MINERAL INTELLIGENCE FOR EUROPE

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Report on harmonization issues, data gaps and challenges, reviewing also the quality of Pan-European aggregated inventories for selected commodities

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GENERAL INTRODUCTION

The purpose of this work package is to show how the application of the United Nations Framework Classification for Resources (UNFC) reporting increases harmonization of mineral resource data, and to demonstrate the strength of the United Nations Resource Management System (UNRMS) as a tool for improving the accuracy of Pan-European mineral inventories. Task T4.3 of WP4 aims to review harmonization issues, data gaps and challenges based on the assessment of the case study reports received reported in D4.1 (Simoni *et al.* 2021). Essentially, task T4.3 investigates how the UNFC has been applied for the data described in these case studies.

The case studies demonstrate different approaches in how the UNFC has been used according to its guidelines or otherwise, for a range of mineral commodities. These results clearly indicate that the existing guidelines for the UNFC are not very clear when dealing with limited data availability, regional data, or resources which cannot be categorised by using the CRIRSCO–UNFC bridging document (UNECE 2015).

In this report, we focus on issues where the UNFC has been interpreted differently. We aim to 1) give solutions for such cases, to make sure that any resource can be properly mapped into a resource category according to the UNFC system, and 2) indicate remaining issues where further work beyond this report is needed for better harmonization. Aggregation of data within a country and between countries can only be done when issues on data gaps and challenges are resolved.

We use the term '*evaluator*' in this report in the meaning of a person, typically employed by a government organisation, who does the classification of a resource into a UNFC category, often from information provided by commercial operators. Such work may also be called *'mapping'* of a resource, even though no field work is included.

The term CRIRSCO-compliant is referred, within this report, to any public disclosure documentation (e.g., annual reports, quarterly reports, company web sites, social media, press releases, technical reports) which comply with the International Reporting Template (IRT) for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves set by Committee for Mineral Reserves International Reporting Standard (CRIRSCO). Hence, a Public Report prepared by a company following the CRIRSCO-compliant reporting of Mineral Resources and Mineral Reserves is also referred, in this report, to as CRIRSCO-compliant Project. The IRT is not an international reporting code *per se,* rather a document that integrate the best of the CRIRSCO-style reporting standards (e.g., PERC Reporting Standard (Europe), JORC Code (Australia), SAMREC Code (South Africa) and CIM Guidelines (Canada)). The CRIRSCO reporting standards are recognised and adopted world-wide for commodity market-related reporting and financial investment.

EXECUTIVE REPORT SUMMARY

Reliable and meaningful Pan-European resource aggregation requires transparent and consistent classification according to the UNFC system. This calls for a mutual understanding of UNFC and common agreement on how uncertainties related to active and non-active projects are communicated and defined in national, regional and local level amongst European countries. The information is only useful as the basis for a sustainable resource management when classification of national and Pan-European resources is implemented consistently.

All the project case studies are extremely informative and useful for the future work. They indeed present breakthroughs in the use and application of the UNFC system. Case studies included country-wide aggregated assessment to regional and local assessments both with mineral quantities reported in accordance with and not according to the CRIRSCO Template. The case studies with active or non-active project status and quantities complying with the CRIRSCO Template were based on CRIRSCO–UNFC bridging document (UNECE 2015).

The major challenges identified in the case studies, which used different approaches to classify mineral resources according to the UNFC, include:

- Data gaps. Varying accessibility of national resource data and legislative information within and between countries means that aggregation was not possible in most countries. This subsequently also impacts international aggregation efforts.
- Inconsistent use. Lack of understanding of the UNFC and how resource classification can be used to communicate different resource projects and project maturity across commodities on regional and national level. This resulted in inconsistent UNFC mapping which cannot be compared between countries. Related to this, there often was a lack of understanding of the basis of CRIRSCO-compliant resource reporting.
- Poor quality data. Documentation of resource estimates did always not ensure transparent view of the case studies. This does not allow the reader to clearly understand the basis of the resource estimates and their classification.
- Inconsistent results. Several case-studies produced UNFC volume estimates or spatial area (km^2) coverage without tonnage and/or grade information. Other cases only gave commodity grade but no resource volume (tonnage). Yet, UNFC categories were given for these resources.

Both national and Pan-European harmonization and data aggregation is essential. This is only achievable as soon as the issues in data gaps and challenges are solved. The following two conditions must be fulfilled:

1. There must be a common, harmonized understanding on how to apply the UNFC system.
2. National mineral resource accounting practices, i.e., production of and maintaining the aggregated resource data at national level, need to be uniform between the countries to make the Pan-European aggregated data realistic and complete.

