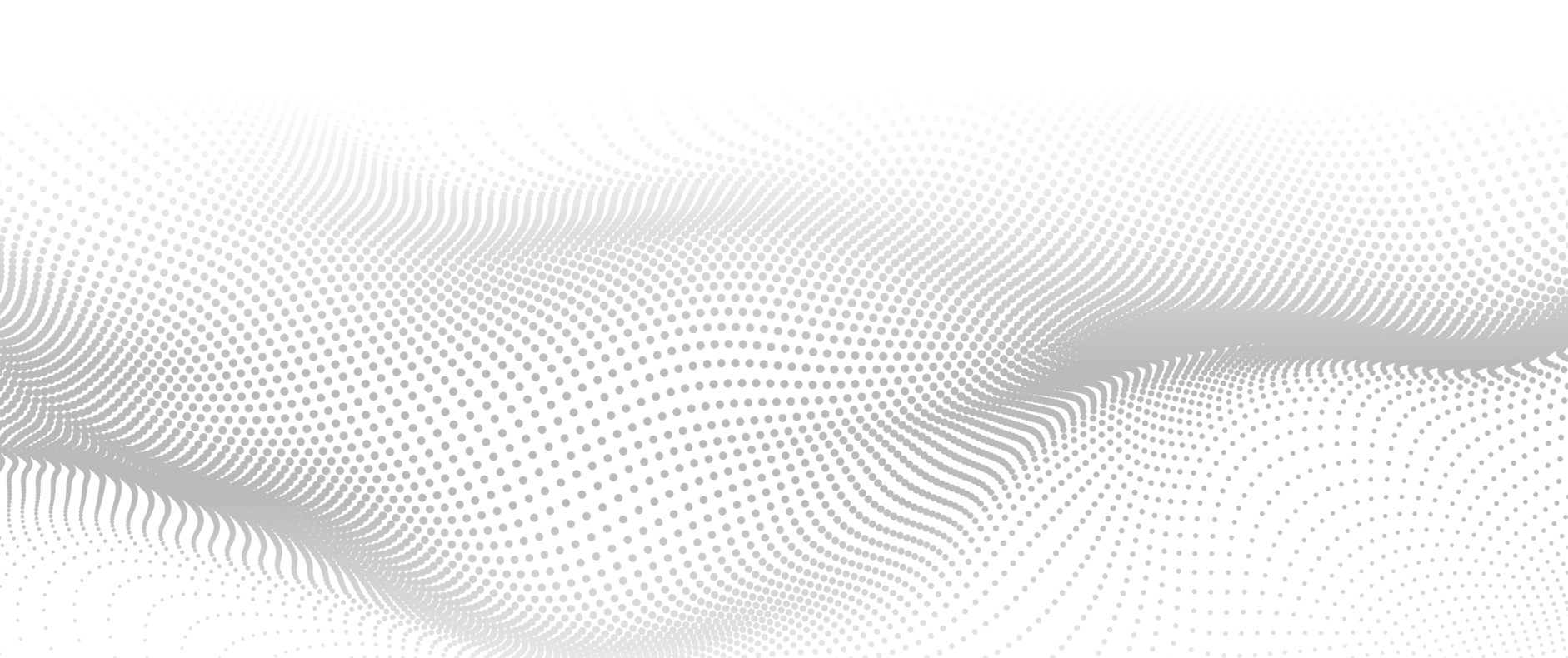
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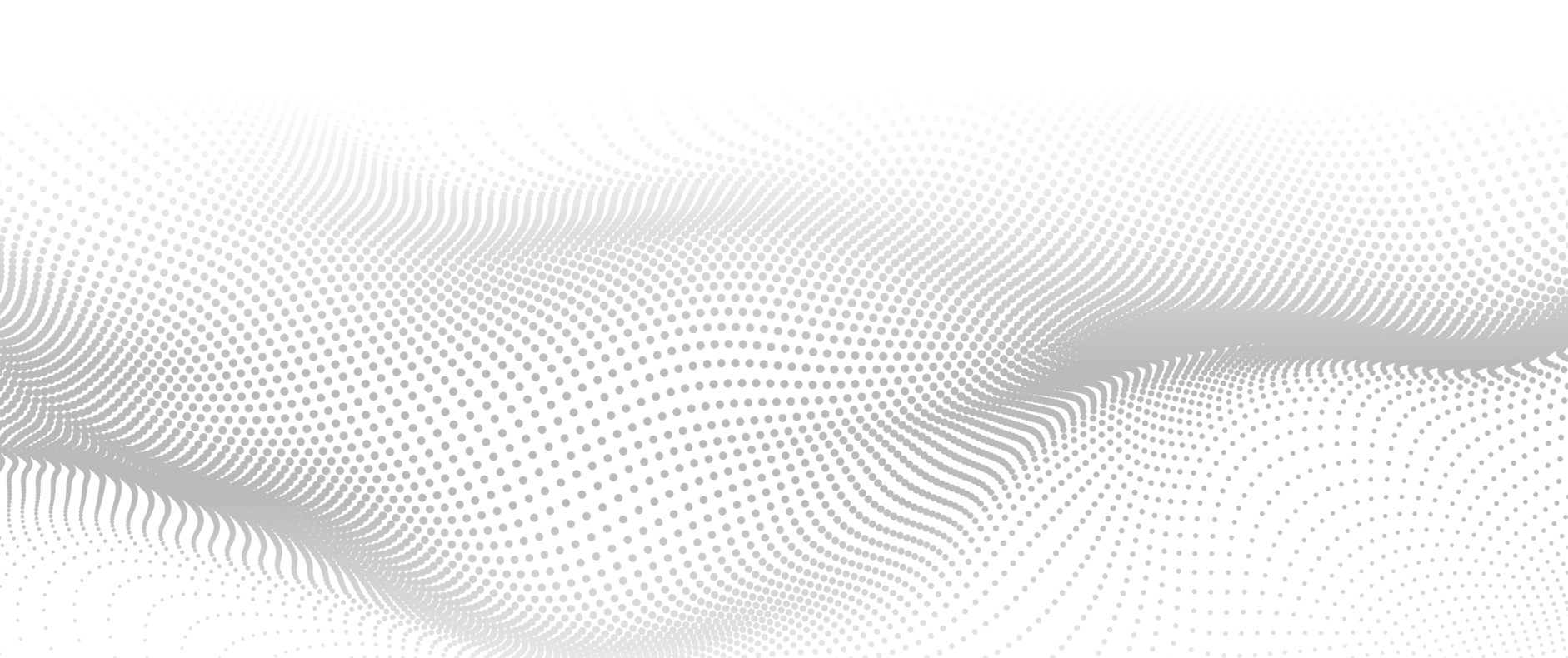
Peer Review Record

