty | 2007 - 2.2  2001 - 2.5 | | The range of possible outcomes in a series of estimates. For recoverable resource assessments, the range of uncertainty reflects a reasonable range of estimated potentially recoverable quantities for an individual accumulation or a project. (See also Probability.) |
| Unconventional Resources | 2007 - 2.4, | | Unconventional resources exist in petroleum accumulations that are pervasive throughout a large area and that are not significantly affected by hydrodynamic influences (also called “continuous-type deposits”). Examples include coalbed methane (CBM), basin-centered gas, shale gas, gas hydrate, natural bitumen (tar sands), and oil shale deposits. Typically, such accumulations require specialized extraction technology (e.g., dewatering of CBM, massive fracturing programs for shale gas, steam and/or solvents to mobilize bitumen for in-situ recovery, and, in some cases, mining activities). Moreover, the extracted petroleum may require significant processing prior to sale (e.g., bitumen upgraders). (Also termed “Non-Conventional” Resources and “Continuous Deposits.”) |
| Undeveloped Reserves | 2001 - 2.1.3.1 and Table 2 | | Undeveloped Reserves are quantities expected to be recovered through future investments: (1) from new wells on undrilled acreage in known accumulations, (2) from deepening existing wells to a different (but known) reservoir, (3) from infill wells that will increase recovery, or (4) where a relatively large expenditure (e.g., when compared to the cost of drilling a new well) is required to (a) recomplete an existing well or (b) install production or transportation facilities for primary or improved recovery projects. |
| Unitization |  | | Process whereby owners group adjoining properties and divide reserves, production, costs, and other factors according to their respective entitlement to petroleum quantities to be recovered from the shared reservoir(s). |
| Unproved Reserves | 2001 - 5.1.1 | | Unproved Reserves are based on geoscience and/or engineering data similar to that used in estimates of Proved Reserves, but technical or other uncertainties preclude such reserves being classified as Proved. Unproved Reserves may be further categorized as Probable Reserves and Possible Reserves. |
| Unrecoverable Resources | 2007 - 1.1 | | That portion of Discovered or Undiscovered Petroleum Initially-in-Place quantities which are estimated, as of a given date, not to be recoverable. A portion of these quantities may become recoverable in the future as commercial circumstances change, technological developments occur, or additional data are acquired. |
| Upgrader | 2007 - 2.4 | | A general term applied to processing plants that convert extra-heavy crude oil and natural bitumen into lighter crude and less viscous synthetic crude oil (SCO). While the detailed process varies, the underlying concept is to remove carbon through coking or to increase hydrogen by hydrogenation processes using catalysts. |
| Well Abandonment |  | | The permanent plugging of a dry hole, an injection well, an exploration well, or a well that no longer produces petroleum or is no longer capable of producing petroleum profitably.  Several steps are involved in the abandonment of a well:  permission for abandonment and procedural requirements are secured from official agencies; the casing is removed and salvaged if possible; and one or more cement plugs and/or mud are placed in the borehole to prevent migration of fluids between the different formations penetrated by the borehole. In some cases, wells may be temporarily abandoned where operations are suspended for extended periods pending future conversions to other applications such as reservoir monitoring, enhanced recovery, etc. |
| Wet Gas | 2001 - 3.2  2007 - 3.2.3 | | Wet (Rich) Gas is natural gas from which no liquids have been removed prior to the reference point. The wet gas is accounted for in resource assessments, and there is no separate accounting for contained liquids. It should be recognized that this is a resource assessment definition and not a phase behavior definition. |
| Working Gas Volume |  | | With respect to underground natural gas storage, Working Gas Volume (WGV) is the volume of gas in storage above the designed level of cushion gas which can be withdrawn/injected with the installed subsurface and surface facilities (wells, flowlines, etc.) subject to legal and technical limitations (pressures, velocities, etc.). Depending on local site conditions (injection/withdrawal rates, usage hours, etc.), the working gas volume may be cycled more than once a year. |
| Working Interest | 2001 - 9 | | A company’s equity interest in a project before reduction for royalties or production share owed to others under the applicable fiscal terms. |