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Master of Science Petroleum and Mining Engineering

Application of United Nations Framework Classification (UNFC) to oil and gas Resources

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ABBREVIATIONS

UNFC	United Nations Framework Classification
SPE	Society of Petroleum Engineers
WPC	World Petroleum Council
AAPG	American Association of Petroleum Geologists
GOIP	Gas Originally In Place
OOIP	Oil Originally In Place
GOR	Gas Oil Ratio
BHP	Bottom Hole Pressure
ADR	Abandonment, Decommissioning and Restoration
NPV	Net Present Value
PSC	Production-Sharing Contract
NOC	National Oil Company
EPSA	Exploration and Production Sharing Agreement
PSA	Production Sharing Agreement
SLO	Social License to Operate

EMV	Expected Monetary Value
VOIP	Volume Originally In Place
HIS	Information Handling Services

ABSTRACT

Countries, businesses, financial institutions, and other stakeholders have access to a cutting-edge instrument for the sustainable development of their endowments in energy and mineral resources thanks to the United Nations Framework Classification for Resources (UNFC). Oil and gas, renewable and nuclear energy, minerals, injection projects for the storage of CO_2, groundwater, and anthropogenic resources including secondary resources reclaimed from residues and wastes are all covered by the UNFC.

The generation of energy and raw materials needed for a growing population, as well as sustainable, environmentally friendly, carbon-neutral, and efficient development, are the emerging difficulties in these areas. The way that the energy and material industries currently operate is being fundamentally challenged by innovations in production, consumption, and transportation. The UNFC is capable of managing the natural resources needed for the society's present and future needs as well as achieving the Sustainable Development Goals because it is a special tool for coordinating policy framework, government oversight, industry business process, and efficient capital allocation (SDGs).

All socioeconomic, technological, and unpredictable aspects of energy and mineral project management are included in the UNFC's basic principles. Projects can be protected from expensive failures by using the UNFC's project maturity and resource progression model. In order to bring clean and inexpensive energy resource projects to the market, UNFC completely incorporates social and environmental concerns as well as the technological readiness needed.

In order to manage the rising demand for bioenergy, geothermal energy, wind energy, and hydropower resources, it is crucial that UNFC provide clear and uniform standards, guidelines, and best practices for all energy and mineral sectors.

CHAPTER 1. INTRODUCTION

A classification and management system known as the United Nations Framework Classification for Resources (UNFC) is applicable to all energy and mineral resource projects.

Countries, businesses, and people can utilize the UNFC as a voluntary system for the management and reporting of sustainable energy and mineral resources. The UN Economic Commission for Europe (ECE), which has more than 70 years of experience in resource management and more than 25 years specifically in resource classification, established the UNFC.

UNFC is a general principle-based system in which quantities are categorized according to the following three essential standards:

1. E Axis (environmental, social and economic viability)
2. F Axis (technical feasibility and maturity)
3. G Axis (degree of confidence in estimates of the potential recoverability of the quantities)

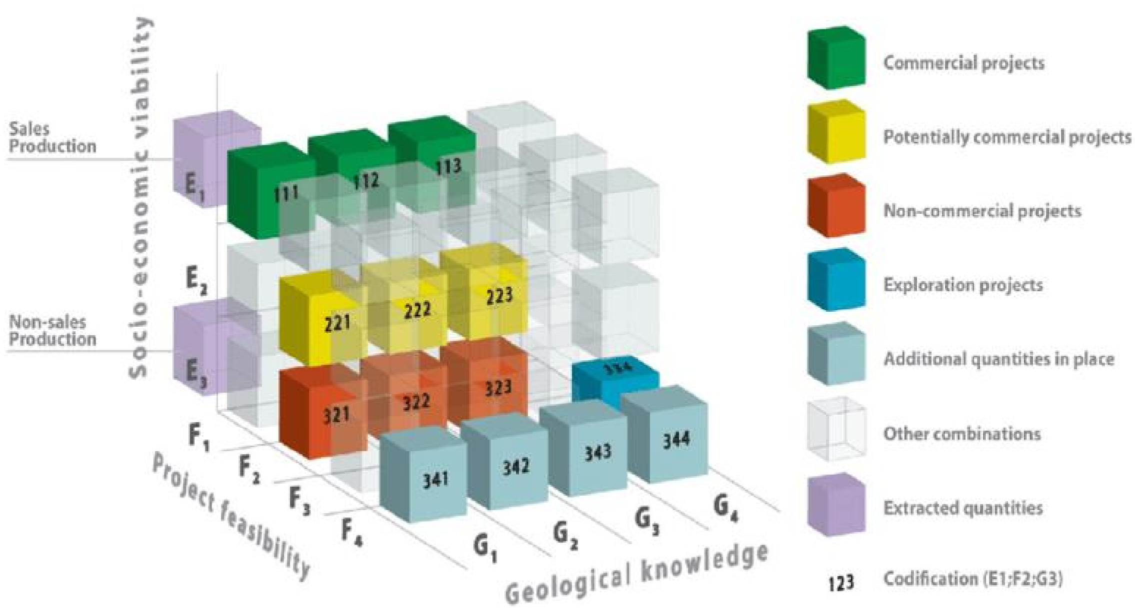


Figure 1. UNFC Categories and Example of Classes. [1]

UNFC employs a coding system that is independent of language and numbers. These criteria can be used to produce a three-dimensional system where the axes stand in for E, F, and G. It has been created to as closely as possible satisfy the requirements of applications for:

1. Policy formulation based on resource studies;
2. Resources management functions;
3. Corporate business processes;
4. Capital allocation.

A three-tier application framework with concepts and definitions at the first level has been accepted by UNFC. Second level general and sectoral specifications, which serve as detailed rules of application, are then presented. The third level offers further instructions or guidance for using UNFC. [1]

1.1. Petroleum Products

After being extracted from the earth, crude oil is transported to a refinery where various components are divided into usable petroleum products. These petroleum products include jet fuel, diesel fuel, heating oil, gasoline, waxes, lubricating oils, asphalt, and distillates like diesel and heating oil. Find out more in Crude oil refining: inputs and outputs. [6]

In respect of liquid products:

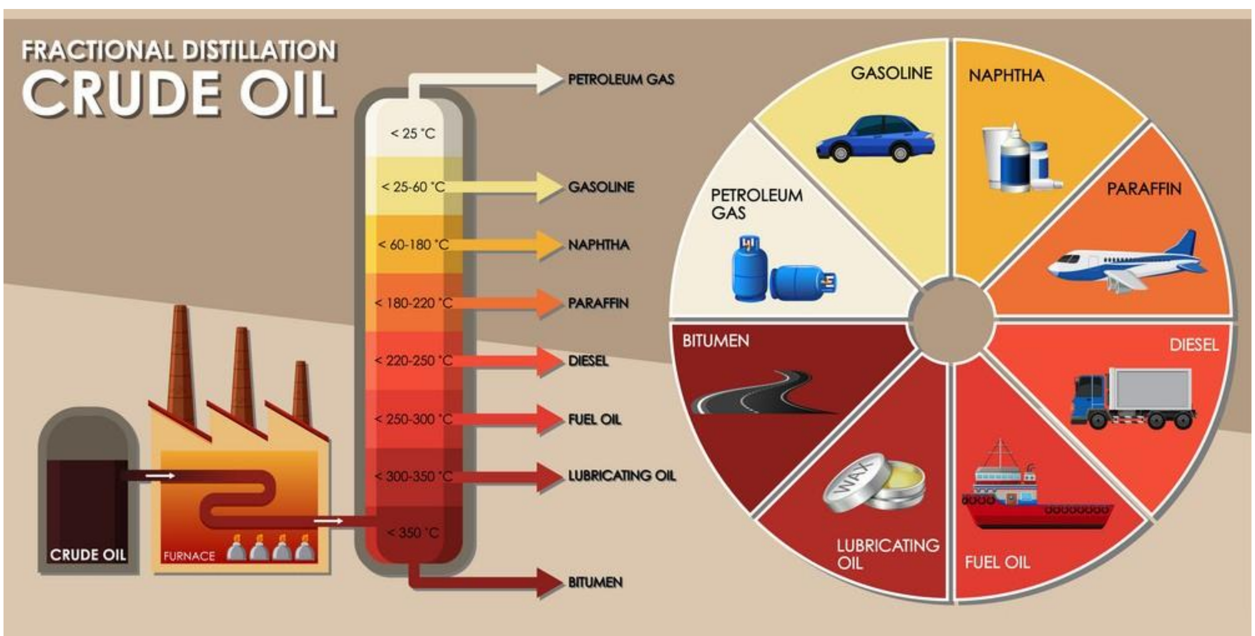


Figure 2. Fractional Distillation of Crude Oil. [6]

- Light crude oil
- Medium crude oil

- Heavy crude oil
- Bitumen
- Natural gas liquid
- Synthetic crude oil

In respect of gaseous products:

- Conventional natural gas
- Unconventional natural gas

1.2. Petroleum project

Any resource evaluation starts with a project, which is a specified action or series of activities for the management of future resource recovery operations that are connected to the decision-making process. The basis for calculating recoverable petroleum quantity and its technical, environmental, social, and economic feasibility is a petroleum project.

A petroleum source is a collection of petroleum that is thought to be present or possibly present for commercially viable production through the use of a development project or projects. One or more petroleum products may be created from a petroleum source and sold. Additionally, this might incorporate substances like carbon dioxide and helium.

An individual project serves as a gauge of investment maturity and makes it easier to decide whether to forward to the following stage of project development. Every project needs a development plan that is appropriate for its stage of maturity. A field development plan must be accepted, practicable, and environmentally, socially, and economically viable for a project to be successful. A development plan is still necessary for all initiatives, whether they are currently viable, not viable, or in the future, but it can be conceptual or preliminary. The likelihood of these initiatives' successful development must be assessed. [6]

1.3. Effective Date

Using all the information available as of a specific date (the "effective date"), estimates and classification of petroleum resource projects are assessed. The effective date must be stated in all reports on the appraisal of petroleum resources. [2]

CHAPTER 2. CLASSIFICATION

The combination of three criteria from the UNFC-defined Categories or Sub-categories defines classification in a singular way.

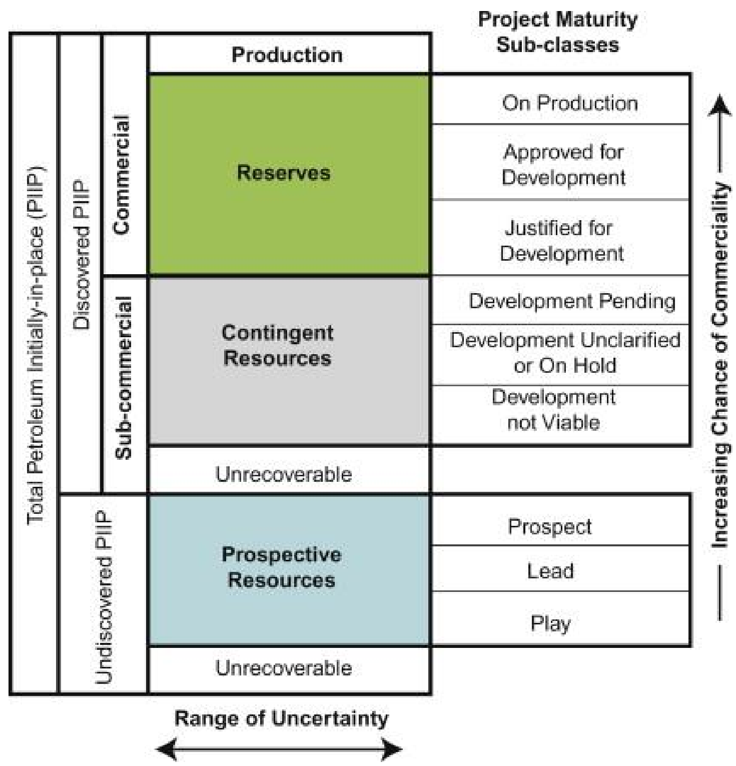


Figure 3. Production and Project Maturity Sub-Classes.[3]

2.1. Viable Projects (E1, F1, G1, 2, 3)

Recoveries made currently or in the future by profitable petroleum activities. It has been established that viable initiatives are commercially, socially, ecologically, and technically sound. Project viability should be further described using the following sub-classes.