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| Date. | Description | Approved By |
|  | Initial Peer Review |  |
|  | Mid-Project Peer Review (if applicable) |  |
|  | Final Peer Review |  |
|  |  |  |

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| --- | --- | --- |
| Prepared For: | Client |  |
| By: | ERCE |
| Date: | [Publish Date] |

Report Title







Document ID: P6049-A-01-v01-Harbour CS005 Licence Independent Audit

Approved by: Paul Chernik

Date released to client: [Publish Date]

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[Table captions should be capitalised unless minor words e.g. “and”, “as of” . A dot (rather than dash) between the section number and the table number should be used]

[Table formatting can be facilitated using the Table Formatting add-in developed by Tom Enos; for the latest version go to “R:\Users\Tom\Excel Wizardry\Add ins”]

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[Capitalisation of figure captions should be consistent throughout the document; one option is to just capitalise proper nouns and defined terms e.g. “Reserves”, as this makes long figure names easier to read. A dot (rather than dash) between the section number and the figure number should be used]

[Publish Date]

Harbour Energy

Rubislaw House

Anderson Drive

Aberdeen

AB15 6FZ

Attn: Andrew Hood

Dear Sirs,

**Re: Competent Person’s Report – Block xxx**

In accordance with your instructions, ERC Equipoise Ltd (“ERCE”) has conducted an audit (“the Audit”) the carbon dioxide (“CO2”) Storage Resource estimates within certain Leman sandstone reservoirs contained within the CS005 licence area (the “Licence”), offshore UK. The results of the Audit are illustrated in this Competent Person’s Report (“CPR” or the “Report”).

The effective date of this report is 31 October 2022 (the “Effective Date”). In the preparation of this report ERCE has incorporated all data available through 30 September 2022, the data cut-off date. Harbour Energy (“Harbour”) has informed ERCE that an application has been recently submitted Carbon Storage Licence application for the CS005 has been recently submitted with primary purpose of carbon storage. ERCE understands that the technical documentation provided for this audit has been used in the application process. Harbour has confirmed that no new data or information that would impact ERCE’s opinions within the Report have been acquired between the data cut-off date and the date of this report.

ERCE has carried out this work in accordance with the July 2017 SPE/WPC/AAPG/SPEE/SEG/SPWLA/EAGE CO2 Storage Resources Management System (SRMS), version 1.01, as the standard for classification and reporting. The document, prepared by a subcommittee of the Carbon Dioxide Capture, Utilization and Storage Technical Section (CCUS), establishes technically-based capacity and resources evaluation standards. In the application of and conformance to SRMS, ERCE refers to the July 2022 Guidelines for Applications of the CO2 Storage Resources Management System

The full text of SRMS can be downloaded from:-

[CO2 Storage Resources Management System (spe.org)](https://www.spe.org/en/industry/co2-storage-resources-management-system/)

Nomenclature that may be used in this report is summarised in Appendix 2: Nomenclature.

**Use of the Report**

This CPR is produced solely for the benefit of and on the instructions of Harbour Energy, and not for the benefit of any third party. Any third party to whom the client discloses or makes available this report shall not be entitled to rely on it or any part of it.

Harbour Energy agrees to ensure that any publication or use of this report which makes reference to ERCE shall be published or quoted in its entirety and Harbour Energy shall not publish or use extracts of this report or any edited or amended version of this report, without the prior written consent of ERCE. In the case that any part of this report is delivered in digital format, ERCE does not accept any responsibility for edits carried out by the client or any third party or otherwise after such material has been sent by ERCE to the client.

**Disclaimer**

ERCE has made every effort to ensure that the interpretations, conclusions and recommendations presented in this report are accurate and reliable in accordance with good industry practice. ERCE does not, however, guarantee the correctness of any such interpretations and shall not be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation or recommendation made by any of its officers, agents or employees.

ERCE has used standard petroleum and carbon capture and storage evaluation techniques in the generation of this report. These techniques combine geophysical and geological knowledge with assessments of porosity and permeability distributions, fluid characteristics, production performance and reservoir pressure. There is uncertainty in the measurement and interpretation of basic data and ERCE has assessed this uncertainty as we have considered the risks presented by Harbour Energy. ERCE reserves the right to review all calculations referred to or included in this report and to revise the estimates in light of erroneous data supplied or information existing but not made available which becomes known subsequent to the preparation of this report.

In the execution of its audit ERCE has also used one or more of the evidence-gathering activities and techniques of verification/validation process illustrated in the ISO ISO 14064-3, listed in the body of our report.

The accuracy of any Contingent Storage Resources and injection estimates is a function of the quality and quantity of available data and of engineering interpretation and judgment. While Contingent Storage Resources and injection estimates presented herein are considered reasonable, the estimates should be accepted with the understanding that reservoir performance subsequent to the date of the estimate may justify revision, either upward or downward, as confidence in storable quantities estimates increases with quantity, quality, and data types available at the time of the assessment.

In the case of Contingent Resources presented in this report, there is no certainty that storage projects will satisfy commerciality requirements.

No site visits were undertaken in the preparation of this CPR.

**Professional Qualifications**

ERCE is an independent consultancy specialising in geoscience evaluation, engineering and economic assessment. ERCE will receive a fee for the preparation of this report in accordance with normal professional consulting practices. This fee is not dependent on the findings of this report and ERCE will receive no other benefit for the preparation of this report.

Neither ERCE nor the signatory of this report who is responsible for authoring this report, nor any Directors of ERCE have at the date of this report any shareholding in Harbour Energy. Consequently, ERCE, the signatory and the Directors of ERCE consider themselves to be independent of the Company, its directors and senior management.

ERCE has the relevant and appropriate qualifications, experience and technical knowledge to appraise professionally and independently the assets.

The work has been supervised by Paul Chernik, Director of ERCE, who holds a B.Sc. in Chemical Engineering from the University of Calgary, M.Sc. in Chemical Engineering from the University of Alberta, and an MBA from the University of Cambridge. He is Professional Engineer, registered with APEGA, and a Member of the Society of Petroleum Evaluation Engineers (SPEE).

Yours faithfully,

Paul Chernik

Director, ERCE

# Executive Summary

ERCE has conducted an audit of the carbon dioxide (“CO2”) Storage Resource estimates within certain Leman sandstone reservoirs contained within the CS005 licence area. The licence was awarded to Harbour Energy in December 2021 and covers area in four North Sea blocks in the U.K. sector Quad 49, in blocks 49/11, 49/12, 49/17, & 49/22 (Figure 1.1).