To achieve harmonised data, it is necessary to create a permanent, Pan-European instrument for training in harmonised mapping of national raw material resources and related data according to the UNFC system.

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1 CASE STUDIES RECEIVED

During the project, 19 case studies were received, between November 2020 to June 2021, as listed in Table 1. In this deliverable, we assess the matters and issues emerging from the case studies, as much as such issues relate to the application of the UNFC. We do not cover the multitude of the matters that are in good shape with respect to the UNFC system.

Table 1. Case studies received in MINTELL4EU WP4.

Country	Commodities assessed	Additional notes
Austria	Aggregates (sand and gravel)	GIS-based assessment; local regional study
Belgium	Phosphate	Local regional
Croatia	Aggregates	GIS-based assessment; local regional study
Denmark	Carbonates	Partly GIS-based assessment
Denmark	Marine aggregates	Country-wide aggregated assessment. Information from national resource database
Finland	Cobalt, copper, gold, graphite	Country-wide aggregated assessments. Information from national resource database
Finland	Peat	Local regional assessment, three different types of application mapped into UNFC for the same resource
Hungary	Manganese, perlite, gypsum–anhydrite	Local regional; country-wide
Norway	Aggregates from hard rock sources	Local regional
Norway	Dimension stone	Local regional, focus on one rock type with a long history of production
Norway	Graphite, phosphate	Local focus and extension to country-wide assessment
Slovenia	All national resources	Mapping all resources into UNFC; scant information in the case study report
Sweden	Rare earth elements	Two deposit cases with a resource, and one no-resource case where the REE are in iron ore

2 DESCRIPTION OF ISSUES IN APPLYING THE UNFC

The case study reports identified a number of issues. We describe these here, first by discussing those that are related to specific UNFC axes, then focus on those relating to all UNFC axes in general.

A UNFC category can be given to any deposit, prospect or occurrence (or any part of it) for which there is an exploration target, mineral resource or mineral reserve estimated by competent person(s). That quantity may be reported as CRIRSCO-compliant or non-compliant. In addition, the UNFC may be used as a classification tool for probability estimates of prospective resource quantities on a regional scale.

The UNFC case studies produced within the MINTELL4EU project covered country-wide, regional and local (site) assessments. Several case studies approached the UNFC classification as means of forecasting the future viability of resources. This resulted in either probability estimates or estimates of surface area (km^2) with given confidence categories. Other case studies produced UNFC categories from active and non-active projects, CRIRSCO-compliant and non-compliant, from deposit-scale to national aggregation.

The criteria for classification varied drastically between the case-studies. For example, one case study modified the EFG categories for their sand and gravel resources based on accessibility and likelihood of mining. Also, in several case studies the mapped resource quantities were given such UNFC categories which could translate to Mineral Reserves or Mineral Resources compliant with the CRIRSCO Template. For example, high certainty EFG classes were given for resources which, in reality, did not fulfil active/commercial or potentially active/commercial project status as needed for UNFC categories from 111 to 223 (c.f., UNECE 2015, CRIRSCO 2019). This meant that, in some cases, historical resource quantities were classified as Potentially Commercial Projects (e.g., E2; F4; G1, G2, G3) without any active project status and commercial operator. It is important that bridging, both ways, between UNFC and other International Standards meet requirements of aligned systems (PERC, JORC, Ni 43-101, etc.).

The major challenges experienced in the UNFC case studies were the following:

- Accessibility to national resource data and legislative information varied between the countries. This meant that national aggregation was not achieved in many countries due to data gaps.
- Lack of understanding of the UNFC and how resource classification can be used to communicate project maturity and uncertainties across commodities in regional and national level. This resulted in inconsistent UNFC mapping which cannot be compared between countries and makes pan-European aggregation challenging. Related to this, there often was a lack of necessary understanding of the CRIRSCO-compliant resource reporting. The point is that understanding the CRIRSCO system, even at a basic level, helps a lot if one attempts to classify resources into UNFC categories which can also be mapped into CRIRSCO-compliant categories (UNECE 2015).
- The evaluator has taken the role of an operator or given forward-looking statements regards to the aspects of technical feasibility or economic viability. This means that in regional-scale assessments (e.g., scenario-based predictive models), the results, in part, look like economic assessments when they, in fact, are information on a region's endowment and resource potential.