- **On Production** is applied when the project is currently producing and supplying one or more petroleum products to the market as of the evaluation's effective date.
- **Approved for Development** requires that the necessary permits, agreements, and approvals be in place, along with the commitment of capital funds.
- **Justified for Development** demands that there be a reasonable expectation (high confidence) that all essential contracts and permits will be obtained in a fair amount of time for the project to move forward with development. The permissible time limit is typically five years, but if sufficient justification is offered, a longer term may be taken into account. [1]

2.2 Potentially Viable Projects (E2, F2, G1, 2, 3)

Where possible future petroleum operations recovery has been detected, but where development is waiting or on hold. The project can be on hold because its technical viability or environmental, social, and economic viability are still up in the air. The projected project feasibility should be further described using the following sub-classes.

- **Development pending** is only applicable to projects that are actively undergoing project-specific activities, such as the gathering of new information (such as appraisal drilling) or the conclusion of feasibility studies and related economic analyses meant to confirm the viability, including the identification of the best development scenarios or plans. Projects with non-technical contingencies may also be included in the status if their developers are actively pursuing them right now and anticipate that they will be addressed favorably in the near future.
- **Development on Hold** is applied when a project is thought to have at least a reasonable chance of becoming viable (i.e., there are reasonable prospects for eventually viable development), but there are currently significant non-technical contingencies that must be resolved before the project can move towards development, such as environmental or social issues. [3]

2.3 Non-Viable Projects (E3, F2, G1, 2, 3)

Projects that are now deemed to be non-viable in the near future or whose development is questionable fall under this category.

- **Development Unclarified** is appropriate for initiatives that are in the early stages of technical and commercial evaluation (such a recently made discovery) and/or where significant further data collecting is required to make a meaningful assessment of the possibility for a viable development
- **Development not Viable** is used when a project is technically possible but has been determined to have inadequate potential to support any more data collecting operations or any direct measures to address development-impairing factors. If conditions don't improve, projects in this subclass should only be kept up for a recommended five years before being reclassified as F4. Additionally, F4 should be assigned to projects that would require development assumptions that could not fairly be anticipated during the appraisal phase in order to reach viability. [3]

2.4 Prospective Projects

These are projects where the effectiveness of exploratory efforts will determine their ability to develop and recover in the future. For the time being, there is not enough knowledge about the source to evaluate the project's technical viability and environmental-socioeconomic viability. An accumulation that is connected to a prospective project has not yet been proven to exist through direct evidence (such as drilling), but has been evaluated mostly through indirect evidence (e.g., surface or airborne geophysical measurements).

It could be useful in some circumstances to divide potential projects into different categories according on their maturity. The following specification must be followed in such circumstances:

- **F3.1** : when site-specific investigations have sufficiently confidently identified a viable resource supply and product (s) to support testing.
- **F3.2** : when local investigations suggest the possibility of one or more resource sources in a particular location, but additional data must be gathered and/or evaluated to have sufficient confidence to allow further testing.
- **F3.3 :** early stages of research, when regional studies may suggest favorable conditions for the eventual identification of a resource source in a region. [1]

2.5 Remaining products not developed from identified projects (E3, F4, G1, 2, 3)

Unrecoverable or extra amounts connected to a known deposit that cannot be recovered by a project that is currently characterized as technically feasible. According to the degree of technological development at the time, it might be useful in some cases to subclassify any leftover items that weren't created from the stated initiatives. In these circumstances, the following requirement must be followed:

- **F4.1** : Following successful pilot tests on other resource sources, the technology required to create some or all of these quantities is currently being actively developed, although it has not yet been shown to be technically feasible for the project.
- **F4.2** : Although research is being done on the technology required to create any or all of these quantities, no successful pilot projects have yet been carried out.
- **F4.3** : It is not being researched or developed right now. [3]

2.6 Remaining products not developed from Prospective Projects (E3, F4, G4)

In the future, as technology or environmental-socio-economic conditions alter, these ideas might be developable. Due to physical and/or environmental-socio-economic factors, some or all of these estimates might never be developed. The source locked-in potential may be indicated using this categorization. [3]

	Class	Minimum Categories		
		E	F	G
The project's environmental-socio-economic viability and technical feasibility has been confirmed	Viable Projects	1	1	1,2,3
The project's environmental-socio-economic viability and/or technical feasibility has yet to be confirmed	Potentially Viable Projects	2	2	1,2,3
	Non-Viable Projects	3	2	1,2,3
Remaining products not developed from identified projects		3	4	1,2,3
There is insufficient information on the source to assess the project's environmental-socioeconomic viability and technical feasibility	Prospective Projects	3	3	4
Remaining products not developed from prospective projects		3	4	4

Figure 4. Classes and Minimum Categories. [3]

2.7 Future Production and G-Axis Methods

E3.1 refers to future production that is either not sold, such as flare and losses, or fuel, also known as consumed in operations. The G-axis categories can be utilized singly (G1, G2, and G3) or in the form of a cumulative scenario (G1, G1+G2, G1+G2+G3). [1]

2.8 Relationships between UNFC and the SPE/WPC/AAPG classification

The project status method of the SPE/WPC/AAPG classification corresponds with the field project axis:

- Both classifications include production.
- Reserves align with undertaken projects. On the economic and geological axes, reserves will have proved or investigated and delimited geology. Proven reserves must have proven geology on the geology axis and be commercial at typical commercial conditions on the economic axis (subset of Commercial).

- Contingent projects on the F axis will always create contingent resources. They could fit into any of the E axis categories and any of the G axis categories that have been identified. This indicates the UNFC's strength as a cubic organization.
- On the F axis, prospective resources are always being explored; on the G axis, they are still undiscovered. They will typically be conditional (at least upon establishing their presence) or non-commercial on the E axis. [18]

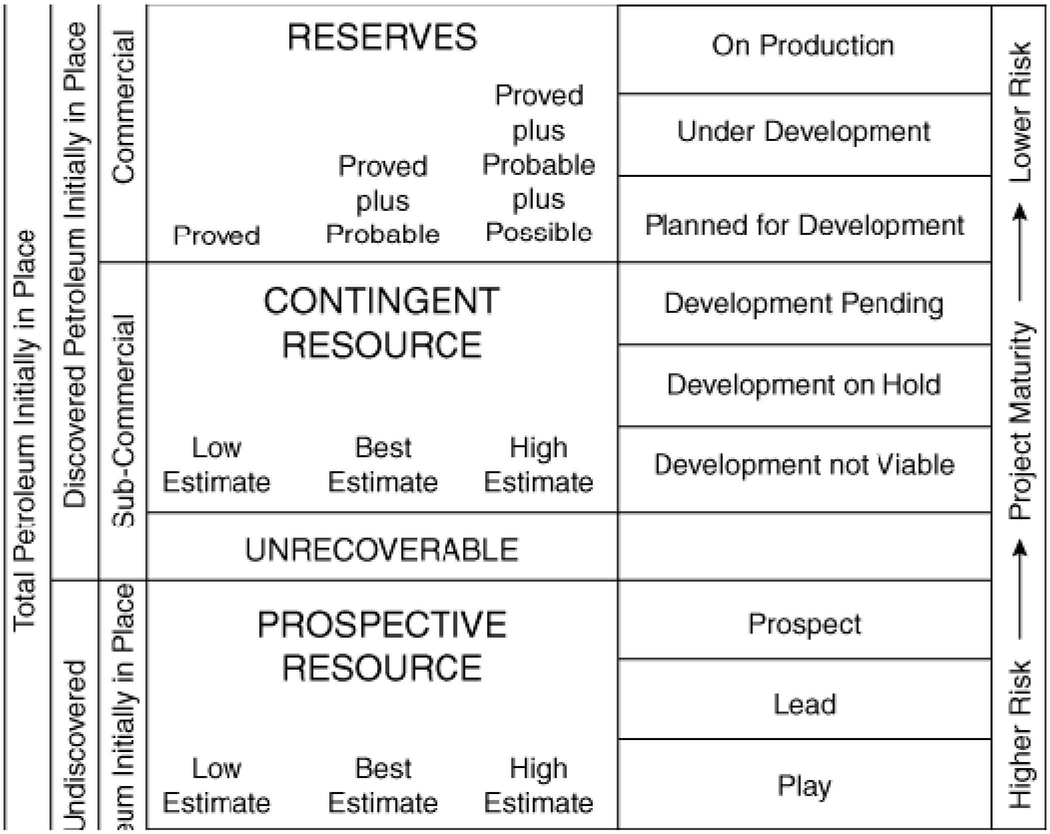


Figure 5. Relationship between UNFC and SPE/WPC/AAPG classification.[18]

CHAPTER 3. ENVIRONMENTAL – SOCIO – ECONOMIC VIABILITY (E AXIS)

All non-technical factors, such as product price, capital and operational expenses, legal/fiscal framework/regulations, and environmental or social ramifications, are included in the Environmental-Socio-Economic Axis (E Axis) categories. The project-relevant environmental and social factors are clearly included in the E-axis classification. According to pertinent social and environmental indicators, environmental and social issues can be used as a traffic light to indicate if a project is viable and should move forward. The suspension or postponement of a planned project may also result from noncompliance with pertinent environmental and social requirements. Project initiation may be significantly impacted by the E axis classification's positive maturity for environmental and social elements. [7]

Figure 6. Relationship between Environmental, Social and Economic Viability.[7]

3.1. Viability Considerations

Technical feasibility and environmental-socioeconomic state distinguish viable projects from possibly viable, non-viable, or prospective initiatives. When a project meets all of the pertinent requirements of the E, F, and G Axes, it is considered viable and can move forward. The following factors should be taken into account when assessing environmental-socio-economic viability:

- A fair assessment that the development project will be financially viable and satisfy specified investment and operating criteria.
- Evidence in favor of a realistic and attainable development timeline.
- a realistic anticipation that there will be enough demand for the production quantities needed to support development.
- Evidence that the political, social, and environmental circumstances will permit the development initiative under review to actually be implemented.
- Proof that all necessary internal and external approvals have been granted or will soon. Items like signed contracts, budget approvals, regulatory approvals, budget approvals, and expenditure approvals may serve as evidence of this. [19]

3.2. Cash Flow Evaluation

To evaluate a project's economic viability, cash flows are necessary. They are based on an estimation of the production of future petroleum sales (G2 production prediction as the best case, but also frequently conducted on G1 to analyze the low case outcome) over the evaluation period and the related net cash flow assessment. An appropriate analogue can serve as the foundation for the evaluation of potential initiatives. A net entitlement basis must be used for the cash flow analysis.

The following elements must be taken into account when conducting a cash flow assessment:

- Every cash flow analysis must be done at a specific reference point and on the designated effective date.
- For development, recovery, and production, only use future expenses, which includes ADR (abandonment, decommissioning and restoration) expenditures. Sunk expenses, also known as previously incurred expenditures, are frequently excluded yet may serve as a guide when determining future costs. An evaluation of the overall project value should take into account all past and future expenses.

