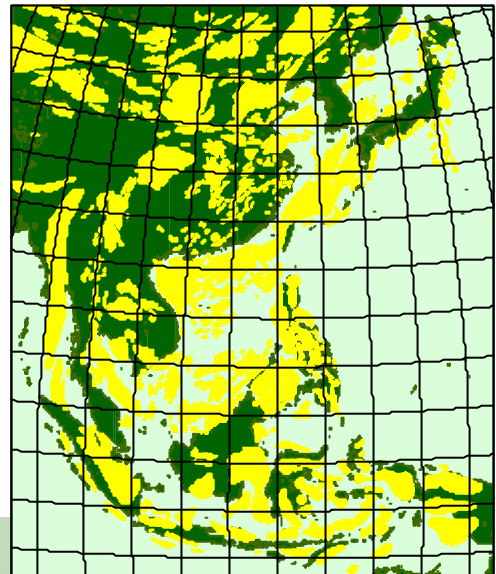
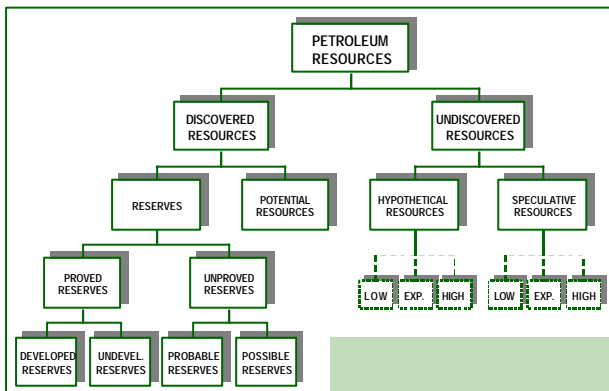




The CCOP Petroleum Resource Classification System



CCOP

The Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP) is an intergovernmental organisation with purpose to carry out joint applied geoscience programmes for sustainable development of the coastal and offshore areas in East and Southeast Asia.

The CCOP ("Coordinating Committee for Offshore Prospecting in Asia") was initiated in 1966 by China, Japan, Republic of Korea and The Philippines under the auspices of ESCAP and the United Nations. CCOP became an independent intergovernmental organisation in 1987 based on the common understanding of its member countries and the aspirations of the United Nations. The name was changed in 1994, but the acronym CCOP was retained. CCOP has during this period devoted itself to co-ordination of, and co-operation in, scientific activities related to coastal and offshore areas with respect to geological/geophysical surveys, regional map compilations, data-base development, development of human resources and transfer of state of the art technology.

CCOP has divided its technical activities into four sectors:

- the energy sector,
- the mineral sector,
- the coastal zone sector and
- the geo-hazard sector.

CCOP has 11 member countries; Cambodia, China, Indonesia, Japan, Malaysia, Papua New Guinea, The Philippines, Republic of Korea, Singapore, Thailand and Vietnam.

CCOP has been supported by 14 co-operating countries and several international organisations. For the last few years, the major contributing donor-countries have been Japan, the Netherlands and Norway.

The CCOP Technical Secretariat is responsible for the daily co-ordination of all activities carried out by CCOP. The Secretariat is headed by a Director, who is reporting to the CCOP Steering Committee consisting of one permanent representative from each member country. The CCOP Technical Secretariat is located in Bangkok, Thailand.

CCOP's present activities are aimed at:

- development of human resources in the public sector,
- transfer of tailor-made technology to its member countries,
- promotion of technical co-operation among member countries,
- compilation of regional geological data,
- co-ordination of joint activities within the four sectors of CCOP.

Preface

Petroleum is a key factor in the sustainable development of the economy of CCOP member countries. CCOP therefore started to prepare a common project proposal on assessment and economic evaluation of petroleum resources in 1993-94. The Resource Evaluation and Planning project (REP) was formally approved for funding by Norwegian Agency for Development Cooperation (NORAD) in August 1995 (phase 1) and in July 1996 (phase 2). The project comprised training courses, workshops, assessment software, as well as seminars on bilateral basis.

As a part of the REP, phase 2 project, where nine of the CCOP member countries have participated, two working groups were also established. One of the working groups was given the task to establish a petroleum resource classification system that is common for the CCOP member countries.

It is important to note that this system is a supplement, and is not supposed to replace any national classification system that is established in the CCOP member countries. However, we do hope that the CCOP petroleum resource classification system will act as a guide for those member countries that have not yet worked out their own system. We also hope that the CCOP system will contribute to a common understanding and future standardisation of terms and definitions used in resource classification in the region.

Furthermore, this system will contribute to improve all communications on resources across borderlines and also be a vital tool for common promotion activities of the region. When CCOP, as an organisation, approaches the international oil companies in order to attract investment, common definitions and classification of resources will be of importance.

The CCOP petroleum resource classification and definitions have been discussed in several workshops of the REP, phase 2 project. These workshops are: (1) Resource Assessment and Management in Shanghai, China, 22-28 October 1996; (2) Resource Classification and Inventory Systems in Phnom Penh, Cambodia, 21-30 April 1997; (3) Basic Petroleum Economy in Cheju, Korea, 16-22 October 1997; (4) Risk Assessment and Prospect Evaluation in Chengdu, China, 7-13 May 1998; and (5) Decision Making in Manila, Philippines, 11-19 October 1998.

The CCOP petroleum resource classification system is compiled by Mr. Jan-Erik Kalheim (the REP-II project co-ordinator), Professor Liu Shugen (Chengdu University of Technology, China), Mr. Mat Arifin Ismail and Mr. Badrul Hisham Ismail (PETRONAS, Malaysia) assisted by the CCOP Technical Secretariat and all the participants of the above-mentioned workshops.

Taking this opportunity, I on behalf of all CCOP member countries would like to extend our heartfelt appreciation and acknowledgement to the Royal Norwegian Government through NORAD for their long-term financial and technical support to CCOP energy programmes.



