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Decision support: Development and deployment of the United Nations Framework Classification for Resources: Accelerated adoption of the United Nations Framework Classification for Resources: Understanding the G axis

Task Force report and recommendations on the use of the G axis of the United Nations Framework Classification for Resources

Prepared by the G axis Task Force on behalf of the Bureau of the Expert Group on Resource Management

Summary

At its fourteenth session, the Expert Group on Resource Management of the United Nations Economic Commission for Europe (UNECE) recognized the need for further clarification on how the United Nations Framework Classification for Resources (UNFC) G axis is used and decided to form a Task Force. Its purpose was to summarise differences in how the G axis is interpreted and applied, to clarify the consequences of these differences, and to identify options for the Expert Group.

This report identifies the different uses of the G axis which have been adopted for different resources in case studies and bridging documents. In the absence of any definition and guidance on the potentially different uses in UNFC documentation, the current situation leads to significant lack of clarity. This can result in poor communication and misunderstanding. A key risk is that that different inventories of resources will be misunderstood resulting in incorrect resource statistics that are then used as a basis for policy and decision-making. The report explains and clarifies the different uses and shows the approximate correspondence between G-axis Categories in these alternative approaches.

It is recommended that the Expert Group recognises and accepts that the G axis is used differently for different purposes, and that it documents guidance for these uses, based on the material within this report. Initially this guidance should be a standalone document. In the next update of UNFC the guidance should be added to the specifications. This approach will add necessary clarity whilst minimising disruption.

It is also recommended that several related issues are addressed: clarification of direct versus indirect evidence, updated guidance on the definition of a project, guidance on aggregation, and an online list of all relevant UNFC documents for different types of users.

Contents

I. Introduction

1. The United Nations Framework Classification for Resources (UNFC) is a principles-based system in which resource projects are classified on the basis of the three fundamental criteria of environmental-socio-economic viability (E), technical feasibility (F), and degree of confidence in the estimate of the quantities of products from the project (G) using a numerical coding system.

2. At its fourteenth session in 2023, the Expert Group on Resource Management of the United Nations Economic Commission for Europe (UNECE) recognized the need for further clarification on how the UNFC G axis is used and decided to form a G axis Task Force. The meeting report[1] states: "*The Expert Group recognized that there is a need for further clarification on how the G axis of UNFC is used for different resources and in different applications, and potentially a need for further guidance or standards so as to ensure consistent use of UNFC and clear communication. The Expert Group agreed to form a G-axis Task Force and requested the Bureau to elaborate on the organizational issues*".

3. This document has been prepared by the G axis Task Force on behalf of the Bureau of the Expert Group on Resource Management. The membership of the G axis Task Force is shown in Annex I. Soraya Heuss-Aßbichler, Sigurd Heiberg, Zoltán Horváth and members of the Technical Advisory Group of the Expert Group are thanked for reviewing this document and for providing valuable comments on an earlier version.

II. Objectives and Approach

4. The objectives agreed at the fourteenth session of the Expert Group on Resource Management[2] were to:

- Summarise differences in how the G axis is interpreted and applied for different resources i.e. whether there are different meanings attached to the G-axis Categories when classifying different resources[3] and what these different meanings are
- Clarify the consequences of these differences in interpretation i.e., do differences in use of the G axis matter and if so, how?
- Identify options for the Expert Group e.g.: (i) recognize, clarify and accept differences, or (ii) provide additional guidance on the use of the G axis, or (iii) modify generic and/or supplementary specifications to harmonize them. There is no intent with this initiative to change UNFC.

5. It is noted that a G axis Working Group was established in 2015 and ran until 2017. Its purpose was that the *"G axis name, Category definitions and supporting explanations be reviewed in detail during the next update of UNFC-2009 and one or more proposals developed for modifications that would better reflect the needs of the renewables sector without compromising their applicability to solid minerals and petroleum*[4]*."* The Working Group reported to the Expert Group in 2017[5] and its recommendations were adopted in the 2019 update of UNFC[6]. The current Task Force follows on to this previous work.

6. The approach taken to the work by the current Task Force was to review case studies and bridging documents to understand how the G axis has been applied. This review is documented in Annex II. The Task Force then discussed and clarified these uses, the consequences and options. These are explained in sections III, IV and V. During discussions,

[1] ECE/ENERGY/GE.3/2023/2 Report of the Expert Group on Resource Management, paragraph 35.
[2] ECE/ENERGY/GE.3/2023/2 Report of the Expert Group on Resource Management, paragraph 35.
[3] Strictly this should read "…when classifying different resource projects…".
[4] ECE/ENERGY/GE.3/2015/2 Report of the Expert Group on Resource Classification.
[5] ECE/ENERGY/GE.3/2017/10 Recommendations for possible future changes to the G-axis name, category definitions and supporting explanations.
[6] United Nations Framework Classification for Resources, Update 2109. ECE Energy Series No. 61, Geneva 2020.

a number of related issues were identified as explained in section VI. Recommendations to the Expert Group are presented in section VII.

7. The intent of the work of the Task Force is to be principles-based, as is the intent of UNFC, rather than prescriptive.

III. Use of the G axis

8. Annex I of UNFC (2019)[6] provides the definition and supporting explanation for the G axis Categories. These are reproduced in the first three columns of Table 1, below.

