

Standardization of the Evaluation Criteria on Petroleum Resources

Standardization of Korean Petroleum Resources Classification
and Definition

(Unofficial Report)

Contents

I. Introduction

1. Significance
2. Purposes
3. Scope
4. Planning Group
5. Expected Effects
6. Basic Principles

II. Standardization of Petroleum Resources Classification

1. Classification Framework
 - 1.1. Superordinate Classification
 - 1.2. Subordinate Classification
2. Definition of Terminologies
 - 2.1. Basic Terms
 - 2.2. Reserves
 - 2.3. Contingent Resources
 - 2.4. Prospective Resources
 - 2.5. Project Maturity Sub-Classes

III. Petroleum Resources Classification Based on Project Stages

1. Exploration Project
 - 1.1. Before Exploratory Drilling
 - 1.2. After Exploratory Drilling
2. Development Project
3. Production Project
4. Resources Totalization

IV. Comparison of Resources Classification System

I. Introduction

1. Significance

- Insufficient understanding of petroleum reserves terminology and definition in Korean domestic petroleum industry
- Intentional misuse of reserves terminology and arbitrary translation
- Confusion in global communication regarding resources classification systems of western and CIS (Commonwealth of Independent States) countries

2. Purposes

- Standardization of petroleum resources classification and category definition in Korea
- Standardization of terminology used in petroleum resources in Korea

3. Scope

- Provision of the definition and extent of reserves classification (including Korean terminology)
- Guidelines for determining project stages (exploration, development, and production)
- Comparison of the resources classification system with petroleum-producing countries (including CIS countries)

4. Planning Group

- Korean government department supervising petroleum E&P projects
- Korean public and private firms participating in overseas petroleum E&P projects
- Professionals in universities and research institutes
- Planning committee, subcommittee, and consultative organization and committee compose the planning group

5. Expected effects

- Prevention of misunderstanding and social turmoil by providing standardization of petroleum resources for
 - Petroleum resources management of government and companies
 - Public announcement and valuation of investment assets of financial and securities agencies
- Efficient management of government funding for financing support program for petroleum E&P project
- Improvement of quality assessment of overseas petroleum E&P project
- Improvement of national energy resources supply

6. Basic Principles

- The Petroleum resources classification system is based on PRMS (Petroleum Resources Management System, 2007) of SPE (Society of Petroleum Engineers), WPC (World Petroleum Council), AAPG (American Association of Petroleum Geologists), and SPEE (Society of Petroleum Evaluation Engineers) in common use internationally within the petroleum industry.
- The terminologies, classes and sub-classes, categories, definitions, and guidelines are nearly identical with them of PRMS.
- Unconventional resources classification uses the same terminologies and classes of petroleum resources classification system, the details of which have been excluded in this informal report.

II. Standardization of Petroleum Resources Classification

1. Classification Framework

1.1. Superordinate Classification

- Petroleum resources are classified into three classes: Reserves, Contingent Resources, and Prospective Resources (Figure II-1).

