Economic Commission for Europe

Committee on Sustainable Energy

Expert Group on Resource Classification

Fifth session
Geneva, 29 April–2 May 2014
Item 14 of the provisional agenda
Use of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 for classifying injection projects

Classification of injection projects and possible application of UNFC-2009

Draft for discussion prepared by the Task Force on UNFC-2009 and recipient Reservoirs

I. Introduction

1. As per the Programme of Work for the Expert Group on Resource Classification for 2013-2014, it was agreed that the Task Force on UNFC-2009 and Injection Projects continue work to investigate how, for example, oil and gas companies classify and evaluate the maturity of their gas injection projects today, and propose a draft bridging document for application of UNFC-2009 to injection projects, in particular to the storage of carbon dioxide.

2. Bridging Documents explain the relationship between UNFC-2009 and another classification system that has been endorsed by the Expert Group on Resource Classification as an Aligned System. They incorporate instructions and guidelines on how to classify estimates generated by application of that Aligned System using the UNFC-2009 Numerical Codes. The relevant Bridging Document shall be identified when reporting estimates using the UNFC-2009 Numerical Codes.

3. There is currently no universally accepted classification system for injection projects such as carbon storage projects. Mapping the UNFC-2009 directly to an established system for classification of injection projects, and using this as basis for a bridging document, is therefore not possible. Several proposals for how to classify injection projects have however been published over the years. A high level mapping of the UNFC-2009 for extraction projects, in its current form, to some of the previously proposed and more widely used systems for classification of geologic storage, is here used to demonstrate that the principles of the UNFC-2009 can be applied also to injection projects.

4. Resource classification is used in the oil and gas industry as well as the mining industry to assess the commercial attractiveness of different extraction projects. Each project is associated with a certain quantity that can be extracted, given a defined technical solution and a certain investment. Projects can be of different size and have different degree of maturity. For injection projects, the resource is defined as the pore space available for storage, rather than the quantity that can be extracted. The activities necessary establish an injection site, are however comparable to those of an extraction project. UNFC-2009 is a principles based system that classifies the maturity of a project activity. Even though it was

developed with extractive activities in mind, the principles of project maturity should be applicable also to other, project based activities, such as injection projects.

5. This document focuses on how UNFC-2009 can be applied to injection projects, primarily for carbon storage or Carbon Capture and Sequestration (CCS), where CO_2 is injected in to a recipient porous and permeable reservoir rock formation in the sub-surface for long term storage, also referred to as geologic storage. The same principles of project maturity should be applicable also for other forms of underground gas storage or waste injection in to geologic media. The term quantity, as well as the terms storage capacity and storage resource, refers to the mass of a substance that could be stored in the pore space available for storage. A defined storage space can however only be used by one commodity, though the potential may be there for various substances. Both the project maturity and the quantities available for storage may therefore differ for a specific site, depending on the injected substance.

6. CCS technology involves capturing, transporting and storing CO_2. The term injection project is in this document intended to cover only the storage part of the CCS activity.

7. Another CCS challenge, is the lack of commonly accepted storage capacity estimation methods that can result in reliable, transparent and comparable estimates. This document only discusses classification of injection project maturity, and does not include any proposals for how the quantities associated with the classified project(s) should be estimated.

II. OVERVIEW OF OTHER PROPOSED SYSTEMS AND HOW THEY CAN BE MAPPED TO THE UNFC-2009

A. The Techno-Economic Resource-Reserve Pyramid for CO2 Storage

8. The Techno-economic resource pyramid is a concept initially used for describing hydrocarbon accumulations. It was proposed applied to carbon storage in geological media by Bradshaw et al. in 2006. In 2007, the Carbon Sequestration Leadership Forum (CSLF) proposed the Techno-Economic Resource-Reserve Pyramid for CO2 Storage (*Bachu* et al.) and applied the concept of resources and reserves as used in the petroleum industry. This classification has since been applied by, for instance, the Coordinating Committee for Geoscience Programs in East and Southeast Asia (CCOP) and by the Norwegian Petroleum Directorate (NPD) in their CO_2 storage atlases. It combines the estimated storage capacity with the degree of certainty of the storage potential, and is normally presented as a pyramid representing the total theoretical capacity available for storage, with certainty increasing towards the top of the pyramid. For practical purposes, this classification is here represented as a two dimensional table. CSLF, CCOP and NPD use slightly different terminology in their application of the pyramid, but the principles of capacity and certainty are the same.

