Supplementary Specifications for the application of the United Nations Framework Classification for Resources (Update 2019) to Injection Projects for the Purpose of Geological Storage

Prepared by the Injection Projects Working Group of the Expert Group on Resource Management

Geneva, 26 April 2024

Summary

This document outlines the Supplementary Specifications for the Application of the United Nations Framework Classification for Resources (Update 2019) (UNFC (2019)) to Injection Projects for the Purpose of Geological Storage. The intended use of these Specifications is in conjunction with UNFC (2019). It supersedes and replaces the Specifications for the Application of the United Nations Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) to Injection Projects for the Purpose of Geological Storage, which were released on 30 September 2016.

These Specifications approved by the Expert Group on Resource Management at its fifteenth session, 22-26 April 2024.

Preface

The 2009–2010 work plan of the Expert Group on Resource Classification (now the Expert Group on Resource Management) included an agreement to explore how the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) could be used to classify injection projects (e.g., carbon dioxide (CO_2) storage and natural gas storage). A small Task Force of industry, government and academic experts was established in early 2011 to work on this issue. Draft Specifications for the Application of UNFC-2009 to Injection Projects were first presented to the Expert Group at its sixth session in 2015 (ECE/ENERGY/GE.3/2015/4). The draft text was issued for public comment from 8 July to 15 September 2015. The Specifications were subsequently revised in response to the comments received. An accompanying document was prepared to summarize the comments received and how the Task Force responded to them (EGRC-7/2016/INF.2). The revised draft Specifications were then submitted to the Expert Group for review at its seventh session (26–29 April 2016). Following review, the Expert Group recommended that the draft Specifications be submitted to the Committee on Sustainable Energy for endorsement.

In 2019, an updated version of the United Nations Framework Classification for Resources (UNFC) was published, which normalized some of the terminologies for broader use by all resources. This update to the UNFC Supplementary Specifications for Injection Projects is aligned with UNFC (2019) and responds to the current needs of the sector.

The initial and main focus of the Specifications is on classifying injection projects related to the geological storage of CO_2, but they could also be applied to other types of injection projects for storage in geological formations, for example natural gas and hydrogen gas. Geological CO_2 storage in the context of carbon capture and storage (CCS) refers to the containment of CO_2 in deep subsurface geological "reservoirs", with the purpose of isolating the CO_2 emissions from the atmosphere. Storage of natural gas is crucial to securing supply at daily to seasonal time intervals. Storage of hydrogen gas (either derived from renewable and zero-carbon sources or from non-renewable and fossil sources) and other green gases are expected to play a major role in stabilizing energy demands (e.g. electric grid), supporting integration of variable renewable energy sources, ensuring supply reliability during fluctuations, and facilitating deep decarbonization in future energy systems... Therefore, this update also emphasizes the escalating significance of temporary storage solutions for hydrogen and other renewable gases, reflecting a broader industry trend. This focus underscores the vital role these storage systems play in enhancing the synergy between various renewable resources, ensuring a more integrated and resilient energy network.

The Expert Group on Resource Management has noted that this work is important for the future development of CCS. A reliable estimate of CO_2 storage capacity is a vital aspect of site selection.

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Contents

I. Introduction

1. This document outlines the Supplementary Specifications for the Application of the United Nations Framework Classification for Resources (UNFC (2019)) to Injection Projects for the Purpose of Geological Storage. Its intended use is in conjunction with UNFC (2019).[1]

2. This document supersedes and replaces the Specifications for the Application of the United Nations Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC 2009) to Injection Projects for the Purpose of Geological Storage, which were released on 30 September 2016.

3. This document is intended for a broad audience, including (i) policymakers and those responsible for government and regulatory resource management, (ii) companies developing a portfolio of injection projects (often referred to as transportation & storage companies), (iii) companies securing injection storage services from transportation and storage companies (for example industrial emitters of CO_2), (iv) financial investors in injection projects, such as banks, and (v) financial reporting, especially for users that report on sustainability and wish to facilitate the realization of the Sustainable Development Goals (SDGs).

4. The SDGs were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. The 17 SDGs are integrated – they recognize that action in one area will affect outcomes in others and that development must balance social, economic and environmental sustainability. Ensuring sufficient, reliable, affordable, and environmentally responsible supplies of energy and raw materials for sustainable development is a key challenge for all countries. UNFC is a tool for the effective management of national resource endowments needed for realizing the SDGs. UNFC aims to provide necessary specifications and guidelines for optimizing the sustainable management and development of resources, with positive impacts on society, the environment, local economies and employment.

II. Injection Projects Definitions

A. General Definitions

5. Geological storage refers to a broad range of technologies intended for either long-term (permanent) or temporary containment of fluids in underground geological formations. In the remainder of this document, "Injection Projects for the Purpose of Geological Storage" will be simply referred to as "injection projects" or as "storage projects".

6. This document mainly focuses on the classification of projects for geological storage of carbon dioxide (CO_2), natural gas and hydrogen (H_2). The same principles of project maturity may however

[1] United Nations Framework Classification for Resources - Update 2019. ECE ENERGY SERIES No. 61 – 2020 https://unece.org/sustainable-energy/publications/united-nations-framework-classification-resources-update-2019-ece

also be applicable to storage projects in which other types of fluid are injected into a subsurface geological formation for storage for the purpose of long-term (permanent) or temporary storage.

7. These specifications do not apply to projects for (i) the injection of water as part of a geothermal doublet or an underground thermal storage project (this is covered by the UNFC 2019 specifications for geothermal resources; (ii) the injection of water or steam as part of an enhanced oil extraction project (here, only CO_2 is considered as it serves the additional purpose of mitigating CO_2 emissions); and, (iii) the storage of nuclear waste or other toxic waste products in the subsurface.

8. For Injection Projects for the Purpose of Geological Storage, the resource is the reservoir available for geological storage. The product represents the fluids that are injected and stored by a storage project. The quantity that is classified is the quantity of a given fluid, such as CO_2, that can be stored in this reservoir by implementing an injection project. Fluids that are injected and stored are supplied by or bought from a given source (e.g. a CO_2 capture plant, a gas transport network).

9. Given that in UNFC (2019) the quantity of the product is captured under the G axis, it is also important to link the resource definition to that of the product being stored.

B. Project Definition

10. (Refer to UNFC (2019) p1; Chapter I. Application 4th paragraph; UNFC (2019), Annex I Glossary of terms, and UNFC – Glossary of Common Terms (2022) Annex I, No. 16)

11. A project within the context of the "Specifications for the Application of the United Nations Framework Classification for Resources (Update 2019) to Injection Projects for the Purpose of Geological Storage," refers to a systematic and coordinated set of activities with one of the following objectives:

(a) Long-term or permanent geological storage (hereafter indicated as “long-term storage”) of carbon dioxide (CO_2) in deep, porous rock formations with the purpose of isolating CO_2 emissions from the atmosphere;

(b) Temporary geological storage (hereafter indicated as “temporary storage”) of e.g. natural gas, hydrogen, nitrogen, helium, gasoil and several other types of fluids which are injected and withdrawn again in a cyclic fashion with the purpose to balance variable supply and demand of energy products (e.g. natural gas, hydrogen) or to secure continuous access to industrial feedstock products;

(c) Injection of CO_2 as part of a hydrocarbon extraction project to increase the recovery of natural occurrences of oil or gas. This is also referred to as Enhanced Oil Recovery (EOR) or Enhanced Gas Recovery (EGR) or Secondary Recovery.

