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Status of the development of other applications of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (a) Application to nuclear fuel resources

Draft Bridging Document between the Organisation for Economic Co-operation and Development Nuclear Energy Agency/International Atomic Energy Agency Uranium Classification and the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009

Prepared by the Working Group on Nuclear Fuel Resources

I. Introduction

1. This document provides the draft bridging document between the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA)/International Atomic Energy Agency (IAEA) Uranium Classification and the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). The document is intended to provide a draft text for discussion by the Expert Group on Resource Classification at its fourth session.

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. The NEA/IAEA uranium and thorium¹ resources reporting scheme was tentatively aligned to the UNFC of 2004 using the G categories. Along with the more recently developed Generic Specifications for the application of UNFC-2009, these guidelines provide the foundation and keystones for consistent application of UNFC-2009 towards the reporting of uranium resources.

4. The application of the NEA/IAEA Uranium Classification shall not limit in any way the use of the full granularity provided in UNFC-2009.

II. Overview of NEA/IAEA Uranium Classification Scheme

A. Overview

5. In the mid-1960s, NEA and IAEA began the publication of a report entitled: “Uranium – Resources, Production and Demand”. The report, commonly known as the ‘Red Book’, has been published at roughly two-year intervals; the 2011 edition is the 24th edition. The report has become widely recognised in the international nuclear community as a primary reference document for world uranium supply and demand. IAEA publishes other technical reports, analyses and on-line databases which include this data, such as “IAEA Analysis of Uranium Supply to 2050”, “World Distribution of Uranium Deposits Database (UDEPO)”, and “World Thorium Deposits and Resources Database (ThDEPO)”.

6. Each edition of the ‘Red Book’ contains estimates of uranium resources divided into several categories of assurance of existence and economic attractiveness, along with projections of production capability, installed nuclear capacity and related reactor requirements. Annual statistical data are included on exploration expenditures, uranium production, employment, and levels of uranium stocks. In addition to a global analysis, the report contains detailed reviews of uranium-related developments in Member countries over the two-year reporting period. The ‘Red Book’ is based on official submissions by NEA and IAEA Member States, as well as secretarial (NEA and IAEA) estimates.

7. Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product. Unconventional resources are very low-grade uranium resources from which the uranium is only recoverable as a minor product of developing and processing a mineral ore.

8. Uranium resources are classified according to geological certainty and costs of production (Figure 1). The scheme is used to combine resource estimates from a number of different countries into harmonised global figures.

B. Cost categories

9. Uranium resource estimates are reported in cost categories. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant. When estimating the cost of production for assigning resources within these cost categories, the following costs have been taken into account:

¹ In the past, the NEA/IAEA Uranium Classification reported thorium resources in the same way as it reports uranium. Since there is no current major market for thorium, but it is being or could be produced with other, commercially saleable commodities, thorium thus can be reported under UNFC-2009 (see Section III E in this document).

- (a) the direct costs of mining, transporting and processing the uranium ore;
- (b) the costs of associated environmental and waste management during and after mining;
- (c) the costs of maintaining non-operating production units, where applicable; in the case of on-going projects, those capital costs that remain non-amortised;
- (d) the capital cost of providing new production units where applicable, including the cost of financing;
- (e) indirect costs, such as office overheads, taxes and royalties, where applicable;
- (f) future exploration and development costs wherever required for further ore delineation to the stage that it is ready to be mined;
- (g) sunk costs are not normally taken into consideration.

10. The cost categories, in United States dollars (USD), currently used in the NEA/IAEA Uranium Classification are defined as: <USD 40/kgU, <USD 80/kgU, <USD 130/kgU and <USD 260/kgU. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

11. Figure 1 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of a given tonnage based on varying degrees of geologic knowledge. The vertical axis expresses the economic feasibility of exploitation separated into cost categories.