9. The different levels of certainty in the *Techno-Economic Resource-Reserve Pyramid for CO_2 Storage* can be mapped to the UNFC-2009 classes as shown in Figure 1.

Figure 1

The Techno-Economic Resource-Reserve Pyramid for CO_2 Storage compared with UNFC-2009

Extraction Projects					Injection Projects		
UNFC-2009 defined by Classes, Sub-classes and Categories					Techno-economic Resource-reserve Pyramid		
Class	Sub-class	Categories E	F	G	CSLF	CCOP	NPD
Commercial projects	On Production	1	1.1	1,2,3	Matched Capacity	Operational Capacity	Development of Injection Site
	Approved for Development	1	1.2	1,2,3			
	Justified for Development	1	1.3	1,2,3			
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Practical Capacity	Contingent Capacity	Suitable for Long Term Storage
	Development on Hold	2	2.2	1,2,3			
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3			
	Development Not Viable	3.3	2.3	1,2,3			
Additional Quantities in Place		3.3	4	1,2,3			
Exploration Projects	(No sub-classes defined)	3.2	3	4	Effective Capacity	Prospective Capacity	Exploration
Additional Quantities in Place		3.3	4	4	Theoretical Capacity	Total Pore Volume	Theoretical Volume

10. **Theoretical capacity** (CSLF terminology) represents the total pore volume believed to be available for storage in a given area. This applies to an early screening phase in an area where separate exploration projects are not yet defined. Since the UNFC-2009 is project based, there is no class that directly transfers in to Theoretical capacity. However, estimates resulting from an early screening phase can be classified using the F3.3 sub-class for the earliest stage of exploration activities, as proposed in the UNFC-2009 Commodity Specific Specifications, or through the Play sub-class in the Petroleum Resource Management System (PRMS) to the Exploration Projects class in UNFC-2009.

11. **Effective capacity/Prospective capacity/Exploration** can be mapped directly to the Exploration Projects class in UNFC-2009 and to the F3.2 and F3.1 sub-classes or through the Lead and Prospect sub-classes in PRMS.

12. **Practical capacity/Contingent capacity/Suitable for long term storage** applies when the exploration activity has resulted in defined projects that are brought forward for further studies. This would represent both Potentially Commercial and Non-commercial projects in the UNFC-2009. Since this category in the pyramid would include a wide variety of projects, with different level of certainty and/ or maturity, applying the higher granularity of the UNFC-2009 could increase the usefulness of a classification system for carbon storage projects significantly.

13. **Matched capacity/Operational capacity/Development of injection site** applies when the capacity of the recipient reservoir has been matched to the carbon emitting source(s) and a project is matured in to a decided development of an injection site. It can be mapped directly to the Commercial projects class in UNFC-2009 or the Reserves class in PRMS. Also here, the higher degree of granularity in UNFC-2009 could increase the usefulness of a classification system for more mature carbon storage projects.

B. The CO2CRC classification

14. Several arguments have been raised in favor of using the same approach as currently used in the petroleum industry to classify injection projects such as carbon storage projects.

15. The CO2CRC is one of several proposed classifications that are based on the classes in PRMS. In the CO2CRC, storage capacities are either discovered or undiscovered, and the discovered volumes are further divided in to commercial and sub-commercial. This results in three main classes as shown in Figure 2, with no further sub-classes.