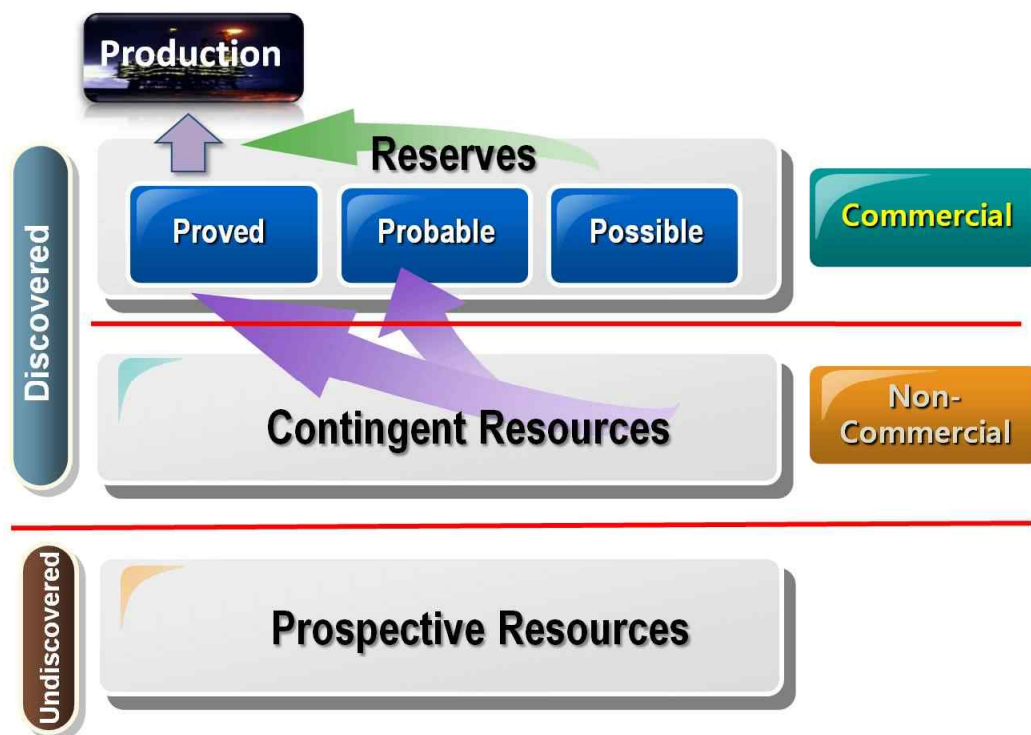


Figure II-1. Superordinate classification of petroleum resources

- Petroleum discovery differentiates between Contingent Resources and Prospective Resources. 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. Discovered (or known) accumulations are classified as Contingent Resources or Reserves, while yet-to-be-discovered accumulations are classified as Prospective Resources.
- Commerciality differentiates between Contingent Resources and Reserves. Quantities of known accumulations can be evaluated as Reserves, only if they are commercial on both

technical and economical point of view at a given date. The term "commercial" indicates recoverable by application of development projects to known accumulations from a given date forward under defined conditions (see Determination of Commerciality, section 2.2.1.).

1.2. Subordinate Classification

- Resources are classified based on range of uncertainty for available information at a given date and project maturity according to increasing chance of commerciality (Figure II-1).