- Quality of documentation of estimates to permit transparent and material view of the case-studies and to allow the reader to clearly understand the basis of the estimate and their classification. This is, at least in part, a matter arising from the case study template where such information was not explicitly asked for.

- Several case-studies included parts with only volumes and land area (km^2) coverage without tonnage and grade information. Other cases only gave commodity grade but no resource volume (tonnage) for all or parts of the resources described. Yet, UNFC categories were given for all of the resources.

2.1 E-axis issues

The E-axis of the UNFC refers to Environmental-Socio-Economic Viability of a resource. This designates the degree of favourability of environmental, social, and economic conditions in establishing the viability of the project, including consideration of market prices and relevant legal, regulatory, social, environmental and contractual conditions. The Environmental-Socio-Economic axis encompasses the non-technical issues that directly impact the viability of a project.

Major challenges in the case studies, specifically related to E-axis were the following:

- Missing information on existing permits, yet an E-axis category was given as E1 or E2

- An attractive commodity grade, such as “European-level estimated potential for REE” was used as denominator for the E-axis value.

- Drilling data was used as basis for the E-axis category.

- The UNFC sub-classes were not effectively used to enhance clarity of the environmental and social issues

2.2 F-axis issues

The F-axis refers to technical feasibility which designates the maturity of technology, studies and commitments necessary to implement the project. Such projects range from early conceptual studies to a fully developed project in production (i.e., in active mining stage), and reflect standard value chain management principles.

The major challenges in the case studies, specifically related to F-axis were the following:

- E-axis category matters affecting F-axis values. This is seen, for example, in 1) a resource being “inside legal (or de facto) ban” resulted in F4, 2) mining “application pending” resulted in F1, or 3) “If an application for a mining permit has already been filed, the F-axis code becomes F1”.

- Built land, road and railway lines mapped to F4, purely on the assumption that they are no-go areas for mining.

- Information was not available, yet the F-axis value given. In one case, “all deposits were rated F4 as no mining project is under consideration”, without any further information if any technical studies have been done for these resources

- The categories F1 and F2 were given to non-active projects with historical estimates.

- The usage of high confidence F-axis categories (F1, F2) for regional scenario-based predictive models without defined Preliminary Economic Assessments and Feasibility Studies by the operator.

2.3 G-axis issues

The G-axis refers to the degree of ‘geological’ confidence which designates the degree of certainty in the estimate of the quantities of products from the project. Thus, the knowledge of the spatial distribution of grade and the particular locations of volumes of mineralized rock that are above the cut-off grade or the volume and locations of a bulk material such as aggregates is essential. Mainly, the G-axis reflects the confidence through geological studies which have been carried out. The G-axis categories are intended to reflect all significant uncertainties (e.g., source location and geologic uncertainty) impacting the estimate forecast for the project. For some commodities it can also be understood as an estimate of the quantity of mineralization that is possible to be estimated (volume, tonnes, grade/quality, etc.).

The major challenges in the case studies, specifically related to the G-axis were the following:

- Exclusion zones (e.g., building land, environmentally protected areas, cultural areas) had an impact on the G-axis categories.

- A G-axis value was given to a deposit based on the current distance from the location of the utilisation of the resource. For example, G-axis values were differentiated by using status of external factors like distance to markets as confidence threshold for economic viability.

- The UNFC category 224 were given to mineral resources. This contradicts with the CRIRSCO–UNFC Bridging Document (UNECE 2015) and does not meet requirements of aligned systems (PERC, JORC, NI43-101, etc.).

- Probable Reserves reported in accordance with the CRIRSCO Template (‘CRIRSCO-compliant’) were mapped to G1.

- Tonnage and grade figures were not quoted according to the level of accuracy and precision of the estimate.

2.4 Issues related to all axes

When reporting national or regional resources aggregation, it is important to be transparent and neutral with respect to the commercial and potentially commercial projects under evaluation. The classification should not include the evaluator’s forecasts nor forward-looking statements. It was noted that, in some case studies, the classification

of existing quantities into UNFC and forecasting of future projects were mixed up. The evaluator should be careful not to create any so-called 'artificial boundaries' (e.g., distance from the mill or markets that could affect the potential economic viability), as this goes into forecasting and should not be confused with the classification of the currently known resources. The risks and uncertainties related to geologic knowledge and other factors are reflected via confidence categories in resource definition. For example, in the CRIRSCO Template, the Mineral Resources are subdivided into Inferred, Indicated and Measured categories reflecting the confidence in the estimation made by the Competent Person (CRIRSCO Template 2019).