Dr. Sahng-Yup Kim
Director, CCOP Technical Secretariat

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1. Introduction

Each country needs to have a total overview of their petroleum resources, including present reserves, other discovered resources and the potential for future discoveries. Such an overview will form the basis for the Government's resource management. It is therefore necessary to have a resource classification system with consistent definitions of terms and expressions related to all resource quantities. The classification system is a vital tool for establishing a national resource inventory, which has to be periodically updated. The classification system should be defined according to each country's needs, but it should also be comparable with systems that are established and used by international organisations. Such a classification system is a necessary tool for establishing a total and appropriate resource inventory system, which is making us able to:

- Make a total overview and valuation of the resource base;
- Rank resources and accumulations according to a series of defined specifications;
- Monitor activities and decisions in all phases: exploration, development and production;
- Establish a national long-term planning of the petroleum activities;
- Evaluate impact of the petroleum activities on other industry-related activities.

A proper petroleum resource classification system should be understandable not only to technical people, but also to financial advisors, analysts and politicians.

How to classify petroleum resources and reserves has been widely discussed among geo-scientists, petroleum engineers and resource economists during the last 30 to 40 years. Because of the large variety of purposes for such classification, governmental agencies, international organisations and oil companies have worked out their own classification systems.

As new technology and methodology for resource and reserve estimation have evolved, the various classification systems have been adjusted and refined. Some systems have been very detailed and sophisticated, while others are more briefly defined. The great challenge has always been to compare different systems and different definitions. Because of different definitions, confusion and misunderstanding are common when governments communicate with oil companies and international organisations.

As shown in Chapter 5, there occur significant differences of petroleum resource classification systems also in CCOP member countries, although there are some common points in these systems. The situation is certainly not helpful for common communication among CCOP member countries until the terms are carefully defined. It seems necessary to suggest a region-wide classification system, which will improve the communication not only among CCOP member countries but also between CCOP member countries and the outside.

Even though there are established some international standards, they are not completely describing the entire resource base. The CCOP resource

classification system is meant to be supplementary to both national classification systems of CCOP member countries and the internationally recognised classification of the reserves that the Society of Petroleum Engineers (SPE) and the World Petroleum Congresses (WPC) published in March 1997.

The basic principles for the CCOP petroleum resource classification system is as follows:

- the petroleum resources should be considered as a whole,
- possess clear and consistent definitions of the terms,
- general and flexible guidelines,
- clear boundaries between different levels, and
- be easy to be used as well for the governmental agencies as for the petroleum industry.

The working group has tried to make the petroleum resource classification system to be a simple, practical and readily understandable system that receives general acceptance in the CCOP region.

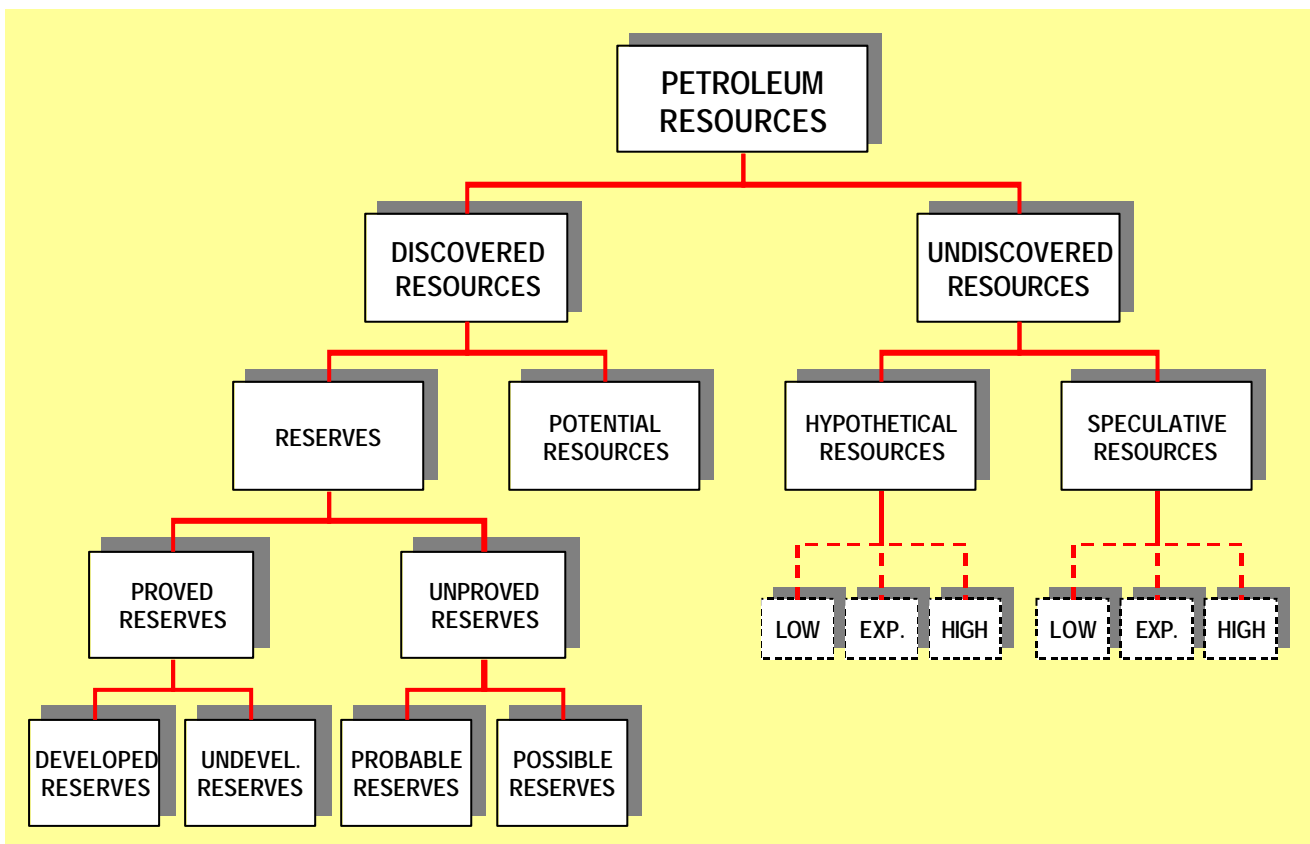


Figure 1. CCOP Petroleum Resource Classification Chart of Recoverable Resources

2. The frame of CCOP resource classification

2.1. Petroleum and petroleum resources

Petroleum includes crude oil, condensates, natural gas and related substances, i.e., (1) thermal or biogenic gas found in conventional reservoirs or in gas hydrate, tight reservoirs, fractured shale, and coal; (2) condensates, crude oils, and asphalt found in nature. Petroleum is predominately comprised of hydrocarbon compounds. However, petroleum may also contain non-hydrocarbon compounds in which sulphur, oxygen, and/or nitrogen atoms are combined with carbon and hydrogen. Common examples of non-hydrocarbons found in petroleum are nitrogen, carbon dioxide, and hydrogen sulphide.