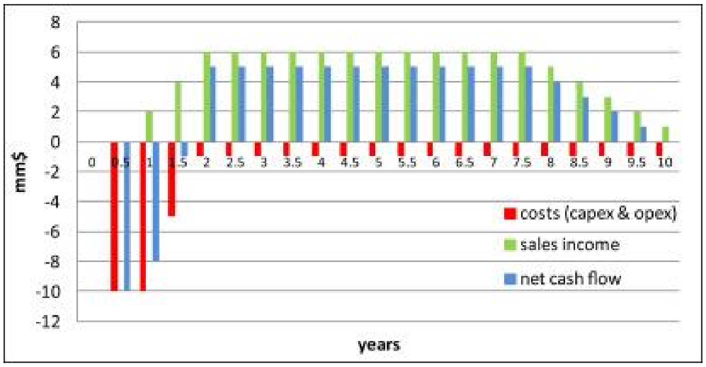


Figure 7. Costs, Sales Income and Net Cash Flow per Years.[12]

- A reasonable projection of future price and cost assumptions, as well as projected revenues, should be used to prepare evaluations. Constant pricing and expenses may be required by some regulatory bodies and accounting systems, which may not reflect expected market value.
- Future taxes and royalties related to production and revenue (including those necessary to satisfy social or environmental obligations).
- the use of a suitable discount rate that is acceptable for the investment need.
- The duration of a viable project is capped at the time frame of economic interest or shortened at the earliest occurrence of a technical, license/regulatory, or economic constraint.
- Because they are non-cash elements, accounting depreciation, depletion, and amortization computations are excluded from a cash flow.
- Split conditions, which are prohibited, are those that use various business assumptions to classify amounts. To analyze G1 (low case), G2 (best case), and G3 in the UNFC, all economic assumptions related to a given project must be the same (high case). These presumptions cover the price of oil, the status of sales contracts, and project-related operating and capital costs. This implies that for all categories, the project development and economic assumptions should be the same. A development is evaluated individually as a distinct project if it has changeable project scope, such as a different well count or enhanced facility capacity as a result of an upside scenario. This distinct project will be connected with its own E and F categories, as well as confidence in estimations (G1,G2 and G3). [12]

3.3. Economic Criteria

When the predicted financial revenues, after taking into account risks and possibilities, meet or surpass the projected costs by an amount that fulfills financing criteria, the project is deemed to be economically viable. The project offers a favorable return on investment, which is frequently expressed in monetary terms, such as having a favorable net present value (NPV) at the agreed-upon discount rate necessary for development to move forward.

Future Net Revenue

Future net revenue is the forecasted revenue from the anticipated development and production of a potentially viable project or viable project, less any associated royalties, operating costs, development costs, and ADR costs. This revenue is estimated using forecast prices and costs or constant prices and costs. Financing costs and corporate general and administrative (G&A) costs are not subtracted. A predetermined discount rate will be used to compute the net present values of future net revenue. The discount rate typically employed in project comparison analysis is 10%.

The same financial criteria should be used to assess the economic viability of potentially feasible, non-viable, or prospective initiatives, such as acceptable predicted circumstances. These initiatives are then categorized as E2 or E3. E2 refers to situations when it is anticipated that a project will soon become economically feasible. E3 refers to situations where extraction and sale are either too early in the evaluation process to determine economic viability or are not anticipated to become economically feasible in the near future. [16]

3.4. Economic Limit

When profits from the sale of generated oil and gas stop outpacing costs of operation, an economic limit has been reached. Development is assumed for determining a project's economic limit, and potential future production can be tested at an undiscounted rate. When net revenue surpasses operating costs, the production is considered to be economically producible in this analysis (excluding ADR). Forecasts of the future situations must be accurate. Projects belonging to the same categorization and using the same reference point may be combined for the purposes of testing the economic limit.

The physical lifting limit of the fluids in the wellbore or the economic limit may be used to establish the final rate of a specific well. If the project is still lucrative, an individual well may be allowed to fall below an economic cap. It is also important to take into account the reservoir's physical pressure limit. [16]

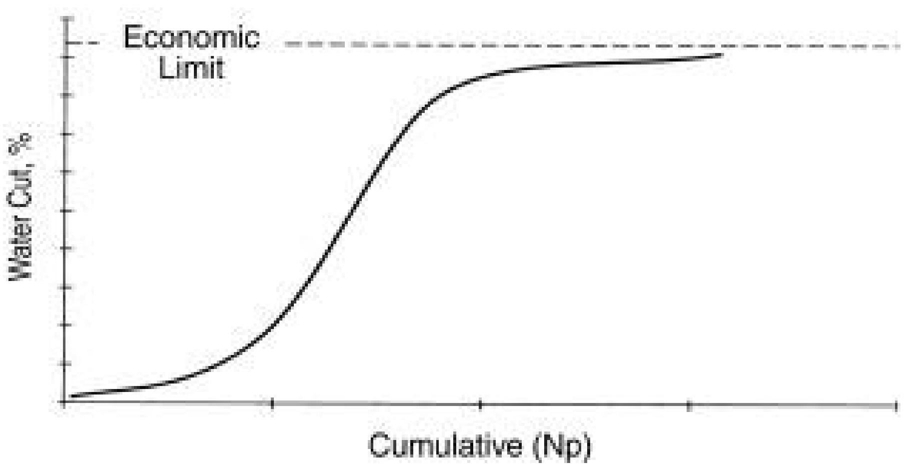


Figure 8. Economic Limit plot. [16]

3.5. Resources Entitlement and Recognition

The portion of future output (and thus resources) that legally belongs to a business under the terms of the mineral lease or license agreement is known as the net entitlement. An entity must fulfill a few essential requirements before it may recognize resource entitlements. These include (a) exposure to market and technical risk (i.e., right to sale revenues); (b) exposure to economic interest through the mineral lease or concession agreement; and (c) the potential for reward through involvement in exploration, appraisal, and development activities.

Evaluators must make sure that, to the best of their knowledge, the rights to recoverable resources from each participating entity equal the overall amount of recoverable resources. Securities authorities may establish standards for the classifications and categories that can be declared for publicly traded corporations. The reporting of 100% quantities without restrictions imposed by concession agreements is often specified for national interests.[19]

3.6. Royalty

In a resource project, a royalty is an entitlement stake that exempts the owner from paying any capital or operating expenses necessary to generate oil or gas. When granting rights to the producer, the resource lessor frequently keeps a royalty. Based on a portion of the production, a royalty is paid in either cash or kind (depending on the lease).[12]

3.7. Production-Sharing Contract

A Production Sharing Contract (PSC) between an international operating business (or group of enterprises) and the host government, which may be represented by its Energy Ministry or National Oil Company, is a typical fiscal structure in many nations (NOC). The "contractor" is the foreign operational company or companies. The terms Exploration and Production Sharing Agreement and PSC are frequently used interchangeably (EPSA or PSA).

With a PSC, the contractor is only entitled to a certain amount of production in kind at the designated point of delivery (net entitlement). The host government retains ownership of the production. This net entitlement may be counted as a component of the contractor's project inventory. [10]

Figure 1- Main Features of PSCs (Bindemann, October 1999)

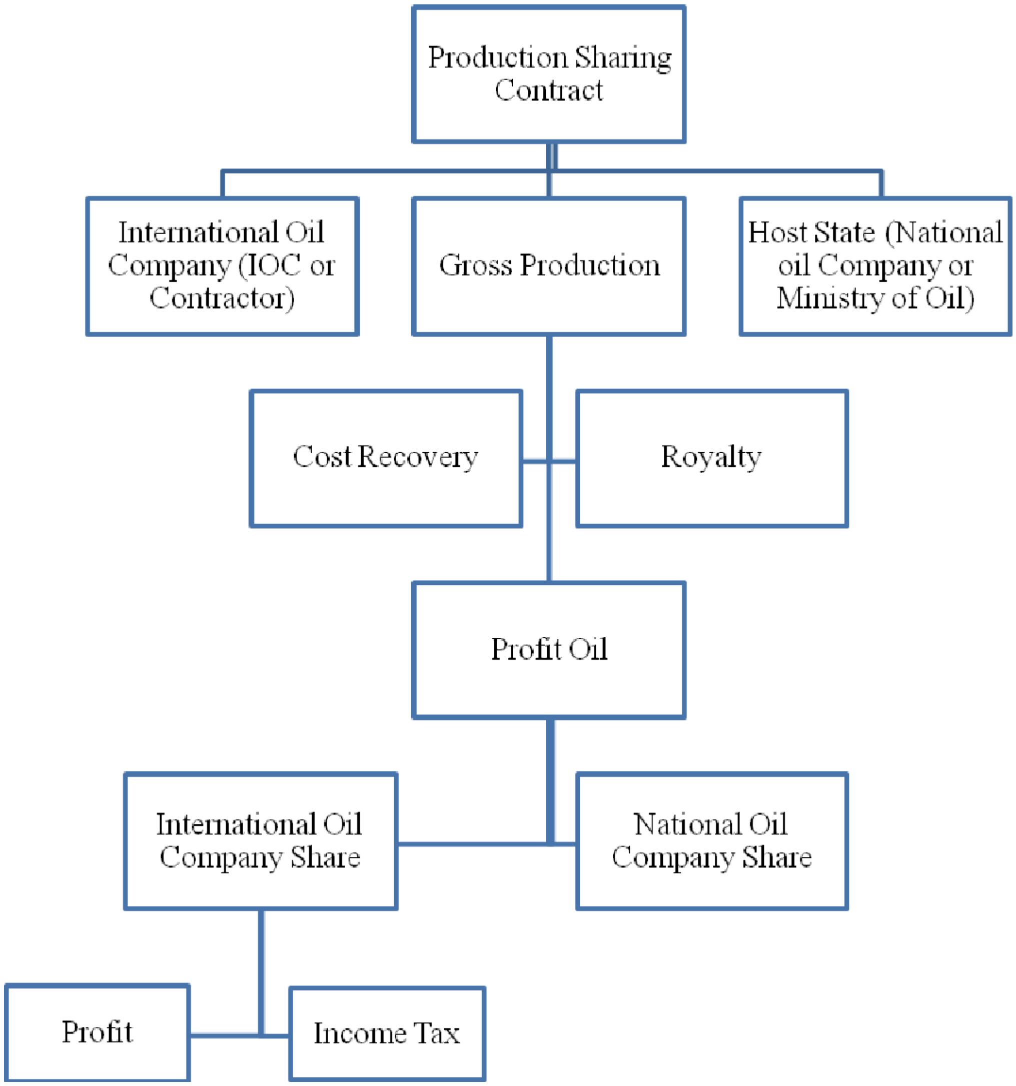


Figure 9. Main Features of PSCs. [10]

3.8. Social Criteria

Neither the UNFC nor any of the resource-specific standards identify social aspects. An example of a practical application of social criteria would be the project's effect on people and society as a whole.

- • Affects of environmental changes on the local population
- changes to social processes and structures (such as ownership disputes, long-standing land use patterns, shifts in the value of land and other assets, or adjustments to the socioeconomic makeup of the neighborhood).

Indigenous communities' presence, the existence of urban and rural areas, the strains on local infrastructure, and the local community's economic development are other social factors. Although it is sometimes assumed that this impact is harmful, it can also be advantageous. [23]

3.9. Environmental Criteria

Environmental factors are not defined by the UNFC or any of the resource-specific standards.

A practical application of environmental criteria would be the effects on, or modifications to, the project area and surroundings as a result of a project

A practical application of environmental criteria would be the effects on, or modifications to, the project area and surroundings as a result of a project

Additional environmental factors that might affect the development of a project include safeguard districts, lake sites, species of animals and plants that are protected by the law, and the presence of essential water and land uses in the area.

Just as it was done for social issues, a matrix can be utilized to classify the anticipated environmental implications of petroleum developments.[3]

3.10. Environmental and Social Assessment

Getting a "social license to operate" is a common term used to describe the resolution of pertinent social and environmental issues (SLO). SLO is an ambiguous term that is not advised for use as a classification criterion. The distinctive and unique conditions that apply to a project at the time of a review should be the basis for classification.

SLO can take the form of addressing formal concerns from groups or people who wouldn't be directly impacted by a petroleum project or it can take the shape of formal approvals. Normally, interested parties would engage in conversation and negotiation to resolve these matters, which might then lead to more activity in a formal legal or regulatory framework.

Although there isn't a set procedure for evaluating social and environmental contingencies, the following procedures are advised:

- Determine any pertinent environmental and societal repercussions;

- Calculate the likelihood that pertinent socio-environmental issues will be addressed and maintained during the project's existence. The characteristics of a resource or project, as well as the legal, regulatory, and social context in which it is intended to be implemented, will determine how this resolution is reached. The presumed resolution should be as much as feasible based on a recorded analysis, albeit being qualitative and subjective. There will frequently be a history of project developments that are analogous and can be cited as examples;
- Think about the current state of the efforts being made to address social and environmental problems. The project will determine the required amount of work and involvement;
- In a report, give the relevant justification.[20]

3.11. Use of Numerical Codes

The defined Classes and Sub-classes depicted in Figures 4 may be used as additional nomenclature, but the pertinent Numerical Code(s) must always be stated together with the expected number. These may, for instance, be documented using the formats 111, 111+112, or 1.1;1.2;1, as necessary.