Figure 21
The CO2CRC classification compared with UNFC-2009

<table>
<tr><th colspan="5">Extraction Projects</th><th colspan="3">Injection Projects</th></tr>
<tr><th colspan="5">UNFC-2009 defined by Classes, Sub-classes and Categories</th><th colspan="3">CO2CRC classification (2008)</th></tr>
<tr><th rowspan="2">Class</th><th rowspan="2">Sub-class</th><th colspan="3">Categories</th><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2"></th></tr>
<tr><th>E</th><th>F</th><th>G</th></tr>
<tr><td rowspan="3">Commercial projects</td><td>On Production</td><td>1</td><td>1.1</td><td>1,2,3</td><td rowspan="6">Discovered pore volume</td><td rowspan="3">Commer-cial</td><td rowspan="3">Operational storage capacity</td></tr>
<tr><td>Approved for Development</td><td>1</td><td>1.2</td><td>1,2,3</td></tr>
<tr><td>Justified for Development</td><td>1</td><td>1.3</td><td>1,2,3</td></tr>
<tr><td rowspan="2">Potentially commercial projects</td><td>Development Pending</td><td>2</td><td>2.1</td><td>1,2,3</td><td rowspan="4">Subcommercial</td><td rowspan="4">Contingent storage capacity</td></tr>
<tr><td>Development on Hold</td><td>2</td><td>2.2</td><td>1,2,3</td></tr>
<tr><td rowspan="2">Non-commercial projects</td><td>Developmet Unclarified</td><td>3.2</td><td>2.2</td><td>1,2,3</td></tr>
<tr><td>Development Not Viable</td><td>3.3</td><td>2.3</td><td>1,2,3</td></tr>
<tr><td colspan="2">Additional Quantities in Place</td><td>3.3</td><td>4</td><td>1,2,3</td></tr>
<tr><td>Exploration Projects</td><td>(No sub-classes defined)</td><td>3.2</td><td>3</td><td>4</td><td rowspan="2">Undiscovered pore volume</td><td rowspan="2">Might be commercial in the future</td><td rowspan="2">Prospective storage capacity</td></tr>
<tr><td colspan="2">Additional Quantities in Place</td><td>3.3</td><td>4</td><td>4</td></tr>
</table>

16. **Prospective storage capacity** can be mapped directly to the Exploration Projects class in the UNFC-2009, or through the Prospective Resources class in PRMS.

17. **Contingent storage capacity** would represent both Potentially Commercial and Non-commercial projects in the UNFC-2009. Again, the higher degree of granularity in UNFC-2009 could be an advantage, in particular for more mature projects where specific sites are evaluated for commercial use.

18. **Operational storage capacity** is used for decided injection projects, and can be mapped directly to the Commercial projects class in UNFC-2009 and would be the equivalent of the Reserves class in PRMS.

19. As in PRMS, the CO2CRC includes a range of uncertainty (not shown in the figure above), with low, best and high estimates in all three classes. In the Operational storage capacity class, the terms Proved, Probable and Possible are used in the same way as for the Reserves class in PRMS. These can be mapped directly to the G Axis categories in UNFC-2009 in the same way as described for petroleum in the "*Bridging document between PRMS and UNFC-2009*".

C. Storage classification system proposed by Gorecki et al

20. This proposed classification system of Gorecki et al (2009) builds on the CSLF Techno-Economic Resource-Reserves Pyramid for CO_2 storage, the CO2CRC and PRMS. One important distinction is that the term Capacity is here used only for commercial projects, whereas the term Resource is used for less mature projects. Several publications of proposed classification systems have argued that the term Capacity should be applied only to the most certain estimates, or mature projects, and only once relevant economic and regulatory constraints have been applied. In addition, this system introduces a class for resources that have been characterized but found to be unusable for geologic storage, and a class for theoretical but not yet characterized storage resources.