Issues with UNFC modification according to specific commodity

Some of the case studies for aggregate (sand and gravel) resources presented new criteria for UNFC classification. This was considered more applicable for these specific resources with, e.g., good accessibility, no technical challenge, simple geology. The criteria for classification were scenario-based and confidence categories were defined on basis of different zones or boundaries that reflected the likelihood of exploitation. For example, F-axis confidence was defined based on proximity to "markets". Thus, quantities with large spatial distance (<30 km) to markets were automatically defined as F4.

Several UNFC case-studies conflicted with the CRIRSCO-UNFC Bridging Document (UNECE 2015) which were result of evaluators classifying historical estimates of non-active projects into Potentially Viable or Viable UNFC Classes. For example, UNFC classification E2, F4, G1, G2, G3 was given for historical estimate but failed to communicate the project status (active or non-active) and confidence in data quality.

Issues with criteria for aggregate, industrial mineral and industrial rock resources classification

For aggregate resources, criteria deviating from the UNFC guidelines were proposed in regional case studies and include, e.g., class 111 for any permitted resource no matter if it is in production or not and no matter how much of the material is probable or proved resources (only the latter is class 111 according to the reporting guidelines). This included data density information estimated by the national geological survey and not by the owner or holder of the project. Also, the resource potential is modelled by GIS using predictive model(s), i.e., scenarios. These assessments have resulted in the use of the entire range of 111, 112, 221, 222, and 223, in addition to E3, F3 to F4, and G3 to G4 categories, some of which were based on unsubstantiated assumptions.

Issues with national or regional aggregation: data only from areas where mining is permitted; UNFC categories for 'exclusion zones'

There are cases where only "reserve and resources within mining areas and exploration areas (where mining rights and/or exploration permits are granted) are classified". This means that the national aggregation does not include all the resources there are in a country. In fact, it may mean that a vast majority of resources are not included. If on the other hand, 'exclusion zones' were given a UNFC category in the case studies, it was typically 344. No other basis for the class 344 is given than the resources being in areas allocated for other uses than mining.

Issues with national or regional aggregation: confidential data

In some countries, all resource information that can be connected to an individual deposit is confidential. This means that national aggregation and national resources accounting is not transparent. This may not be a problem, if the confidential information is available for the government organisation responsible for resources accounting as it still is possible to provide aggregated and harmonised data to the national government and the EU.

If the relevant confidential information is not available beyond the company holding the data, then a comprehensive national resources accounting is not possible. Often, this comes from the company policies which are against releasing any resource data (typical for many industrial mineral companies), and the legislation not requiring data even for a strictly confidential use of the national government.

Misuse of classification terminology

Inconsistent and negligent use of resource classification terminology may confuse and mislead the reader, especially terms that are defined in CRIRSCO Template. In a chalk and limestone case study, Proven, Probable and Indicated resources were mapped as E1; F1,1; G1, E1; F1.1; G2 and E2; F1.1 (1.2, 1.3); G3, respectively. In the text, the resource definitions were referred as proved (measured), indicated and inferred resources. In the CRIRSCO Template, Reserves are defined as Proved and Probable. Also, an 'indicated' resource was given the category F1, G3. If a resource is Indicated, it cannot be better than F2, and by definition must be G2 (UNECE 2015). In another case study, all resources in an active mine were classified into 111, without any mention if they really were Proved Reserves. These examples show inconsistent use of terminology (c.f., Fig. 2) and may or may not indicate that quantities are reported as CRIRSCO-compliant, but we cannot possibly know from the case study reporting.

3 SUGGESTIONS HOW TO SOLVE INCONSISTENT APPLICATION OF THE UNFC

Below, we first describe the background of the UNFC for matters that relate to the issues detected in the case studies followed by a discussion on general issues. At the end, we present suggestions on how to solve axis-specific issues.

3.1 General

A UNFC classification document based on mapping of resource quantities into UNFC categories prepared by an evaluator should be solely based on information that was available to the evaluator, and all such information must be referenced accordingly. This means that if the project owner (the entity, past or present) or anybody else with the necessary data has not reported any quantities and put them available for an evaluator, the resource cannot be mapped according to UNFC by an evaluator. The evaluator cannot make a decision on behalf of the project owner or other body with original reporting, neither for a commercial active project, nor for a non-active project. This means that if data on resource quantity are not available or is inaccessible, the resource cannot be UNFC categorised. However, this does not include scenario-based, regional-scale models prepared by Geological Survey Organizations (GSO) using UNFC for resource accounting.