12. Depending on the type and purpose of the storage project, the fluids considered for injection might typically comprise carbon dioxide, hydrogen, natural gas, oil/condensate or even combinations of fluids.

13. The Storage Project is bounded by the point where fluids enter the storage facility and, in the case of temporary storage, the point where fluids that are withdrawn from the store, exit the storage

facility. This may be a direct connection to a fluid supplier (purchase) or end-user (sale), or a connection to any means for transportation and distribution of fluids such as pipelines, ships, trucks and rail with tube trailers (pressurised vessels) etc.

14. A Storage Project comprises the following main physical elements within its defined boundary:
    - The underground storage space for containment of fluids (resource)
    - Wells for injection of the fluids and optionally wells for withdrawal of fluids from the store.
    - Monitoring wells and other equipment for monitoring storage operations such as reservoir pressures, induced seismicity, fluid front propagation through the reservoir
    - All surface facility components that are needed to operate the storage project such as connections to fluid supply, compressors, gas treatment, intermediate surface storage tanks, flow lines, connections to end-users or transport facilities for further distribution of fluids withdrawn from the store.
15. In some cases, the Storage Project may incorporate facilities for on-site production of a storable fluid using electricity (e.g. electrolysers, compressors). Vice versa, the withdrawn fluids may again be used for on-site production of electricity.

16. The storage project may also comprise various activities such as exploration drilling, geophysical surveys, geological and environmental studies, economic assessments, and communications that are needed to verify the existence and suitability of the storage space, obtain permits and licenses for storage development and operation, and assess the social, economic and environmental viability of the project.

17. The definition of a storage project should include:
    - The purpose for geological storage and development concept: e.g. injection only, injection plus pressure management, cyclic injection & withdrawal)
    - A description of the fluids (product) to be stored
    - A description and definition of the geological storage space being used or planned to be used for storage
    - Actual quantities of fluid stored and estimated future quantities of fluids that are expected to be stored by the project.
18. Depending on the project maturity and type of project, the project definition may additionally comprise:
    - A full characterization of the storage space and any storage space requirements to meet the project goals and relevant regulations, and to obtain a license to operate
    - Injection rates, well counts and types of wells, description of primary storage mechanisms
    - Potential environmental impacts
    - Description of surface facilities for processing of fluids including energy uses and emissions.

- Economic evaluation including projections of investments and other costs as well as revenues from storage.

19. In UNFC, it is possible and encouraged to include other metrics that a project carries and that users need. These can be scalars as explained above, but also vectors, i.e. time distributed forecasts.[2]

20. The project's definitions are used to classify the actual and future quantities of fluid to be stored according to the maturity of the defined project activities.

C. Geological Storage Resource Definition

21. (Refer to UNFC (2019) Part I; chapter I. (Application, 2nd paragraph; "Sources") and Annex I (Known Source and Potential Source) and to UNFC – Glossary of Common Terms (2022) Annex I, No. 26 and 29)
22. The geological storage resource defines the portion of an underground formation (e.g. pores or caverns) that is available and suitable for injection and containment of fluids as specified by a storage project. In this context, 'suitable' means that the storage reservoir or storage cavern is capable of containing the expected quantities of fluid (e.g. CO_2, natural gas, hydrogen, etc.) during and after storage operations, while sustaining commercial injection (and withdrawal) rates without jeopardizing the integrity of the reservoir and seal.

23. Storage spaces in porous rock formations such as sandstones or carbonates typically allow the injected fluid to migrate into the reservoir via interconnected pores and fractures. The fluids are contained by sealing formations such as impermeable clays or rock salt (halite) and/or any other geological features and trapping mechanisms prohibiting lateral and vertical migration of the injected fluids beyond the spatial boundaries as determined by the storage project, storage license and regulatory framework. Typical examples are (partially) depleted hydrocarbon reservoirs and deep saline aquifers.]

24. Storage spaces in caverns and tunnels may result from either natural processes (e.g. cavities formed by dissolution processes in carbonate rock formations) or artificially induced processes (e.g. caverns leeched in rock salt formations or tunnels excavated in hard rock formations). The rock formation in which caverns are developed is typically impermeable by nature (e.g. clays), or can be made impermeable through the application of a sealing coat to the cavern or tunnel wall (i.e. lining).

25. A "known geological storage resource" is one where the existence of a porous reservoir or a cavern for the purpose of storing fluids has been demonstrated by direct evidence such as observations and measurements in wells, geophysical measurements (e.g. seismic surveys) and/or prior extractive activities (hydrocarbon production, rock salt mining) which have resulted in the generation of the storage space. This includes evidence of a sealing formation or other trapping mechanism capable of containing injected fluids for the expected duration of storage.

26. A "potential geological storage resource" is one where the existence of a suitable storage space has not yet been demonstrated by direct evidence. Typically the presence of porous reservoirs or

[2] https://unece.org/sites/default/files/2023 01/ECE_ENERGY_GE.3_2022_2_e.pdf

potentially suitable rock formations for creating storage caverns is inferred from indirect methods such as geophysical measurements, regional geological studies based on surrounding well data and/or known analogues in a similar geological setting.

D. Product Definition

27. (Refer to UNFC (2019) Part I; Chapter I. Application 3rd paragraph, Part II; Chapter IV, Section D and Annex I Glossary of terms.)

28. A product in the context of injection and geological storage is either a:

(a) Non-combustible fluid that is being captured from a local, large and continuously emitting location (typically CO_2 from a fossil power plant or CO_2-intensive industrial process) or from the atmosphere, through Direct Air Capture, with the purpose to permanently remove it from atmosphere and/or to enhance the extraction of hydrocarbons, or,

(b) Combustible fluid that is converted from excess energy streams (e.g. hydrogen), or bought (e.g. natural gas, gasoil, oil) and temporarily stored with the intention to recover and sell it when needed (e.g. at high demand), or,

(c) Fluid used by industrial processes as feedstock (e.g. helium, hydrogen or nitrogen) which is temporarily stored to secure constant supply.

29. Fluids may be injected as liquids (e.g. oil), gases (e.g. natural gas, hydrogen) or as fluids in a supercritical state (e.g. CO_2). The fluid phase and composition may change at various points within the project boundary (e.g. well injection point, the underground storage space, before or after withdrawal and gas treatment).

30. In most cases, only one fluid is expected to be stored in the same reservoir. However, temporary storage projects may inject different gases as either working gas and as cushion gas.

E. Projects with Multiple Storage Products

31. Storage projects typically inject one type of fluid, however, there are some exceptions. In temporary storage projects, the cushion gas and working gas may have different compositions, for example to reduce cost and limit the amount of a valuable gas that is excluded from usage over a long period of time. Another example concerns the simultaneous injection of two gasses such as hydrogen and CO_2. The combination of these two gasses can be allowed to be converted into methane under the influence of micro-organisms in the subsurface reservoir. Alternatively, there are cases where hydrogen is blended with natural gas, provided that the percentage of hydrogen complies with the grid-regulated compositions. Upon production, these gases may be separated again or be used as a mixed fuel.

32. When additional fluids are considered for injection in a storage project then these quantities should be estimated and reported along with, but separately from, the fluids that are the main objective of the storage project to ensure that the economic /commercial value of the project is accurately represented.

F. Quantities Stored

33. The quantitative evaluation shall consider both the geological knowledge of the storage resource at the time of the evaluation, and the engineering parameters relating to the properties of the geologic storage space as well as the chosen technical solutions and the social, economic and environmental conditions that develop from the project. The quantity available will also depend on the composition of the injected fluid and the prevailing temperature and pressure conditions in the reservoir or cavern during storage. These conditions should be reported with the quantity at the relevant parts of the project and storage facility.