Table 1.1: Licenced Area Details

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Country | Licence | Licensee | licStart Date | Deadline of Storage Permit Application | Appraisal Term Expiry |
| UK | CS005 | Chrysaor Production U.K. | 15-Oct-21 | 14-Oct-25 | 14-Oct-27 |

Harbour’s proposal is to reuse the depleted Rotliegend gas fields, to securely store the CO2 in deep geological formations. At the Effective Date of this Report, Harbour, through its venture V Net Zero (“VNZ”), is carrying out technical studies to mature storage projects by hitting several milestones along the way as per licence requirements

Diagram, map

Description automatically generated

Figure 1.1: CS005 Licence Location Map

The nominated storage site is the Leman sandstone in the Rotliegendes Group, a depleted gas reservoir which exists as a hydraulic unit at both the Viking A and Victor depleted gas fields. Current technical characterisation has matured the complexes in both fields, and has allowed Harbour to estimate CO2s storage resources that “can be stored”[[1]](#footnote-2) with future actions (development project), quantification (storable resources) and containment (cap rock seal).

Additional screening has also provided a high-level ranking assessment of further storage potential with the identification of additional complexes, which would progress as parallel storage opportunities or to build up on initial projects with infrastructures build-out options. The documentation reviewed by ERCE also mentions the potential to utilise the Bunter Formation aquifer which could offer additional options to increase the future storage capacity of the project. ERCE understands that Bunter Aquifer Appraisal activities are included in the Licence work programme commitment. A list of complexes presented to ERCE for the CS005 licence is provided in Table, with annotation of those audited by ERCE.

Table 1.1: List of Complexes in the Licence Audited by ERCE

|  |  |  |
| --- | --- | --- |
| Complex | Site/Segment | ERCE Audit |
| Victor | JD+M | Audited |
| Viking C | E | Audited |
| Viking B | C | Audited |
| Viking A | A+H | Audited |
| Viking D | G | Audited |
| Viking B | B | Audited |
| Viking B | D | Audited |
| Viking F | F/Fs |  |
| Victoria |  |  |
| Viking E | E |  |

The Project is to provide geological storage of CO2 volumes of the Immingham emitters.

New greenfield infrastructure will be required in the form of; a 53km onshore pipeline section linking the Immingham emitters with Theddlethorpe Gas Terminal (“TGT”), CO2 handling facilities at TGT, a new 20km span of 36” offshore pipeline linking LOGGS to either storage site and a new Normally Unmanned Installation (NUI) at the storage site. In addition, the 120 km 36” LOGGS pipeline will be repurposed for CO2 transportation. Current development plan includes foresees the drilling of four injection wells in Victor.

**Contingent Storage Resources**

***Contingent Storage Resources*** *are those quantities of Total Storage Resources estimated, as of a given date, to be accessible in known geologic formations, but the applied project(s) are not yet considered mature enough for commercial development, as a result of one or more contingencies.* *Contingent Storage Resources are further categorized in accordance with the level of certainty associated with the estimates as 1C, 2C and 3C*

[Include some pre-amble as to how the Reserves are being reported and a cross reference to the tables]

Table 1.3: Contingent Storage Resources as of 31 October 2022

|  |  |  |  |
| --- | --- | --- | --- |
|  | CO2 (MMtonne) | | |
| 1C | 2C | 3C |
| Gross Contingent Storage Resource |  |  |  |
| Working Interest Contingent Storage Resources |  |  |  |

Notes

1. Company working interest is based on a diluted working interest of xx percent assuming the Government backs-in and takes a 20 percent interest.
2. These are unrisked Contingent Resources that have not been risked for chance of development and are sub-classified as development unclarified
3. Totals are added arithmetically which means statistically there is a greater than 90% chance of exceeding the Total 1C and less than a 10% chance of exceeding the Total 3C

Table 1.4 provides a list of all of the projects defined by Harbour and reviewed by ERCE.

Table 1.4: Contingent Storage Resources by Project and by sub-class as of 31 October 2022

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Project | | CO2 (MMtonne) | | | SRSM Classification | |
| Field | Reservoir or Segment | 1C | 2C | 3C | Class | Sub-Class |
| Victor | JD+JM |  |  |  | Cont.t Storage Resource | DOH |
| Viking A | A |  |  |  |  |  |
| Viking A | H |  |  |  |  |  |
| Viking B | B |  |  |  |  |  |
| Viking B | C |  |  |  |  |  |
| Viking B | D |  |  |  |  |  |
| Viking C | E |  |  |  |  |  |
| Viking D | G |  |  |  |  |  |
| Total |  |  |  |  |  |  |

# Introduction

[Include an overview of the block together with a location map]

[For single asset CPRs it can be better to include production/injection history plots and discuss future development plans in this section]

Diagram

Description automatically generated

Figure 2.1: Block xxxxx location map

## Data Provided

[Example shown below]

ERCE has relied upon data and information made available by Harbour. [If a representation letter has been provided include a sentence to this effect.] These data comprise details of CS005’s licence interests, seismic data, basic exploration and engineering data (including well logs, core, PVT and test data), technical reports, interpreted data (including reservoir simulation studies), production and injection, where available data. Preliminary field development plans were described in the main report V Net Zero – Preliminary Subsurface, often referred to in this Report.

ERCE has reviewed data made available through to xxxx 2022.

No site visit was undertaken in the preparation of this report.

## Work Completed

[Example shown below]

ERCE has used standard petroleum evaluation techniques in the generation of this report. These techniques combine geophysical and geological knowledge with assessments of porosity and permeability distributions, fluid characteristics, production performance and reservoir pressure. There is uncertainty in the measurement and interpretation of basic data. We have estimated the degree of this uncertainty and determined the range of petroleum initially in place. Estimates of recovery factors were prepared based on consideration of the results of production performance analysis, reservoir simulation models, classical reservoir engineering calculations and the performances of analogue fields. ERCE has derived independent estimates of reserves and prepared forecasts of production of oil and gas.

In the execution of its audit ERCE has also used one or more of the evidence-gathering activities and techniques of verification/validation process illustrated in the ISO ISO 14064-3, listed in the body of our report.

a) observation

b) inquiry

c) analytical testing

d) confirmation

e) recalculation;

f) examination

g) retracing

h) tracing

i) control testing

j) sampling

k) estimate testing

l) cross-checking

m) reconciliation

Production profiles have been generated by ERCE for both Reserves and Contingent Resources. The forecasts generated for Reserves have then been used as input to an economic model to undertake an Economic Limit Test (ELT) and assess commerciality. The economic model has been provided to ERCE by xxxx and has been reviewed by ERCE to confirm the terms of the various Production Sharing Contracts (PSCs) and fiscal regimes represented are correctly represented.

ERCE has evaluated the development plans for the various assets. For each field, ERCE has audited forecasts of capital, operating and abandonment costs from xxxx. The costs provided were reviewd and benchmarked them against our internal database to ensure they are reasonable. Where possible these estimates are compared to historical, actual costs. ERCE has used its own cost estimates where these differ significantly from these presented. The economic analysis does not take into account any outstanding debt, nor future indirect corporate costs.