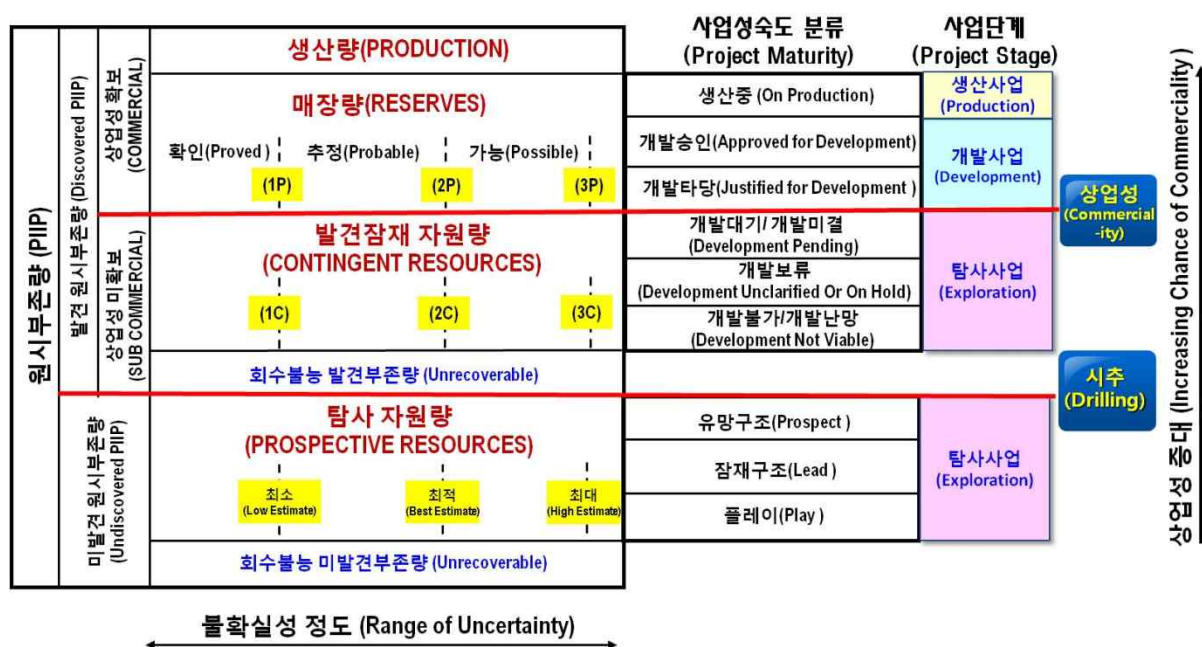


Figure II-2. Subordinate classification of petroleum resources

2. Definition of Terminologies

2.1. Basic Terms

2.1.1. Petroleum

- Petroleum is defined as a naturally occurring mixture consisting of hydrocarbons in the gaseous, liquid, or solid phase. Petroleum may also contain non-hydrocarbons, common examples of which are carbon dioxide, nitrogen, hydrogen sulfide and sulfur.

2.1.2. Resources

- The term "resources" as used herein is intended to encompass all quantities of petroleum naturally occurring on or within the Earth's crust, discovered and undiscovered (recoverable and unrecoverable), plus those quantities already produced.

2.1.3. Petroleum Initially in Place (PIIP)

- PIIP is that quantity of petroleum that is estimated to exist originally in naturally occurring accumulations.
- It includes that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations prior to production plus those estimated quantities in accumulations yet to be discovered.
- Discovered Petroleum Initially-in-Place is that quantity of petroleum that is estimated, as of a given date, to be contained in known accumulations prior to production.
- Undiscovered Petroleum Initially-in-Place is that quantity of petroleum estimated, as of a given date, to be contained within accumulations yet to be discovered.

2.1.4. Production

- Production is the cumulative quantity of petroleum that has been recovered.

2.1.5. Unrecoverable Discovered or Undiscovered Petroleum Initially in Place

- Unrecoverable is that portion of Discovered or Undiscovered Petroleum Initially-in-Place quantities which is 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 or technological developments occur; the remaining portion may never be recovered due to physical/chemical constraints represented by subsurface interaction of fluids and reservoir rocks.

2.1.6. Range of Uncertainty

- The horizontal axis in the Resources Classification (Figure II-1) defines the range of uncertainty in estimates of the quantities of recoverable, or potentially recoverable, petroleum associated with a project.

- The range of uncertainty of the recoverable and/or potentially recoverable volumes may be represented by either deterministic scenarios or by a probability distribution

2.1.7. Increasing Chance of Commerciality

- The vertical axis in the Resources Classification (Figure II-1) represents the Chance of Commerciality, that is, the chance that the project that will be developed and reach commercial producing status.

2.2. Reserves

- 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 the evaluation date) based on the development project(s) applied.

2.2.1. Determination of Commerciality

- 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 a market for all or at least the expected sales quantities of production required to justify development
- Evidence that the necessary production and transportation facilities are available or can be made available
- Evidence that legal, contractual, environmental and other social and economic concerns will allow for the actual implementation of the recovery project being evaluated
- Discovered recoverable volumes may be considered commercially producible, and thus Reserves, if license holder possess authority on the license renewal and demonstrate the renewal history at the expiration of duration of license.

2.2.2. Reserves Uncertainty Categories

- Reserves are categorized as Proved, Probable, and Possible according to uncertainty (Table II-1).
- 1P: Proved Reserves (Low Estimate)
- 2P: Sum of Proved plus Probable Reserves (Best Estimate)
- 3P: Sum of Proved plus Probable plus Possible Reserves (High Estimate)

Table II-1 Reserves Category Definitions and Guidelines

Category	Definition	Guidelines
Proved Reserves	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.	<ul style="list-style-type: none"> • Reserves in undeveloped locations may be classified as Proved provided that: <ol style="list-style-type: none"> ① The locations are in undrilled areas of the reservoir that can be judged with reasonable certainty to be commercially productive. ② Interpretations of available geoscience and engineering data indicate with reasonable certainty that the objective formation is laterally continuous with drilled Proved locations. • In the absence of data on fluid contacts, Proved quantities in a reservoir are limited by the lowest known hydrocarbon (LKH) as seen in a well penetration unless otherwise indicated by definitive geoscience, engineering, or performance data. Such definitive information may include pressure gradient analysis and seismic indicators. Seismic data alone may not be sufficient to define fluid contacts for Proved reserves. • 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.
Probable Reserves	Probable Reserves are those additional Reserves which analysis of geoscience and engineering data indicate are less likely to be recovered than Proved Reserves but more certain to be recovered than	<ul style="list-style-type: none"> • Probable Reserves may be assigned to areas of a reservoir adjacent to Proved where data control or interpretations of available data are less certain. The interpreted reservoir continuity may not meet the reasonable certainty criteria. • 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