C. Production terminology

12. The NEA/IAEA ‘Red Book’ uses production terminology for uranium reporting. A production centre, as referred to in this report, is a production unit consisting of one or more ore processing plants, as well as one or more associated mines and uranium resources that are tributary to these facilities. For the purpose of describing production centres, they have been divided into four classes, as follows:

- (a) **Existing** production centres are those that currently exist in operational condition; this category also includes plants that are closed but could be readily brought back into operation.
- (b) **Committed** production centres are those under construction or firmly committed for construction.
- (c) **Planned** production centres are those for which feasibility studies are either completed or under way, but construction commitments have not yet been made. This class also includes plants that are closed and would require substantial expenditures to bring back into operation.
- (d) **Prospective** production centres are those that could be supported by tributary Reasonably Assured Resources (RAR) and Inferred Resources (in combination they comprise “Identified Resources”), but for which construction plans have not yet been made.

The diagram shows a 4x4 matrix. The vertical axis is labeled 'Decreasing economic attractiveness' with a downward arrow. The horizontal axis is labeled 'Decreasing confidence in estimates' with a rightward arrow. The matrix is divided into 'Identified resources' and 'Undiscovered resources'. The 'Identified resources' column is split into 'Reasonably assured resources' and 'Inferred resources'. The 'Undiscovered resources' column is split into 'Prognosticated resources' and 'Speculative resources'. The rows represent different cost ranges: '<USD 40/kgU', 'USD 40-80/kgU', 'USD 80-130/kgU', and 'USD 130-260/kgU'. A vertical label 'Recoverable at costs' is placed to the left of the cost range rows.

		Identified resources		Undiscovered resources	
		Reasonably assured resources	Inferred resources	Prognosticated resources	Speculative resources
Decreasing economic attractiveness ↓	Recoverable at costs	<USD 40/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources
	USD 40-80/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	Speculative resources
	USD 80-130/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	
	USD 130-260/kgU	Reasonably assured resources	Inferred resources	Prognosticated resources	
Decreasing confidence in estimates →					

Figure 1: Classification scheme for uranium resources as presented in the NEA/IAEA ‘Red Book’

III. Direct mapping of Categories and Sub-Categories

A. Application of the G-axis

13. Conventional uranium and thorium resources are sub-divided according to different confidence levels of occurrence, into Identified Resources and Undiscovered Resources. Identified Resources are further sub-divided into Reasonably Assured Resources (RAR) and Inferred Resources (IR). Undiscovered Resources are sub-divided into Prognosticated Resources (PR) and Speculative Resources (SR).

14. Identified resources (RAR and IR) refer to uranium deposits delineated by sufficient direct measurement to conduct pre-feasibility studies, and sometimes feasibility studies. For Reasonably Assured Resources (RAR), high confidence in estimates of grade and tonnage are generally compatible with standards for making mining decisions. Inferred Resources (IR) are not defined with such a high a degree of confidence and generally require further direct measurement prior to making a decision to mine. The Geological Knowledge (G) axis has a direct mapping to the NEA-IAEA Uranium Classification as shown in Figure 2.

UNFC-2009 Classification					NEA/IAEA Classification		
UNFC-2009 Classes and Sub-classes		UNFC-2009 Categories					
Class	Sub-Class	E	F	G	Status	IAEA-NEA Cost Categories ²	
Commercial Projects	On Production	1	1.1	1,2	Existing	Reasonably Assured Resources (RAR) <USD 130/KgU <USD50/lb U3O8	
	Approved for Development	1	1.2	1,2	Committed		
	Justified for Development	1	1.3	1,2	Planned		
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Prospective	Identified Resources	
	Development On Hold	2	2.2	1,2,3		RAR	IR*
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3		Identified Resources	
	Development not Viable	3.3	2.3	1,2,3		RAR	IR*
Exploration projects		3.2	3	4		>USD130/KgU >USD 50/lbU3O8	>USD130/KgU >USD 50/lbU3O8
						Undiscovered Resources	

Figure 2: Mapping of NEA/IAEA uranium resource categories to UNFC-2009 Classes and Sub-classes.