34. The estimated quantity range associated with the storage project is determined by the amount of fluid that can be injected and contained in the subsurface reservoir or cavern (i.e. the storage resource). The storage quantity ranges are typically limited by physical, economic, and regulatory boundaries:

(a) Physical boundaries are typically defined by the geometrical volume and rock characteristics of the storage space, the allowable pressure ranges to secure the geomechanical integrity of the reservoir rock, seal's extension, technical constraints of the injection wells, injection rates, etc. that may take place without risking leakage via lateral or vertical pathways (e.g. beyond spill point in case of hydrocarbon reservoirs);

(b) Economic boundaries are typically defined by the costs of creating the storage facility (e.g. wells, platforms etc.), compression for injection, injectivity, the recovery factor and withdrawal rates for stored fluids (in case of a temporary storage project), and the limitations of the supply/demand chain to which the Storage Project is connected (e.g. capture and transport in case of Carbon Capture, Utilization, and Storage (CCUS));

(c) Regulatory boundaries (international and national) may be defined by the licenced area, the allowable and regulated pressures, permit constraints (e.g. injection quantity or operational timeframe), and the licenced storage space that may include a boundary for migration of injected fluids or pressure effects.

35. Reported injected fluid quantities may be those quantities attributable to the injection project as a whole, or to an asset, e.g. the proportion of those quantities that is attributable to the reporting entity's interest in the injection project. The reporting basis and the proportions shall be clearly stated in conjunction with the reported quantities.

36. The quantity stored in one reservoir may be the aggregated quantities from several sources, from one single source or part of the total quantity from one source.

37. Quantities estimated at different reference points in the same project can be aggregated. The evaluator shall ensure coherence of the aggregation. UNFC, Part II, Section II provides additional guidance on the issue of aggregation of estimated quantities. In general, aggregated quantities must be compatible and at least be associated with the same type of fluids and have a similar maturity. The reporting should also explain how the quantities are aggregated.

1. Quantities for Long-term Storage Projects

38. Projects intended for long-term storage of fluid (typically CO_2) should report the total quantity (volume or mass) of CO_2 that is expected to be injected over the entire duration of the storage project

until the cease of operations. This includes any quantities that might dissolve in the formation water (e.g. storage in saline aquifers), be trapped by capillary forces, at residual saturations or chemical reaction within the formation, or be adsorbed by rock the formation (e.g. in coal bed methane recovery projects).

39. How much of the total available storage space of a given resource will eventually be utilized for the injection of fluids, depends on the specifics of the storage project being evaluated. Potential quantities that could be injected by a future (follow-up) storage project in the remaining (unused) storage space, should be classified separately.

40. In the case of an enhanced hydrocarbon extraction project (e.g. EOR), the injection part of the project is likely to be developed in parallel with the hydrocarbon extraction part, where the two activities may have the same project maturity, but with two different types of fluid quantities, i.e.: the quantities of hydrocarbons that will be extracted and the fluid quantities that will be injected. The classification and estimated quantities of fluid (e.g. CO_2) that are expected to be injected, shall be reported according to the UNFC (2019) Specifications for Injection Projects as described in this document. The estimated quantities of extracted oil and/or gas shall be reported according to the Supplementary Specifications for Petroleum Resources. The injected quantities and produced hydrogen quantities must be estimated on a consistent basis, e.g. with consistent project constraints and uncertainty ranges.

41. Some of the CO_2 that is injected as part of an EOR project, may come back to surface via the hydrocarbon extraction wells. These quantities may be reported as lost quantity within the classification of the injection project and may be separated for re-injection.

2. Quantities for Temporary Storage Projects

42. Storage projects for temporary containment of fluids are operated on the basis of alternating injection and extraction (withdrawal) cycles. Several different quantity measures may be associated with such projects. The total quantity that can be stored will be the sum of the quantity that is currently in storage and can be withdrawn (often referred to as working gas), the quantity of permanent inventory gas necessary to maintain sufficient pressure for withdrawal purposes (base gas or cushion gas), and the quantity that may still be injected at any point of an injection and withdrawal cycle. In applying UNFC (2019) to temporary storage projects, it may be relevant to distinguish these quantities in the reporting.

43. Projects for temporary storage may involve numerous injection and withdrawal cycles during a single year. Under these circumstances, the storage project may also report the cumulative volume of fluid that is (expected to be) injected over an entire year as well as the number of injection and withdrawal cycles per year.

44. If a partly depleted hydrocarbon field is being used for the development of a temporary storage project, then the remaining hydrocarbons and other fluids in place that have not been extracted by the hydrocarbon extraction project, may serve as cushion gas needed to operate the storage project. In this specific case, the remaining hydrocarbon quantities should be classified as a petroleum resource as these quantities are not injected by the storage project. Once the storage project has

ended its operations, the remaining cushion gas may be produced by implementing a petroleum project.

G. Reference Points

45. (Refer to UNFC (2019) Part II; Chapter IV; Section F - Reference Point.)

46. The Reference Point is a defined location within an injection operation at which the reported quantities are measured or estimated. The Reference Point may be the custody transfer point from a pipeline operator to a storage site operator, or the last metered quantity prior to injection. The Reference Point shall be disclosed in conjunction with the reported quantities. Where the Reference Point is not the point where custody is transferred to the storage site (or the entity's downstream operations), and such quantities are classified as E1, the information necessary to derive estimated quantities shall also be provided.

47. In a temporary storage project there may be two reference points, one for inflow and one for outflows.

H. Project Lifetime

48. (Refer to UNFC (2019) Part I, Chapter III, 3rd paragraph.)

1. Phases in the Project Lifetime

49. Project lifetime refers to the complete duration over which a geological storage project remains under operator management, whereas the conclusion of liability and responsibilities may happen long after cessation of injection, possibly requiring an extended monitoring period to demonstrate a safe containment (e.g. in case of CO_2 storage). A typical injection project life has 4 different phases: Preparation, Operation, Closure and Post-Closure Phases.

50. The Preparation phase involves site selection, exploration and appraisal data gathering activities, geological assessments, environmental impact assessments and risk assessments, permit requests, financing and establishing the general feasibility of the entire project. When the technical, economic and environmental feasibility is established, and regulatory permits and funding have been secured and agreed upon, this is followed by a construction phase where all remaining project facilities are constructed including wells.

51. The Operational phase describes the period when fluids are actively injected into the geologic formation and/or extracted (cyclic storage) for use.

52. The Closure Phase includes the plugging and abandonment of the project injection wells (or their conversion to monitoring wells) and the termination of extraction activities (in the case of temporary storage). Typically, the project site is closed for operations and prepared for long-term monitoring

in the case of long-term storage. This closure may warrant a certificate issued by the government or government designee based on regulations governing the project.

53. Post-Closure Phase: This phase begins after the closure certificate of the site is issued and injection and withdrawal operations cease. The applicable regulations will require a period of monitoring and potential interventions to ensure that the stored fluids remain safely contained and that there are no leakages or other adverse events from the project. Depending on risk assessment of the geological store and applicable regulations, this phase can last for decades. Once the regulator accepts that the site data and monitoring strategy supports an acceptably low forward-looking residual risk then liabilities can be transferred to the government or a government designee, if applicable. This process usually requires approved documentation demonstrating that:

- The injected fluids and pressure response behave in accordance with the modelled behaviour
- There is no ongoing unremediated and unacceptable leakage
- The storage location is developing toward a condition of long-term stability, and
- Residual risk of leakage or adverse impacts from the project meet acceptable thresholds for liability transfer
- The long-term monitoring strategy is fit for purpose and satisfies regulatory requirements.