	Possible Reserves.	50% probability that the actual quantities recovered will equal or exceed the 2P estimate.
Possible Reserves	Possible Reserves are those additional reserves which analysis of geoscience and engineering data indicate are less likely to be recoverable than Probable Reserves.	<ul style="list-style-type: none"> • Possible Reserves may be assigned to areas of a reservoir 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 reservoir limits of commercial production from the reservoir by a defined project. • 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.

2.2.3. Reserves Status Classification

- Quantities may be subdivided by Reserves Status as Developed and Undeveloped Reserves based on the funding and operational status of wells and associated facilities within the reservoir development plan (Table II-2).
- Development and production status are of significant importance for project management. While Reserves Status has traditionally only been applied to Proved Reserves, the same concept of Developed and Undeveloped Status is applicable throughout the full range of Reserves uncertainty categories (Proved, Probable and Possible).
- Developed Reserves are expected quantities to be recovered from existing wells and facilities
 - Developed Producing Reserves are expected to be recovered from completion intervals that are open and producing at the time of the estimate.
 - Developed Non-Producing Reserves include shut-in and behind-pipe Reserves at the time of estimate.
- Undeveloped Reserves are quantities expected to be recovered through future investments
- Developed and/or Undeveloped Reserves quantities may be identified separately within each Reserves category like PDP (Proved Developed Producing), PDNP (Proved Developed Non-Producing) and PUD (Proved Undeveloped).

Table II-2 Reserved Status Definitions and Guidelines

Category	Definition	Guidelines
Developed Reserves	Developed Reserves are expected quantities to be recovered from existing wells and facilities.	<ul style="list-style-type: none"> · 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. · Where required facilities become unavailable, it may be necessary to reclassify Developed Reserves as Undeveloped. · Developed Reserves may be further sub-classified as Producing or Non-Producing.
Developed Producing Reserves	Developed Producing Reserves are expected to be recovered from completion intervals that are open and producing at the time of the estimate.	<ul style="list-style-type: none"> · Improved recovery reserves are considered producing only after the improved recovery project is in operation.
Developed Non-Producing Reserves	Developed Non-Producing Reserves include shut-in and behind-pipe Reserves.	<ul style="list-style-type: none"> · Shut-in Reserves are expected to be recovered from <ol style="list-style-type: none"> 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 expected to be recovered from zones in existing wells which will require additional completion work or future recompletion 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.
Undeveloped Reserves	Undeveloped Reserves are quantities expected to be recovered through future investments:	<ol style="list-style-type: none"> 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 <ul style="list-style-type: none"> - recomplete an existing well or - install production or transportation facilities for primary or improved recovery projects.

2.3. Contingent Resources

- Quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations, but the applied project(s) are not yet considered mature enough for commercial development due to one or more contingencies.
- Contingent Resources may include, for example, projects for which there are currently no viable markets, or where commercial recovery is dependent on technology under development, or where evaluation of the accumulation is insufficient to clearly assess commerciality.
- Contingent Resources are further categorized as 1C, 2C, and 3C in accordance with the level of certainty associated with the estimates and may be subclassified based on project maturity and/or characterized by their economic status.

2.3.1. Contingent Resources Uncertainty Categories

- 1C: Low estimate
- 2C: Best estimate
- 3C: High estimate

2.4. Prospective Resources

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

2.4.1. Prospective Resources Uncertainty Categories

- Low Estimate
 - 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.

- Best Estimate
 - A best estimate of the quantity that will actually be recovered from the accumulation by the project.
 - 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.
- High Estimate
 - 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.