9. In practice, the G axis has been used in different ways, as explained in the last three columns of Table 1. The "confidence in estimate" usage focusses on how confidently the quantity of production can be estimated. It is based on the first part paragraph of the supporting explanation given in UNFC (2019) "*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.*" The "position in uncertainty range" usage focusses on defining different positions in the uncertainty range of the estimate. It is based on the second paragraph of the supporting explanation. This usage is applied in two different ways, deterministic or probabilistic, as explained in the last two columns of Table 1.

10. The two usages are shown schematically in Figure I. This diagram illustrates the alternative ways in which a project[7] is categorized on the G axis with increasing knowledge. In both usages of the G axis, the quantity associated with a prospective project is categorized as G4 i.e. whilst a source is unknown. Once a source is known, through direct evidence, the G axis Categories are used differently:

(a) Where a "confidence in estimate" use has been adopted, a project progresses up the G axis from G3 to G2 to G1, denoting increasing confidence in the estimate (decreasing uncertainty) gained through increased knowledge. At the date of the evaluation (the Effective Date), only one value of the quantity is estimated and categorized (as G1, G2 or G3). Categories G1+G2 and G1+G2+G3 are not defined in this usage;

(b) By contrast, where a "position in uncertainty range" use has been adopted, up to 3 estimates may be made at the Effective Date and categorized (as G1, G2 and G3 or as G1, G1+G2 and G1+G2+G3), whatever the level of knowledge. As knowledge increases it is the spread of values between G1, G1+G2, G1+G2+G3 which potentially changes - typically decreasing.

11. The review of case studies, provided in Annex II, shows that the "confidence in estimate" usage has been adopted in studies of minerals, nuclear and anthropogenic resources, whilst the "position in uncertainty range" usage has been adopted in studies of petroleum, injection and renewable energy resources. There is a long practice of minerals and petroleum classification which developed these different ways of categorizing estimated quantities. Nuclear and anthropogenic studies have followed the minerals approach. Injection and renewable energy studies have followed the petroleum approach. In some case studies, the aggregation of estimated quantities was presented in a manner inconsistent with the UNFC specifications.

[7] Guidance Note to support the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 Definition of a Project. UNECE Expert Group on Resource Classification, 15 July 2016.

Table 1
Definition and use of G-axis Categories

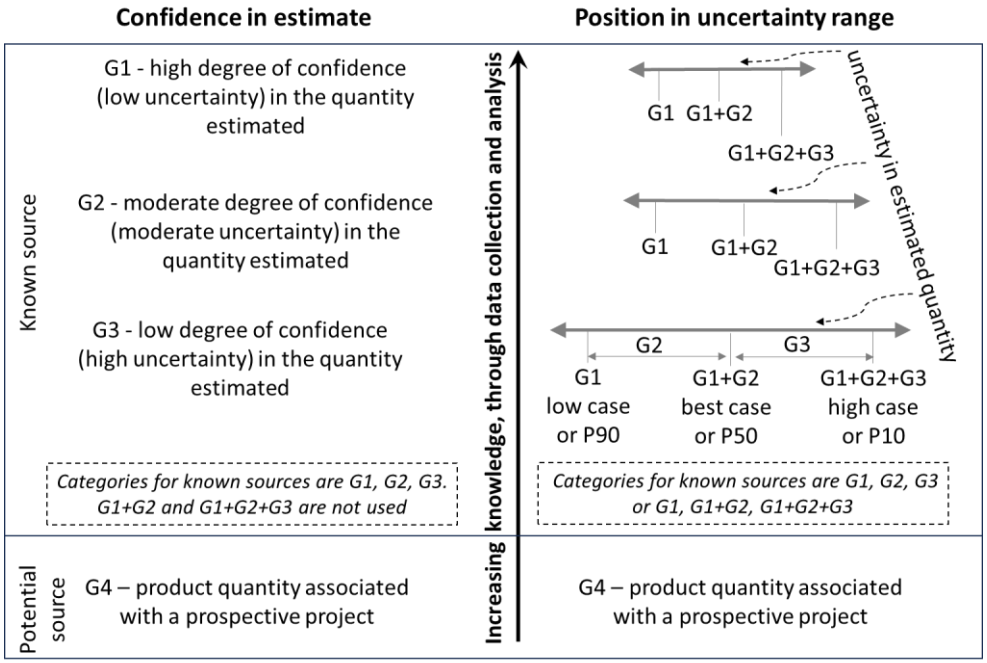
	Definition[a]	*Supporting Explanation*[a]	*Confidence in estimate*[b]	*Position in uncertainty range*[c]	
				Deterministic	*Probabilistic*
G1	*Product quantity associated with a project that can be estimated with a high level of confidence.*	*Product quantity estimates may be categorized discretely 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, geologic uncertainty, facility efficiency, etc.) impacting the estimate forecast for the project. Uncertainties include both variability and the efficiency of the development and operation (where relevant). 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.*	There is a high degree of confidence (low uncertainty) in the estimated quantity of products based on direct evidence as of an effective date.	The low estimate of the quantity of products.	The P90 estimate of the quantity of products.
G2	*Product quantity associated with a project that can be estimated with a moderate level of confidence.*		There is a moderate degree of confidence (moderate uncertainty) in the estimated quantity of products based on direct evidence as of an effective date.	The estimated incremental products such that G1+G2 is the best estimate. Since G2 is incremental, it cannot be estimated unless G1 is also estimated.	The estimated incremental products such that G1+G2 is the P50 estimate. Since G2 is incremental, it cannot be estimated unless G1 is also estimated.
G3	*Product quantity associated with a project that can be estimated with a low level of confidence.*		There is a low degree of confidence (high uncertainty) in the estimated quantity of products based on direct evidence as of an effective date.	The estimated incremental products such that G1+G2+G3 is the high estimate. Since G3 is incremental, it cannot be estimated unless either G1 and G2 or G1+G2 are also estimated.	The estimated incremental products such that G1+G2+G3 is the P10 estimate. Since G3 is incremental, it cannot be estimated unless either G1 and G2 or G1+G2 are also estimated.
G4	*Product quantity associated with a prospective project, estimated primarily on indirect evidence.*	*A potential 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 potential 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.*	The use is as described in the supporting explanation given in column 3.	The use is as described in the supporting explanation given in column 3.	The use is as described in the supporting explanation given in column 3.