Petroleum Resources are defined as the total quantities of discovered (including hydrocarbon produced already from known accumulations) and undiscovered petroleum at a specific date in a given area.

DEFINITION OF FREE AND ASSOCIATED GAS

There are several definitions of free and associated gas in the oil industry. Some organisations and companies define associated gas only as dissolved gas, which means that gas cap is regarded as free gas.

SPE define associated gas to comprise gas dissolved in oil and gas in gas cap. CCOP has chosen to follow the SPE definition.

2.2. Petroleum resources originally in-place

Resources originally in place comprise the petroleum resources which are mapped/unmapped by geological methods, and which are estimated by geological and petroleum technological methods, to be in place in a deposit. Gas originally in place is divided into free gas and associated gas. According to SPE's definition (H.B. Bradley: SPE: Petroleum Engineering Handbook, 1987) associated gas is defined as natural gas, commonly known as gas cap, that overlies and is in contact with crude oil in the reservoir. Non-associated gas is defined as natural gas in reservoirs that do not contain significant quantities of crude oil. This means that gas cap and solution gas are categories under associated gas, and that gas in reservoirs that not contain significant quantities of crude oil or do not contain crude oil at all are classified as non-associated gas. By NGL (Natural Gas Liquid) originally in place is meant components dissolved in free gas, all of which will be converted to NGL phase by means of the current/planned gas processing.

2.3. Recoverable resources

Recoverable resources comprise the total deliverable petroleum quantities, from the start of production to the cease of production, based on the current understanding of the quantities in place and the recovery factor. Recoverable resources can be subdivided into two categories: potential recoverable resources and reserves. Only reserves are anticipated to be commercially recoverable at present date.

Undiscovered recoverable resources are defined as the total estimated quantities of petroleum at a specific date to be recoverable from accumulations that remain to be discovered.

2.4. The Framework of CCOP petroleum resource classification system

THE CCOP PETROLEUM RESOURCE CLASSIFICATION SYSTEM

Petroleum Resources

Undiscovered resources

Speculative Resources
Hypothetical Resources

Discovered Resources

Potential Resources
Reserves

Unproved reserves

Possible Reserves

Probable Reserves

Proved Reserves

Proved Undeveloped Reserves

Proved Developed Reserves

In order to have a consistent system the CCOP Petroleum Resource Classification System is entirely based on recoverable petroleum resources. The classification system comprises the following two major parts (Fig.1): undiscovered recoverable resources and discovered recoverable resources.

The undiscovered recoverable resources are further subdivided into speculative and hypothetical resources. The discovered recoverable resources are further subdivided into potential recoverable resources and reserves. For further subdivision (see Fig. 1) of the reserves, the CCOP Petroleum Resource Classification System has adopted the Reserve Classification as described and published by the Society of Petroleum Engineers (SPE) and the World Petroleum Congresses (WPC) in March 1997.

Some organisations, companies and countries might want to report their petroleum resources as in-place quantities on an aggregated level. Even though this is not in accordance with the proposed CCOP Petroleum Resource Classification System, the basic CCOP classification concept can also be used for in-place resources.