Figure 3
Classification proposed by Gorecki et al. compared with UNFC-2009

<table>
<tr><th colspan="5">Extraction Projects</th><th colspan="4">Injection Projects</th></tr>
<tr><th colspan="5">UNFC-2009 defined by Classes, Sub-classes and Categories</th><th colspan="4">Classification system proposed by Gorecki et al, SPE126421 (2009)</th></tr>
<tr><th rowspan="2">Class</th><th rowspan="2">Sub-class</th><th colspan="3">Categories</th><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2"></th></tr>
<tr><th>E</th><th>F</th><th>G</th></tr>
<tr><td rowspan="3">Commercial projects</td><td>On Production</td><td>1</td><td>1.1</td><td>1,2,3</td><td rowspan="8">Theoretical Storage Resource</td><td rowspan="7">Characterized Storage Resource</td><td rowspan="4">Effective Storage Resource</td><td>Practical Storage Capacity</td></tr>
<tr><td>Approved for Development</td><td>1</td><td>1.2</td><td>1,2,3</td></tr>
<tr><td>Justified for Development</td><td>1</td><td>1.3</td><td>1,2,3</td></tr>
<tr><td rowspan="2">Potentially commercial projects</td><td>Development Pending</td><td>2</td><td>2.1</td><td>1,2,3</td><td rowspan="3">Contingent Storage Resource</td></tr>
<tr><td>Development on Hold</td><td>2</td><td>2.2</td><td>1,2,3</td></tr>
<tr><td rowspan="2">Non-commercial projects</td><td>Development Unclarified</td><td>3.2</td><td>2.2</td><td>1,2,3</td></tr>
<tr><td>Development Not Viable</td><td>3.3</td><td>2.3</td><td>1,2,3</td><td colspan="2">Unusable Storage Resource</td></tr>
<tr><td colspan="2">Additional Quantities in Place</td><td>3.3</td><td>4</td><td>1,2,3</td><td colspan="3" rowspan="3">Uncharacterized Storage Resource</td></tr>
<tr><td>Exploration Projects</td><td>(No sub-classes defined)</td><td>3.2</td><td>3</td><td>4</td></tr>
<tr><td colspan="2">Additional Quantities in Place</td><td>3.3</td><td>4</td><td>4</td></tr>
</table>

21. The classes **Theoretical Storage Resource, Characterized Storage Resource and Effective Storage Resource**, can be mapped to UNFC-2009 in the same way as the Theoretical Capacity, Practical (or Contingent) Capacity and Matched Capacity in the CSLF version of the Techno-Economic Resource-Reserves pyramid described above.

22. **Uncharacterized Storage Resource** refers to pore space in rocks that are known to exist, but where the injective potential cannot be determined due to too little or no data. This class has been mapped directly to the Exploration Projects class UNFC-2009.

23. **Unusable Storage Resource**, a subset of characterized storage resource, is defined as the pore volume that exists in known storage sites, but is unavailable for injection because of current technical conditions. This has been mapped to the Non-commercial Projects class in UNFC-2009, but also includes pore space that would be the equivalent of Additional Quantities in Place in UNFC-2009.

24. **Contingent Storage Resources** are described as Effective Storage Resources where relevant technical limitations have been considered, but where economic considerations have not yet been included. This can be mapped to the Potentially Commercial Projects class in UNFC-2009, where the technical or commercial viability of a project has not yet been confirmed.

25. **Practical Storage Capacity** applies to projects where future injection has been evaluated to be economically feasible. This can be mapped directly to the Commercial Projects class in UNFC-2009. Note that Practical Storage Capacity as applied here must not be confused with the same term used in the CSLF classification, where it applies to less mature projects.

26. The terms Proved, Probable and Possible are used also in this proposed classification to demonstrate the range of uncertainty of the pore space estimates. Proved storage capacity is defined to be a reasonably certain estimate, based on current technical and economic conditions, whereas Probable and Possible storage capacities are based on anticipated future economic conditions under which injection will become economic within what is referred to as a reasonable time frame. This definition of Probable and Possible is not in line with UNFC-2009 nor the PRMS, where a project classified as E1 or Reserves must be economic based on the same realistic assumptions of future conditions regardless of the certainty of the volume estimate. These sub-categories can therefore not be mapped directly to the UNFC-2009 G-Axis in the same way as for the CO2CRC, if the assumptions for future conditions are applied as proposed by Gorecki et al (2009).

D. DOE/NETL Geologic Storage Framework

27. The US DOE/NETL proposed a classification in 2009, which was a direct application of PRMS. This can therefore be mapped directly to the PRMS as defined for extraction projects and through this to UNFC-2009 as shown in Figure 4.