[a] The Definitions and Supporting Explanations, shown in italics, are quoted directly from UNFC (2019).

[b] The "confidence in estimate" usage focusses on how confidently the quantity of production can be estimated. It is based on the first paragraph of the supporting explanation "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." For each set of activity, a single estimate of production is typically made at the effective date and is assigned to a single G axis Category G1, G2 or G3. Categories G1+G2 and G1+G2+G3 are not defined in this usage.

[c] The "position in uncertainty range" usage focusses on defining different positions in the uncertainty range of the estimate. It is based on the second paragraph of the supporting explanation. The estimated quantities may be either deterministic (low/best/high) based on deterministic scenarios, or probabilistic (P90/P50/P10, where P means the probability the estimate will be exceeded) based on probabilistic analysis. For each set of activity, a range of estimated quantities of production/injection may be made at the effective date. The range of estimates is assigned to G-axis Categories either discretely as G1, G2, G3 or as G1, G1+G2, G1+G2+G3.

Figure I
Schematic illustration of G axis uses



12. In both "confidence in estimate" and "position in uncertainty range" usages, the quantities categorized on the G axis are estimates of how much will be produced (injected) if the project is successfully executed, and the current assumptions which impact the estimated forecast continue to apply. With immature projects (high EF Categories) there will often be a low level of knowledge and high uncertainty in estimated quantities. With "confidence in estimate" usage, the lower the level of knowledge, the higher the G-axis Category. With "position in uncertainty range" usage, three estimated quantities may be categorized. The higher the uncertainty the wider the separation between G1, G1+G2 and G1+G2+G3 estimated quantities. But in both usages, whatever the level of project maturity, the estimates do not incorporate any reduction in quantities due to the chance that the project will not go ahead.

13. In the supporting explanation for G-axis Categories, P90, P50 and P10 are the probabilities that the actual outcome will equal or exceed the estimate and are used in the probabilistic application of "position in uncertainty range". They are not probabilities that the project will be executed.

14. UNFC (2019) recommends additional assessment and documentation of the chance that a Prospective project will progress to a Viable project. It can also be useful to assess and document the chance of progression to Viability for Potentially-Viable and Non-Viable projects.

15. It is noted that UNFC (2019) defines the principles for classification rather than relating to terminology and methodology for specific resources. Hence the definitions and explanations of G-axis Categories in UNFC (2019), described in Table 1, and the alternative uses shown in Figure I only explain principles. Resource-specific terminology and methods for assessing "confidence in estimate" or "position in uncertainty range" are contained in industry practice. This is a shift from earlier versions of UNFC specifications where more industry- and resource-specific terms were utilized. However, it is in keeping with UNFC (2019) where language was changed from UNFC (2009) so as to be applicable to all resources.

16. As an example of a resource-specific terminology and approach: for minerals, common industry terminology for G1, G2 and G3 levels of confidence are measured, indicated and inferred. A probabilistic definition of these levels is still being developed by the minerals industry, with recommendations suggesting that a measured resource would be

a production quarter known within ± 15 %, 90 % of the time; an indicated resource, within ± 30 %, 90 % of the time; and inferred, within ± 30 % and ± 100 %, 90 % of the time.

17. Annex II of this document also reports the review of bridging documents. There is consistency between usages in case studies and in bridging between UNFC and other classification systems: Bridging for minerals and nuclear resource classifications has applied the "confidence in estimate" usage, whilst bridging for petroleum resource classifications has applied the "position in uncertainty range" usage.

18. There is an approximate correspondence between the two types of use ("Confidence in estimate", "Position in uncertainty range") as shown in Table 2. This correspondence was applied in the bridging between The National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2020) and UNFC[8] and first endorsed by the Expert Group in 2018. The Chinese petroleum classification system categorizes quantities in a similar way to "confidence in estimate" usage but has been bridged by relating this to the "position in uncertainty range" usage for consistency with practice in other petroleum classification systems.

Table 2
Approximate correspondence between uses of the G-axis Categories

Class	*Minimum E and F Categories*		*Approximate correspondence between uses of G axis*	
			Confidence in estimate	*Position in uncertainty range*
Viable Projects	E1	F1	G1	G1
			G2	G1+G2
			G3	G1+G2+G3
Potentially Viable Projects	E2	F2	G1	G1
			G2	G1+G2
			G3	G1+G2+G3
Non-Viable Projects	E3	F3	G1	G1
			G2	G1+G2
			G3	G1+G2+G3
Prospective Projects	E3	F3	G4	G4

19. In summary, the G axis is being used in different ways. On the evidence of published UNFC case studies and bridging documents, there is consistent use within a resource type but not between different resources.