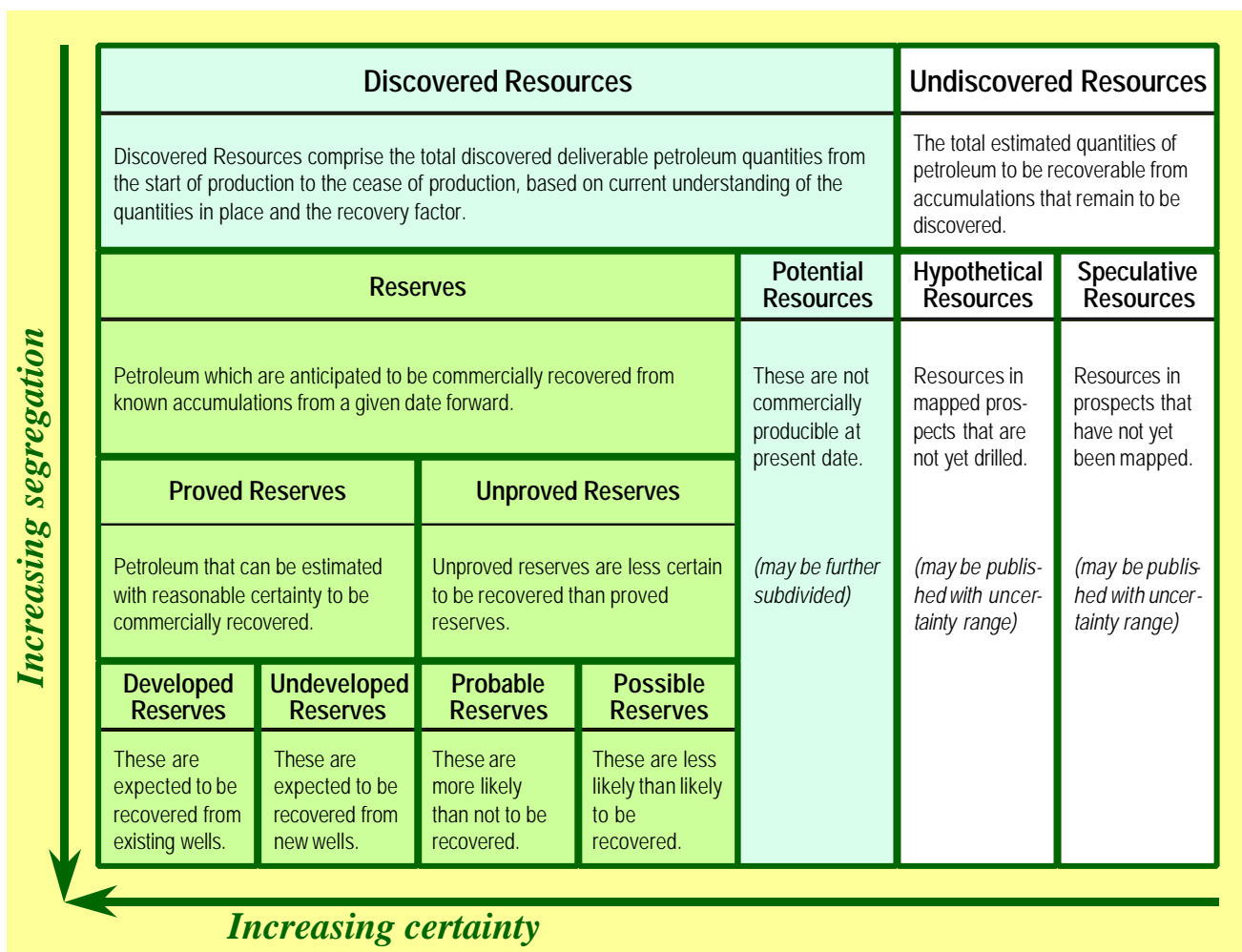


Figure 2. The major principles and a schematic description of the petroleum resource categories in the CCOP classification system

3. Undiscovered petroleum resources

Estimates of undiscovered resources are arrived at by means of geological, geophysical, and geochemical data, which are chiefly derived from surface geological and geophysical surveys. Based on compilation of these data into geological models and maps, hydrocarbon plays are defined. Discovery of petroleum accumulations in such plays is contingent upon that a set of geological factors is in place simultaneously.

The estimated quantities of hypothetical and speculative resources are based on the probabilistic approach. The estimated quantities are displayed on a frequency distribution curve and are subdivided into Low, Expected (or Mean) and High values as shown in Fig. 3. For example, the Low and High values may mean that at least the quantities at the 90-percentile and the 10-percentile, respectively, remain to be discovered. Note that different organisations and companies may chose different percentiles for the Low and the High values. The Low percentile may vary from 75 to 95%, and the High percentile may vary from 5 to 25%. Expected value means the area under the cumulative frequency curve.

The geological risk or the probability of geological success is the chance of the geological model being correct, i.e. the chance of finding at least the minimum quantity of recoverable petroleum as indicated at the distribution curve. The geological risk is established based on technical assessment of key geological variables (e.g. trap, reservoir, source and retention). In play analysis, the geological probability factor is subdivided into a play probability factor and an average prospect probability factor. For confirmed plays the play probability factor is equal to one.

Undiscovered petroleum resources can be subdivided into two categories: speculative resources and hypothetical resources.

A prospect is a mappable, possible petroleum accumulation that is relying on a reservoir entrapped by sealing rocks and charged with hydrocarbons. The prospect is called **a lead** if it is a very low probability of existence of one of the three factors.

A play is a geographically and stratigraphically delimited area where a set of specific geological factors is in place simultaneously, thus making it possible to discover petroleum in producible quantities. Such geological factors are reservoir rocks, traps, mature source rocks and migration paths, plus the condition that the traps were formed before the migration of petroleum came to an end. All fields, discoveries and prospects within the same play are characterised by the play's specific set of geological factors and can therefore be distinguished from fields, discoveries and prospects of other plays.

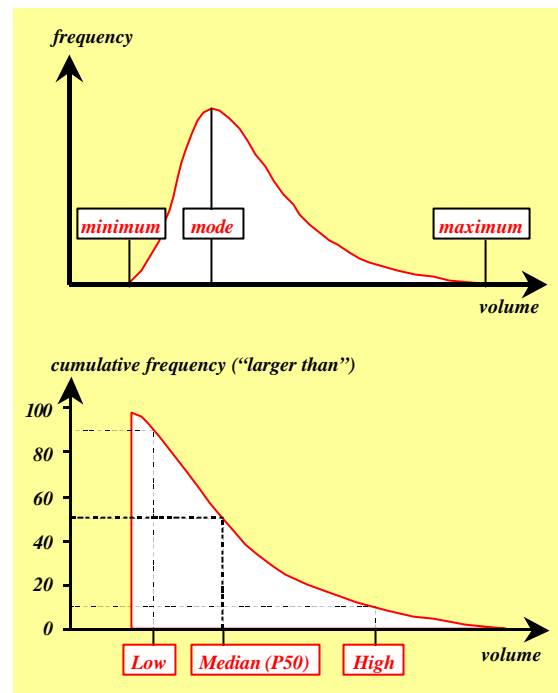


Figure 3. Uncertainty in volume estimates illustrated by frequency diagrams.

Confirmed plays contain a minimum of one discovery of producible quantities of petroleum. It is thus confirmed that the critical factors are in place simultaneously for these plays.

Unconfirmed plays contain no discovered petroleum for the time being. This may be a result of having drilled only dry wells in the play, or of not having started exploration activities.

3.1. Speculative resources

Speculative Resources is referred to the unmapped prospects that have not yet been mapped in the basin. The unmapped resources are estimated by play assessment methods. The total resources of such plays comprise both discovered and undiscovered resources. The unmapped resources are the difference between the plays' total resources and the discovered and mapped resources. In general, most organisations carry out play assessments only on the undiscovered resources. A statistical aggregation of all play assessments will give the estimate of the total undiscovered resources.

3.2. Hypothetical resources

Hypothetical resources comprise resources which are mapped in the form of prospects, but which have not yet been discovered by drilling. It is uncertain if the estimated resources are actually in place. Prospects may be identified in undrilled frontier provinces as well as in reservoirs underlying or adjacent to producing fields. The resource estimates are given a probability of discovery. The estimates of the total hypothetical resources are given by statistic aggregation of the risk-weighted resource estimate of each prospect in a play or a basin.