# Licence Overview

Geological info

# Victor

[The contents of the CPR will vary depending on the intended use. Public documents should not be as expansive as bank reports or internal reports. The lists provided are a minimum and as such are more likely to correspond to public documents.]

[Initial section should provide field history with details of development to date, production/injection history. Figures should include a map with location of fields]

## Project Description

### Determination of Discovery Status

*Discovery*: One geologic formation, or several collective geologic formations, for which one or several wells have established through testing, sampling, and/or logging the existence of significant storable quantities. (See also *Discovered Storage Resources* and *Discovered*.)

#### G&G Data

Core data, log data, and seismic data providing direct and convincing evidence (from the geologic formation) of a significant pore volume of permeable formation, and suitable caprock that will provide containment.

#### Dynamic Data

A well test (production or injection) of any test fluid within all or a subinterval of the geologic formation at relevant flow rates that support the expectation that the planned number of injection wells can achieve the annual quantity of CO2 injection, and that this injection can be sustained over the life of the project. 7

#### Containment

A reasonable expectation that Stored CO2 will not migrate vertically or laterally out of the specified area and geologic formation(s).

### 

## Assessment of the Accessible Pore Volume

***Accessible Pore Volume*** *is the portion of a geologic formation with porosity that is connected and deemed suitable for CO2 storage. Accessible pore volume is a requirement for a mass or volume to be called storable quantity.*

Here we will have the analysis of geoscience and engineering data

### Seismic review

### Petrophysics

### Pore volume calculation

### Material balance

## Total Storage Resources (TSR) ~ equivalent to PIIP (QUANTITIFICATION)

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

### Injectivity Assessment

This section describes the review of hydrodynamic and geochemical factors affecting the mobility and fate of the injected CO2

The section must support the expectation that the planned number of injection wells can achieve the annual quantity of CO2 injection, and that this injection can be sustained over the life of the project.

#### Maximum average pressure buildup

#### Storage Efficiency

### Containment Assessment

This section describes the review of the extent and competence of the containment system

#### Containment: Wellbores

#### Containment: Geological (leakage pathways)

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

 Maximum storage and injection pressures defined not to damage the caprock

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

 CO2 injection only or injection and water extraction to mitigate pressure buildup

### Development Plan and Storable Quantities Calculation (Calculation)

#### Development Plan

Where a detailed development plan is prepared for a partner and/or government approval, the plan itself defines the project.

#### Storable quantities

Rationale from efficiency, dynamic model, discount from injectivity, repressurisation, time dependant

## Classification: Contingent Storage Resources

### Comments on Containment Assessment and Project Maturity

Wellbores Containment Is there any pending work necessary to “Assess barriers’ (integrity and depth relative to geologic containment) effect on storable quantities. If remediation is necessary, add remediation strategies and cost estimates to project development plans”?.

Is there any pending work to Update geologic containment assessments using additional data and evolving project description?

### Status, explanation of contingencies

#### Major Contingencies

#### Risk Assessment, MMV plan and residual risks

# Viking C(E)

# Viking B(C)

# Viking A+H

# Viking D(G)

# Viking B(B)

# Viking B(D)

# Appendix 1: SPE SRMS Guidelines

This report references the July 2017 SPE/WPC/AAPG/SPEE/SEG/SPWLA/EAGE CO2 Storage Resources Management System, version 1.01. The full text of the SRMS document can be viewed at:

https://www.spe.org/en/industry/co2-storage-resources-management-system/

Definitions of the key SRMS Reserves and Resource classes, categories and a glossary of related terms can be found at the above address.

Diagram

Description automatically generated

Figure A: SRMS Storage Resources classification framework

(from Storage Petroleum Resources Management System (SRMS), version 1.01, page 4, Figure 1.1)

Table

Description automatically generated

Figure B: SRMS Sub-classes based on Project Maturity

(from Storage Petroleum Resources Management System (SRMS), version 1.01, page 11, Figure 2.1)