2. Project Lifetime Constraints

54. Technical constraints on the project lifetime might include the evaluated integrity constraints for the geological storage complex (ability to contain injected fluids) for a determined (cyclic storage) or indefinite (long-term storage) period of time, capacity of the system in relation to pressure management constraints (e.g. prevent overpressure development, pressure interactions between adjacent projects, mitigative extraction of brine to reduce pressures), the minimum technically feasible injection rates and extraction rates (for cyclic storage), key facility design life e.g. wells and surface facilities, and/or possible equipment failures and interventions. It may also relate to environmental constraints of a project such the acceptable level of surface impacts and risks (e.g. subsidence, seismicity, leaking incidents).

55. Commercial constraints on the project lifetime might include the period of market availability for storage e.g. duration of associated CO_2 source projects, or excess product availability for cyclic storage, as well as storage contracts where 'spot markets' are not available.

56. Regulatory or legal constraints on the project lifetime include the end of resource exploitation entitlement (e.g., end of storage licence period) and any limits defined in permits under which the project establishes license to operate (e.g. maximum capacity for long-term storage or agreed project duration).

#. Ownership of CO2 can pose legal challenges, especially in scenarios where multiple CO2 plumes interact, leading to potential violations due to unexpected CO2 movement. Determining the appropriate proportion of responsibility among different operators or countries involved can be particularly challenging. This complexity can arise from issues such as overlapping jurisdictions, varying regulatory frameworks, and differing interpretations of liability, further complicating the resolution of disputes."

#. There is a combined commercial and regulatory requirement for financial assurance from the operator, who must demonstrate through bonding, insurance, or other financial assurance mechanisms that it has the financial means and stability to execute these projects successfully over their entire lifetime including the mitigation and compensation of potential negative impacts and damages occurring as a result from injection and storage. For CO_2 projects this could be 60+ years

57. Usually, a competent party approved by the government should issue a certificate once all the conditions have been met. All liability responsibilities must be fulfilled as per local legal requirements.

58. Reduced or halted injection and withdrawal due to a *force majeure* event (e.g., armed conflict, typhoon, landslide, flooding, earthquake, volcanic eruption) or unexpected operational issues are generally not included in the operations forecast. If operation is halted for an extended period of time (>1 year), then the classification of the Geological Storage Resources should be reviewed, and an updated resource assessment prepared, which discusses and explains the likelihood of restarting operations.

I. Access to Storage Resources

59. The storage operator must have the entitlement to develop and exploit the underground storage space and linked surface storage facilities for the duration of the project. Entitlement is typically conferred through the award of a storage licence for the area containing the project surface and subsurface footprint, or through lease agreements and/or land purchase where pore space development rights are under private ownership. Entitlement provides the entity the legal right to develop and monetise the underground formation for storage for the duration of the license.

60. In addition to the entitlement to access and develop the applicable pore space associated with the Project, the entity will require approval for all necessary permits for project activities in alignment with the current project phase e.g. for construction, injection operations, site closure and long-term storage accreditation. These are granted by the applicable regulatory authorities, which may be independent of the legal entity conferring development entitlement rights.

61. The developers of injection projects gain and secure access to the storage space through licences and permits, or other contracts, issued by the applicable government authorities. These licences and permits typically allow the entity, subject to applicable regulations, to:

(a) Explore and appraise the storage space, and

(b) After final investment decision, to develop, a project or projects for injection and storage, and

(c) during the operational phase, inject, store and eventually withdraw fluids from the storage space.

62. For an injection project to be classified as socially, environmentally and economically viable according to UNFC, all required storage permits or other relevant permits for the operation of the Storage Project must be in place, or there must be reasonable expectations that such permits will be

in obtained within a reasonable time frame. Many distinct permits from regulatory authorities may be required for a single project e.g. at international, national (or federal) and local level.

63. There is not a single regulatory framework available to permit injection storage project types (e.g. CO_2 storage) globally. A project under assessment in a region that is lacking the regulatory framework to permit all necessary activities for the Project, may be classified as too early a stage to determine environmental-social and economic viability (E3.2) unless the reporting entity can demonstrate that the necessary regulatory system will be clarified in the foreseeable future (E2).

J. Access to Market

64. (Refer to UNFC (2019) Part I; chapter VII)

65. A storage project requires customers who provide injection fluids and gas to the storage facility and connected Geological Storage Resource through commercial agreements. The ownership of the infrastructure and commercial agreement should determine how risk and reward are allocated.

66. Business models for injection projects may or may not be supported by government incentives. A storage project may serve local, regional, or international customers (either the entity itself, or third-party customers) requiring storage services with viable connections to the storage site. The commercial agreements by which a storage project monetises the storage space may vary by project type, e.g. through:

- A contract for regulated storage
- Servicing spot markets and the ability to benefit from price fluctuations for the fluid stored
- Sale of associated hydrocarbon production in EOR projects
- Integrated projects where the storage of fluids or gasses is funded through the sale of other associated low carbon and renewable power products.

67. For an injection project to be classified as economically viable, it must be demonstrated that there is high confidence that the project will have access to a market. The market availability must be aligned with the project forecast (rates, total capacity, duration, and availability). To demonstrate high confidence, the storage project must either have signed storage contracts (or there must be reasonable expectations that such contracts will be signed within a reasonable time frame) or be part of an integrated project at an equivalent environmental-socio-economic maturity level.

68. For an injection project to be classified with a reasonable expectation of economic viability, the reporting entity must demonstrate that a market exists and is aligned with the project forecast (rates, total capacity, duration and availability) exists or will develop in the required foreseeable future.

K. Corporate versus National Resource Reporting

69. (Refer to UNFC (2019) Part II; Chapter II.)

70. (UNFC (2019), Part II, Section IV J provides guidance on the issues of national resource reporting and aggregation of estimated quantities.)

71. UNFC is designed to evaluate and classify resources associated with single projects. For reporting corporate or national Geological Storage Resources, the estimated quantities of the '*single*' projects may be aggregated. In this case, the quantities can only be aggregated for a single type of storage product and for comparable storage projects with a similar classification.

72. The quantities associated with a storage project should be reported by only one entity. For example, in a CO_2 storage project, the quantity should not be reported also by the CO_2 emitter as this could lead to a duplication of captured and stored quantities of CO_2.

L. E- Axis Categories

73. (Refer to UNFC (2019) Part I, Annex I, p6 E Axis – Environmental-Socio-Economic Viability; Part I, Annex I, p8 Definition of Sub-categories; Ref to UNFC (2019) Part II p14; Chapter IV, Section H.)

74. (Annex I provides the definition of E-axis Categories and Sub-categories with additional geological storage context.)

I. Treatment of Policy Support

75. It is recognized that:
    - A variety of policy support mechanisms, regulatory instruments, and financial incentives (e.g., feed-in tariffs, premiums, grants, tax credits etc.) are offered by government bodies with the intention of promoting development and to reflect the value that off-takers (the party who buys the product being produced by the project or uses the services being sold by the project) or the government gives on injection projects
    - Some subsidies for geological storage may be available on a project-by-project basis, while others may be generally available to specific categories of geological storage projects in the market
    - Subsidies applied to a storage project are available for only a limited period, phased out over time or stopped once a pre-determined threshold is met. This should be accounted for in economic forecasts and project viability assessment. An assumption that subsidies might continue beyond the current agreed period is not supported without the entity demonstrating a case which supports the validity of this assumption.