IV. Consequences

20. In the absence of any definition and guidance on the potentially different uses in UNFC documentation the current situation leads to significant lack of clarity. This has four significant and related consequences:

(a) The first consequence is poor communication. There will be a lack of clear communication between experts from different resource areas resulting in misunderstandings. It was noted at the fourteenth session of Expert Group on Resource Management, that non-minerals experts found it difficult to understand some of the presentations on mineral resources and questioned their correctness. If experts in resource

[8] Bridging Document between the National Standard of the People's Republic of China "Classification for Petroleum Resources/Reserves (GB/T 19492-2020)"and the "United Nations Framework Classification for Resources (UNFC). UNECE, Geneva, 25 October 2022.

classification from different disciplines misunderstand each other, then it is very likely non-expert users, such as those who commission studies, will also be confused;

(b) A key risk is that that different inventories of resources will be misunderstood. This can lead to incorrect resource statistics which are then used as a basis for policy and decision-making;

(c) A related consequence is the difficulty of comparing production from projects of different resource types where the G axis has been used in different ways. One of the primary purposes of UNFC is to enable decision makers to compare and rank a range of projects across different resources. For example, a government planning energy provision will want to understand the potential production of energy from different resources. Understanding the potential supply of critical raw materials both from mining and anthropogenic sources will also be important. The mix of G axis usages between different resources will lead to potential difficulties in comparison. Table 2 shows how to make an approximate comparison, but clarity in usages will be required to apply this correctly;

(d) There is a risk of inexperienced users misapplying UNFC. For example, in some presentations of minerals studies, quantities were categorised using the "confidence in estimate" approach, but aggregated quantities were categorised as "G1+G2", which is not a Category in the "confidence in estimate" usage. There is also a risk of inappropriate G axis use in fields with a short history of resource classification. The short timespan results in less standardization, guidance and practice compared with traditional resource sectors. For example, anthropogenic resource classification started to evolve a decade ago, whereas mineral resource classification started a century ago. However, classifying mineral and anthropogenic resource projects based on the same UNFC principles is a key strength for sustainable resource management.

21. With some case studies the problem has not been due to how the G axis was used but with insufficient guidance and experience leading to incorrect assessment and classification. It is a challenge to make good quality assessments of resources and to assign the correct G-axis Categories. Technical knowledge, experience and judgment are required. Some UNFC supplementary specifications, such as Petroleum[9], contain a section of guidance on estimation methods. UNFC may need an extra layer of guidance on appropriate methods for each resource type.

V. Options

22. Having explained the different ways in which the G axis is being used and the consequences, the Task Force identified alternative options for the Expert Group. These are shown in Table 3.

23. In discussions, the Task Force recognised a range of considerations in deciding on the best option. These can be grouped under four headings of universality, clarity, comparability and no disruption:

(a) **Universality**: The fact that UNFC is a framework means that some different uses are inevitable. The different uses of the G axis may be for different resources or just different applications, and these should be accommodated in some way since the aim of UNFC is either to be used directly for all resources, or to bridge with other systems. Furthermore, it should be possible to accommodate other uses of the G axis if those are required in the future. This includes other types of description of product quantities, and other project metrics. The use of the metrics that decisions require was agreed at the thirteenth session of the Expert Group. The use of UNFC for defining not only production and other quantities that projects carry (e.g. measures of economic, social and environmental impacts) is a key recommendation of the work by the UNFC Adoption Group;

[9] Supplementary Specifications for the Application of the United Nations Framework Classification for Resources to Petroleum (24 September 2022). https://unece.org/sites/default/files/2022-01/UNFC%20Petroleum%20Specifications%202021.pdf

(b) **Clarity**: Clarity is required on how the G axis is being used in every application, both for preparers and for receivers of classifications. It should be simple for non-experts. Without clarity there will be confusion;

(c) **Comparability**: As explained in paragraph 15, it is important to be able to compare different projects, not only of the same resource type but also of different resources;

(d) **No disruption**: It is desirable not to change established UNFC specifications and associated documents, but rather to maintain the status quo and familiarity of current documents, and that the chosen option is simple to implement. UNFC has already been adopted by countries, regions and some professional bodies. For example, it has been incorporated into laws and planning by the African Union and the European Union. In considerations for any future additions and changes to specifications or guidance, it is therefore important to be mindful of the impact on current uses of UNFC and to minimise disruption to these.

Table 3
Options

Option	*Description*	*Comments*
(a) No change	Accept that the G axis is used differently for different purposes Make no changes to UNFC specifications or guidance.	Maintains universality of UNFC but lack of clarity remains resulting in a loss of trust. **Not recommended.**
(b) Provide guidance and naming convention	Accept that the G axis is used differently for different purposes. Develop guidance which documents the uses, and provides a naming convention for these uses, as described in section III. Direct that the type of G axis usage whether “confidence in estimate or “position in uncertainty range” is documented in each study. Initially this guidance will be a standalone document, but in the next update of UNFC it will be added to the specifications e.g. replacing the current G axis table (given in Part I of UNFC (2109)) with the expanded table shown in Figure1, and adding a generic specification to Part II of UNFC (2019) on documentation of the naming convention for G axis usage i.e. “confidence in estimate or “position in uncertainty range”. This does not preclude adding additional uses in the future if agreed by the Expert Group.	Maintains universality, provides more clarity and minimises disruption. Comparability is possible by using the approximate correspondence shown in Table 2. **The majority of the task Force recommends this option.**
(c) Replace the G axis with two axes	Accept that the G axis is used differently for different purposes. Develop two descriptions of the usage of the G axis for inclusion in the UNFC specifications. Change UNFC specifications by replacing the G axis with two new axes. One axis would be used to categorise quantities using the "confidence in estimate" approach. The other axis would be used to categorise quantities using the "position in uncertainty range" approach. Users would be able to choose which of these two axes to use.	Maintains universality, provides good clarity. Comparability is possible by using the approximate correspondence shown in Table 2. Significant disruption because UNFC specifications are changed. **A minority of the Task Force members recommends this option.**
(d) Only allow "confidence in estimate" usage	Do not accept that the G axis can be used differently for different purposes. Instead modify the UNFC specifications to make clear that only the "confidence in estimate" approach, as defined in section III, can be used.	Provides good clarity and enables accurate comparability. Undermines universality and will cause significant disruption. **Not recommended.**