2.5. Project Maturity Sub-Classes

2.5.1. Discovered and Commercial

2.5.1.1. On Production

- The development project is currently producing and selling petroleum to market.

2.5.1.2. Approved for Development

- All necessary approvals have been obtained, capital funds have been committed, and implementation of the development project is under way.
- The project must not be subject to any contingencies such as outstanding regulatory approvals or sales contracts.
- Forecast capital expenditures should be included in the reporting entity's current or following year's approved budget.

2.5.1.3. Justified for Development

- Implementation of the development project is justified on the basis of reasonable forecast commercial conditions at the time of reporting (based on the reporting entity's assumptions of future prices, costs, etc. and the specific circumstances of the project), and there are reasonable expectations that all necessary approvals/contracts will be obtained.
- There should be a development plan in sufficient detail to support the assessment of

commerciality and a reasonable expectation that any regulatory approvals or sales contracts required prior to project implementation will be forthcoming.

- There should be no known contingencies that could preclude the development from proceeding within a reasonable timeframe.

2.5.2. Discovered and Sub-Commercial

2.5.2.1. Development Pending

- A discovered accumulation where project activities are ongoing to justify commercial development in the foreseeable future.
- 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.

2.5.2.2. Development Unclassified or On Hold

- Further appraisal/evaluation activities are required to clarify the potential for eventual commercial development.
- 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.
- 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 reclassification of the project to "Not Viable" status.

2.5.2.3. Development Not Viable

- 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.

2.5.3. Undiscovered

2.5.3.1. Prospect

- A project associated with a potential accumulation 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 recoverable quantities under a commercial development program.

2.5.3.2. Lead

- 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.
- 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 recovery under feasible development scenarios.

2.5.3.3. Play

- Project activities are focused on acquiring additional data and/or undertaking further evaluation designed to define specific leads or prospects.
- Detailed analysis of chance of discovery and, assuming discovery, the range of potential recovery under hypothetical development scenarios are included in the evaluation.

2.5.4. Nonrated

- A project not yet considered mature enough for play class
- A project on research phase

III. Petroleum Resources Classification Based on Project Stages

1. Exploration Project

- A project including geological and geophysical survey, geochemical prospecting, exploration and evaluation drilling, and project feasibility study to prospect undiscovered petroleum

1.1. Before Exploration Drilling

- Resources class: Prospective Resources (Undiscovered)
- Project maturity sub-class: Nonrated, Play, and Lead
- Prospective Resources Uncertainty Categories: Low Estimate, Best Estimate, and High Estimate
- Estimation method: Analogs and Probabilistic method (Deterministic method is inappropriate for the estimation due to that input parameters are unpredictable.)
- Representative value: Mean referenced with P10, P50, and P90 values from probabilistic method

1.2. After Exploration Drilling

- Undiscovered Resources
 - Class: Prospective Resources
 - Project maturity sub-class: Prospect
- Discovered Resources
 - Class: Contingent Resources
 - Project maturity sub-class: Development Pending, Development Unclassified or On Hold, and Development Not Viable
- Contingent Resources Uncertainty Categories: 1C, 2C, and 3C
- Analysis of engineering data from evaluation drilling designed to move the project to the level of development and production is required to justify project maturity and commerciality
- Estimation method: Volumetric Estimate of Deterministic and Probabilistic method
- Representative value of Contingent Resources: 2C referenced with 1C

2. Development Project

- A project associated with acquisition of rights and stake purchase for discovered petroleum fields or development fields and installation of production and transportation facilities
- Project maturity sub-class: Approved Development and Justified for Development
- Uncertainty categories: Proved, Probable, and Possible Reserves
- Estimation method: Volumetric Estimate of Deterministic and Probabilistic method, and Reservoir Simulation
- Representative value: 2P (Proved plus Probable) referenced with 1P (Proved)

3. Production Project

- A project including acquisition of rights and stake purchase for production fields, installation of production and associated facilities, and drilling to secure additional reserves
- Project maturity sub-class: On Production
- Uncertainty categories: Proved, Probable, and Possible Reserves with cumulative production volume
- Estimation method: Volumetric Estimate of Deterministic and Probabilistic method, Reservoir Simulation, Decline Curve method, and Material Balance
- Representative value: 2P (Proved plus Probable) referenced with 1P (Proved)
- Abandonment pressure should be considered for commercial production.