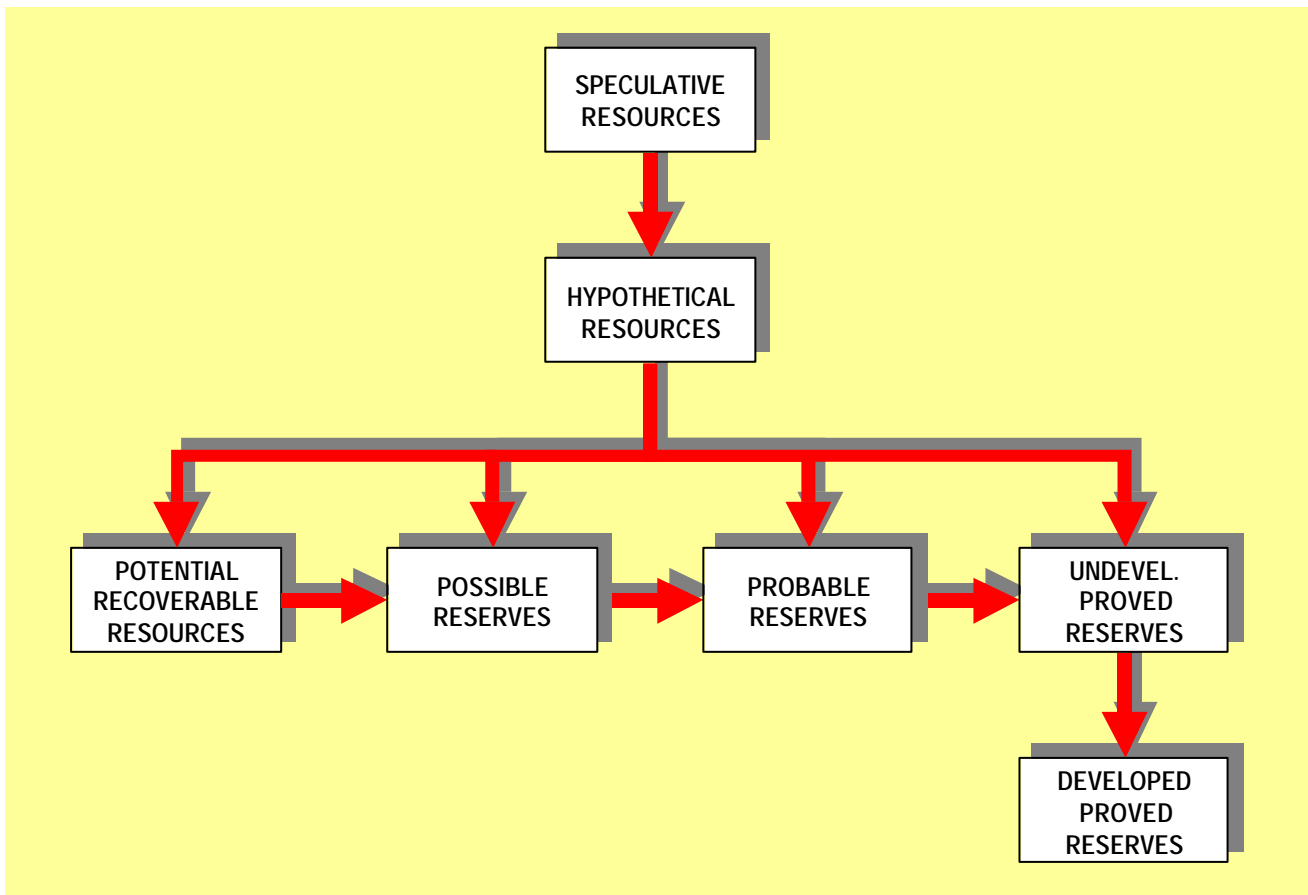


Figure 4. The dynamic movement between resource categories

4. Discovered petroleum resources

The Discovered Petroleum Resources can be sub-divided into potential resources and reserves.

A petroleum deposit is defined as an accumulation of petroleum in a geological unit limited by the rock characteristics by structural or stratigraphic boundaries, contact surface between petroleum and water in the formation, or a combination of these. All the petroleum comprised is in pressure communication through liquids or gas.

A discovery is a petroleum deposit or several petroleum deposits combined (i.e. they have been discovered in the same exploration well) in which the existence of mobile petroleum has been made probable through testing, sampling or logging.

4.1. Potential Resources

Potential Resources is defined as the discovered resources that are recoverable but not economically producible at a specific date due to economic, political, environmental or technological reasons. Potential Resources include all volumes of known hydrocarbons that lack the technology to be produced or are economically unacceptable in today's environment. While these volumes do not meet the requirements to be classified as reserves, they are a potential resource to the country where they exist.

Generally, potential recoverable resources refer to the amount of petroleum, of which the recovery project would be feasible based on reasonable assumptions about the success of additional data acquisition, an improved technology from current research, relaxation in the market constraints and/or the term and conditions for implementation. Potential Resources may include:

- Accumulations being held in inventory such as marginal fields, relinquished fields, fields under dispute, or reservoirs with inconclusive data.
- Accumulations that will probably be commercially recoverable in the near future/short term, under currently forecasted conditions but further evaluation work will be required before they can qualify as reserves. Examples are new discoveries undergoing appraisal or fields under negotiation.
- Accumulations that have no plans for developments in the near future/short term because they are judged to be non-commercial under currently forecasted conditions based on their size, location, technology requirements or economics.
- Improved Oil Recovery (IOR) that changes characteristics of the fluid in the reservoir through steam, gas, or chemical.
- Non-producible reservoir due to:
 - a) adverse parameters such as very low or erratic porosity development, low permeability, high pressure and geopressure dissolved gas.
 - b) unfavourable petroleum parameters such as gravity and viscosity.
 - c) extreme non hydrocarbon content, e.g. CO₂ and H₂S.

In order to separate between Potential Resources and Reserves (see chapter 4.2), there should be less than 10% probability of the Potential recoverable resources to be commercially recovered if the probabilistic approach is used for definition of reserve categories.