Note that certain additional subcategories to those offered by UNFC are defined in the text that follows. These optional Subcategories have been specified here to guarantee uniformity in their use and have been regarded as possibly beneficial in specific circumstances. Nothing in this document is intended to exclude the future usage of new Sub-classes that may be deemed useful in specific circumstances, particularly when those Sub-classes are described in Bridging Documents and help link systems. [17]

3.12. Bridging Document

There may be additional categorization systems with which UNFC is compatible. An explanation of the connection between UNFC and another classification system, as well as guidelines for classifying estimates produced by the use of that system using UNFC Numerical Codes, are provided in a bridging document. The reported quantities must be provided along with the Bridging Document that served as the foundation for the evaluation. [9]

3.13. Basis for Estimate

Estimates may be related to the project in its entirety or may show the percentage of those estimates that is related to the reporting entity's environmental-socio-economic interest in the project. The estimate must be accompanied by a clear statement of the reporting rationale. Government royalties are typically classed as a cost of operations since they are frequently viewed as taxes that must be paid in cash. In certain circumstances, the fraction attributable to the royalty obligation may be included in the reported estimate. The fraction due to the royalty obligation that is excluded from the stated estimate must be disclosed. [17]

3.14. Reference Point

The given estimate or measurement is made at the Reference Point, which is a predetermined place within a development. The reference point may be the point at which the product is sold, transferred, or used, or it may be a stage in between; in this case, the reported numbers account for losses that occur before but not after the delivery point. The Reference Point must be made public alongside the classification. When amounts are categorized as E1 and the Reference Point is not the point of sale to third parties (or when custody is transferred to the entity's other operations), the data required to estimate sales must also be given. [22]

3.15. Distinction between E1, E2 and E3

The term "reasonable expectations for environmental-socio-economic feasible development in the foreseeable future" serves as the basis for differentiating between quantities that are categorized as E1, E2, or E3 on the Environmental-Socio-Economic Axis. More information can be found in the pertinent standards contained within the UNFC. The meaning of "foreseeable future" can vary based on the development.
The non-technical factors that directly affect a project's feasibility are included in the environmental-socio-economic axis Categories. These factors include product costs, legal and fiscal frameworks, environmental regulations, and recognized environmental or social impediments, benefits, or hurdles. Any one of these problems may impede the start of a new project (and thus, quantities would be categorized as E2 or E3, respectively), or it could cause production operations in an existing operation to be suspended or stopped altogether. The project shall be reclassified from E1 to E2 when development or operation activities are ceased but there are "fair possibilities for environmentally, socially, and commercially sustainable output in the foreseeable future." The project will be downgraded from E1 to E3 if "realistic prospects for environmentally, socially, and commercially feasible production in the foreseeable future" cannot be shown.

Positive social or environmental externalities may occasionally serve as a major motivator for beginning a project. The classification will note the level of development and the project's influence of the social or environmental issues. [4]

CHAPTER 4. TECHNICAL FEASIBILITY (F AXIS)

4.1. General overview and principles

The F Axis evaluates and depicts the viability of extraction for a development project. This comprises:

- Evidence of technological knowledge and data gathering
- The technological maturity and application of petroleum recovery
- Status of the development plan, including
  - Outlined and approved
  - Project execution requires the producer's aptitude and dedication.
  - a realistic anticipation that the required infrastructure, production capabilities, and transportation options are already in place or will be soon.

In general, there are four main sub-categories that divide up project development feasibility:

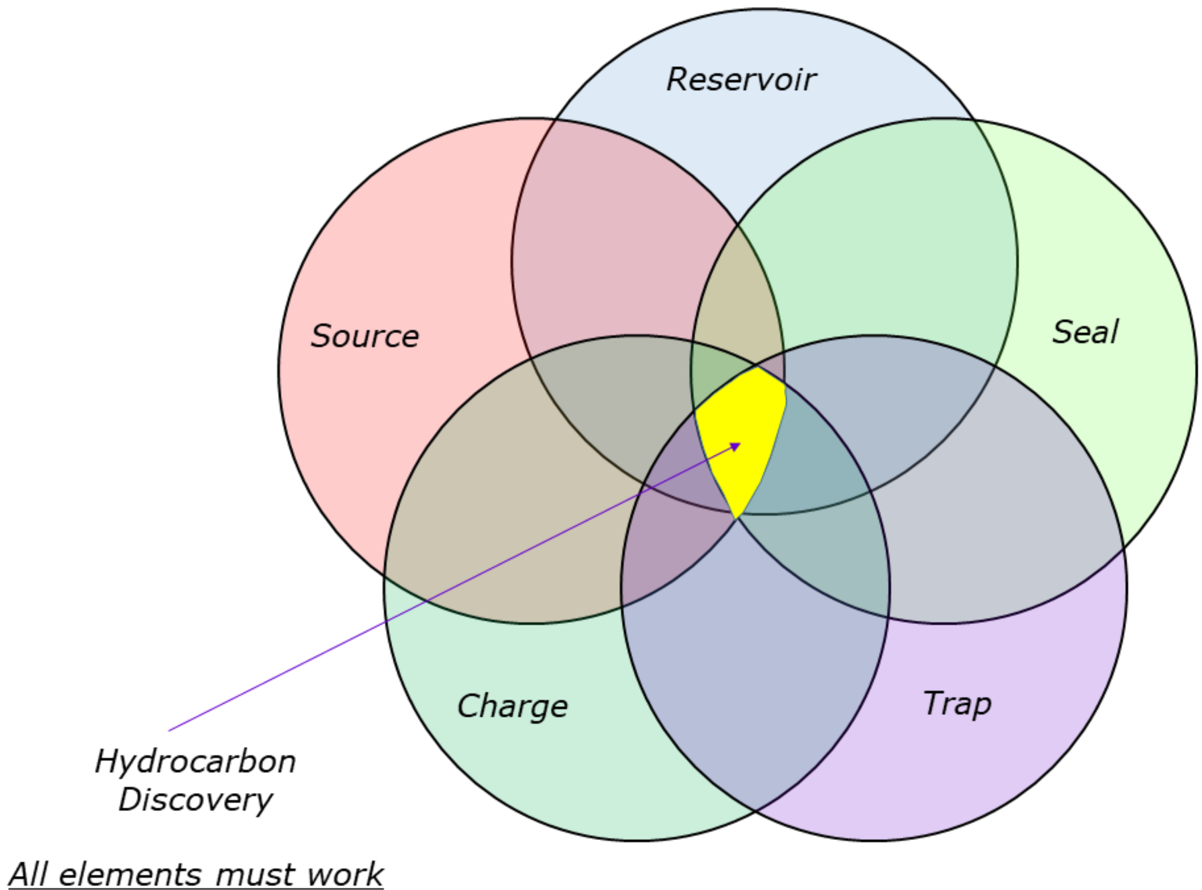
- F1: Outlined development project with extraction's technological viability established
- F2: Specified development project with technical extraction feasibility to be confirmed (needs additional review or approval) or a defined project that is not viable.
- F3: Conceptual development project for which there is insufficient data to evaluate the technological viability of extraction in its entirety
- F4: No defined or hypothetical development project to evaluate

It should be emphasized that only the mature status of the development projects is taken into account when determining the extraction feasibility and the F Axis. All initiatives are assessed based on how mature and resilient the potential future development project (which may be hypothetical) will be at the time of implementation. [11]

4.2. Probability and Risk

Before they are developed, all petroleum projects have a chance of being technically feasible, economically viable, and environmentally viable, as well as a chance that anything could go wrong. This includes the end result of the probability of discovering a fruitful reservoir and the probability of project development (including the proof of concept of a workable recovery technique).

Figure 10. Risk Variables. [11]



For evaluating the risk variables in a petroleum system, such as the source, migration, reservoir, seal, and trap are commonly coupled, there is a generally well-accepted technique. Prior to achieving project viability, the technical, environmental, and socio-economic variables must also be proven for development risk. Subsurface (resource quality and continuity), surface (well locations and infrastructure), application of the recovery technique, project execution (funding and capability), economics, permissions (government and regulatory), and time are a few of these factors. Factor dependencies should be taken into account. These variables can be utilized in a methodology that groups them in a matrix or scorecard so they can be multiplied or averaged.

The evaluation should take into account the subsurface, surface, and development hazards of the local project. The likelihood of a project developing would decline and risk would increase where data quality and/or quantity is poor or where there are various environmental socio-economic concerns to manage. An assessment and representation of risk must be included in every review of a petroleum project.[11]

4.3. Resource Distribution and Viability Assessment

The range of uncertainty for project evaluations should be based on the un-truncated resource distribution, which includes both economically feasible and non-viable result scenarios. Economic study is frequently conducted on situations where the scale of the finding surpasses the viability threshold, despite the fact that the viability of the project is frequently a result of the size of the discovery. In this method, the original distribution is trimmed to create a fresh, workable success distribution. Applying deterministic conceptual development scenarios to a subset of the outcomes on the trimmed resource distribution is the advised course of action for viable resource outcomes. The results of this research can then be utilized to determine important metrics like Expected Monetary Value (EMV). A truncated distribution would have a higher risk than an untruncated distribution. Additionally, because outcomes from a single prospective project outcomes from a single prospective project outcomes from a single Prospective projects are so ill-defined outcomes from a single prospective project outcomes from a single prospective project outcomes from a single prospective project outcomes from [11]

4.4. Recovery Technology Feasibility

Applying a recoverable technology to estimate recoverable quantities is a crucial evaluation process choice, and it should not be made without careful analysis of the degree of understanding of the technology's viability and its applicability to the reservoir in the project under consideration. The recovery process recovery technology feasibility can be categorized according to the following subcategory:

- In the reservoir under consideration, established technologies have demonstrated their technical and economic feasibility, or there is sufficient direct evidence to support technical and economic viability from a known similar reservoir. This is necessary for a project to be successful.
- Field testing is being conducted to determine the economic viability of the recovery method in the reservoir under consideration using technology that is still under development. Technical viability has already been demonstrated, either directly in the reservoir or with adequate direct evidence from a known comparable reservoir. a prerequisite for potential successful, unsuccessful, or future ventures
- When field testing is being done to determine a recovery process's technical viability or suitability for the reservoir under consideration, that technique is known as experimental technology. No assignable recoverable resources are allowed.[11]

4.5. Development Plan Status

The maturity of the development plan is used to evaluate the project feasibility state, which ranges from no identified projects to projects that have proven to be viable and committed. The maturity range indicated above can be qualitatively assessed as:

- "Null Maturity" (F4): For project evaluations where no specific projects have been identified
- "Low Maturity" (F3): When a project is being evaluated at an early stage, the development plan is conceptual, and exploration investigations are being conducted prior to the confirmation of a recognized resource
- "Medium Maturity" (F2): For assessments when a resource has been identified as possibly viable but needs additional data collection, field testing, or producer intent is still waiting or where it has been shown that extraction is not feasible
- "High Maturity" (F1): For project evaluations where there is enough data, research and/or field testing have shown the potential of economic extraction, and development is either planned or underway as of the effective date. [3]

Table 1 displays this qualification:

Table 1. F-axis Categories according to Project Classes (viability) [3]

Project classes	Categories	Project Maturity	Development Plan
Viable Projects	F1	HIGH	Development
Potentially Viable Projects	F2	MEDIUM	Pre-development
Non-Viable Projects	F2	MEDIUM	Pre-development
Prospective Projects	F3	LOW	Conceptual
Remaining Products	F4	NULL	None

4.6. Project Maturity Sub-categories

In addition to the previously mentioned Categories (F1, F2, F3, and F4), UNFC defines Sub-categories that are displayed in Table 2 for more clarity and precision in project maturity characterization.