4. Resources Totalization

- When total reserves of petroleum fields or a company need to be evaluated, the principle of resources totalization is to add all the quantities together within the same class.

IV. Comparison of Resources Classification System

- Table IV-1 shows various petroleum resources classification systems according to countries, international organizations, and financial institutes.
- The representative system in common use internationally within the petroleum industry is PRMS of SPE, WPC, AAPG, and SPEE, which is not identical to that of Russia and CIS countries due to the difference in classes and definitions.

Table IV-1. Petroleum Resources Classification System according to country countries, international organizations, and financial institutes (Huh, 2009, modified)

Organization	International Organization		Financial Institute			Government		
	SPE-PRMS 2007	UNFC 2003	USA SEC 1978	UK SORP 2001	Canada CSA 2002	USA USBM/USGS 1980	Norway	
Petroleum Resources	total PIIIP	total PIIIP	-	-	total PIIIP	-	total recoverable petroleum resources	
Discovered	discovered PIIIP	discovered PIIIP	-	-	discovered PIIIP	identified resources	discovered	
Produced	production	produced	production	production	production	cumulative production	historical production	
Discovered Commercial	commercial	reserves	reserves	reserves	reserves	reserves	reserves	
		proved	111	proved	proven estimate	proved estimate	-	-
		probable	112	-	probable estimate	probable estimate	-	-
		possible	113	-	-	possible estimate	-	-
Discovered Sub-commercial	sub-commercial	contingent (recoverable) resources	12* 22* 31*, 32* 33*	-	-	contingent resources	marginal reserves	contingent resources
Discovered Unrecoverable		(discovered) unrecoverable	341 342 343	-	-	(discovered) unrecoverable	demonstrated sub-economic resources	-
Undiscovered	undiscovered PIIIP	-	-	-	undiscovered PIIIP	undiscovered resources	-	
Undiscovered recoverable		prospective (recoverable) resources	234 334	-	-	prospective resources	hypothetical/ speculative	undiscovered resources
Undiscovered unrecoverable		(undiscovered) unrecoverable	344	-	-	(undiscovered) unrecoverable	-	-

Table IV-1. Petroleum Resources Classification System according to country countries, international organizations, and financial institutes (Continued)

Organization	Government														
	Korea (2009)		Russia	China	Indonesia	Malaysia	Thailand	Vietnam							
Petroleum Resources	total PIIIP	원시부존량	total initial resources	total PIIIP	total resources	resources	resource	petroleum resources							
Discovered	discovered PIIIP	발견 원시부존량	geological reserves	discovered geological reserves(GR)	identified	discovered	discovered resources	discovered							
Produced	production	생산량	produced reserve	-	-	-	cumulative production	cumulative production	produced						
Discovered Commercial	reserves	매장량	recoverable reserves	measured geological reserves	proved technically EJOR	economic	measured	ultimate recovery	reserves	reserves	planned				
	proved	확인	reasonably assured(A) identified(B) estimated(C1)									demonstrated	potential recovery	proved	proved
	probable	추정	inferred(C2)												
possible	가능	sub-economic		possible	possible										
Discovered Sub-commercial	contingent resources		발견잠재 자원량			contingent recoverable reserves	residual	inferred	-	proved	-	improved			
Discovered Unrecoverable	discovered unrecoverable		회수불능 발견부존량			unrecoverable reserves				unproved			unrecoverable resources	-	
Undiscovered	undiscovered PIIIP	미발견 원시부존량	geological resources	undiscovered PIIIP	undiscovered	undiscovered	undiscovered resources	undiscovered resources	undiscovered						
Undiscovered recoverable	prospective resources	탐사자원량	recoverable resources: - localized D1 - prospective D2 (in-place only) - predicted D3 (in-place only)	in prospects	recoverable resources	hypothetical	speculative recovery	-	hypothetical						
					residual	speculative				-	speculative				
Undiscovered unrecoverable	undiscovered unrecoverable	회수불능미 발견부존량	unrecoverable resources	unmapped	recoverable resources	-	-	-	-						
					residual					-	-				