76. Use of sub-category E1.2 requires disclosure of the type of government subsidies and/or other considerations that make storage viable, together with their anticipated future availability as at the defined effective date.

2. Considerations for Market Conditions

77. In accordance with the definitions of E1, E2 and E3, economic assumptions shall be based on current market conditions and realistic assumptions of future market conditions. Except where constrained by regulation, assumptions of future market conditions should reflect the view of either:

(a) The organization responsible for the evaluation;

(b) The view of an independent evaluator; or,

(c) An independent publication, which is considered to be a reasonable forecast of future market conditions. The basis for the assumptions (as opposed to the actual forecast) shall be disclosed.

3. Considerations for Category E3 - Non- Viable Projects

78. Category E3 is subdivided in three Sub-categories (E3.1, E3.2 and E3.3). The quantities associated to a storage project may be distributed over one or more of these Sub-categories as described below.]

79. Sub-category E3.1 is used only for products supplied to the storage site that are unused (not marketed) by the project, whereas the to-be-stored quantities of the project will require their own classification on the E axis. Reporting of E3.1 is therefore optional. E3.1 for example considers:

- Quantities that are lost in the transportation to storage facilities prior to injection
- Quantities recovered from the storage reservoir and used internally for operating the storage site (in case of cyclic storage of energy carriers)
- Conversion and gas treatment losses
- Fugitive losses during injection and exogeneous losses in the reservoir (non-recoverable quantities in case of cyclic geological storage projects)
- Unrecoverable cushion gas
- Back-produced fluids that are contaminated beyond acceptable specifications for use or sales.

80. Sub-category E3.2 is considered for cases where, for example:

- Required regulations to permit project development and operations are not yet in place and are subject to further definition and implementation
- There is a market gap and therefore crucial information is lacking to establish a firm business plan
- The application for a storage license or permit is suspended because required information or assessments are incomplete and therefore the entity is unable to determine the socio-economic-environmental viability of the storage project

81. Sub-category E3.3 is considered for cases where, for example:

- Storage site(s) cannot be connected to a market for supply/demand (e.g., due to large distance, absence of a transport pipeline or other viable route, lack of market in the region)
- Projects lack a viable business model in the foreseeable future to be economically viable (e.g., insufficient income stream and/or grants to support project operations)

- Approvals for project development and operations are unlikely, e.g., due to social acceptance issues, conflicting and interfering uses at the surface or in the subsurface, impacts on environment, containment risk etc,
- Projects for storage or transfer of fluids are expected to be prohibited by policies and legislation and/or where the necessary regulatory framework cannot be established.

4. Considerations for suspended projects

82. When activities in a project on injection (E1) are suspended due to social, economic or environmental concerns, yet the resumption of injection and storage operations is expected to become socially, economically and environmentally viable again in the foreseeable future, then the estimated remaining technically available quantities shall be reclassified as E2. If the resumption of injection and storage operations is not expected to become socially, economically and environmentally viability in the foreseeable future then the estimated remaining technically available quantities shall be reclassified to E3.

M. F-Axis Categories

83. (Refer to UNFC (2019) Part I, Annex I, p6 F Axis – Technical Feasibility and Maturity; Part I, Annex I, p8-9 Definition of Sub-categories; Part II p14; Chapter IV, Section I.)

84. (Annex I provides the definition of F-axis Categories and Sub-categories with additional geological storage context.)

1. Distinctions between and considerations for F2 and F3

85. Category F2 is used for projects where the presence of the storage space has been confirmed by exploration and appraisal wells (e.g. saline aquifers), prior extraction of hydrocarbons, (e.g. depletion of porous reservoir space), or the mining of rock (development of salt caverns and rock caverns). Additional site-specific studies and/or appraisal (drilling, testing, geophysical surveys) are needed to confirm the suitability of the storage space, injection wells and other technical components for the injection and storage of fluids and application of operational parameters as described by the storage project. The Sub-categories distinguish situations were such studies and appraisal activities are either ongoing (F2.1), on-hold or significantly delayed (F2.2) or not pursued because of limited potential (F2.3).

86. Category F3 is used for projects where the presence of the storage space is not yet demonstrated by a well or by prior extractive activities (hydrocarbons, salt mining, etc.). This is typically the case for undrilled saline aquifers and rock formations which are inferred from indirect observations, surface geophysical measurements and geological studies. In some cases a well may have been drilled, but not yet been successful in confirming the required characteristics of the storage space.
87. A project in Sub-category F3.1 has finished all necessary site-specific studies and thereby gained sufficient confidence for development to warrant the drilling of an exploration well.

88. Sub-category F3.2 is appropriate when specific leads for geological storage have been identified and additional studies such as surface-based (geophysical) exploration or pre-feasibility and de-

risking studies are required to gain sufficient confidence to justify and plan any exploration drilling and testing.

89. Sub-category F3.3 is appropriate when detailed local exploration studies have not been made of a project location and potential storage spaces have been inferred from regional geological and geophysical studies. Sub-category F3.3 can also be used for international, national and regional inventory assessments of development potential for which no site-specific storage projects have been defined.

90. Note that, by definition, storage quantity estimates associated with undiscovered storage resources (F3) are also classified as G4 under the 'G' Category.

2. Considerations for Category F4 - New Technologies

91. Category F4 is provided for situations where a conceptual project is defined based on technology that is yet to be demonstrated as technically and commercially viable. Specifically for underground storage projects this may include proof that long-term storage requirements can be met and that associated risks can be monitored and mitigated during injection and after closure of the project.

92. F4 shall not be reported without specifying one of the three F4 Sub-categories.

93. By definition, the quantities associated with F4 Sub-categories are classified as G4 and shall represent expected quantity ranges of a theoretical project that is anticipated once the technology is ready to be deployed at a commercial scale.

3. Remaining Storage Resources

94. Where an identified Storage Resource is not expected to be fully utilized by a proposed Project, the remaining storage resource may be addressed with a separate conceptual project that has a different E-F-G category reflecting the lesser maturity and definition of the project.

N. G-Axis Categories

95. (Refer to UNFC (2019) Part I, ANNEX I, p7 G Axis – Degree of Confidence; Part I, Annex II, p9 G Axis – Degree of Confidence; Part II p15; chapter IV, section M.)

96. Annex I provides the definition of G-axis Categories and Sub-categories with additional geological storage context.

97. Estimated storage quantities shall be auditable and documented in sufficient detail that would allow an independent evaluator or auditor to clearly understand the basis for estimation of the reported quantities and their classification (data/information, methodology, constraints, assumptions, and forecasts).

98. The level of confidence for storage quantities that are classified on the G-axis as G1, G2 and G3 are defined as "high", "medium" and "low". The terms "Low Estimate", "Best Estimate" and "High Estimate" may be used to correspond to quantities that are classified on the G-axis as G1, G1+G2 and G1+G2+G3, respectively. Alternatively, P90-P50-P10 may be used respectively.

99. The reported ranges reflect all uncertainties impacting the estimated quantities of fluid that are forecast to be injected and stored by the project. For storage projects, this typically includes uncertainties in the geological parameters needed to estimate the storage quantities associated with the storage resource and the expected injection rates, operational parameters which determine the efficiency of operation, or market conditions which may determine the range for economically viable operations. In projects for temporary storage this may also relate to the withdrawal rates and recovery factors.