**Table 1: Glossary of Terms Used in SRMS**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| **1C:** | Denotes low-estimate scenario of Contingent Storage Resources. |
| **2C:** | Denotes best-estimate scenario of Contingent Storage Resources. |
| **3C:** | Denotes high-estimate scenario of Contingent Storage Resources. |
| **1P:** | Taken to be equivalent to Proved Capacity; denotes low-estimate scenario of Capacity. |
| **2P:** | Taken to be equivalent to the sum of Proved plus Probable Capacity; denotes best-estimate scenario of Capacity. |
| **3P:** | Taken to be equivalent to the sum of Proved plus Probable plus Possible Capacity; denotes high-estimate scenario of reserves. |
| **1U:** | Denotes low-estimate scenario of Prospective Storage Resources. |
| **2U:** | Denotes best-estimate scenario of Prospective Storage Resources. |
| **3U:** | Denotes high-estimate scenario of Prospective Storage Resources. |
| **Accessible Pore Volume:** | Portion of a geologic formation with porosity that is connected and deemed suitable for CO2 storage. Accessible pore volume is a requirement for a mass or volume to be called storable quantity. Accessible may also include access at the surface to the subsurface storable quantity. |
| **Aggregation:** | The process of summing site (or project) level estimates of storage resources to higher levels or combinations such as field, country, or company totals. Arithmetic summation of incremental categories may yield different results from probabilistic aggregation of distributions. Consistent injectate composition is a requirement for aggregation of resources. |
| **Analogous Projects:** | Analogous projects, as used in resources assessments, have similar rock and fluid properties, subsurface conditions (depth, temperature, and pressure), and drive mechanisms, but are typically at a more advanced stage of development than a geologic formation of interest and thus, may provide concepts to assist in the interpretation of more limited data and estimation of storage. |
| **Approved for Development:** | All necessary approvals have been obtained, capital funds have been committed, and implementation of the development project is underway. |
| **Assessment:** | See Evaluation. |
| **Associated Injectants:** | Constituents present in the CO2 stream, other than CO2. |
| **Behind-Pipe Capacity:** | Expected to be stored within geologic formations in existing wells, which will require additional completion work or future recompletion before the start of injection. In all cases, injection can be initiated or restored with relatively low expenditure compared with the cost of drilling a new well. |
| **Best Estimate:** | With respect to resource categorization, this is the estimate of the quantity that will actually be stored by the project. It is the most realistic assessment of storable quantities, if only a single result were reported. If probabilistic methods are used, there should be at least a 50% probability (P50) that the quantities actually stored will equal or exceed the best estimate. |
| **Capacity:** | Capacity refers to those storable quantities anticipated to be commercially stored by application of development projects to known storable quantities from a given date forward under defined conditions. Capacity must further satisfy four criteria: |
| **Chance:** | The probability of gain or success. As risk is generally associated with a negative outcome, the term chance is preferred for general usage to describe the probability of a discrete event occurring (see Risk). |
| **Chance of Commerciality:** | The product of the Chance of Discovery and the Chance of Development. |
| **Chance of Development:** | The chance that the storable quantities will be commercial after they are discovered. |
| **Chance of Discovery:** | The chance that the geologic formation will result in the discovery of storable quantities. |
| **Characterized Geologic Formation:** | Describes the status of an assessment to ascertain the presence of storable quantities in a specific geologic formation. |
| **CO2 Generator:** | Source of CO2; typically anthropogenic industrial sites such as a coal-fired power plant, cement plant, ethanol plant, and natural gas processing. |
| **CO2 Stream:** | Fluid injected that is predominantly CO2. |
| **Commercial:** | When a project is commercial, this implies that the essential social, environmental, and economic conditions are met, including political, legal, regulatory, and contractual conditions. In addition, a project is commercial if the degree of commitment is such that the storage project is expected to be developed and placed on injection within a reasonable timeframe. While five years is recommended as a benchmark, a longer timeframe could be applied where, for example, development of economic projects are deferred at the option of the operator for, among other things, market-related reasons, or to meet contractual or strategic objectives. In all cases, the justification for classification as Capacity should be clearly documented. |
| **Completion:** | Completion of a well. The process by which a well is brought to its final status: |
| **Completion Interval:** | The specific geologic formation(s) or portion of a geologic formation that is (are) open to the borehole and connected to the surface facilities for injection. |
| **Conditions:** | The economic, marketing, legal, environmental, social, and governmental factors forecast to exist and impact the project during the time period being evaluated (also termed Contingencies). |
| **Constant Case:** | Modifier applied to project resources estimates and associated cash flows when such estimates are based on those conditions (including costs and product prices) that are fixed at a defined point in time (or period average) and are applied unchanged throughout the project life, other than those permitted contractually. In other words, no inflation or deflation adjustments are made to costs or revenues over the evaluation period. |
| **Containment:** | Part of the subsurface assessment that controls movement of stored CO2 within a specific area. Necessary criteria for estimating and identifying storable quantities. A projected timeframe (e.g., 1,000 years) should be stated with the assessment. |
| **Contingency:** | See Conditions. |
| **Contingent Storage Resources:** | Those storage quantities, as of a given date, to be potentially stored in geologic formations by application of development projects, but which are not currently considered to be commercial because of one or more contingencies. Contingent Storage Resources are a class of discovered storage resources. |
| **Cost Recovery:** | Under a typical storage-sharing agreement, the contractor is responsible for the field development and all exploration and development expenses. In return, the contractor recovers costs (investments and operating expenses) out of the gross injection stream. The contractor normally receives payment in CO2 storage and is exposed to both technical and market risks. |
| **Cumulative Injection:** | The sum of injection of CO2 to date (see also Injection). |
| **Current Conditions:** | Establishment of current economic conditions should include relevant historical prices, subsidies, tax credits, and associated costs of the project or related project (e.g., an industrial plant, power generation, or a hydrocarbon-producing project); and may involve a defined averaging period. The SPE PRMS guidelines recommend that a one-year historical average of costs and prices be used as the default basis of constant-case resources estimates and associated project cash flows. Where historic data are not available to define economic conditions, these must be assumed by the evaluator and assumptions clearly documented. |
| **Custody Transfer Point:** | See Reference Point. |
| **Decision Gates:** | The boundaries between different levels of project maturity. |
| **Deterministic Method:** | The method of estimation of Capacity or Resources is called deterministic if a discrete estimate(s) is made on the basis of known geoscience, engineering, and economic data. |
| **Developed Capacity:** | Expected to be stored from existing wells, including capacity behind pipe. Developed Capacity may be further subclassified as Injecting or Noninjecting. |
| **Developed Injecting Capacity:** | Expected to be stored from completion intervals that are open and injecting at the time of the estimate. |
| **Developed Noninjecting Capacity:** | Includes shut-in and behind-pipe Capacity. Shut-in Capacity is expected to be stored from: |
| **Development Not Viable:** | Discovered storable quantities for which there are no current plans to develop or to acquire additional data at the time as a result of limited storage potential. A project maturity subclass that reflects the actions required to move a project towards commercial storage. |
| **Development On Hold:** | Discovered storable quantities for which project activities are on hold and/or in which justification as a commercial development may be subject to significant delay. A project maturity subclass that reflects the actions required to move a project toward commercial storage. |
| **Development Pending:** | Discovered storable quantities for which project activities are ongoing to justify commercial development in the foreseeable future. A project maturity subclass that reflects the actions required to move a project towards commercial storage. |
| **Development Plan:** | The design specifications, timing, and cost estimates of the development project including, but not limited to, well locations, completion techniques, drilling methods, processing facilities, transportation, and marketing. (See also Project.) |
| **Development Unclarified:** | Discovered storable quantities in which project activities are on under evaluation and in which justification as a commercial development is unknown on the basis of available information. |
| **Discovered:** | Refers to storable quantities for which one or several exploratory wells have established through testing, sampling, and/or logging the existence of a significant storage quantity. In this context, “significant” implies that there is evidence of sufficient storable quantities to justify estimating the in-place quantity demonstrated by the well(s) and for evaluating the potential for economic storage (see also Discovered Storage Resources and Discovery). |