Figure 4
The US DOE/NETL Geologic Storage Framework compared with UNFC-2009

Extraction projects					Injection Projects		
UNFC-2009 defined by Classes, Sub-classes and Categories					DOE/NETL Geologic Storage Framework (Adapted PRMS)		
Class	Sub-class	Categories E	F	G		Injection	Project Status
Commercial projects	On Production	1	1.1	1,2,3	Commercial	Storage Capacity	Current Injection
	Approved for Development	1	1.2	1,2,3			Approved Injection Project
	Justified for Development	1	1.3	1,2,3			Planned Injection Project
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Sub-Commercial	Contingent Storage	Site Characterization/ Project Pending
	Development on Hold	2	2.2	1,2,3			Site Characterization/ Development on hold
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3			
	Development Not Viable	3.3	2.3	1,2,3			Site Characterization/ Development Not Viable
Additional Quantities in Place		3.3	4	1,2,3		Un-Injectable CO2	
Exploration Projects	(No sub-classes defined)	3.2	3	4	Geologic Storage	Prospective Storage	Site Characterization (Initial)
							Site Selection
							Site Screening (Sub-Regional)
Additional Quantities in Place		3.3	4	4		Un-Injectable CO2	

28. This proposed classification applies the same level of classes and sub-classes as the PRMS, and parts of the same terminology. The term **Storage Capacity** is also here proposed used only for commercial projects, similar to the term Reserves. The system classifies the storage space and the injection project activities, but also introduces the stored substance through a class called Un-Injectable CO_2. The system has, to our knowledge, so far not been used by the US Department of Energy (DOE) in its *Carbon Sequestration Atlas of the United States and Canada*, since CCS is still very much a young technology and the need for a detailed classification has been regarded as limited.

E. CSRCC proposed by Frailey & Finley (2009)

29. Another proposal for a classification of injection projects based on PRMS, the CO_2 Storage Resource and Capacity Classification (CSRCC) (Figure 5), has been published by Frailey & Finley of the Illinois State Geological Survey. Again, the classes and sub-classes of the PRMS are applied in the same way as with the US DOE Geologic Storage Framework, classifying the maturity of the injection project activities.

Figure 5
CSRCC compared with UNFC-2009

Extraction Projects					Injection Projects		
UNFC-2009 defined by Classes, Sub-classes and Categories					CSRCC Frailey & Finley (2009)		
Class	Sub-class	Categories				Injection	Project Status
		E	F	G			
Commercial projects	On Production	1	1.1	1,2,3	Commercial	Capacity	Active Injector
	Approved for Development	1	1.2	1,2,3			Under Development
	Justified for Development	1	1.3	1,2,3			Planned for Development
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Sub-Commercial	Contingent Resource	Development Pending
	Development on Hold	2	2.2	1,2,3			Development on Hold
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3			
	Development Not Viable	3.3	2.3	1,2,3			Development Not Viable
Additional Quantities in Place		3.3	4	1,2,3		Unattainable	
Exploration Projects	(No sub-classes defined)	3.2	3	4	Undiscovered	Prospective Resource	Propsect
							Lead
							Play
Additional Quantities in Place		3.3	4	4		Unattainable	

30. Less mature projects are classified as a storage resource, with the term **Prospective Resource** used for storage sites that are in the exploration or screening phase, and **Contingent Resource** for projects where commerciality has yet to be established. A mature project, which meets the economic and regulatory requirements at the time of the storage assessment, is classified as a storage **Capacity**.

31. The sub-classes are identical to the Project Maturity Sub-classes in PRMS, with the exception of the most mature sub-class where the term **Active Injector** is used.

32. Since this proposed classification system for injection project activities is a direct adaption of PRMS, it can be mapped to UNFC-2009 through PRMS in the same way as for extraction projects.

F. The Global CCS Institute

33. The Global CCS Institute has identified several large-scale integrated CCS projects around the world and provides an overview of these projects on its home page. A series of attributes are used to define the different projects, including Project Status and Stage. These attributes define the maturity of the different projects, and can be thought of as a classification system in the same way as the systems described above. They can be mapped to UNFC-2009, as shown in Figure 6.

Figure 6
Global CCS Institute attributes compared with UNFC-2009

Extraction Projects					Injection Projects	
UNFC-2009 defined by Classes, Sub-classes and Categories					Global CCS Institute	
Class	Sub-class	Categories			Project Status	Project Stage
		E	F	G		
Commercial projects	On Production	1	1.1	1,2,3	Active	Operate
	Approved for Development	1	1.2	1,2,3		Execute
	Justified for Development	1	1.3	1,2,3		
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Planned	Define
	Development on Hold	2	2.2	1,2,3		Evaluate
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3		
	Development Not Viable	3.3	2.3	1,2,3		
Additional Quantities in Place		3.3	4	1,2,3		
Exploration Projects	(No sub-classes defined)	3.2	3	4		Identify
Additional Quantities in Place		3.3	4	4		