*Inferred Resources

² Refer to Section III B of this document for use of cost categories.

B. Detailed mapping of the E and F axes

15. Figure 3 shows a mapping of the E-F Sub-category matrix to the NEA/IAEA Classification Scheme with a colour coded–numeric key. Note that colours and numbers are aligned with the PRMS³ mapping (see Annex IV of the Specifications for the Application of UNFC-2009 document) and hence not all numbers are used here.

16. Where cost of production can be assumed, Identified Resources estimated at production cost less than or equal to the current market price would range from E1F1 to E2F2. As an illustrative example, apply a cost of production for a thoroughly explored resource under consideration (deposit) as equal to or less than USD 130/kgU, which is approximately the recent spot market price. Sufficiently detailed studies of this project have been completed to demonstrate the feasibility of economic extraction by implementing the defined development project or mining operation; thus, this project corresponds to classifications E1F1. Optionally, it may be further sub-classified on the F axis into F1.1, F1.2 or F1.3 and on E axis into E1.1 or E1.2 (refer to Figure III.3 and Annex V of the Specifications for the Application of UNFC-2009 document, which provides specific guidance in the differentiation between the project maturity Sub-classes).

17. Where the cost of production is estimated to be in the cost category higher than that of the current market price, the Identified Resources will correspond to UNFC-2009 requirements of E2 and F2.1 or F2.2.

18. Quantities of Identified Resources reported at cost of production equal or less than USD 130/kgU shall correspond to UNFC-2009 requirements of E2 and F2.1 or F2.2 where: (a) project activities are on-going to justify development in the foreseeable future, or (b) are on hold and/or where justification as a commercial development may be subject to significant delay.

19. Quantities of Identified Resources reported at cost of production in the category USD 130 – 260/KgU, or where the cost of production cannot be clarified, shall correspond to UNFC-2009 requirements of E3 and F2.2 or F2.3. In this case, the quantities are technically recoverable, however (a) economic viability cannot yet be determined due to insufficient information (sub-categories E3.2, F2.2) or (b) the resources are not expected to become economically viable in the foreseeable future (sub-categories E3.3, F2.3).

20. Mapping of E and F categories to NEA/IAEA production terminology is shown in Figure 3. The optional UNFC-2009 sub-classes ‘On Production’, ‘Approved for Development’ and ‘Justified for Development’ shall correspond to NEA-IAEA production terminology ‘Existing’ (E1, F1.1), ‘Committed’ (E1, F1.2) and ‘Planned’ (E1, F1.3). NEA/IAEA production terminology ‘Prospective’ shall correspond to both ‘Development Pending’ (E2, F2.1) and ‘Development on Hold’ (E2, F2.2).

21. Note that the E and F Categories set minimum standards for the UNFC-2009 Classes. For example, a Potentially Commercial Project (Development Pending in Figure 2) must be at least E2 and F2, but it could be also E1, F2 or E2, F1.

22. UNFC-2009 is a project-based system. Where a production centre has uranium resources in different cost categories, these may correspond to different projects in UNFC-2009. Referring to Figure 2, Reasonably Assured Resources <USD 130/KgU are associated

³ Petroleum Resources Management System (PRMS) approved by the Society of Petroleum Engineers (SPE) Board in March 2007 and endorsed by the World Petroleum Council (WPC), the American Association of Petroleum Geologists (AAPG), the Society of Petroleum Evaluation Engineers (SPEE) and the Society of Exploration Geophysicists (SEG).

with a Potentially Commercial Project. These may be further subdivided using the UNFC-2009 Sub-classes (Figure 3) if desired. Irrespective of the production cost, assigning uranium resources to any particular UNFC Class or Sub-class should satisfy all the minimum requirements of E, F and G Categories.