| **Discovered Storage Resources:** | That quantity of storage that is estimated, as of a given date, to be contained in geologic formations before injection. Discovered Storage Resources may be subdivided into Commercial, Sub-Commercial, and Inaccessible, with the estimated commercially storable portion classified as Capacity, and the estimated subcommercial recoverable portion classified as Contingent Storage Resources. |
| **Discovery:** | One geologic formation, or several collective geologic formations, for which one or several wells have established through testing, sampling, and/or logging the existence of significant storable quantities. (See also Discovered Storage Resources and Discovered.) |
| **Economic:** | In relation to Storage Capacity and Resources, economic refers to the situation in which the income from an operation exceeds the expenses involved in, or attributable to, that operation. |
| **Economic Interest:** | An Economic Interest is possessed in every case in which an investor has acquired any Interest in mineral in place, and secures, by any form of legal relationship, revenue derived from the extraction of the mineral to which he must look for a return of his capital. |
| **Economic Limit:** | The injection rate beyond which the net operating cash flows (after royalties or share of storage owing to others) from a project—which may be an individual well, lease, or entire field—are negative. |
| **Entitlement:** | That portion of future storage (and thus resources) legally accruing to a lessee or contractor under the terms of the development and storage contract with a lessor. |
| **Entity:** | A legal construct capable of bearing legal rights and obligations. In resources evaluations, this typically refers to the lessee or contractor, which is some form of legal corporation (or consortium of corporations). In a broader sense, an entity can be an organization of any form and may include governments or their agencies. |
| **Estimated Ultimate Stored:** | Those storable quantities that are estimated on a given date to be potentially stored, plus those quantities already stored therein. |
| **Evaluation:** | The geosciences, engineering, and associated studies, including economic analyses, conducted on an exploration, development, or storage project resulting in estimates of the quantities that can be stored and the associated cash flow under defined forward conditions. Projects are classified and estimates of derived quantities are categorized according to applicable guidelines. (Also termed Assessment.) |
| **Evaluator:** | The person or group of persons responsible for performing an evaluation of a project. These may be employees of the entities that have an economic interest in the project or independent consultants contracted for reviews and audits. In all cases, the entity accepting the evaluation takes responsibility for the results, including Capacity and Resources and attributed value estimates. |
| **Exploration:** | Prospecting for undiscovered petroleum. |
| **Forecast Case:** | Modifier applied to project resources estimates and associated cash flow when such estimates are based on those conditions (including costs and product price schedules) forecast by the evaluator to reasonably exist throughout the life of the project. Inflation or deflation adjustments are made to costs and revenues during the evaluation period. |
| **Formation Tests:** | Any type of direct injection or production test that is used to ascertain CO2 injection rates. |
| **Geostatistical Methods:** | A variety of mathematical techniques and processes dealing with the collection, methods, analysis, interpretation, and presentation of masses of geoscience and engineering data to (mathematically) describe the variability and uncertainties within any geologic formation, specifically related here to resources estimates, including the definition of (all) well and geologic formation parameters in 1, 2, and 3 dimensions and the resultant modeling and potential prediction of various aspects of performance. |
| **High Estimate:** | With respect to resource categorization, this is considered to be an optimistic estimate of the quantity that will actually be stored by a project. If probabilistic methods are used, there should be at least a 10% probability (P10) that the quantities actually stored will equal or exceed the high estimate. |
| **Hydrocarbons:** | Chemical compounds consisting wholly of hydrogen and carbon. |
| **Inaccessible Storage Resources:** | Storable quantities classified as Discovered or Undiscovered Storage Resources, which are estimated as of a given date, not to be developed for storage. These quantities may be developed for storage in the future if circumstances change. For example, current regulatory restrictions may prohibit storage at the time of the assessment and foreseeable future. |
| **Injection:** | The forcing, pumping, or free flow under vacuum, of substances into a porous and permeable subsurface rock formation. Injected substances can include either gases or liquids (see Cumulative Injection). |
| **Injection-Sharing Contract:** | In an injection-sharing contract between a contractor and a host government, the contractor typically bears all risk and costs for exploration, development, and storage. In return, if exploration is successful, the contractor is given the opportunity to recover the incurred investment from storage, subject to specific limits and terms. Ownership is retained by the host government; however, the contractor normally receives title to the prescribed share of the stored quantities. |
| **Justified for Development:** | Implementation of the development project is justified on the basis of reasonable forecast of commercial conditions at the time of reporting, and there are reasonable expectations that all necessary approvals/contracts will be obtained. A project maturity subclass that reflects the actions required to move a project toward commercial storage. |
| **Known:** | The key requirement to consider storable quantities as known, and thus containing Capacity or Contingent Resources, is that it must have been discovered, that is, penetrated by a well that has established through testing, sampling, or logging the existence of a significant storable quantities. |
| **Known Geologic Formation:** | A geologic formation that has been assessed and presence is verifiable. |
| **Lead:** | A project associated with storable quantities that is currently poorly defined and requires more data acquisition and/or evaluation to be classified as a prospect. A project maturity subclass that reflects the actions required to move a project toward commercial production. |
| **Low/Best/High Estimates:** | The range of uncertainty reflects a reasonable range of estimated storable quantities at varying degrees of uncertainty (using the cumulative scenario approach) for an individual storage project. |
| **Low Estimate:** | With respect to resource categorization, this is considered to be a pessimistic estimate of the quantity that will actually be stored by a project. If probabilistic methods are used, there should be at least a 90% probability (P90) that the quantities actually stored will equal or exceed the low estimate. |
| **Measurement:** | The process of establishing quantity (volume or mass) and quality of storage products delivered to a reference point under conditions defined by delivery contract or regulatory authorities. |
| **Monte Carlo Simulation:** | A type of stochastic mathematical simulation that randomly and repeatedly samples input distributions (e.g., geologic formation properties) to generate a resulting distribution (e.g., storable quantities). |
| **Net Present Value:** | The summation of the discounted cash flows when the cash flows are discounted according to a defined discount rate and time. |
| **Net Storage Resources:** | The incremental storable quantities used by each project. |
| **On Injection:** | The development project is currently injecting. A project status/maturity subclass that reflects the actions required to move a project toward commercial storage. |
| **Operator:** | The company or individual responsible for managing an exploration, development, and/or storage operation of the storage site and project. |
| **P1:** | Equivalent to Proved Capacity. |
| **P2:** | Equivalent to Probable Capacity. |
| **P3:** | Equivalent to Possible Capacity. |
| **Penetration/ Penetrated:** | The intersection of a wellbore with a geologic formations. |
| **Petroleum:** | Petroleum is defined as a naturally occurring mixture consisting of hydrocarbons in the gaseous, liquid, or solid phase. Petroleum may also contain nonhydrocarbon compounds, common examples of which are carbon dioxide, nitrogen, hydrogen sulfide, and sulfur. In rare cases, nonhydrocarbon content could be greater than 50%. |
| **Play:** | A project associated with a prospective trend of potential prospects, but which requires more data acquisition and/or evaluation to define specific leads or prospects. A project maturity subclass that reflects the actions required to move a project toward commercial storages. |
| **Point of Sales:** | See Reference Point. |
| **Possible Capacity:** | An incremental category of estimated storable quantities associated with a defined degree of uncertainty. Possible Capacity is the additional Capacity that analysis of geoscience and engineering data suggest are less likely to be stored than Probable Capacity. The total quantities ultimately stored from the project have a low probability to exceed the sum of Proved plus Probable plus Possible (3P), which is equivalent to the high-estimate scenario. When probabilistic methods are used, there should be at least a 10% probability that the actual quantities stored will equal or exceed the 3P estimate. |
| **Probability:** | The extent to which an event is likely to occur, measured by the ratio of the favorable cases to the whole number of cases possible. SPE convention is to quote cumulative probability of exceeding or equaling a quantity in which P90 is the small estimate and P10 is the large estimate. (See also Uncertainty.) |
| **Probable Capacity:** | An incremental category of estimated storable quantities associated with a defined degree of uncertainty. Probable Capacity are those additional Reserves that are less likely to be stored than Proved Capacity but more certain to be stored than Possible Capacity. It is equally likely that actual remaining storable quantities will be greater than or less than the sum of the estimated Proved plus Probable Reserves (2P). In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities stored will equal or exceed the 2P estimate. |
| **Probabilistic Method:** | The method of estimation of Resources is called probabilistic when the known geoscience, engineering, and economic data are used to generate a continuous range of estimates and their associated probabilities. |