100. For projects for the purpose of temporary storage the uncertainties may also extend to the total quantity of fluid that can be injected into and withdrawn from the store on an annual basis, as well as the total number injection and withdrawal cycles that are expected to be operated per year.

101. The rate of injection (and withdrawal in the case of a temporary storage project) of fluids (for example, in terms of GW, m^3/day, M tons/year) is often a key parameter of any storage project, and in turn, this is of importance for markets and regulators. The associated projected forecast of injection (and production) should be defined and documented based on the results of integrated subsurface studies looking at capacity, injectivity and containment to determine low, base and high cases or P90, P50, P10 estimates as mentioned in UNFC (2019) as the basis for estimating the quantities associated with the Storage Resource.

102. Estimated storage quantities associated with injection projects and geological storage operations that are classified in different categories on the economic or feasibility axis shall not be aggregated with each other without proper justification and disclosure of the methodology adopted. The specific classes that have been aggregated shall be disclosed in conjunction with the reported quantity and given units of measurement (e.g., 111+112+221+222) and a footnote added to highlight the fact that there is a risk that projects that are not classified as E1F1 (Commercial Projects) may not eventually achieve commercial operation.

103. Where estimated quantities have been aggregated from multiple projects, consideration should be given to sub-dividing the aggregated totals by geologic formation and by location/project.

1. Classifying known versus prospective Storage Projects

104. Estimated storage quantities associated with known storage resources in potentially viable projects shall be classified and reported using the 'G' Categories, G1, G2 and G3.

105. Estimated storage quantities associated with prospective storage projects shall be classified and reported using the 'G' Category G4 or its Sub-categories G4.1, G4.2 and G4.3.

2. Probability of discovery for Potential Storage Resources

106. For prospective storage projects based on a potential and undiscovered storage resource (i.e. to be classified as F3 and using the G4 category for the quantity ranges), the probability of discovering a suitable storage resource by means of drilling an exploration well and performing well tests, should also be reported. The report may also mention the method and information used to determine the probability of discovery.

107. The probability of discovery is the chance that further exploration, drilling, and well testing of a potential and unproven storage space will result in the confirmation of the technical viability of the storage resource and a validation and improved estimation of the associated storage quantities. This will typically be assessed considering the key factors that are required to achieve a discovery such as the presence of an interconnected storage space that can be accessed by one or more wells, a competent seal and/or trapping mechanism, sufficient permeability to support economic injection (and withdrawal) rates and other geological parameters that are relevant for evaluating the technical feasibility of the project.

108. The quantities reported in the 'G' Category G4 or its Sub-categories G4.1, G4.2 and G4.3 are 'un-risked' in that they are the quantities that may be expected to be reported for the project once Known, regardless of the Probability of Discovery.

O. Evaluator Qualifications

109. (Refer to EGRM-14 §§ 15 (https://unece.org/sites/default/files/2023-01/ECE_ENERGY_GE.3_2022_2_e.pdf) and the referenced revised Guidance Note on Competency Requirements for the Estimation, Classification and Management of Resources: (https://unece.org/sites/default/files/2022-10/ECE_ENERGY_GE.3_2022_4-Competency-Guidance-revised-11.10.2022_clean_0.pdf))

110. Evaluators shall demonstrate documented expertise and relevant experience in the estimation of geological storage resources associated with the type of injection projects under evaluation.

111. In addition, relevant government, industry, or financial reporting regulations may require an Evaluator to have specific qualifications and/or experience. Regulatory bodies may explicitly mandate specific qualifications and/or experience, as defined by regulation.

112. Any public report detailing the storage resources shall disclose the name of the evaluator (company and person), including qualifications and experience, state whether the evaluator is an employee, officer or owner of the entity preparing the report, and, if not, name the Evaluator's employer and state its relationship to the reporting entity.

113. Estimation of storage resources is typically a team effort involving several technical and geological disciplines. The reporter remains responsible for the report being correct. This will typically be the head of the reporting organisation. It is, however, recommended that only one evaluator signs the storage resources report and that this person is authorised and accountable to the responsible person

for the whole of the documentation. The evaluator accepts overall responsibility towards the responsible person for a storage resource estimate and supporting documentation prepared in whole or in part by others and is satisfied that the work of the other contributors is acceptable.

114. Reports on the application of UNFC (2019) to Injection Projects for the purpose of Geological Storage should be provided separately for organizations or entities such as national governments, financial institutions and companies who wish to establish appropriate quality assurance mechanisms, qualification criteria and/or disclosure obligations that can be adopted in circumstances where competency requirements are considered desirable. The recommendations are available on the UNECE website and should be read in conjunction with the Guidance Note on Competency Requirements for the Estimation, Classification and Management of Resources.[3]

P. Units

115. In order to facilitate global comparability of product estimates, it is recommended that the Système International d'Unités (SI units) is used for reporting of estimates. However, it is recognized that there are traditional measurement units that are widely used and accepted for certain products; where such units are used for reporting purposes, conversion factors to SI units shall be provided. Similarly, where quantities are converted from volume or mass to energy equivalents, or other conversions are applied, the conversion factors shall be disclosed.

Q. Reporting a Project Classifcation

116. (Refer to UNFC (2019) Part II p15; Chapter IV, Section N.)

117. Project classification shall be supported by a Project description and summary of the key elements of the Project upon which the classification is based. This should include a description of:

- The geological storage resource including the state of knowledge about the resource and uncertainties about its characteristics including volumes and injectivity
- The project design summary including technology applied for injection, storage, and (where applicable) withdrawal and conversion. Conversion efficiency should be stated for any energy conversions
- Any additional inputs into the storage system (e.g. fluids and associated emissions) at intermediate transport nodes within the project boundary
- The storage product (e.g. CO_2, natural gas, hydrogen, energy content, etc.)
- The point(s) at the project boundary where the product is bought, sold, used or transferred to a transport network
- The project lifetime and what are the key factors that limit that lifetime, for example results of monitoring verification
- For long-term storage projects, the storage efficiency should also be reported
- For temporary storage projects, the expected project capacity factor (percentage of total injection and storage capacity being used on yearly basis) considering daily or annual

3 https://unece.org/sites/default/files/2022-03/ECE_ENERGY_GE.3_2022_4.pdf

variability and possible trends of injection and/or production over the lifetime. This includes the swing frequency that the facility is designed for (hourly, annually, over decades) which would relate to costs, recognising that return on capital employed requires that capital is employed.

118. The basis for calculating the expected resource quantity, including the basis for the G1, G2, G3 (or G4.1, G4.2, G4.3) range:

- The project's license to operate including access to the storage resource, including licences, permits, and ownership
- The environmental and social impact of the project
- The proposed timeline for the Project – at least for the next development or evaluation phase and including any pending key decision points
- Access to the market or other off-take agreements are necessary for the products to be used or sold.

119. The reporting of quantities should include specific conditions (e.g. temperature, pressure conditions, fluid phase), composition and/or any conversion factors used in the estimations.

120. The final classification should include reasons for the selection of the E and F Categories that are applied and state the E, F Categories, along with the G1, G2, G3 estimates.