34. **Active** projects can be mapped directly to Commercial Projects in UNFC-2009. Active projects are either classified as **Operate**, the equivalent of On Production in UNFC-2009, or **Execute**, the equivalent of the sub-classes Approved for Development or Justified for Development**.**

35. **Planned** projects are subdivided in to three different stages; **Identify,** which can be mapped to Exploration Projects; **Evaluate,** which includes both Non-commercial and Potentially Commercial Projects where development is on hold; and **Define,** which can be mapped to the Development Pending sub-class in the Potentially Commercial Projects UNFC-2009 class.

36. The terminology used here is a direct parallel to the project evaluation stages or value chain processes applied in the petroleum industry, which some companies refer to as a Capital Value Process. This is a decision process with pre-defined stages, often referred to as decisions gates, which has many similarities with project maturity based classification systems such as UNFC-2009.

III. PROPOSED APPLICATION OF UNFC-2009 TO INJECTION PROJECTS

37. The Task Force believes that UNFC-2009 can be applied to injection projects such as carbon storage projects in its current form, either directly, or as in some of the classifications described above, through application of a version of PRMS modified for injection projects.

38. Figure 7 shows the UNFC-2009 scheme, in its abbreviated version, with primary classes and categories, adapted for application to injection projects. The classes and categories are the same as for extractive activities, except for the Non-Sales production category, which has been removed because it is not relevant to injection projects.

Figure 7
UNFC-2009 major Classes applied to Injection Projects

Total Pore Volume In Place	Injected				
		Class	Categories		
			E	F	G
	Future storage by commercial injection projects	Commercial Storage Projects	1	1	1, 2, 3
	Potential future storage by commercial injection projects	Potentially Commercial Storage Projects	2	2	1, 2, 3
		Non-Commercial Storage Projects	3	2	1, 2, 3
	Storage Unattainable		3	4	1, 2, 3
	Potential future storage by succesful screening activities	Screening Projects	3	3	4
	Storage Unattainable		3	4	4

39. The total storage quantity is here defined as the mass of a substance that could be stored in the pore space available. The pore space available for injection is classified at a given date in terms of the following:

(a) Pore volume where CO_2 (or other substance) has been injected;

(b) Pore volume associated with a known recipient reservoir that may be used for storage in the future. The classification is based on technical and commercial studies based on defined injection activities;

(c) Additional pore volume associated with a known recipient reservoir that will not be used for storage by any currently defined injection project;

(d) Pore volume associated with a potential recipient reservoir that may be used for storage in the future provided that the reservoir is confirmed;

(e) Pore volume which will not be available for storage or where storage is unattainable.

40. The full granularity of the UNFC-2009 sub-classes can be applied to injection as shown in Figure 8.

Figure 8
UNFC-2009 with Sub-classes applied to Injection Projects

UNFC-2009 for Injection Projects				
UNFC2009 - Prposed Application to Injection Projects such as CO_2 Storage Projects				
Class	**Sub-class**	**Categories**		
		E	**F**	**G**
Commercial Storage Projects	Active Injection	1	1.1	1, 2, 3
	Approved for Development	1	1.2	1, 2, 3
	Justified for Development	1	1.3	1, 2, 3
Potentially Commercial Storage Projects	Development Pending	2	2.1	1, 2, 3
	Development on Hold	2	2.2	1, 2, 3
Non-Commercial Storage Projects	Development Unclarified	3.2	2.2	1, 2, 3
	Development not Viable	3.3	2.3	1, 2, 3
Storage Unattainable		3.3	4	1, 2, 3
Screening Projects	Storage Potential Identified	3.2	3.1	4
	Storage Potential Indicated	3.2	3.2	4
	Storage Potential Inferred	3.2	3.3	4
Storage Unattainable		3.3	4	4

41. In this proposal, the categories used to make up the classes are the same as those used for Extractive activities. However, it should be possible to apply different combinations of Categories and Sub-categories as necessary, depending on the project(s) that are classified.