| **Project:** | Represents the link between the storable quantities and the decision-making process, including budget allocation. A project may, for example, constitute the development of a single site, or an incremental development in a storage site, or the integrated development of several sites and associated facilities with a common ownership. In general, an individual project will represent a specific maturity level at which a decision is made on whether or not to proceed (i.e., spend money), and there should be an associated range of estimated storable quantities for that project. (See also Development Plan.) |
| **Property:** | A volume of the Earth’s crust wherein a corporate entity or individual has contractual rights to extract, process, and market a defined portion of specified in-place minerals (including petroleum). Defined in general as an area but may have depth and/or stratigraphic constraints. May also be termed a lease, concession, or license. |
| **Prospect:** | A project associated with a undiscovered storable quantities that is sufficiently well defined to represent a viable drilling target. A project maturity subclass that reflects the actions required to move a project toward commercial production. |
| **Prospective Storage Resources:** | Those storable quantities, which are estimated as of a given date, to be potentially stored from undiscovered storage resources. |
| **Proved Capacity:** | An incremental category of estimated storable quantities associated with a defined degree of uncertainty. Proved Capacity are those storable quantities which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially stored, from a given date forward, from known storable quantities and under defined economic conditions, operating methods, and government regulations. If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be stored. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually stored will equal or exceed the estimate. Often referred to as 1P, also as Proven. |
| **Pure-Service Contract:** | An agreement between a contractor and a host government that typically covers a defined technical service to be provided or completed during a specific period of time. The service-company investment is typically limited to the value of equipment, tools, and expenses for personnel used to perform the service. In most cases, the service contractor’s reimbursement is fixed by the terms of the contract with little exposure to either project performance or market factors. |
| **Range of Uncertainty:** | The range of uncertainty of the storable quantities may be represented by either deterministic scenarios or by a probability distribution. (See Resource Uncertainty Categories.) |
| **Reasonable Certainty:** | If deterministic methods for estimating recoverable resource quantities are used, then reasonable certainty is intended to express a high degree of confidence that the estimated quantities will be recovered. |
| **Reasonable Expectation:** | Indicates a high degree of confidence (low risk of failure) that the project will proceed with commercial development or the referenced event will occur. |
| **Reasonable Forecast:** | Indicates a high degree of confidence in predictions of future events and commercial conditions. The basis of such forecasts includes, but is not limited to, analysis of historical records and published global economic models. |
| **Reference Point:** | A defined location within an injection and storage operation where quantities of injected CO2 are measured under defined conditions before injection. This may also coincide with the Custody-Transfer Point. |
| **Remaining Storage Resources:** | The sum of Storage Capacity, Contingent Storage Resources, and Prospective Storage Resources, and inaccessible storage resources, excluding stored (i.e., previously injected) quantities. |
| **Reservoir:** | A subsurface rock formation containing an individual and separate natural accumulation of moveable petroleum that is confined by impermeable rocks/formations and is characterized by a single-pressure system. |
| **Resources:** | As used herein, is intended to encompass all storable quantities (accessible and inaccessible) within geologic formations—discovered and undiscovered—plus those quantities already stored. |
| **Resources Categories:** | Subdivisions of estimates of resources to be stored by a project(s) to indicate the associated degrees of uncertainty. Categories reflect uncertainties in the total storage resources remaining, that portion of the total storage resources that can be used for storage by applying a defined development project or projects, and variations in the conditions that may impact commercial development (e.g., market availability, contractual changes). (See also Proved, Probable, and Possible; 1C, 2C, 3C, 1P, 2P, and 3P.) |
| **Resources Classes:** | Subdivisions of Resources that indicate the relative maturity of the development projects being applied to yield the storable quantities. Project maturity may be indicated qualitatively by allocation to classes and subclasses and/or quantitatively by associating a project’s estimated chance of reaching injecting status. |
| **Resources Uncertainty Categories:** | See Resources Categories. |
| **Risk:** | The probability of loss or failure. As risk is generally associated with the negative outcome; “Chance” is preferred for general use to describe the probability of a discrete event occurring. (See Chance.) |
| **Risked-Service Contract:** | These agreements are very similar to the injection-sharing agreements, with the exception of contractor payment, but risk is borne by the contractor. With a risked-service contract, the contractor usually receives a defined share of revenue rather than a share of the stored quantities. |
| **Royalty:** | Royalty refers to payments that are due to the host government or storage-rights owner (lessor) in return for the operator (lessee/contractor) to have legal access to the storage resources. Many agreements allow for the operator to inject the royalty quantities, sell them on behalf of the royalty owner, and pay the proceeds to the owner. Some agreements provide for the royalty to be taken only in kind by the royalty owner. |
| **Shut-in Capacity:** | Expected to be recovered from completion intervals that are open at the time of the estimate, but that have not started injecting; wells that were shut in for market conditions or pipeline connections; or wells not capable of injection for mechanical reasons. |
| **Significant Quantity:** | Implies that there is evidence of a sufficient quantity of Total Storage Resources to justify estimating the storable quantity (volume or mass) demonstrated by the well(s) and for evaluating the potential for commercial storage. |
| **Storable Quantities:** | Quantities of CO2 that can be stored as part of an estimated pore volume of a geologic formation that is accessible to CO2 via a CO2 injection well (i.e., a storage project) sometime in the future and can be reported as mass or volume of CO2. To be considered a storable quantity, an assessment of the longevity of the storage of the CO2 is required (i.e., containment will be part of the analyses). |
| **Storage Efficiency:** | Fraction of the Storage Capacity, Storage Resource, total pore volume, effective pore volume, bulk volume, and/or storable quantity expected to be used for storage by a specific project. May be based on actual injection, planned project, or a regional assessment. The basis for the storage efficiency must be clearly identified and documented. |
| **Stored:** | A classification that includes the cumulative quantity of CO2 that has been actually injected and retained over a defined time. Any back-produced CO2 quantities or emissions to atmosphere or seabed are deducted. Quantities of CO2 that have migrated beyond the defined boundaries of the project but remain isolated from the atmosphere and hydrosphere may be considered retained.  While all storage-resources estimates and injection are reported in terms of the metered CO2 specifications, raw-injection quantities (including non-CO2 constituents) are also measured to support engineering analyses requiring voidage calculations. |
| **Stored Quantities:** | Part of the Capacity for a geologic formation that has injected and retained CO2 occupying pore volume; it can be reported as mass or volume. |
| **Subcommercial:** | A project is Subcommercial if the degree of commitment is such that the storable quantities are not expected to be developed and placed on injection within a reasonable timeframe. While five years is recommended as a benchmark, a longer timeframe could be applied at the point at which, for example, development of economic projects are deferred at the option of the operator for, among other things, market-related reasons or to meet contractual or strategic objectives. Discovered subcommercial projects are classified as Contingent Storage Resources. |
| **Taxes:** | Obligatory contributions to the public funds, levied on persons, property, or income by governmental authority. |
| **Technical Uncertainty:** | Indication of the varying degrees of uncertainty in estimates of storable quantities influenced by range of storage resources and the range of the storage efficiency of the project being applied. |
| **Total Storage Resources:** | Generally accepted to be all those estimated storable quantities contained in the subsurface, as well as those quantities already stored. |
| **Ultimate Storage Efficiency:** | Defined as the ratio of EUS to a base, which can be the Storage Capacity, Storage Resource, total pore volume, effective pore volume, bulk volume, and/or storable quantity expected to be used for storage by a specific project. May be based on actual injection, planned project, or a regional assessment. The basis for the storage efficiency must be clearly identified and documented. (See Storage Efficiency and Estimated Ultimate Storage.) |
| **Uncertainty:** | The range of possible outcomes in a series of estimates. For Storage Resource assessments, the range of uncertainty reflects a reasonable range of estimated storable quantities for a project. (See also Probability.) |
| **Uncharacterized Geologic Formation:** | A known geologic formation that has inadequate data for estimating storable quantities to be considered discovered. |
| **Undeveloped Capacity:** | Quantities expected to be stored through future investments: |
| **Undiscovered Geological Formation:** | A yet-to-be-discovered geologic formation. |