Annex I

E/F/G Table

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
E1	Development and operation are confirmed to be environmentally-socially-economically viable.	Development and operation are environmentally-socially-economically viable based on current conditions and realistic assumptions of future conditions. All necessary conditions have been met (including relevant permitting and contracts) or there are reasonable expectations that all necessary conditions will be met within a *reasonable timeframe* and there are no impediments to the delivery of the product to the user or market. Environmental-socio-economic viability is not affected by short-term adverse conditions provided	**E1.1**	Development is environmentally-socially-economically viable based on current conditions and realistic assumptions of future conditions.	E1.1 is provided to differentiate projects that are environmentally-socially-economically viable without project-specific subsidies or environmental and regulatory considerations. Use of E1.1 is acceptable if the viability of the project depends on generic tax measures or subsidies. If the use of subsidies is not clear or if it is inappropriate to make this differentiation, then the project may be classified as E1. Environmental and social aspects should align with the UN SDG's.
			E1.2	Development is not environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions but is made viable through government subsidies and/or other considerations.	This includes project-specific subsidies or considerations other than generic needed for present or anticipated development and operation. If subsidies were used in the past (e.g. to drill a well), they are no longer relevant to the classification of the Geological Storage Resource.

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
		that longer-term forecasts remain positive.			
E2	Development and operation are expected to become environmentally-socially-economically viable in the foreseeable future.	Development and operation are not yet confirmed to be environmentally-socially-economically viable but, based on realistic assumptions of future conditions, there are reasonable prospects for environmental-socio-economic viability in the *foreseeable future*.	**No Sub-categories defined**	-	In the geological storage context, the foreseeable future is within a maximum of ten years from the effective date of evaluation and is in terms of when the (irreversible) commitment to build the project will be made.
E3	Development and operation are not expected to become environmentally-socially-economically viable in the foreseeable future ***or*** evaluation is at too early a stage to determine environmental	On the basis of realistic assumptions of future conditions, it is currently considered that there are not reasonable prospects for environmental-socio-economic viability in the foreseeable future; or, environmental-socio-economic viability cannot yet	**E3.1**	Estimate of product that is forecast to be developed, but which will be unused or consumed in operations.	This classification is only for the products that are unused (i.e. not injected and/or stored) by the project, whereas the used (i.e. injected and stored) quantities of the main project will require their own classification on the E axis. Reporting of E3.1 is therefore complementary to the main project and optional. E3.1 for example considers (i) quantities that are lost in the transportation to storage facilities prior to injection, (ii) quantities recovered from the storage reservoir and used internally for operating the storage site (in case of cyclic storage of energy carriers), (iii) conversion and gas treatment losses, (iv) fugitive losses during injection or exogeneous losses in the reservoir (non-recoverable quantities in case of cyclic

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
	- socioeconomic viability.	be determined due to insufficient information. Also included are estimates associated with projects that are forecast to be developed, but which will be unused or consumed in operations.			geological storage projects), or (v) quantities of re-produced CO_2 in an EOR project.
			E3.2	Environmental-socio-economic viability cannot yet be determined due to insufficient information.	Use of E3.2 is considered for example in cases where (i) required regulations are not yet in place and are subject to further definition and implementation, or (ii) there is still a market gap and therefore crucial information is lacking to establish a firm business plan, or (iii) the application for a license is delayed because required information or assessments are incomplete.
			E3.3	Based on realistic assumptions of future conditions, it is currently considered that there are not reasonable prospects for environmental-socio-economic viability in the foreseeable future.	Use of E3.3 is considered for example in cases where (i) sites cannot be connected to a market for supply/demand (e.g. due to large distance, absence of a transport pipeline), or (ii) sites lack a viable business model, with no line of sight to a carbon tax or other incentive to make a storage project economically viable, or (iii) the likelihood of receiving approval is low, e.g. due to social acceptance issues, conflicting and interfering uses at the surface or in the subsurface, impacts on environment, etc., or (iv) the deployment of underground storage is being prohibited by policies and legislation and/or where the necessary regulatory framework cannot be established.

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
F1	Technical feasibility of a development project has been confirmed.	Development or operation is currently taking place or, sufficiently detailed studies have been completed to demonstrate the technical feasibility of development and operation. A commitment to develop should have been or will be *forthcoming* from all parties associated with the project, including governments.	**F1.1**	Production is currently taking place.	In the context of geological storage, this relates to "injection currently taking place" and may also include production (or withdrawal) in case of a temporary storage project. The storage project is operational. Injection, containment and extraction (in the case of a cyclic storage project) are all performing in accordance with all agreed and required technical specifications and safety norms. There is a fully functional connection between the underground storage reservoir, the surface facilities for injection, extraction and treatment of the storage product, and supply/demand (e.g. transport/distribution infrastructure or on-site capture, production, conversion and usage). Commercial projects may evolve from a pilot/demonstration phase that remains in many cases operational to a commercial project phase with the pilot as part of it.
			F1.2	Capital funds have been committed and implementation of the development is *underway*.	F1.2 is used to distinguish a project that is 'under construction' from a project that is operating (i.e. F1.1). Upon realization, commissioning will be required to confirm that the entire storage project operates in accordance with all agreed and required technical specifications and safety norms. This includes the connection with supply and demand of the storage product
			F1.3	Studies have been completed to demonstrate the technical feasibility of development and operation. Projects can be scaled up from	F1.3 may be used for projects that are justified for development but are awaiting other approvals (e.g. final investment decision, contracts) that are expected to be forthcoming in a short timeframe. The technical feasibility has been proven and any adverse operational issues related to the required processing of fluids

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
				the operational/ proven pilot scale. There shall be a reasonable expectation that all necessary approvals/contracts for the project to proceed to development will be *forthcoming*.	before and before injection and after extraction, the containment of injected fluids in the reservoir or the safe and efficient performance of injection and extraction can be managed.
F2	Technical feasibility of a development project is subject to further evaluation.	Preliminary studies of a defined project provide sufficient evidence of the potential for development and that further study is warranted. Further data acquisition and/or studies may be required to confirm the feasibility of development.	**F2.1**	Project activities are ongoing to justify development in the *foreseeable future*.	The storage space has been identified based on available well data, geophysical data and/or information from prior extractive activities (e.g. hydrocarbon production or rock salt mining). While further planning and preparation for development is justified, additional site-specific studies and/or appraisal (drilling, testing, geophysical surveys) are needed to de-risk and confirm the technical viability of the storage space, injection wells and other technical components for the application of the type of fluid and operational parameters considered by the storage project
			F2.2	Project activities are on hold and/or where justification as a development may be subject to *significant delay*.	A potential reservoir (geological storage resource) has been identified based on available geophysical data and/or well data. Additional geophysical data acquisition, drilling and testing is needed to complete the technical feasibility assessment and de-risking of the site, yet the funding/financial investment decision for such investigations is still unconfirmed or put on hold.
			F2.3	There are no plans to develop or to acquire additional data at the	Although a potential reservoir (geological storage resource) has been identified based on available geophysical data and/or well data, the

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
				current time due to limited potential.	available evaluation studies and/or reservoir tests have found unfavourable characteristics for injection and geological storage to a degree that further drilling, investigation and development cannot be justified at the current time.
F3	Technical feasibility of a development project cannot be evaluated due to limited data.	Very preliminary studies of a project, indicate the need for further data acquisition or study to evaluate the potential feasibility of development.	**F3.1**	Site-specific studies have identified a potential development with sufficient confidence to warrant further testing.	F3.1 is used for prospective projects in which a potential storage resource has been evaluated by regional and local geological and geophysical exploration studies to the point that drilling of exploration wells and/or testing of existing wells is essentially needed to confirm the presence of the reservoir and seal, test whether geological conditions are present to inject and store fluids/gases and determine the storage capacity and performance.
			F3.2	Local studies indicate the potential for development in a specific area but require more data acquisition and/or evaluation to have sufficient confidence to warrant further testing.	Use of F3.2 is appropriate for prospective projects in which specific leads for geological storage have been identified and further studies such as surface-based (geophysical) exploration or pre-feasibility and de-risking studies are required to gain sufficient geological confidence to justify and plan any exploration drilling or testing.
			F3.3	At the earliest stage of studies, where favourable conditions for the potential development in an area may be inferred from regional studies.	Use of F3.3 is appropriate when detailed local exploration studies have not been performed yet and the potential for geological storage is based on, or inferred from regional geological storage potential studies or the investigation of aspects that define the geological play for storage. F3.3 can also be used for international, national and regional inventory assessments of development potential for which no site-specific storage projects have been defined yet.