A. Definition of Injection Project Categories and Supporting Explanations

42. In the tables below, the UNFC-2009 Definitions of Categories and Sub-categories, with Supporting Explanations, from Annex 1 and Annex 2 of the United Nations Publication "*United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 incorporating Specifications for its Application"*, has been modified to show how these categories can be applied to injection projects.

(a) "*Extraction and sale*" has been replaced with "*Injection and storage*";

(b) "*Quantities that are forecasted to be extracted, but which will not be available for sale*" has been removed, as there is no direct equivalent for injection projects;

(c) "*Additional quantities in Place*" has been replaced with "*Pore space where storage is unattainable*". There may be parts of a recipient reservoir where storage is not possible, for instance due to difficulties accessing the area given the chosen technical solution or conflict of interest with other injection or extraction projects, water resources etc.

43. As for extraction projects, the phrase "Economically viable" encompasses economic factors (in the narrow sense) plus other relevant legal, regulatory, environmental, social and all other non-technical factors that could directly impact the viability of an injection project.

Table 1.

UNFC-2009 Definitions and Supporting Explanations modified for application to Injection Projects

Category	Definition	Supporting Explanation
E1	Injection and storage has been confirmed to be economically viable.	Injection and storage is economic on the basis of current market conditions and realistic assumptions of future market conditions. All necessary approvals/contracts have been confirmed or there are reasonable expectations that all such approvals/contract will be obtained within a reasonable time frame. Economic viability is not affected by short-term adverse market conditions provided that longer term forecasts remain positive.
E2	Injection and storage is expected to become economically viable in the foreseeable future.	Injection and storage has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic injection and storage in the foreseeable future.
E3	Injection and storage is not expected to become economically viable in the foreseeable future, or the evaluation is a too early a stage to determine economic viability.	On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic injection and storage in the foreseeable future; or, economic viability of injection and storage cannot yet be determined due to insufficient information (e.g. during the screening phase).
F1	Feasibility of storage by a defined injection project has been confirmed.	Injection is currently taking place; or, implementation of an injection project is underway; or, sufficiently detailed studies have been completed to demonstrate the feasibility of injection by implementing a defined project.
F2	Feasibility of storage by a defined injection project is subject to further evaluation.	Preliminary studies demonstrate the existence of a recipient reservoir in such form, quality and quantity that the feasibility of injection by a defined project can be evaluated. Further data acquisition and/or studies may be required to confirm the feasibility of injection.
F3	Feasibility of storage by a defined injection project cannot be evaluated due to limited technical data.	Very preliminary studies (screening phase), which may be based on a defined project activity, indicate the need for further data acquisition and/or further geological studies in order to confirm the existence of a porous and permeable geologic formation and seal in such form, quality and quantity that the feasibility of injection can be evaluated.
F4	No injection project has been identified.	Pore volume that will not be utilised for injection by any currently defined project activity or operation.

Category	Definition	Supporting Explanation
G1	Storage associated with a known recipient reservoir that can be estimated with a high level of confidence.	Available storage space is estimated based on detailed geological data from the recipient reservoir and the overlying seal(s), including injection data and results from monitoring of the sealing capacity during injection.
G2	Volumes associated with a known recipient reservoir that can be estimated with a moderate level of confidence.	Available storage space is estimated based on geological data including porosity, permeability and structure of the recipient reservoir and properties of the seal. The evaluation is based on geological modelling and reservoir simulation. G1+G2 represent the best estimate of the total available storage space.
G3	Volumes associated with a known recipient reservoir that can be estimated with a low level of confidence.	Available storage space is estimated from geologically mapped pore volume and permeability of the recipient reservoir and sealing capacity of the overlying seal, based on available data. Volumes which are likely to be in conflict with future management of ground water, petroleum or other resources have been excluded. G1+G2+G3 represent a high estimate of the total available storage space.
G4	Estimated volumes associated with screening projects.	Available reservoir volumes that are estimated during a screening phase. Normally subject to a substantial range of uncertainty as well as a major risk that no injection project may be implemented.

B. Definition of sub-categories as applied to Injection Projects

44. As for the Definitions and Supporting Explanations described above, the UNFC-2009 Sub-Categories and its definitions can be modified as shown below when the classification is applied to injection projects. Some of the distinctions here may be even more important for these projects. An example of this is the E1 category for projects that have been confirmed to be economically viable. As injection projects may often struggle to meet the requirements for economic production in the same commercial sense as an extraction project, being able to make the distinction between E1.1 and E1.2, where E1.2 applies to projects that are made viable through government subsidies and/or other considerations, is an advantage.