C. Undiscovered Resources

23. Undiscovered Resources (Prognosticated Resources and Speculative Resources) refer to resources that are expected to exist based on geological knowledge of previously discovered deposits, regional geological mapping and other geologic data sources. In UNFC-2009, the quantities estimated for Undiscovered Resources can correspond to E3 and F3. Both Prognosticated and Speculative Resources require significant amounts of exploration before their existence can be confirmed and grades and tonnages of discovered resources can be defined. Additional sub-classification into Prognosticated Resources and Speculative Resources can be aided by generic specifications (Section VI R of the Specifications for the Application of UNFC-2009 document).

24. Prognosticated Resources refer to those expected to exist in known uranium provinces, generally supported by some direct evidence. Quantities estimated shall correspond to UNFC-2009 E3.2 and F3.1. As defined by F3.1, the estimates shall be based on “where site-specific geological studies and exploration activities have identified the potential for an individual deposit with sufficient confidence to warrant drilling or testing that is designed to confirm the existence of that deposit in such form, quality and quantity that the feasibility of extraction can be evaluated.”

25. Speculative resources refer to those expected to exist in geological provinces that may host uranium deposits based on favourable regional geologic features for uranium occurrence. Quantities estimated will correspond to UNFC-2009 E3.2 and F3.2 and/or F3.3. As defined by F3.2, estimates are based on where “local geological studies and exploration activities indicate the potential for one or more deposits in a specific part of a geological province, but requires more data acquisition and/or evaluation in order to have sufficient confidence to warrant drilling or testing that is designed to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated.” As defined by F3.3, studies are “at the earliest stage of exploration activities, where favourable conditions for the potential discovery of deposits in a geological province may be inferred from regional geological studies.”

D. Recoverable resources

26. Identified Resources (RAR and IR) estimates are expressed in terms of recoverable tonnes of uranium—quantities of uranium recoverable from mineable ore—as opposed to quantities of uranium contained in mineable ore or quantities in situ, which does not take into account mining and milling losses. While using UNFC-2009, the unrecoverable quantities correspond to E3 and F4. Undiscovered Resources (PR and SR) estimates are expressed in terms of uranium contained in mineable ore; that is., in-situ quantities. However, such quantities must still be “potentially recoverable” in order to be designated F3. In some situations, these quantities could be sub-classified based on F4.1, F4.2 and F4.3 (see Section VI S in the Specifications for the Application of UNFC-2009 document).

	F1.1	F1.2	F1.3	F2.1	F2.2	F2.3	F3.1	F3.2	F3.3	F4
E1.1	1	2	3	4						
E1.2	1	2	3							
E2			4	4	11					
E3.1										
E3.2				5	5		8	9	9	
E3.3					6	6				7

NEA/IAEA Classification	NEA/IAEA Classification	NEA/IAEA Cost Category	NEA/IAEA Production Terminology	UNFC-2009 Sub-classes	Mapping
Identified Resources	Reasonably Assured Resources	Cost of Production ≤ USD 130/KgU	Existing	On Production	1
			Committed	Approved for Development	2
			Planned	Justified for Development	3
			Prospective	Development Pending	4
	Development on Hold	11			
	Reasonably Assured Resources + Inferred Resources	Cost of Production USD 130-260/KgU or Unclassified		Development Unclassified	5
				Development Not Viable	6
			Unrecoverable	7	
Undiscovered Resources	Prognosticated Resources				8
	Speculative Resources				9
				Unrecoverable	7
				Less Common Mappings	

Figure 3: Mapping of NEA/IAEA Classification Scheme to E-F matrix of UNFC-2009.

E. Thorium resources

27. Thorium currently has minor commercial applications. It is considered as a potential fuel for present and future generation nuclear reactors. Presently, thorium is being produced as a by-product of mining and processing other mineral commodities, such as rare earth elements; at some operations thorium minerals are stockpiled for future use. Provided that thorium is stored in a manner in which it remains available for future commercial sale, it may be assigned to E3.2 or E3.3 (and subsequently moved to E2 and E1 once large scale commercial market emerges for thorium as a nuclear reactor fuel).