# Appendix 2: Nomenclature

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| --- | --- |
| **3D** | three dimensional |
| **ABEX** | abandonment cost |
| **API** | American Petroleum Institute |
| **bbl** | barrel (42 US gallons) |
| **Bg** | gas formation volume factor, in scf/rcf |
| **BH** | bottom hole |
| **BHA** | bottom hole assembly |
| **Bo** | oil formation volume factor, in rb/stb |
| **Bscf** | thousands of millions of standard cubic feet |
| **C&P** | cased and perforated |
| **CGR** | condensate gas ratio |
| **CO2** | carbon dioxide |
| **CoP** | cessation of production |
| **COS** | geological chance of success |
| **CPI** | computer processed interpretation |
| **d** | day |
| **DCA** | decline curve analysis |
| **DST** | drill stem test |
| **Eg** | gas expansion factor |
| **ELT** | economic limit test |
| **FBHP** | flowing bottom hole pressure |
| **FDP** | field development plan |
| **FMB** | flowing material balance |
| **FPSO** | floating production storage and offloading vessel |
| **ft** | feet |
| **FTHP** | flowing tubing head pressure |
| **FVF** | formation volume factor |
| **FWL** | free water level |
| **GDT** | gas down to |
| **GEF** | gas expansion factor |
| **GIIP** | gas initially in place |
| **GOC** | gas oil contact |
| **GOR** | gas oil ratio |
| **GRV** | gross rock volume |
| **GSA** | gas sales agreement |
| **GWC** | gas water contact |
| **H2S** | hydrogen sulphide |
| **HIIP** | hydrocarbons initially in place |
| **HLV** | Heavy Lift Vessel |
| **HPHT** | high pressure, high temperature |
| **ICV** | interval control valve |
| **kh** | permeability thickness |
| **km** | kilometres |
| **Kr** | relative permeability |
| **LNG** | liquefied natural gas |
| **LPG** | liquefied petroleum gas |
| **LTC** | long term compression |
| **m** | metre |
| **M MM** | thousands and millions respectively |
| **MD** | measured depth |
| **md or mD** | millidarcy |
| **MDRKB** | measured depth below Kelly Bushing |
| **MDT** | modular dynamic tester |
| **MSL** | mean sea level |
| **mss** | metres subsea |
| **N2** | nitrogen |
| **NAG** | non-associated gas |
| **NBP** | National Balancing Point |
| **NPV xx** | net present value at xx discount rate |
| **NTG** | net to gross ratio |
| **NUI** | normally unmanned installation |
| **ODT** | oil down to |
| **OPEX** | operating cost |
| **OWC** | oil water contact |
| **P90** | low case (probabilistic) estimate (there should be a 90% probability of exceeding this estimate) |
| **P50** | mid or best case (probabilistic) estimate (there should be a 50% probability of exceeding this estimate) |
| **P10** | high case (probabilistic) estimate (there should be a 10% probability of exceeding this estimate) |
| **Pb** | saturation, or bubble point, pressure |
| **PBU** | pressure-build-up |
| **Phi** | porosity |
| **Phie** | effective porosity |
| **Phit** | total porosity |
| **PI** | productivity index, in stb/d/psi for oil or MMscf/d/psi or Mscf/d/psi for gas |
| **POD** | plan of development |
| **PSA** | production sharing agreement |
| **PSC** | production sharing contract |
| **psi** | pressure, measured in pounds per square inch |
| **psia** | absolute pressure, measured in pounds per square inch |
| **psig** | gauge pressure which is the pressure above atmospheric pressure, measured in pounds per square inch |
| **PSDM** | post stack depth migration |
| **PSTM** | post stack time migration |
| **PVT** | pressure volume temperature experiment |
| **rb** | reservoir barrels |
| **RCA** | routine core analysis |
| **rcf** | cubic feet at reservoir conditions |
| **RFT** | repeat formation tester |
| **Rs** | solution gas oil ratio |
| **scf** | standard cubic feet measured at 14.7 pounds per square inch and 60 degrees Fahrenheit |
| **SNA** | sum of negative amplitudes |
| **ss** | sub-sea |
| **stb** | stock tank barrel (42 US gallons measured at 14.7 pounds per square inch and 60 degrees Fahrenheit) |
| **STOIIP** | stock tank oil initially in place |
| **Sw** | water saturation |
| **Swc** | connate water saturation |
| **TD** | total depth |
| **THP** | tubing head pressure |
| **TVD** | true vertical depth |
| **TVDSS** | true vertical depth sub-sea |
| **TWT** | two way time |
| **WGR** | water gas ratio |
| **WOR** | water oil ratio |
| **WUT** | water up to |

1. See 1.3 Key Concepts in CO2 Storage, 2022 Guidelines for Applications of the CO2 Storage Resources Management System [↑](#footnote-ref-2)