Table 2. F-axis Sub-Categories according to Project Classes (viability) [3]

Categories	Project Maturity	Resource Source Status	Subcategories	Commercial Extraction Viability	Project Status
F1	High Maturity	Discovered	F1.1	Confirmed-Established technology	On production
			F1.2		Development approved
			F1.3		Development justified
F2	Medium Maturity	Discovered	F2.1	Imminent Confirmation	Feasibility in the foreseeable future - development pending
			F2.2	To be confirmed	On hold (viable projects) or unclarified feasibility (nonviable projects)
			F2.3	Not confirmed / Not viable	Not currently feasible
F3	Low Maturity	Undiscovered	F3.1 F3.2 F3.3	Not confirmed	Prospective Projects
F4	Null Maturity	Remaining Products	F4.1 F4.2 F4.3	Not evaluated or experimental technology	Not developed from prospective resources

The resource must offer proof of discovery for a project to progress from an unproven state to one that is well-known. The term "discovery" in this sense refers to evidence of recoverable hydrocarbon amounts large enough to assess the possibility of feasible recovery within a reasonable and realistic timescale. Drilling and reservoir testing are often needed for demonstrations to verify producibility. Furthermore, proof of continuity and/or repeatability should be used to support the extrapolation of a discovery. Projects still under development (F2.1) might meet the criteria for E1.

When a project's viability has been established, this needs to be well-documented. For projects that have been in this classification for more than five years, the assessor must provide justification for why the project should not be moved to the F4 category.

4.7. Prospective Projects

Prospective projects (F3 category) can be subcategorized according to their maturity level so that more specific information can be provided as needed. In these circumstances, Table 3's sub-categories should be applied.

Table 3. Prospective projects Sub-categories Specifications. [3]

Category	Sub-category	Specifications
F3	F3.1	Site-specific research Finding potential sources of resources (individual) Assurance for additional testing
	F3.2	Local research Potential sources of resources in a certain location Needs more information to ensure future testing
	F3.3	First year of study (Regional studies) Identification of favorable circumstances for the prospective finding of a resource source in a region

4.8. Additional guidelines

It is feasible to divide the remaining items into subcategories based on the stage of technological progress for the specific scenario of undeveloped (or unrecoverable) products. In these circumstances, Table 4's Sub-categories should be used.

Table 4. Additional Quantities Sub-categories Specifications. [3]

Category	Sub-category	Specifications
F4	F4.1	Actively developing essential technology Successful trials using different sources of information Initial success was not generalized to the studied resource source
	F4.2	Technology that is required and is being studied No resource source has carried out any successful pilot studies.
	F4.3	No study or analysis has been done on the required technology.

CHAPTER 5. DEGREE OF CONFIDENCE (G AXIS)

5.1. General overview and principles

On the G Axis, the level of estimation confidence is shown. This axis corresponds to the degree of uncertainty in production projections for any petroleum development project. As a result, the G Axis differs significantly from the E and F Axes, which are concerned with the development project's technical viability and environmental-socio-economic viability, respectively. The G Axis's guiding concepts are:

- The G Axis represents the range of project outcomes assessed at defined technical and forecast economic conditions based on the data available at the effective date. While each project will be assigned to a single class or subclass (E and F categories), the G Axis represents the full range of project outcomes. For any given project, a corresponding G1, G2, and G3 should be offered, representing the related low, best, and high scenarios. The range of outcomes may be expressed as G1, G1+G2, G1+G2+G3 where it indicates a cumulative scenario form. The range of uncertainty shows the outcomes that would be commercially recoverable for initiatives that are or could be successful. If the values were calculated in a system with a lower level of granularity and transferred to UNFC through the appropriate bridging method, it is only allowed to not provide a range of outcomes for a specific project.[3]
- Degree of confidence versus Maturity: The range between G1 (low), G2 (best), and G3 represents the degree of confidence or range of outcomes for a specific project (high). The range increases in size as confidence decreases. While the G Axis stays independent of the E and F Axes, a correlation between project maturity (E and F) and the range along the G Axis may be anticipated. [3]

5.2. Estimation Procedures

A source of petroleum accumulation could have one or more UNFC initiatives. For the Low, Best, and High scenarios, the total of all categories related to all permissible UNFC development projects plus any cumulative production plus unrecoverable volumes (F4) will always be equal to the volume initially in place (VOIP) (material balance). [3]

With:

We consider Low case = G1
Best case is = G1+G2
For the High case = G1+G2+G3

Produced Quantities + Σ Low case estimates + F4G1 = Low case VOIP = G1 VOIP

Produced Quantities + Σ Mid case estimates + F4G2 = Mid case VOIP = G1+G2 VOIP

Produced Quantities + Σ High case estimates + F4G3 = High case VOIP = G1+G2+G3 VOIP

5.3. Analytical procedures

A project's estimated recoverable amounts can be assessed using volumetric, analogous, and performance-based procedures. You can use any of these on their own or in combination.

5.3.1. Volumetric analysis

Using this process, the evaluator can calculate the VOIP and then predict how much will be recovered by a certain development project. Either probabilistic or deterministic methods may be used to base the volumetric estimate. Based on comparable field performance and/or modeling and simulation studies, recovery can be anticipated. Volumetric estimates can be used throughout the entire development process. In an established field, volumetric estimations are still essential for determining whether the field is adequately developed or produced. [9]

$$G = \frac{43{,}560\ Ah\emptyset(1 - S_{wc})}{B_{gi}}$$

5.3.2. Analogues

When there is a lack of direct measurement information, this method is used to help estimate the amount of resources that can be recovered. By contrasting the subject reservoir with another comparable reservoir that is in a more developed stage of development, the estimation is calculated. A similar reservoir should have significant parameters that are equivalent to those of the subject reservoir. To list a few, but not all, of these:

- Depositional and structural environment
- Fluid properties, viscosity
- Drive mechanism
- Petrophysical properties (permeability, porosity and saturation)
- Reservoir conditions (temperature, pressure and aquifer)
- Development plan (well type, artificial lift, well space, completion methods) [9]

5.3.3. Performance-based Estimates

The analysis is mostly based on real data that was obtained during the reservoir's appraisal and production. The information is utilized to calibrate the production forecasting algorithms. When there are sufficient amounts of data, the analysis will be reliable. These techniques include:

- Analysis of the **decline and type curves**. The reservoir must be in a semi-steady state in order for this method to work. The user should be careful to take into consideration all extra elements that could have an impact on production performance, including potential conflicts between new projects and existing wells and changes in operating conditions. Early in the depletion process, there may be a great deal of uncertainty regarding the variables that affect the maximum possible production and the economic limit. [12]

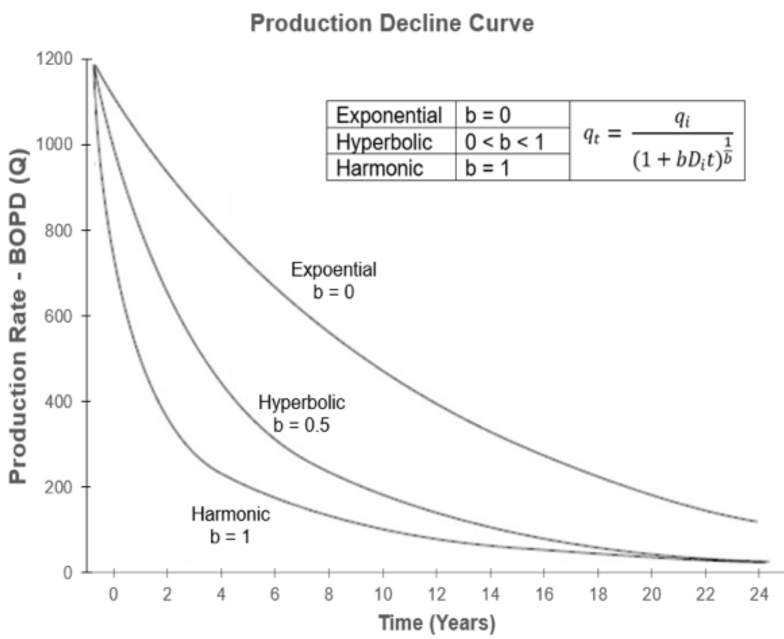


Figure 11. Production Decline Curve [12]

Exponential: The most typical type of decline observed in conventional oil and gas reservoirs and wells is an exponential decrease. The trend line's constant slope indicates that production has been declining steadily over time.

Hyperbolic: The less permeable, tightly constructed reservoirs frequently experience a hyperbolic drop. The drop depicted by the trend line is not consistent and may change over time.

Harmonic : A type of hyperbolic decline known as a harmonic decline is most frequently observed in recent horizontal shale wells. It is characterized by an extremely rapid deterioration at first.

- Analysis of pressure behavior during reservoir fluid withdrawal is a component of **material balance**. The accuracy of the data, the calibration of the model, and the reservoir's complexity will all have a significant impact on the outcomes (drive, baffles or barrier, etc.) [8]

For the Gas reservoirs:

a) P/Z Method:

$$\frac{p}{z} = \frac{p_i}{z_i} - \left(\frac{p_{sc}}{T_{sc}} \frac{T}{V_p(1 - S_{wi})} \right) G_p$$

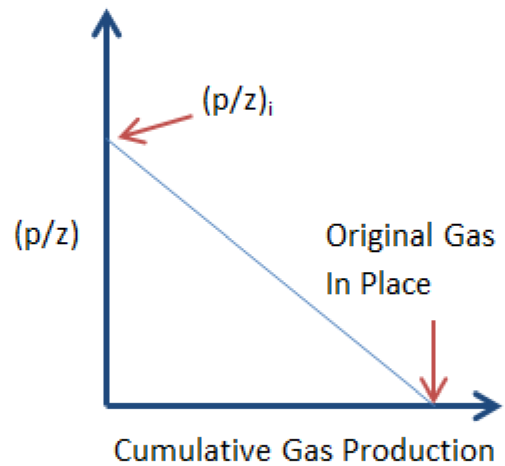
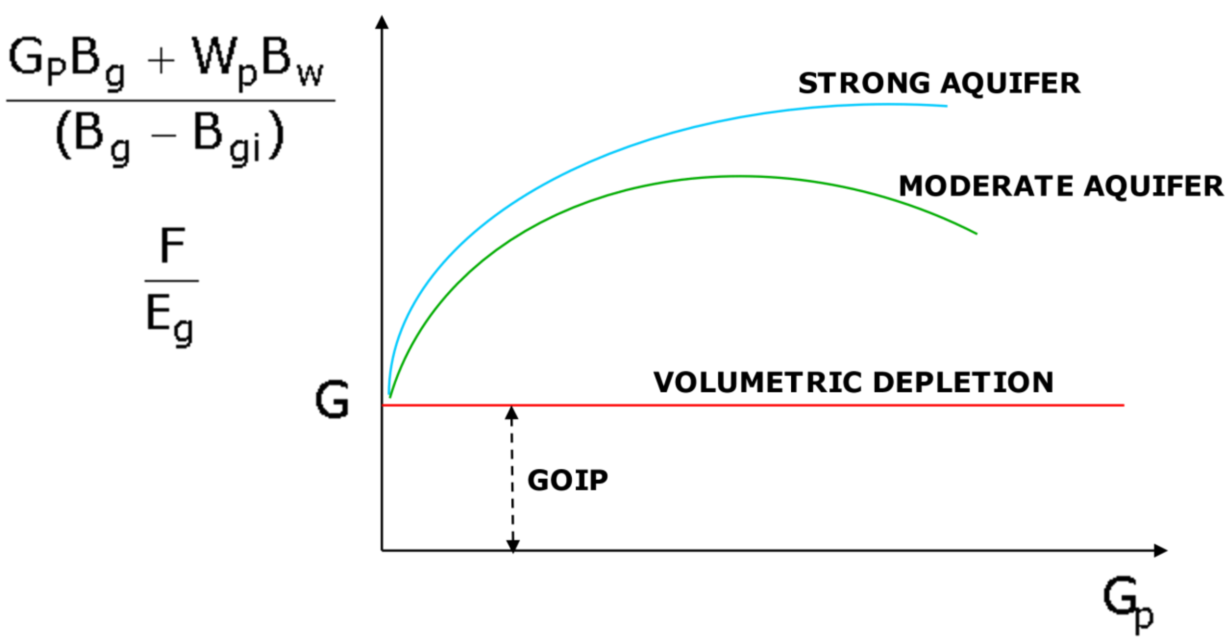