Option	*Description*	*Comments*
(e) Only allow "position in uncertainty range" usage	Do not accept that the G axis can be used differently for different purposes. Instead modify the UNFC specifications to make clear that only the “position in uncertainty range" approach, as defined in section III, can be used.	Provides good clarity and enables accurate comparability. Undermines universality and will cause significant disruption, **Not recommended.**

24. It is not possible to perfectly satisfy all of these considerations and so some compromise is required in the selected option:

(a) **Make no change** maintains the universality of UNFC but does not address the issue of clarity and continues with the current confusing situation. This option is not recommended;

(b) **Provide guidance and naming convention** maintains universality and adds clarity as long as guidance is followed. Adding guidance will provide support to users and will not cause significant disruption. Comparability can be achieved by adopting the approximate correspondence shown in Table 2. The majority of the task Force recommends this option;

(c) **Replace the G axis with two axes** maintains universality and provides good clarity. Comparability can be achieved by adopting the approximate correspondence shown in Table 2. However, this option will cause significant disruption because it requires a change in UNFC generical specifications, UNFC supplementary specifications, bridging documents and some guidance documents. Published case studies will be inconsistent with these updates. Current adopters will be impacted by these changes. A minority of the task Force recommends this option;

(d) **Only allow "confidence in estimate" usage** provides clarity and enables accurate comparability. However, current practice for some resources will not be allowed and so universality will be undermined and there will be significant disruption for many adopters. This option is not recommended;

(e) **Only allow “position in uncertainty range” usage** provides clarity and enables accurate comparability. However, current practice for some resources will not be allowed and so universality will be undermined and there will be significant disruption for many adopters. This option is not recommended.

VI. Related issues

25. During Task Force discussions, four related issues were identified: direct versus indirect evidence, project definition, aggregation, awareness of all relevant UNFC documents.

26. **Direct versus indirect evidence**. The distinction between direct and indirect evidence is important in distinguishing Known Sources from Potential Sources, and Identified from Prospective Projects. The product quantity associated with a Prospective Project, estimated primarily on indirect evidence, is categorized as G4. Product quantities associated with Identified Projects are categorized using G1, G2, G3, where direct evidence is required, as described in Table 1 above. It would be helpful to document what provides direct vs indirect evidence for different resources. This could be summarized as a table for all resources, and supplemented with additional detail in resource-specific guidance. Clarifying the distinction between direct and indirect evidence will present different challenges for different resources.

27. **Project definition**. UNFC is a project-based classification system. It is important to be clear about what is required to define a project and also when activities constitute more than one project, including in the situation where several areas of a source are being developed and/or where multiple types of products are produced (e.g. energy and raw materials). This clarity provides the basis for correct classification, appropriate estimates of

quantities and clarity in aggregation. The guidance note on the definition of a project[10] is helpful, but this was written to support UNFC (2009). This should be updated for consistency of terminology with UNFC (2019). As examples, several relevant parts of the guidance note are quoted:

(a) From paragraph 8 of the guidance "*A Project comprises a defined activity, or set of activities, which provides the basis for estimating both costs and potential revenues associated with its implementation*.";

(b) From paragraph 10 of the guidance "*The activity or set of activities which constitute the defined Project will always include some consideration of the mining operation or development scheme that could or will be implemented, or has been implemented, without which no estimate of potentially recoverable quantities can be made*.";

(c) From paragraph 16 of the guidance "*Sales quantities associated with an individual Project will always be classified under a single Category (or Sub-category) on the E axis and a single Category (or Sub-category) on the F axis*.";

(d) From paragraph 19 of the guidance "*If the planned activities can be separated into different Project Maturity Sub-classes with discrete decision and/or approval processes, then each of these will constitute a separate Project with a separate estimate of potentially recoverable quantities*".

28. **Aggregation**. Appropriate aggregation is needed for developing inventories of resources and correct resource statistics to be used as a basis for policy and decision-making. Guidance on aggregation would be helpful. This would cover a range of topics including methodologies and potential pitfalls, but should include considerations of how the G axis is used and how projects are defined:

(a) Lack of clarity about how the G axis has been used can result in confusion about the nature of aggregated quantities. For example, showing an aggregated quantity as E1,F1,G1+G2 where "confidence in estimate" has been used, would imply that the quantity from one project was categorized as E1F1G1 (high confidence) and the quantity from another project was categorized as E1F1G2 (moderate confidence), but how much of each would be unknown unless separately stated. However, if "position in uncertainty range" had been used, then E1,F1,G1+G2 would mean that the aggregated quantity is a best-case or P50 estimate. In this case it may be that the G1 and incremental G2 estimated quantities for a single project had been combined to give a G1+G2 estimate, or it may be that G1+G2 estimated quantities from two or more separate projects had been combined. Additional explanations would be therefore helpful;

(b) When aggregating estimated quantities it is important to be clear about whether quantities are associated with the same or separate projects. UNFC (2019)[11] states "*Where estimates have been aggregated from multiple projects, consideration should be given to sub-dividing the aggregated totals by product type and by location*." Hence clarity about project definition, mentioned above, is important.