Depending on national needs, potential recoverable resources can be sub-divided into two subcategories, long-term potential recoverable resources

and short-term potential recoverable resources. The size of the hydrocarbon volume is in most cases the main criteria to differentiate between these categories.

4.2. Reserves

CCOP has adopted the SPE/WPC reserve classification and definitions as of March 1997, since this is the only internationally recognised system. The SPE/WPC committee based their system on the old and well-established terminology "proved, probable and possible reserves" that has been in use among the western petroleum industry for more than half of the century and in its very early origin was derived from the coal industry. The following text is based on the core definitions of the text about reserves as published by SPE/WPC, March 1997.

Reserves are those quantities of petroleum, which are anticipated to be commercially recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty. The uncertainty depends chiefly on the amount of reliable geologic and engineering data available at the time of the estimate and the interpretation of these data. The relative degree of uncertainty may be conveyed by placing reserves into one of two principal classifications, either proved or unproved. Unproved reserves are less certain to be recovered than proved reserves and may be further sub-classified as probable and possible reserves to denote progressively increasing uncertainty in their recoverability.

Estimation of reserves is done under conditions of uncertainty. The method of estimation is called deterministic if a single best estimate of reserves is made based on known geological, engineering, and economic data. The method of estimation is called probabilistic when the known geological, engineering, and economic data are used to generate a range of estimates and their associated probabilities. Identifying reserves as proved, probable, and possible has been the most frequent classification method and gives an indication of the probability of recovery. Because of potential differences in uncertainty, caution should be exercised when aggregating reserves of different classifications.

Reserve estimates will generally be revised as additional geologic or engineering data becomes available or as economic conditions change. Reserves do not include quantities of petroleum being held in inventory, and may be reduced for usage or processing losses if required for financial reporting.

Reserves may be attributed to either natural energy or improved recovery methods. Improved recovery methods include all methods for supplementing natural energy or altering natural forces in the reservoir to increase ultimate recovery. Examples of such methods are pressure maintenance, cycling, water-flooding, thermal methods, chemical flooding, and the use of miscible and immiscible displacement fluids. Other improved recovery methods may be developed in the future as petroleum technology continues to evolve.

4.2.1. *Unproved reserves*

Unproved reserves are based on geologic and/or engineering data similar to that used in estimates of proved reserves; but technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved. Unproved reserves may be further classified as probable reserves and possible reserves.

Unproved reserves may be estimated assuming future economic conditions different from those prevailing at the time of the estimate. The effect of possible future improvements in economic conditions and technological developments can be expressed by allocating appropriate quantities of reserves to the probable and possible classifications.

AGGREGATING RESERVE ESTIMATES

Most countries and oil companies aggregate or summarise proved plus probable plus possible reserves to become the total reserves. This is statistically not correct when probabilistic methods are used for determining the reserve categories. The probabilistic method for defining what is proved, probable and possible should therefore not be adopted. The CCOP working group therefore strongly recommends the CCOP member countries to define the three reserve categories on basis of the qualitative measures described by SPE/WPC in the following chapters 4.2.1 and 4.2.2.

4.2.1.1. Possible reserves

Possible reserves are those unproved reserves which analysis of geologic and engineering data suggests are less likely to be recoverable than probable reserves. In this context, when probabilistic methods are used, there should be at least a 10% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable plus possible reserves.

These general guidelines are recommended rather than the probabilistic approach for definition of the possible reserves

In general, possible reserves may include:

- (1) Reserves which, based on geological interpretations, could possibly exist beyond areas classified as probable.
- (2) Reserves in formations that appear to be petroleum bearing based on log and core analysis but may not be productive at commercial rates.
- (3) Incremental reserves attributed to infill drilling that are subject to technical uncertainty.
- (4) Reserves attributed to improved recovery methods when (a) A project or pilot is planned but not in operation and (b) Rock, fluid, and reservoir characteristics are such that a reasonable doubt exists the project will be commercial, and
- (5) Reserves in an area of the formation that appears to be separated from the proved area by faulting and geologic interpretation indicates the subject area is structurally lower than the proved area.

4.2.1.2. Probable reserves

Probable reserves are those unproved reserves which analysis of geologic and engineering data suggests are more likely than not to be recoverable. In this context, when probabilistic methods are used, there should be at least a 50% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable reserves.

For certain reservoirs, geophysical technology combined with regional geological knowledge has shown that reserves are identified with very high confidence, even though they do not stick entirely to the given definitions of SPE/WPC. One example is the Faulted Sand Play of Thailand. In such special cases, the specific reservoir geological understanding should overrun the general criteria.

In general, probable reserves may include:

- (1) Reserves anticipated to be proved by normal step-out drilling where sub-surface control is inadequate to classify these reserves as proved.
- (2) Reserves in formations that appear to be productive based on well log characteristics but lack core data or definitive tests and which are not analogous to producing or proved reservoirs in the area.
- (3) Incremental reserves attributable to infill drilling that could have been classified as proved if closer statutory spacing had been approved at the time of estimate.
- (4) Reserves attributable to improved recovery methods that have been established by repeated commercially successful applications when (a) A project is planned but not in operation and (b) Rock, fluid, and reservoir characteristics appear favourable for commercial application.
- (5) Reserves in an area of the formation that appear to be separated from the proved area by faulting and the geologic interpretation indicates the subject area is structurally higher than the proved area.
- (6) Reserves attributable to a future work-over, treatment, re-treatment, change of equipment, or other mechanical procedures, where such procedure has not been proved successful in wells which exhibit similar behaviour in analogous reservoirs, and
- (7) Incremental reserves in proved reservoirs where an alternative interpretation of performance or volumetric data indicates more reserves than can be classified as proved.

These general guidelines are recommended rather than the probabilistic approach for definition of the possible reserves

4.2.2. Proved reserves

Proved reserves are those quantities of petroleum which, by analysis of geological and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under current 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 90% probability that the quantities actually recovered will equal or exceed the estimate.

Establishment of current economic conditions should include relevant historical petroleum prices and associated costs and may involve an averaging period that is consistent with the purpose of the reserve estimate, appropriate contract obligations, corporate procedures, and government regulations involved in reporting these reserves.