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
F4	No development project has been identified.	Remaining quantities of product not developed by any project. These are quantities which, if produced, could be bought, sold or used (i.e., electricity, heat, etc., not wind, solar irradiation, etc.).	**F4.1**	The technology necessary is under active development, following successful pilot studies, but has yet to be demonstrated to be technically feasible for this project.	F4 alone may not be used for site-specific storage projects. F4 must be associated with a proposed storage technology, the technical status of which is stated by the F4.1, 4.2, 4.3 Sub-categories The quantities should be reported in terms of fluid that is expected to be injected and stored by a theoretical project, and not the quantities associated with a site-specific storage space.
			F4.2	The technology necessary is being researched, but no successful pilot studies have yet been completed.	
			F4.3	The technology is not currently under research or development.	

Category	*Definition*	*Supporting Explanation*	*Sub-Category*	*Sub-Category Definition*	*Additional Geological Storage context*
G1	Product quantity associated with a project that can be estimated with a high level of confidence.	Product quantity estimates may be categorized discretely as G1, G2 and/or G3 (along with the appropriate E and F Categories), based on the degree of confidence in the estimates (high, moderate, and low confidence, respectively) based on direct evidence. Alternatively, product quantity estimates may be categorized as a range of uncertainty as reflected by either (i) three specific deterministic scenarios (low, best and high cases) or (ii) a probabilistic analysis from which three outcomes (P90, P50 and P10) are selected. In both methodologies (the “scenario” and “probabilistic” approaches), the estimates are then classified on the G Axis as G1, G1+G2 and G1+G2+G3 respectively. In all cases, the product quantity estimates are those associated with a project. Additional Comments: The G-axis Categories are intended to reflect all significant uncertainties (e.g. source uncertainty, geological uncertainty, facility efficiency uncertainty, etc.) impacting the estimate forecast for the project. Uncertainties include variability, intermittency and the efficiency of the development and operation (where relevant).	none	-	These quantities represent the amount of storage product (i.e. fluid) which is expected or proposed to be injected by a known project and into a known (discovered) storage resource. It does not represent the volume or size of the storage resource. The estimates of G1, G2, G3 (or G1, G1+G2 and G1+G2+G3) should reflect the degree of confidence in the quantities of geological storage products that are expected to be injected (and/or extracted) over the project lifetime. This should include allowance for uncertainty about the final net maximum production rate from the overall production facility, uncertainty about what capacity factor will be achieved on a daily or annual basis, and any possible degradation in production due to changes in the energy source of production facilities over time. All these factors should be reported in the classification text that supports the G1, G2, G3 (or G1, G1+G2 and G1+G2+G3) estimates. Uncertainties may also relate to the quality of the product withdrawn from a storage and the expected size and performance of
G2	Product quantity associated with a project that can be estimated with a moderate level of confidence.		none	-	
G3	Product quantity associated with a project that can be estimated with a low level of confidence.		none	-	

		Typically, the various uncertainties will combine to provide a full range of outcomes. In such cases, categorization should reflect three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.			the storage facility before its design and realization. A representative injection profile that is expected to be applied in storage operations (e.g. for entire project lifetime for long-term storage and typically on an annual basis for temporary storage) should be included to support each estimate.
G4	Product quantity associated with a Prospective Project, estimated primarily on indirect evidence.	A Prospective Project is one where the existence of a developable product is based primarily on indirect evidence and has not yet been confirmed. Further data acquisition and evaluation would be required for confirmation. Where a single estimate is provided, it should be the expected outcome but, where possible, a full range of uncertainty should be calculated for the prospective project. In addition, it is recommended that the chance of success (probability) that the prospective project will progress to a Viable Project is assessed and documented.	**G4.1**	Low estimate of the quantities.	These quantities represent the expected amount of storage product (i.e. fluid) which may be stored by a prospective project and into a potential (undiscovered) storage resource. These classes are also used for conceptual projects for which the technical feasibility of the storage technology and methodology are still not confirmed and demonstrated.
			G4.2	Incremental amount to G4.1 such that G4.1+G4.2 equates to a best estimate of the quantities.	
			G4.3	Incremental amount to G4.1+G4.2 such that G4.1+G4.2+G4.3 equates to a high estimate of the quantities.	

Annex II

Glossary of Terms in the Context of Injection Projects for Geological Storage[4]

Term	*Definition*
Base Gas or Cushion Gas Quantity	The quantity of permanent inventory gas necessary to maintain sufficient pressure for withdrawal purposes in a temporary storage project.
Enhanced Hydrocarbon Extraction Project	A project in which fluids are injected into a reservoir or coal-bearing interval in order to enable or increase the extraction of hydrocarbons present. Also indicated as Enhanced Oil Recovery (EOR), Enhanced Gas Recovery (EGR), or Enhanced Coal Bed Methane Recovery (ECBM).
Geological Storage Product	The fluids that are injected by a storage project into a geological storage resource.
Geological Storage Resource	The underground geological formation (e.g. a porous reservoir, aquifer, or a cavern) which will act as the storage space for injected fluids. Also indicated as geological storage space.
Known Geological Storage Resource	A storage resources where the existence and suitability of a porous reservoir or a cavern has been demonstrated by direct evidence such as observations and measurements in wells, geophysical measurements (e.g. seismic surveys) and/or prior extractive activities (hydrocarbon production, rock salt mining) which have resulted in the generation of the storage space.
Long-term Storage Project	A storage project with the intention to permanently store fluids and for which the injection of fluid accumulates over the entire project lifetime until the total storage space is filled or the project is ceased for other reasons.
Potential Geological Storage Resource	A storage resource where the existence of a suitable storage space has not yet been demonstrated by direct evidence. Typically, the presence of porous reservoirs or potentially suitable rock formations for creating storage caverns is inferred from indirect methods such as geophysical measurements, regional geological studies based on surrounding well data and/or known analogues in a similar geological setting.
Remaining Storage Quantity	The quantity that may still be injected at any point during operation of a storage project.
Temporary Storage Project	A storage project with the intention to inject and again withdraw fluids in a cyclic fashion. The frequency of injection and withdrawal cycles may vary per project and during the project lifetime.
Total Storage Quantity	The maximum quantity of fluid that may be injected and stored into the storage resource, given technical, economic, environmental, and regulatory constraints.

[4] These terms are in addition to the Glossary of Terms included in Annex I of Part II of UNFC (2019) incorporating Specifications for its Application (ECE Energy Series No. 61) and UNFC – Glossary of Common Terms (2022) (https://unece.org/sed/documents/2022/02/session-documents/unfc-glossary-common-terms).

Term	*Definition*
Working Gas Quantity	The quantity that is currently in storage and that can be withdrawn by a temporary storage project.

Web Links

Sustainable Resource Management:

UNFC documents:

UNRMS:

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