29. **Awareness of all relevant UNFC documents**. During the Task Force discussion, it became clear that not all were aware of all relevant UNFC documents. For example, several members were unaware of the guidance note on the definition of a project[10]. A brief, online summary should be developed which lists all relevant UNFC documents for different types of users.

[10] Guidance Note to support the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 Definition of a Project. UNECE Expert Group on Resource Classification, 15 July 2016.

[11] United Nations Framework Classification for Resources, Update 2109. ECE Energy Series No. 61, Geneva 2020. Part IV, J.

VII. Recommendations

30. It is recommended that Expert Group recognises and accepts that the G axis is used differently for different purposes as described in Figures 1 and 2, but that there is an approximate correspondence between the G-axis Categories in the alternative uses as shown in Table 2.

31. It is recommended that Expert Group documents guidance for these uses, and shows how comparisons may be made. Direct that the type of G axis usage whether “confidence in estimate” or “position in uncertainty range” is documented in each study. This is Option b in Table 3 (It is noted that this recommendation is the majority view of the Task Force, rather than a consensus view):

(a) Initially this guidance should be a standalone document. This will include Figures 1 and 2, which describe the alternative uses of the G axis and the naming convention to be adopted. It will also include Table 2, showing the approximate correspondence between G-axis Categories in the alternative uses;

(b) In the next update of UNFC this guidance should be added to the specifications by replacing the current UNFC (2019) G axis table with the expanded table shown in Table 1, adding a generic specification on documentation of the naming convention for G axis usage i.e. “confidence in estimate” or “position in uncertainty range” and on the approximate correspondence between alternative uses shown in Table 2;

(c) This approach will maintain universality, provide more clarity and minimises disruption. Comparability will be facilitated by using the approximate correspondence shown in Table 2. It does not preclude adding additional uses in the future if agreed by Expert Group.

32. It is recommended that relevant Working Groups consider whether additional resource-specific guidance is required on how to estimate quantities and assign appropriate G-axis Categories.

33. It is also recommended that several related issues, discussed in section VI, be addressed by Expert Group:

(a) Document what provides direct vs indirect evidence for different resources. This could be summarized as a table for all resources, and supplemented with additional detail in resource-specific guidance;

(b) Update the guidance note on the definition of a project, so that the terminology is consistent with UNFC (2019);

(c) Develop guidance on aggregation. This would cover a range of topics including a definition of aggregation, methodologies and potential pitfalls. It should include considerations of how the G axis is used and how projects are defined;

(d) Develop a brief, online summary which lists all relevant UNFC documents for different types of users.

Annex I

Membership of G axis Task Force

Name	*Affiliation / Expertise*
Alistair Jones (Chair)	Academia / oil & gas, carbon storage
Hendrik Falck	Profession regulators and industry / minerals
Ulrich Kral	Government sector / anthropogenic
Alex Shpilman	Private sector / oil & gas
Slavko Šolar	UNECE / minerals
Harikrishnan Tulsidas	UNECE / nuclear
Marina v. Vietinghoff-Scheel	Government sector / anthropogenic

Annex II

Uses of G axis in case studies and bridging documents

A. Purpose of this Annex

1. The purpose of this annex is to provide an overview of the relevant literature and their uses of the G axis. For this work, case studies and bridging documents which have been published previously were reviewed in terms of their G axis interpretation and use.

2. It appears that the UNFC G axis is being applied differently by different users. Two main interpretations could be identified and are presented with the associated resources, case studies and bridging documents in the following sections.

B. Summary of case studies

1. Studies employing "confidence in estimate" usage of the G axis

3. One use for the G Category is to denote the level of confidence (or level of uncertainty) in the estimate of production from a project, at its current level of EF maturity:

Mineral Resource Case Studies

Year	*Title*	*G axis Usage*
2023	UNFC evaluation of Critical Raw Material projects in France, fourteenth session of the Expert Group[a]	There are 2 different uses: First with drilling, sampling and analysis at an appropriate depth to define distribution and abundance then G3 denotes large uncertainty, G2 denotes medium uncertainty. Second, the probabilistic analysis: • G3 if the probability that the resource can be extracted economically is less than 50% • G2 if the probability that the resource can be extracted economically is between 50% and 90% • G1 if the probability that the resource can be extracted economically is greater than 90%.
2023	Graphite case study from Norway, fourteenth session of the Expert Group[b]	Mean values of estimated production are presented for Bukken and Litjkollen and are categorized as G3 because of the level of project maturity/data availability or level of uncertainty in the estimated quantities (p. 9, 12).
2021	Gravel sand study from Austria[c]	The study applies the UNFC EFG Categories to geological units (supply perspective) and application areas (demand perspective). The UNFC G Categories are defined as concrete ranges of Standard deviation of vertical dimension and confidence (p. 71): • G1 standard deviation of vertical dimension 0% to ±5% and confidence 100% to 90% • G2 standard deviation of vertical dimension 5% to ±25% and confidence 90% to 50% • G3 standard deviation of vertical dimension ±25% to ±35% and confidence 50% to 10% • G4 standard deviation of vertical dimension ±45% to ±100% and confidence 10% to 0%.