Table 2.
UNFC-2009 Sub-Categories and its Definitions modified for application to Injection Projects

Category	Sub-Category	Sub-Category Definition
E1	E1.1	Injection (and storage) is economic on the basis of current market conditions and realistic assumptions of future market conditions.
	E1.2	Injection (and storage) is not economic on the basis of current market conditions and realistic assumptions of future market conditions, but is made viable through government subsidies and/or other considerations.
E2		*No sub-categories for extraction projects, probably also applicable for injection projects*
E3	E3.1	Non-sales production. Not relevant for injection projects.
	E3.2	Economic viability of injection cannot yet be determined due to insufficient information (e.g. during the exploration screening phase).
	E3.3	On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic injection (and/or storage) in the foreseeable future.
F1	F1.1	Injection is currently taking place.
	F1.2	Capital funds have been committed and implementation of the injection project is underway.
	F1.3	Sufficiently detailed studies have been completed to demonstrate the feasibility of storage by implementing a defined injection project.
F2	F2.1	Project activities are on-going to justify injection in the foreseeable future.
	F2.2	Project activities are on hold and/or where justification as a commercial injection project may be subject to significant delay.
	F2.3	There are no current plans to develop or to acquire additional data at the time due to limited potential.
F3	F3.1	Site-specific geological studies have identified the potential for geologic storage with sufficient confidence to warrant drilling or testing to confirm the potential.
	F3.2	Local geological studies and exploration activities indicate the potential for geologic storage, but more data acquisition and/or evaluation is required to confirm the potential.
	F3.3	Favourable conditions for geologic storage may be inferred from regional geological studies.
F4		UNFC-2009 sub-classification based on the current state of technological development can be applied if relevant.

References

(a) United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 incorporating Specifications for it Application. UNECE Energy series No. 42, 2013. http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/pub/UNFC2009_Spec_ES42.pdf

(b) Petroleum Resources Management System sponsored by SPE/AAPG/WPC/SPEE. Society of Petroleum Engineering, 2007. http://www.spe.org/industry/docs/Petroleum_Resources_Management_System_2007.pdf

(c) Guidelines for Application of the Petroleum Resource Management System. Society of Petroleum Engineering, 2011. http://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf

(d) Phase II Final Report from the Task Force for Review and Identification of Standards for CO_2 Storage Capacity Estimation. Carbon Sequestration Leadership Forum. S. Bachu et al, 2007. http://www.cslforum.org/publications/documents/PhaseIIReportStorageCapacityMeasurementTaskForce.pdf

(e) CO_2 storage atlas North Sea. Norwegian Petroleum Directorate, 2011. http://npd.no/en/Publications/Reports/CO2-Storage-Atlas-/

(f) Storage Capacity Estimation, Site Selection and Characterisation for CO2 Storage Projects. CO2CRC Report no: RPT08-1001, 2008. http://www.co2crc.com.au/dls/pubs/08-1001_final.pdf

(g) A New Classification System for Evaluating CO_2 Storage Resource/Capacity Estimates. SPE-126421-MS. Charles D. Gorecki et al, 2009. https://www.onepetro.org/conference-paper/SPE-126421-MS

(h) Site Screening, Selection and Charaterization of CO_2 Stored in Deep Geologic Formations. Regional Carbon Sequestration Partnerships Annual Review, November 2009. National Energy Technology Laboratory, United States Department of Energy. http://www.netl.doe.gov/publications/proceedings/09/RCSP/PDF/Rodosta_RCSP_SiteScreenSelChar.pdf

(i) Classification of CO_2 Geologic Storage: Resource and Capacity. Scott M. Frailey and Robert J. Finley, Illinois State Geological Survey. Elsevier Ltd. 2009. http://www.sciencedirect.com/science/article/pii/S1876610209006729

(j) CO_2 Storage Capacity - Combining Geology, Engineering and Economics. SPE-133804-MS. W.G. Allinson et al, 2010. https://www.onepetro.org/conference-paper/SPE-133804-MS