In general, reserves are considered proved if the commercial producibility of the reservoir is supported by actual production or formation tests. In this context, the term proved refers to the actual quantities of petroleum reserves and not just the productivity of the well or the reservoir. In certain cases, proved reserves may be assigned on the basis of well logs and/or core analysis that indicate the subject reservoir is hydrocarbon bearing and is analogous to reservoirs in the same area that are producing or have demonstrated the ability to produce on formation tests.

The area of the reservoir considered as proved includes:

- (1) *The area delineated by drilling and defined by fluid contacts, if any.*
- (2) *The undrilled portions of the reservoir that can reasonably be judged as commercially productive on the basis of available geological and engineering data.*

In the absence of data on fluid contacts, the lowest known occurrence of hydrocarbons controls the proved limit unless otherwise indicated by definitive geological, engineering or performance data.

Reserves may be classified as proved if facilities to process and transport those reserves to market are operational at the time of the estimate or there is a reasonable expectation that such facilities will be installed.

Reserves which are to be produced through the application of established improved recovery methods are included in the proved classification when:

- (1) *Successful testing by a pilot project or favourable response of an installed program in the same or an analogous reservoir with similar rock and fluid properties provides support for the analysis on which the project was based, and*
- (2) *It is reasonable certain that the project will proceed.*

Reserves to be recovered by improved recovery methods that have yet to be established through commercially successful applications are included in the proved classification only:

- (1) *After a favourable production response from the subject reservoir from either*
 - (a) *A representative pilot or*
 - (b) *An installed program where the response provides support for the analysis on which the project is based and*
- (2) *It is reasonably certain the project will proceed.*

These general guidelines are recommended rather than the probabilistic approach for definition of the possible reserves

The reserve status categories have been included in the CCOP classification system to separate the proved reserves into developed and undeveloped proved reserves. The definition of proved undeveloped reserves applies to those reserves that are defined as proved, but not yet developed. The definition of proved developed reserves applies to all developed reserves, since developed reserves conceptually should be regarded as proved reserves.

4.2.3. Reserve status categories

Reserve status categories define the development and producing status of wells and reservoirs.

4.2.3.1. Undeveloped reserves:

Undeveloped reserves are expected to be recovered:

- (1) From new wells on undrilled acreage.
- (2) From deepening existing wells to a different reservoir, or
- (3) Where a relatively large expenditure is required to
 - (a) Recomplete an existing well, or
 - (b) Install production or transportation facilities for primary or improved recovery projects.

4.2.3.2. Developed reserves:

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. Developed reserves may be subcategorised as producing or non-producing.

Producing: Reserves subcategorised as producing are expected to be recovered from completion intervals which 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.

Non-producing: Reserves subcategorised as non-producing 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 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 the start of production.

UNDISCOVERED RESOURCES			
	Oil/NGL	Gas	Total
Speculative Resources			
Hypothetical Resources			
Total Undiscovered Resources			

POTENTIAL RESOURCES			
	Oil/NGL	Gas	Total
Total Potential Resources			

RESERVES			
	Oil/NGL	Gas	Total
Possible Reserves			
Probable Reserves			
Proven Undeveloped Reserves			
Proven Developed Reserves			
Total Reserves			

RECOVERABLE RESOURCES			
	Oil/NGL	Gas	Total
Total Produced Reserves			
Remaining Recoverable Resources			
Total Recoverable Resources			

Figure 5. An example of a petroleum resource classification scheme

5. Current systems in CCOP member countries

5.1. China

In China, petroleum resources are classified into two categories: discovered and undiscovered. Discovered resources are also defined as reserves, which include proved, probable and possible reserves. Within the proved reserves, there are proved developed reserves and proved undeveloped reserves. Under the undiscovered resources, potential and speculative resources are distinguished.

5.2. Indonesia

In Indonesia, a two-fold classification system is applied. Under the total resources, there are proved, probable and possible resources (known as PPP). Total resources may also be classified into identified and undiscovered resources upon customer's needs. The identified resources include the resources demonstrated, which may be further divided into measured (proved producing) and indicated (potentially producing), and the resources inferred (potential but not producing yet). Undiscovered resources include hypothetical (prospect/lead) and speculative (location unknown) resources.

5.3. Malaysia

In Malaysia, the integrated resources classification system consists of two categories of resources: discovered and undiscovered. Recoverable resources under discovered resources include ultimate recovery and potential recovery based on commerciality, producibility and uncertainty. Reserves are defined as remaining commercial quantity of petroleum after deduction of cumulative production from the ultimate recovery and consist of proved, probable and possible. Potential recovery includes the proved, probable and possible as well. The undiscovered resources, i.e. speculative recovery, could be classified into low, expected and high values.

5.4. Thailand

Petroleum Resources comprise all in place volumes both discovered and undiscovered. Some of the discovered volumes cannot be recovered. The recoverable discovered volumes consist of the volumes that have already been produced, (cumulative production), and the remaining recoverable volumes (reserves). The reserves can be subdivided into proved, probable and possible according to their corresponding level of confidence. Some of the undiscovered resources are estimated to be recoverable and the remains are left as unrecoverable resources. The recoverable undiscovered resources are classified as speculative and hypothetical recovery.

5.5. Vietnam

In Vietnam, the current classification chart consists of two categories of petroleum resources, discovered and undiscovered. Discovered resources include reserves and potential resources. Reserves include proved and unproved reserves. Within the proved reserves, there are developed reserves and undeveloped reserves. Within unproved reserves, there are probable and possible reserves. Potential resources could be classified into two: able being reserves and extra reserves. Under the undiscovered resources, hypothetical and speculative resources are distinguished, which could be classified into low, expected and high values.

5.6 Other CCOP member countries

In the Republic of Korea, the petroleum industry is in its early stage and a draft of resource classification system has been proposed in accordance with the CCOP guidelines.

In the Philippines, the work to establish a resource classification system is still on the way, via the Philippine Petroleum Resource Assessment Project, to be implemented early 1999.

Papua New Guinea and Cambodia have not yet established their official petroleum resource classification systems.