Figure 12. GOIP calculation by P/Z Method [13]

b) Havlena – Odeh Method:

Figure 13. GOIP Calculations by Havlena-Odeh Method [13]



- if W_e=0: volumetric depletion; estimate of G
- if the (F/E_g) plot is a concave downward shaped arc: water drive
- if the production rate is constant, the aquifer strength can be qualitatively assessed

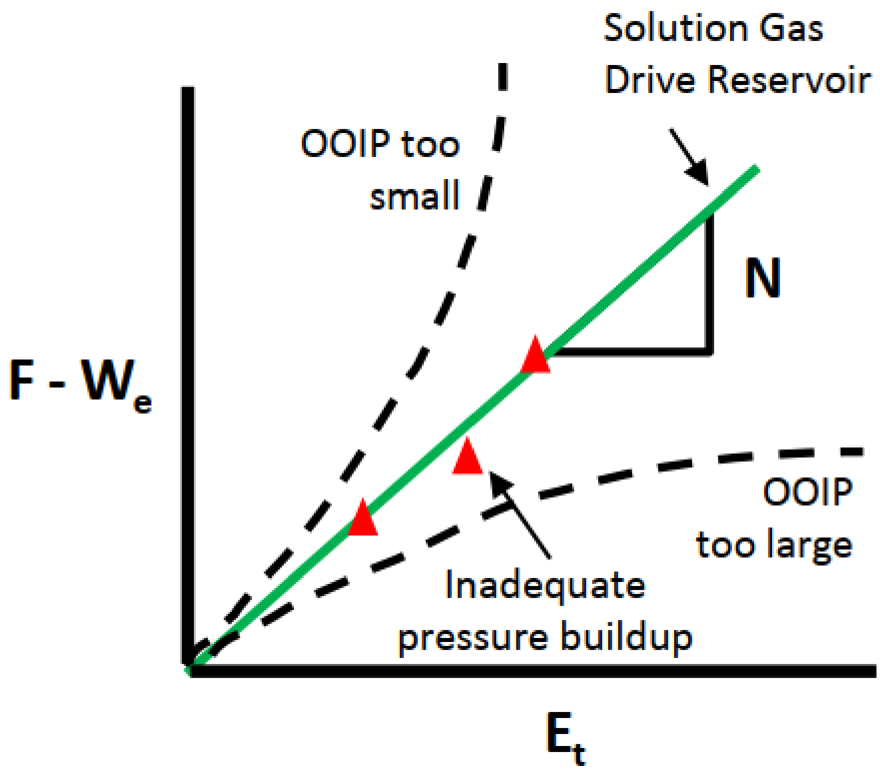


Figure 14. Havlena-Odeh Method. [13]

- If OOIP is too small means that Aquifer support is weak
- Green line shows the correct match
- If OOIP is too large means that Aquifer support is strong

Drive index equations:

$$\frac{G(B_g - B_{gi})}{G_p B_g} + \frac{W_e - W_p B_w}{G_p B_g} = 1$$

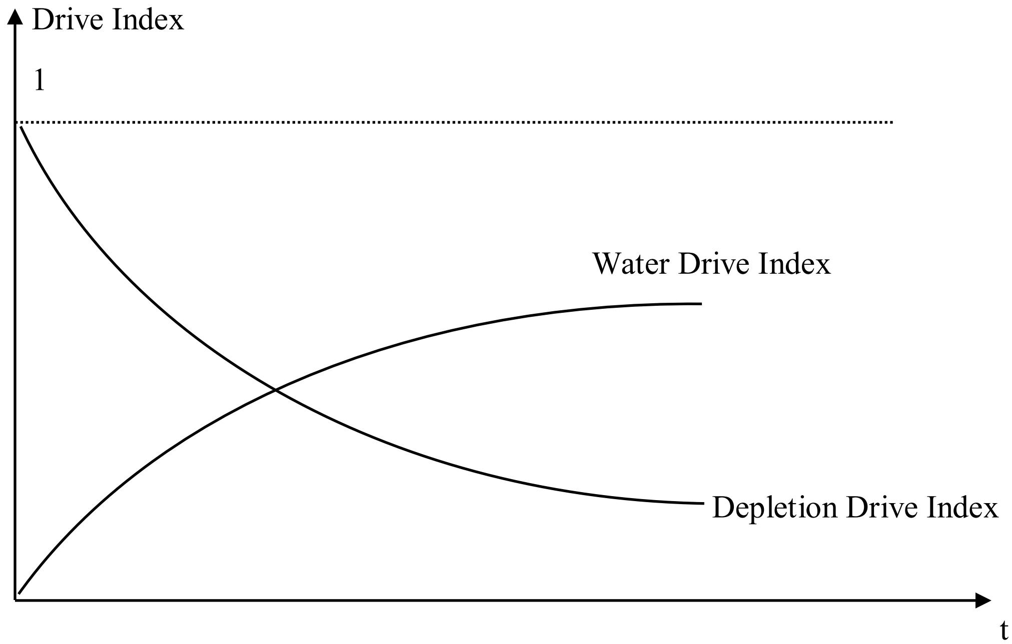


Figure 15. Drive Index Graph. [13]

For the Oil reservoirs:

$$N_{\text{remaining}} = N_{\text{initial}} - N_{\text{removed}}$$

a) Undersaturated oil reservoirs

Underground withdrawal = Expansion of the system + Cumulative water encroachment

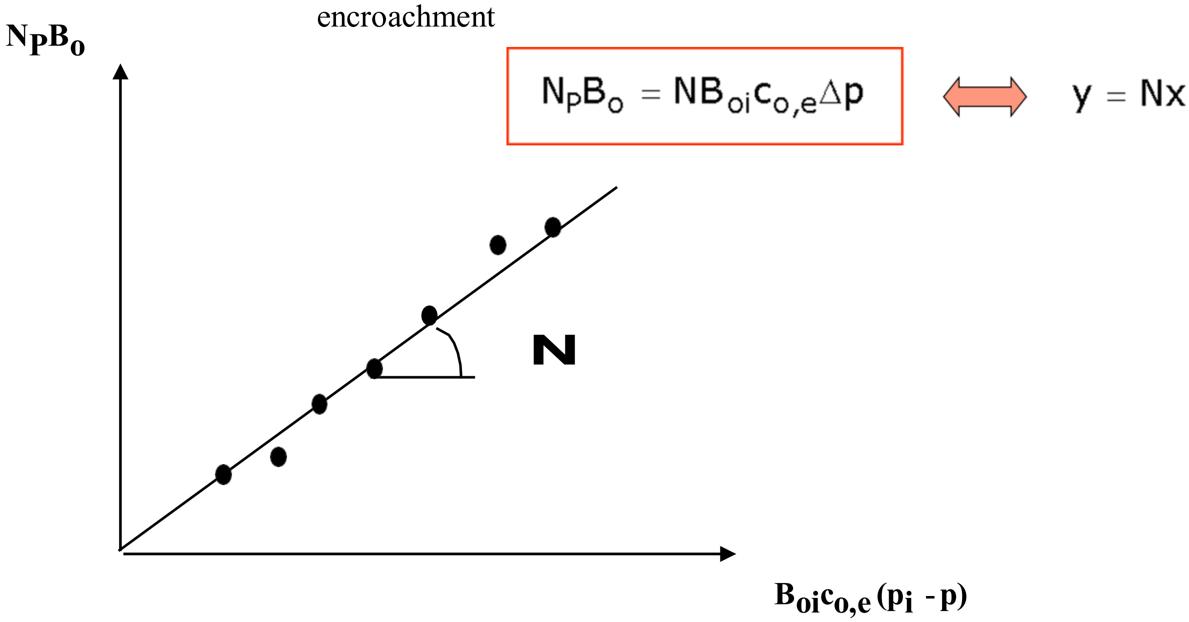


Figure 16. OOIP Calculations in Undersaturated Reservoirs. [13]

b) Saturated oil reservoirs

$$N_P[B_o + B_g(R_P - R_S)] = N[B_o - B_{oi} + B_g(R_{Si} - R_S)]$$

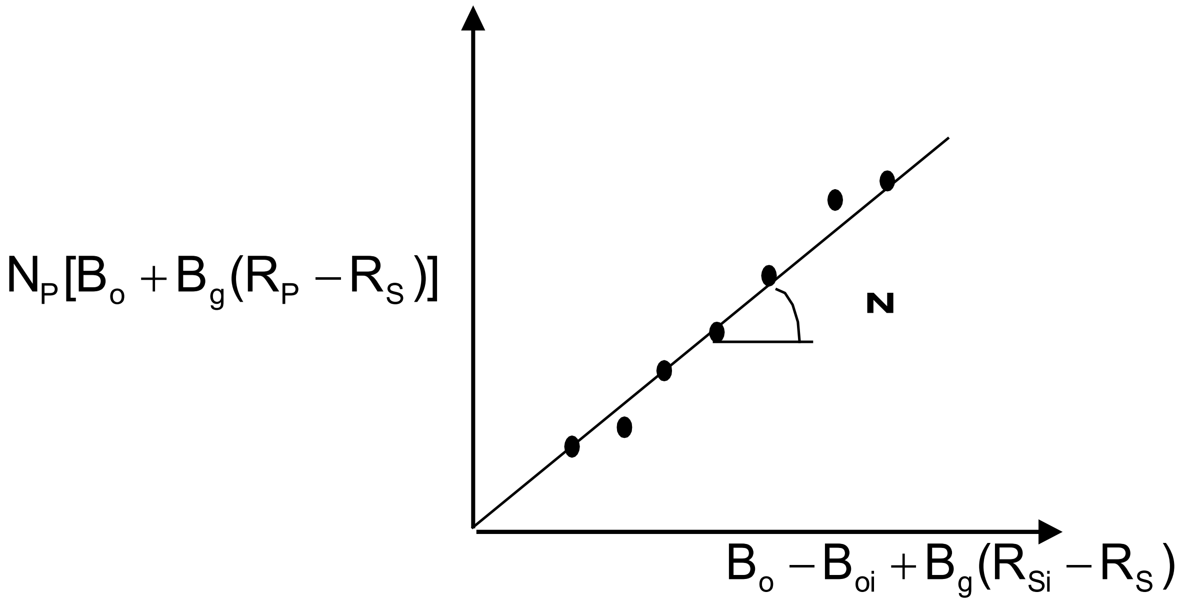
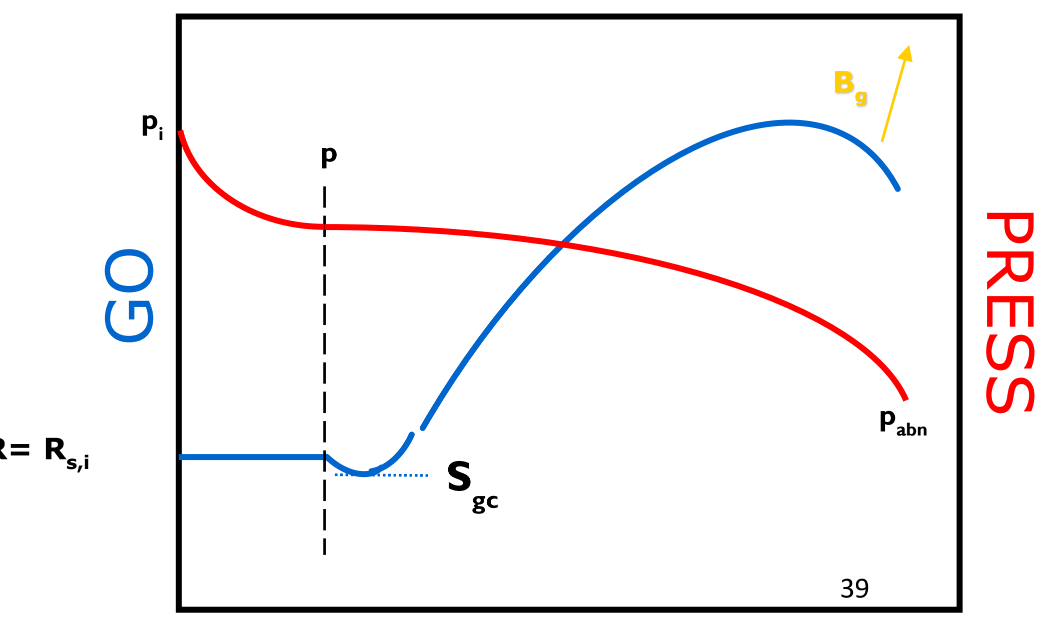


Figure 17. OOIP calculations in Saturated Reservoirs. [13]

Gas oil Ratio:

$$GOR = R_S + \frac{k_{rg}}{k_{ro}} \frac{\mu_o}{\mu_g} \frac{B_o}{B_g}$$

Figure 18. GOR Graph.[13]



- The most effective and flexible tool for examining the status of the reservoir as well as any possible development projects continues to be history-matched dynamic modeling. As models get extremely sophisticated and calibration becomes necessary, due caution must be taken.