[a] https://unece.org/sites/default/files/2023-04/03.%20Leane%20Verhulst_BRGM%20CRM%20Projects%20France%20EGRM-14.pdf

[b] https://unece.org/sites/default/files/2023-04/01.%20Janja%20Solberg%20Graphite%20UNFC%20case%20study%20from%20Norway-Janja%20K.%20Solberg-Geneva%2025%20april%202023_Final%202.pdf

[c] https://opac.geologie.ac.at/ais312/detail.aspx

Anthropogenic Resource Case Studies

Year	*Title*	*G axis Usage*
2020 (2022, 2021, 2023)	Bottom-ash case study, Canton Zurich[a] (Other case studies which have followed the same use: Tailings storage case study, Bollrich, Germany[b], Tailing deposit from mining operation, Portugal[c], A Swiss case study on embedded electronics in end-of-life vehicles, fourteenth session of the Expert Group[d])	The study applies UNFC in a retrospective manner, from project idea to production. Table 5 shows that the G axis is understood as the level of confidence in the potential recoverability of the quantities, which is influenced by two factors (knowledge of material quality and quantity and supply continuity of waste feedstock). Each factor has its own G Category. The lowest rank of the G Categories defines the final G Category. The final G Categories are G1, G2 and G3 (depending on the point of time of the evaluation). This is done similarly in other case studies such as Bollrich 2022, with varying numbers of controlling factors.
2018	Fly ash case study, Vienna[e]	The authors classify salt recovery, metal recovery and the usage of the mineral fraction separately. The fact that fly-ash is sampled and analysed regularly, justified the designation of G1 Category to all recovery operations as a discrete Category.
2016	Landfill mining case study, Belgium[f]	Table 8 shows potentially recoverable and usable resources from an old landfill, whereas the low estimate (G1), best estimate (G1+G2) and high estimate (G1+G2+G3) is given for each product (regained saleable land, refuse-derived fuel, stones/minerals, nonferrous metals, ferrous metals and re-landfilled materials). A discrete classification assigns G2 Category to the landfill mining project. The G2 selection is justified with the knowledge on the waste composition (feedstock) and the efficiency of the recovery technologies.
2016 (2016)	Obsolete computer case study[f] (Another case study which followed the same use: Magnets in wind turbines study, Austria) [f]	The study classifies the waste management systems in a low and a high-income country. The G1 assignment for the high-income country and the G2 assignment for the low-income country are argued by the knowledge on waste composition and recovery efficiencies. The G Category assignment is based on the availability of studies and data, but not on a mathematical model as such.

[a] https://doi.org/10.1016/j.jclepro.2020.120490

[b] https://unece.org/sites/default/files/2022-05/ECE_ENERGY_GE.3_2022_14.pdf

[c] https://doi.org/10.1016/j.jclepro.2021.126446

[d] https://unece.org/sites/default/files/2023-04/03.%20Kirsten%20Remmen_FutuRaMvUNECE%20RMW_SWISS_ELV_EDD.pdf

[e] https://doi.org/10.1016/j.resconrec.2018.08.003

[f] https://doi.org/10.1016/j.jclepro.2016.05.083

Nuclear Resource Case Studies

Year	*Title*	*G axis Usage*
2019	Application of UNFC to Phosphate Rock - Uranium Resources: A Case Study of the El-Sebaeya Projects, Nile Valley, Egypt[a]	In Table 2 of Phosphate recoverable rock (p. 24) and Table 3 of Uranium resources (p. 26) the sum of entries for G1, G2, G3 and additional quantities in place is equal to the total quantities in the Nile Valley deposit. This implies that G1, G2 and G3 are considered best estimates for projects of different maturities.
2019	Case study on application of UNFC to the uranium deposits of Mexico[a]	In Table 2 of Uranium resources (p. 113) the sum of entries for G1, G2, G3 and additional quantities in place is equal to the total quantities for each deposit. This implies that G1, G2 and G3 are considered best estimates for projects of different maturities.

[a] 1919051_E_ECE_ENERGY_109_WEB.pdf (unece.org)

2. Studies following "position in uncertainty range" usage of the G axis

4. This interpretation of the G axis categorizes the location in the uncertainty distribution of the estimated quantities of production (or injection) from a project. In this usage, all 3 G axis Categories may be used for a project (whatever its maturity) and together they describe the best (or P50) estimate, the low side (or P90) estimate and the high side (or P10) estimate of product quantity associated with the implementation of the project. this is sub-divided into the deterministic and probabilistic approaches.

Petroleum Resource Case Studies, Specifications and Bridging Documents

Year	*Title*	*G axis Usage*
2014	Norwegian Petroleum Directorate 2014 Case Study: The 2013 Norwegian Petroleum Resource Accounts presented according to UNFC-2009[a]	Table 3 and Figure 10 show that, for each project of Known Resources G1+G2 is the estimated mean value and G1 and G1+G2+G3 describe the uncertainty range.
2020	Pilot project for the classification of Mexico's petroleum resources and reserves based on the United Nations Framework Classification for Resources (UNFC) – 2019[b]	Paragraph 64 and Table 4 show that for each project of Known Resources G1, G1+G2 and G1+G2+G3 describe the uncertainty range in the estimate.