6. References

- Bradley, H.B., 1987. SPE Petroleum Engineering Handbook.
- Martinez, A.R. and McMichael, C.L., 1997. Classification of Petroleum Reserves. Proceedings of the 15th World Petroleum Congress, Beijing (preprint). John Wiley & Sons Ltd, England
- Norwegian Petroleum Directorate, 1997. Petroleum Resource Classification. Stavanger, Norway
- Zainul, A.J. et al, 1997. An Integrated Approach to Petroleum Resources Definitions, Classification and Reporting. Preprint from 1997 SPE Asia Pacific Oil and Gas Conference, Kuala Lumpur. Society of Petroleum Engineers, Inc. SPE 38044

Units and conversion factors

In the petroleum industry quite a lot of different units have been used, and are in use, for measuring oil and gas quantities, distance, area and weight. This is sometimes very confusing even for technical people dealing with this kind of activities. We have therefore tried to summarise the most usual units and how to convert from one to another unit. Some caution should be paid when you are using the volume conversion factors, since they may have been measured at different physical conditions (pressure and temperature). The factors are picked from internationally published literature.

Distance

1 foot = 0.3048 meters
 1 statute mile = 1,609 meters
 1 nautical mile = 1,852 meters

Area

1 square mile = 640 acres = 2.59 square km
 1 square km = 100 hectares
 1 acre = 43,560 square feet
 1 hectare = 2.471 acres

Volume

1 cubic meter = 35.3 cubic feet
 1 cubic meter = 6.29 barrel
 1 cubic meter = 1,000 litres
 1 barrel = 159 litres
 1 U.S gallon = 3.7854 litres
 1 acre foot = 43,560 cubic feet

Weight

1 short ton = 0.907185 metric tons = 2000 pounds
 1 long ton = 1.01605 metric tons = 2240 pounds
 1 metric ton = 1,000 kilograms

Petroleum volumes and weights

This conversion depends on the density of the oil. In general, the density is in the range of 0.8-0.9 kilograms per cubic meter. By using an average density of 0.85, following conversions may be used:

1 (metric) ton of oil: 1.1765 cubic metres of oil
 1 (metric) ton of oil: 7.4 barrels of oil

Energy conversions

One British Thermal Unit (Btu) is equal to the heat required to raise the temperature of one pound of water one degree Fahrenheit at or near its point of maximum density. This unit is commonly used to compare different energy sources.

1 barrel of crude oil = 5,800,000 Btu
 1 cubic foot of dry natural gas = 1,032 Btu
 1 short ton of bituminous coal = 26,200,000 Btu
 1 kilowatt hour (kWh) of electricity = 3,412 Btu
 1 gigajoule (10^9 J) = 947,820 Btu

Oil equivalents

Oil equivalents (abbreviated o.e.) are used for summation of oil-, gas- and NGL/condensate quantities. This term/unit is used to express the amount of energy that will be released upon combustion of the different types of petroleum. However, it is important to note that this measure is very inaccurate because of large variations in the composition of the various oils and gases. This term is used both for cubic meters (Sm^3 o.e.), tons (t.o.e.) and for barrels (BOE).

1000 Sm^3 of gas: 1 Sm^3 o.e.
 1 Sm^3 of oil: 1 Sm^3 o.e.
 1 ton of NGL/cond.: approx. 1.3 Sm^3 o.e.
 1 ton of oil: 1 t.o.e.
 1 ton of oil: 1.1765 Sm^3 o.e.
 1 barrel of oil: 1 BOE
 1 Sm^3 o.e.: 6.29 BOE
 1 t.o.e.: approx. 7.4 BOE

Some commonly used abbreviations:

1 MBBL = 1000 barrels
 1 MMBBL = 1 million barrels (10^6 barrels)
 1 BCF = 1 billion cubic feet (10^9 cu. feet)
 1 TCF = 1 trillion cubic feet (10^{12} cu. feet)

The Resource Evaluation and Planning Project

The resource Evaluation and Planning project (REP) is funded by the Norwegian Agency for Development Cooperation (NORAD) and started in January 1996. The project is the third major project within the petroleum sector that is funded by NORAD, namely Working Group on Resource Assessment (WGRA) in the period 1989 to 1991, Oil and Gas Resource Management (OGRM) in the period 1992 to 1994 and presently the REP-project that will be finalised in 1999.

The goal of the REP-project is to contribute to sustainable development of the petroleum sector in the CCOP member countries by providing governments with reliable information about their petroleum resources and value estimation. This should allow appropriate planning and management of petroleum exploration and exploitation, and thus in the long term be instrumental in providing higher revenue from the petroleum industry. The purpose of the project is:

- to transfer the know-how and technologies for quality ensured petroleum resource estimation in an economic context and hydrocarbon resource management options,
- to assist CCOP member countries in effective data management and establish resource management systems in individual CCOP member countries,
- to create the government awareness of the necessity of attracting external enterprises and establish realistic commercial expectations and priorities,
- to develop human resources in order to fill the gap between personnel and decision-makers in CCOP member countries.

The REP-project was divided in two phases. Phase 1 concerned basic training courses in petroleum geology and geophysics for the least developed countries in the CCOP-region, namely Cambodia, The Philippines and Vietnam. Thailand was also admitted to participate since they provided geological excursions. Phase 1 lasted for one year.

Phase 2, the main phase, comprise workshops and seminars with focus on resource evaluation, transfer of software tools, some bilateral seminars and training courses for Cambodia and Vietnam and two working groups on petroleum resource classification and on exploration risk assessment. The current publication is a result of the first working group.

CCOP and NORAD are also discussing a future follow-up of the REP-project. Petroleum Policy and Management is the most probable theme for this follow-up activity.

Participating CCOP-member countries in the REP-project are Cambodia, China, Indonesia, Malaysia, Papua New Guinea, The Philippines, Republic of Korea, Thailand and Vietnam.



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**CCOP Technical Secretariat
2nd Floor, OMO Building
110/2 Sathorn Nua Road, Bangrak
Bangkok 10500
THAILAND**

Telephone: (66-2) 234 3578-9, 637 7001-2

Fax: (66-2) 237 1221-2

E-mail: ccopts@ccop.or.th

Website: <http://www.ccop.or.th>