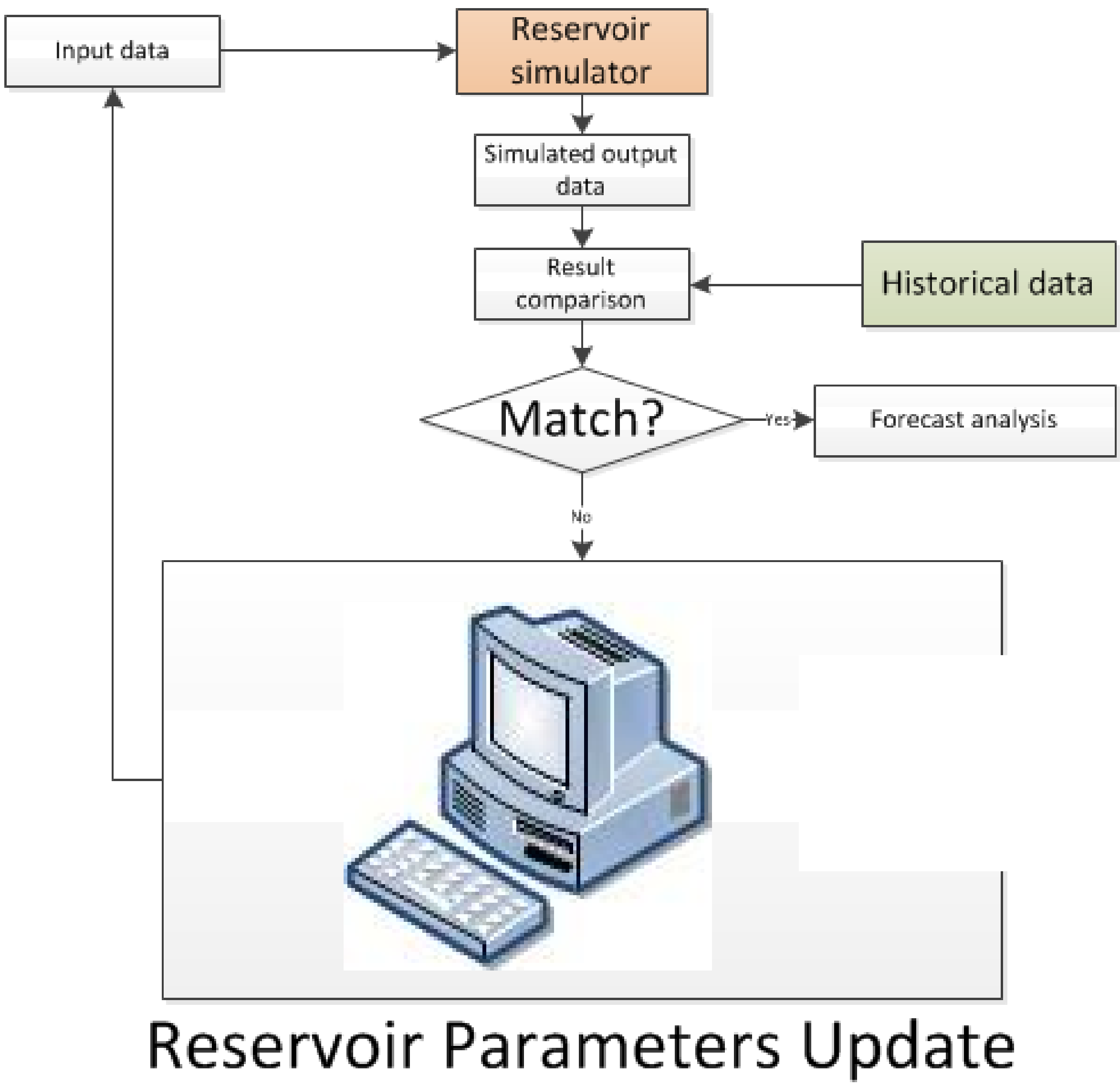


Figure 19. Algorithm of Reservoir Simulation. [14]

To verify accuracy and consistency in the variety of results offered, multiple analytical processes, volume-based and performance-based, should be compared to one another.

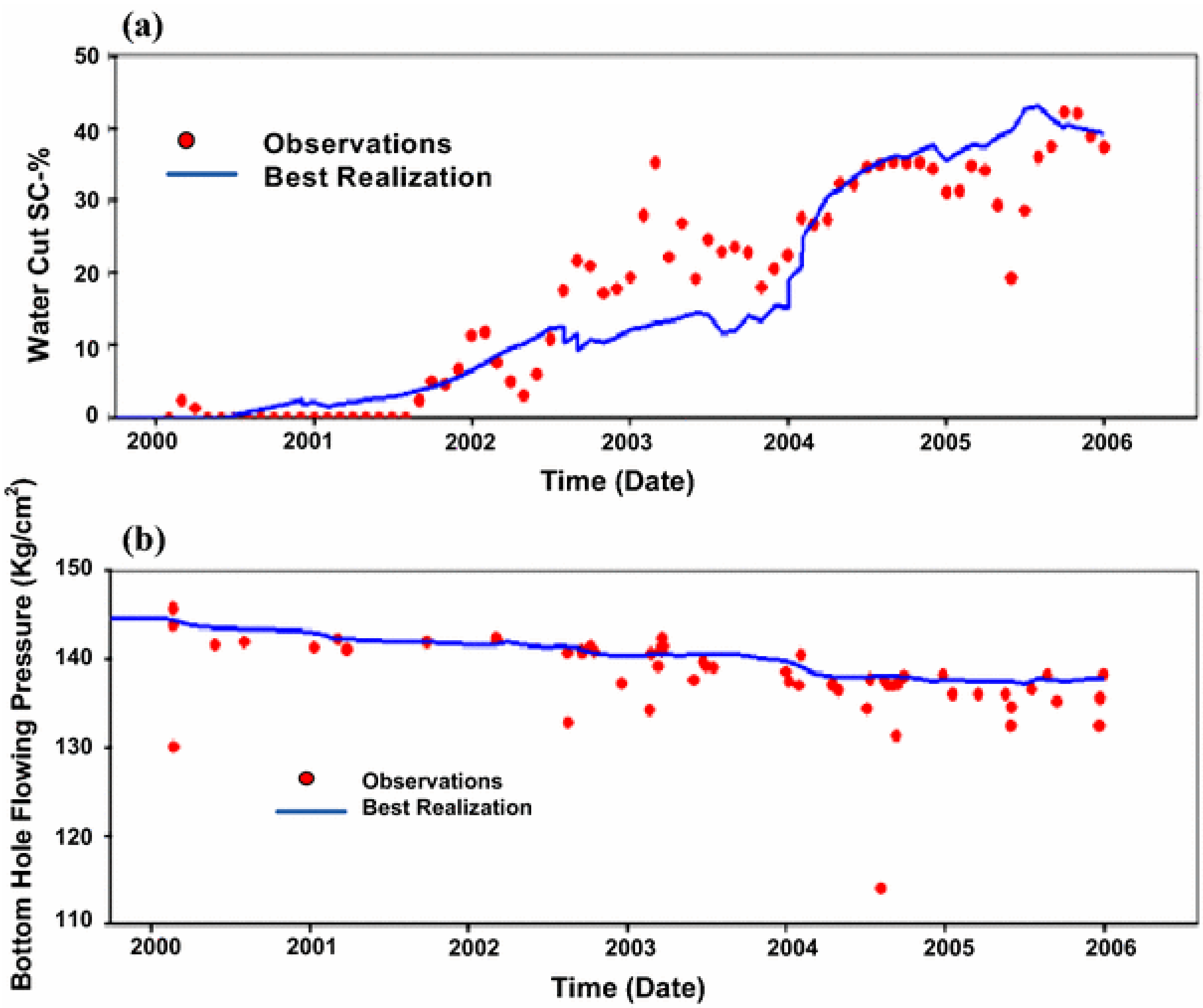


Figure 20. History Match of Water Cut and BHP. [14]

5.4. Resources Assessment Methods

A complete range of uncertainty related to the recoverable resources should always be presented, regardless of the analytical technique utilized. The deterministic method and the probabilistic method are the two main evaluation techniques. Most other techniques are variations of these two.[11]

5.4.1. Deterministic method

(G1), (G2), and (G3) results of the project are evaluated by employing a data point or an assortment of values for each input variables to obtain a discrete output. To reflect the level of confidence, the consistent inputs are selected for the(G1), (G2), and (G3) situation estimations. There is only one recoverable quantity outcome for any deterministic event. [2]

5.4.2. Probabilistic method

Each asset's or development project's low (G1), best (G2), and high (G3) outcomes are provided by the whole distribution of potential in-place or recoverable quantities. This outcome is calculated using random sampling of each sub-distribution representing the whole range of potential values for each input parameter (e.g., using stochastic geological modeling or Monte Carlo simulation). This method may be helpful to quickly determine the impact of important parameters on a specific project even though it is frequently employed at an early stage to compute the range of volumes in place. The G1 represents the P90 when probabilistic methods are applied, the G2 the P50, and the G3 the P10.

Resource assessments frequently incorporate techniques to clarify uncertainty. Potential dependencies between input parameters should always be taken into account.

Regardless of the methodology, the assumptions and underlying assumptions must be documented.[11]

5.5. Aggregation

It is possible to aggregate project resource quantities either mathematically or statistically.

The sum of low cases will frequently be conservative and the sum of high cases will be optimistic as a result of a straightforward arithmetic aggregation. To aggregate project findings to a higher level (field, reference point, block, basin, country), as necessary for public disclosure, simple arithmetic summation should be utilized. As a result, the P90 is typically higher than an arithmetic addition while the P10 is typically lower.

For the sake of internal reporting and corporate asset management strategy, statistical aggregation may be done (portfolio analysis). Any project dependencies and correlations should be taken into consideration.

Without taking into account and expressing the varied risk of environmental-socio-economic viability and technical feasibility, quantities in distinct classes and subclasses cannot be aggregated.[11]

CHAPTER 6. PROSPECTIVE PROJECTS.