[a] https://unece.org/DAM/energy/se/pdfs/egrm/egrc6_apr2015/ECE.ENERGY.GE.3.2015.5_e.pdf
[b] https://www.un-ilibrary.org/content/books/9789210045254c008/read

Renewable Resource Case Studies: Geothermal, Bioenergy, Wind

Year	*Title*	*G axis Usage*
2017	Application of the United Nations Framework Classification for Resources (UNFC) to Geothermal Energy Resources – selected case studies 2017[a]	In case study 2 (p. 9) G1, G2 and G3 are used to describe the uncertainty range in the estimate with G2 being incremental to G1 (G1+G2 is the best estimate) and G3 being incremental to G2 (G1+G2+G3 is the high estimate). Other case studies in this publication demonstrate a similar use of the G axis.
2019	Application of UNFC to Bioenergy Resources Example: Quantifying bioenergy resources, Brazil[b]	Table 6 (p. 166), Table 16 (p. 175), Table 24 (p. 185-187) and Table 29 (p. 193) show that for each project G1, G1+G2, G1+G2+G3 are used to describe the low, best and high scenarios.
2022	Application of the United Nations Framework Classification for Resources to Wind Energy Resources: National Aggregation Case Studies[c]	Paragraph 17, Tables 1 and 2, and Figure II of the reported case study show that G1, G1+G2, G1+G2+G3 are used to describe the low, best and high scenarios.

[a] https://unece.org/sites/default/files/2020-12/1734615_E_ECE_ENERGY_110_WEB.pdf

[b] https://unece.org/sustainable-energy/publications/application-unfc-case-studies-2019-ece-energy-series-no-58

[c] https://unece.org/sed/documents/2022/04/session-documents/application-unfc-wind-energy-resources-national-aggregation

Injection Resource Case Studies

Year	*Title*	*G axis Usage*
2018	Application of UNFC to Injection Projects[a]	The table on p12 for the EIA storage plan presents quantities categorized as G1+G2 and shows that the "low, best, and high scenario" approach is used.

[a] Presentation to the Expert Group on Resource Classification, 9th Session, Geneva, April 2018 https://unece.org/fileadmin/DAM/energy/se/pp/unfc_egrm/egrc9_apr2018/26.04/p.6_K.Ask.pdf

C. How the G axis has been used in bridging documents

5. The following table presents how the G axis has been used in previously published bridging documents and the identified consistent use between them and associated resources.

Bridging to/from UNFC	*Resource*	*Use of G axis*	*Comment*
CRIRSCO[a]	Minerals	confidence in estimate	
Chinese Solid Minerals[b]	Minerals	confidence in estimate	
NEA/IAEA 'Red Book'[c]	Nuclear	confidence in estimate	
PRMS (update 2023)[d]	Petroleum	position in uncertainty range	The G-axis Categories may be used discretely in incremental form (i.e., G1, G2 and G3) or in cumulative scenario form (i.e., G1, G1 + G2 and G1 + G2 + G3).
Bridging to Russian Federation Oil & Gas 2013 (update 2023)[e]	Petroleum	position in uncertainty range	There are two estimated quantities for any given project: G1 and G1 + G2 + G3. The Category G1 + G2 is not used.
National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2020) (2022)[f]	Petroleum	confidence in estimate mapped is to position in uncertainty range	There is a dependence between the maturity of projects and geological knowledge, and the degree of confidence. The most mature projects are categorized as G1 on the G axis whilst at an early stage of development, for known (discovered) fields, projects are categorized as G1 + G2 + G3 on the G axis. At an intermediate level of knowledge they are categorized as G1+G2.

[a] Bridging Document between the Committee for Mineral Reserves International Reporting Standards Template and the United Nations Framework Classification for Resources, 12 February 2024
https://unece.org/sites/default/files/2022-01/UNFC%20Petroleum%20Specifications%202021.pdf

[b] Bridging Document between the National Standard of the People's Republic of China "Classification for Resources/Reserves of Solid Fuels and Mineral Commodities (GB/T 17766-2020)" and the "United Nations Framework Classification for Resources (UNFC)", 2022
https://unece.org/sed/documents/2024/03/reports/updated-chinese-minerals-bridging-document-october-2022-chinese

[c] Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to nuclear fuel resources Bridging Document between the Organisation of Economic Co-operation and Development Nuclear Energy Agency/International Atomic Energy Agency Uranium Classification and UNFC-2009 Prepared by the Expert Group on Resource Classification, 2014
https://unece.org/fileadmin/DAM/energy/se/pdfs/comm23/ECE.ENERGY.2014.6_e.pdf

[d] Bridging Document between the Petroleum Resources Management System and the United Nations Framework Classification for Resources, 2023 Update
https://unece.org/sites/default/files/2023-12/PRMS_UNFC_Bridging_Document_Update_2023.pdf

[e] Bridging Document between the Oil and Fuel Gas Reserves and Resources Classification of the Russian Federation of 2013 and the United Nations Framework Classification for Resources, update 2023
https://unece.org/sites/default/files/2023-12/RF-UNFC_BD_Petroleum_2023.pdf

[f] Bridging Document between National Standard of the People's Republic of China "Classification for Petroleum Resources/Reserves (GB/T 19492-2020)"and "United Nations Framework Classification for Resources (UNFC)", 2022
https://unece.org/sed/documents/2024/03/reports/updated-chinese-petroleum-bridging-document-october-2022-chinese

D. Conclusions

6. The present case studies and bridging documents demonstrate that the G axis has been used in two different ways: “confidence in estimate” and “position in uncertainty range”.

7. The interpretation of the G axis as “confidence in estimate” has been used for the classification of mineral, anthropogenic and nuclear resource projects. It has been employed in all reviewed case studies and bridging documents for these resources.

8. The interpretation of the G axis as “position in uncertainty” has been used for the classification of petroleum, renewable energy and injection projects. The reviewed case studies and bridging documents showed a consistent use of the “position in uncertainty range” for petroleum and renewable energy and in the one case study for injection projects where G axis usage was shown.