6.1. General overview and principles

A prospective project is one that is connected to one or more potential deposits—that is, deposits that have not yet been proven to exist through direct evidence (such as drilling and/or testing/sampling), but are thought to be possible based primarily on indirect evidence—and that are associated with the project (e.g., surface or airborne geophysical measurements). The fraction of the in-place volumes that are thought to be potentially recoverable by the use of a future development project or projects is what is thought to be the related quantities of petroleum as of the effective date. Not every project that is considered will find deposits that are already known to exist. There should always be a technical feasibility and environmental-socioeconomic risk assessment for a potential project. [20]

6.2. Resource Assessment

The goal of the resource assessment for potential projects is to offer a technical assessment that is realistic of the range of outcomes that could occur and the probabilities for resource size. Usually, a probability distribution is used to evaluate the geology and reservoir uncertainty. The potential in-place resources are estimated using a combination of geology, geophysics, and petrophysics. The potential for recovery is then evaluated based on a hypothetical development project, with the recoverable resource assessed using local reservoir engineering knowledge. The whole untruncated distribution of possible outcomes should comprise the spectrum of uncertainty that surrounds a prospective project. When there is a lack of information, analogies are frequently used for future projects.[15]

6.3. Categories

The following UNFC categories are relevant to prospective projects:

- E3: Due to a lack of data, the economic viability of extraction cannot yet be determined. The Pd should be documented using reasonable projections for the state of the market in the future.
- F3: Due to a lack of technical information, the feasibility of extraction by a specific development project cannot be assessed. To determine the likelihood that a development will occur, very early research based on a specific (conceptual) development project should be employed as an input.
- G4: Quantities that are thought to be part of a possible deposit, mostly based on circumstantial evidence. There is a sizable range of uncertainty surrounding the

amounts that are estimated during the exploratory phase, and there is also a significant possibility that no further development project will be executed to extract the projected quantities. When a single estimate is given, it should reflect the anticipated result, but wherever it is practical, the whole range of uncertainty should be stated, maybe in the form of a probability distribution. The likelihood and consistency of reservoir productivity must be taken into account by the risk assessor when calculating risk. [1]

CHAPTER 7. UNCONVENTIONAL RESOURCES.

Both conventional and unconventional petroleum accumulations can be classified and categorized in accordance with UNFC guidelines.

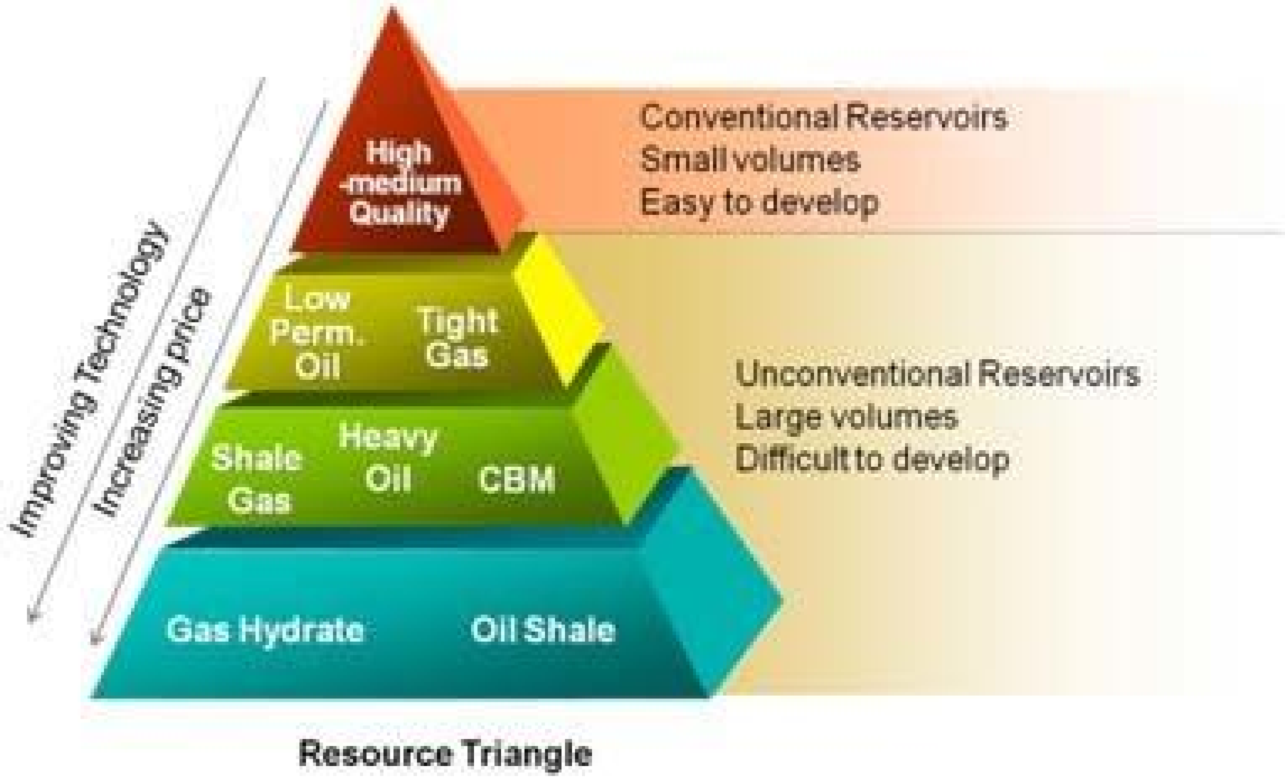


Figure 21. Conventional and Unconventional Resources. [5]

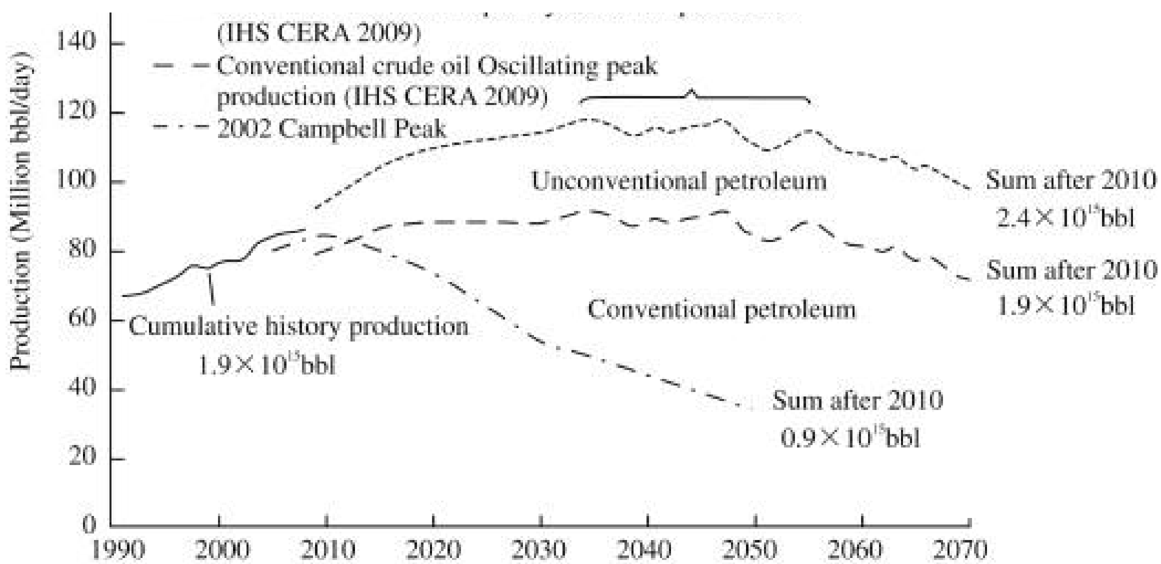
In general, unconventional resources are widespread over a significant area and are not greatly influenced by hydrodynamic factors. Typically, no visible structural, stratigraphic, or hydrodynamic impacts are present. For example, along with methane hydrates, natural bitumen, tight gas (including shale gas), tight oil (including shale oil), and low permeability deposits like tight gas and tight oil. Unusual resources typically demand more technical involvement.

To establish the range of uncertainty and the development plan for unconventional resources, more sampling and different evaluation approaches are often needed than for conventional resources. Extrapolating production beyond a well test should not be done unless there is strong technical evidence to support it since reservoir quality variations can happen over very short distances. In cases where this cannot be proven, that portion of the resource should stay untapped. Pilot projects can also be required to validate finding and future feasibility.

In order to successfully extract the petroleum, the development of unconventional resources frequently necessitates drilling numerous wells over huge areas. Over the course of the project, capital investment may stay high, but performance and cost may improve as a result of the development's repeated character.

Cambridge Energy predicted in 2009 that future production of unconventional petroleum will rise steadily. Assuming a reasonably stable conventional production rate, rising unconventional petroleum production by 2040 might reach another peak of 1.2 108 bbl/day (equal to 6.6 109 t yearly production). With declining conventional output beyond 2040, unconventional production would account for a larger portion of the total petroleum supply and be more crucial to the world petroleum supply [5]

Figure 22. Trend for Unconventional Petroleum Production from HIS [5]



The deterministic "incremental" technique, which is based on estimates for distinct project components and bases each estimate on the best estimate of probable recoverability, is used to evaluate many atypical projects. This strategy should only be used in conjunction with the probabilistic method or the previously mentioned deterministic scenario because it is not thought to be the most appropriate to accurately depict the level of confidence.

CHAPTER 8. ABANDONMENT, DECOMMISSIONING AND RESTORATION.

The term "abandonment, decommissioning, and restoration" (ADR) refers to all the procedures and related expenses required to successfully complete a project and restore a project site to a safe and environmentally sound state following the termination of work. ADR comprises:

- Activities such as wellbore plugging and the removal and disassembly of surface facilities were performed to ensure the final closure of all wells, machinery, and facilities employed throughout the project's lifespan.
- Remediation operations are those carried out with the goal of restoring a site's former state, where any environmental harm that has developed is fixed, or where the site is returned to a condition that is environmentally safe. [21]

Table 5. Variables that affect decommissioning cost: [21]

Variable	**Hypothesized effect on cost**
Well depth	Deeper wells might need more effort and material.
Well age	Older wells could be worse off.
Topography	It could be more expensive to plug and repair wells in high locations.
Surface restoration	It will cost more to restore the surface than it would to just plug the well.
Wells per contract	Arrangements involving numerous wells might provide economies of scale.
Well type	Oil wells or oil and gas wells may not be the same as gas wells.
State	State laws and other elements could have an impact on plugging expenses.

For all development projects, ADR of petroleum facilities must be taken into account while making investment and operational decisions. The time needed to obtain all internal and external permits and authorizations (regulation) necessary for the activities to be carried out within the period of license entitlement must be taken into account while planning abandonment actions. All the activities required to carry out abandonment correctly must be planned ahead of time and effectively to ensure safety and environmental compliance. Structures, equipment, facilities, materials, and garbage collection should always be done responsibly for both the environment and public safety.

In addition to restoring the sites to their original conditions, remediation of the sites used during the project's life must take into account potential future uses in order to allow sustainable development.

Unless otherwise stated in the contract, ADR expenses should be included in the development project's costs. To be declared economically viable, a project's cumulative net cash flow must be greater than the abandonment liability. However, if the maximum cumulative cash flow is reached before desertion is taken into consideration, the economic limit of production calculation may be abbreviated. To prevent a negative influence on the project's economics near or after completion, it is advised to create and fill dedicated funds/trusts for ADR during the project's productive life. In order to confirm that funds are available to cover ADR costs, the organization in charge of evaluating the resources for a development project should make sure that evidence is supplied. [2]

CONCLUSION

This work presents information about Application of United Nations Framework Classification to oil and gas resources.

In the first chapter, It is written about petroleum product which are obtained from distillation of crude oil, petroleum project such as management of future resources and finally effective date of the project.

Second Chapter is about Classification which contains classification of viable projects, potentially viable projects, non – viable projects, prospective projects, remaining products not developed from identified projects, remaining products not developed from prospective projects.

Environmental, social and economic features are written at chapter 3. It is possible to see evaluation of cash flow, economic criteria, relationship between these categories and etc.

Technical feasibility which is F axis assesses and represents the extraction feasibility for a development project like evidence of technical expertise and data gathering and development and practicality of the petroleum recovery technology.

As a conclusion, The UNFC is a flexible system that may be utilized for worldwide communication and global assessments, as well as to successfully meet the requirements for implementation at national, industrial, and institutional level. It satisfies the fundamental requirements for an international standard needed to support resource efficiency, increase management effectiveness, and improve the security of both energy supply and the related financial resources. The new classification will also help transitioning economies in reevaluating their mineral and energy resources in light of market economy standards.

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