The aggregated mineral inventories based on UNFC classification should predominantly reflect the maturity of mineral projects. Structured approach, “decision gates”, should be considered when mapping resources quantities into UNFC, such as described in Brown et al. (2019). In most of the cases, the project status determines progression in E- and F-axes and, therefore, it is recommended to first consider the current project status (active and non-active projects) of specific mineral quantities under assessment (Fig. 1).

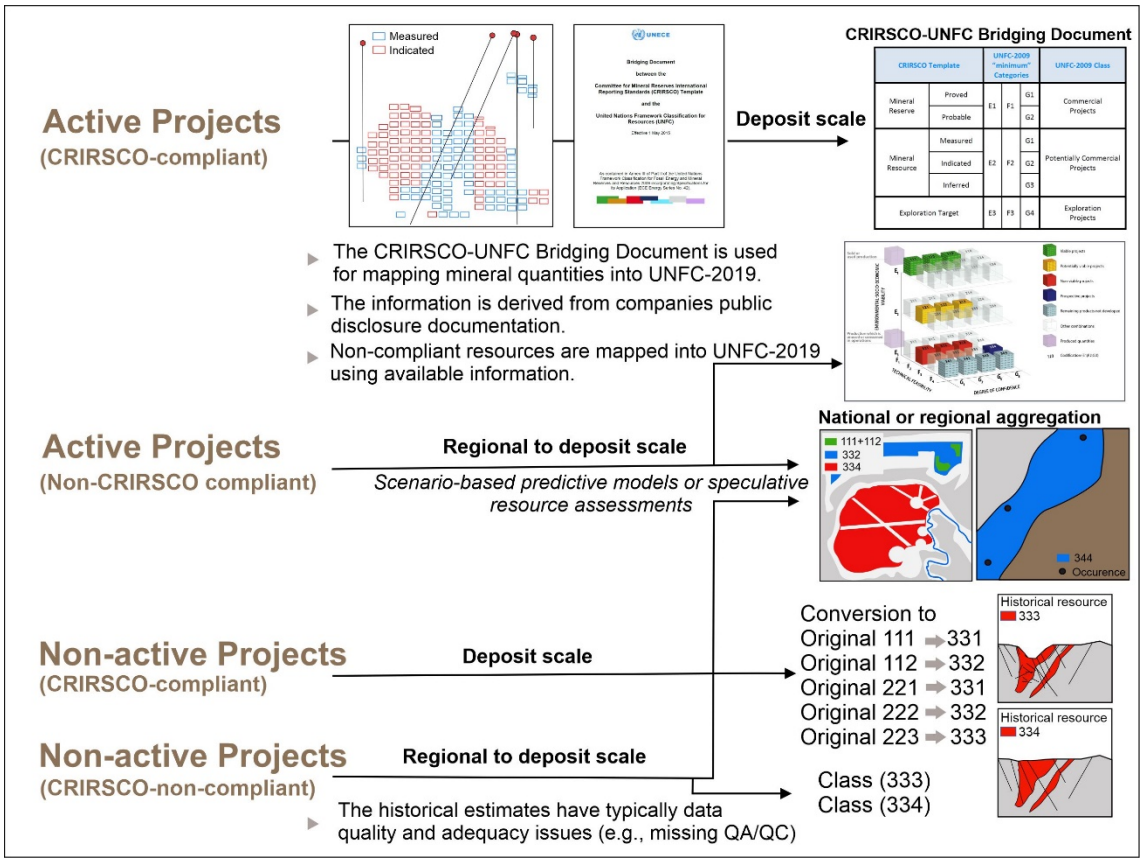

Figure 1. *General overview of project appraisals mapped into UNFC-2019. Projects are defined as 'development' or 'operation' that provides the basis for environmental, social, economic and technical evaluation and decision-making. Regional scenario-based predictive model may include combination of active and non-active projects. If predictive modelling is used as a basis for regional aggregation using direct and indirect information, it should reflect the high uncertainty related to classification (e.g., only E3 and F3 or F4 categories are applicable). Also, in scenario-based estimations, the used estimation methodology and criteria for classification should be described in the report or metadata part of national mineral databases. Note that the term 'CRIRSCO-compliant' is explained in at the end of section 'General Introduction' of this report.*

In cases of data gaps and/or limited access to resources data, the resource quantities may be communicated using UNFC classification based on scenarios or predictive modelling. However, the confidence should not be higher than at the values E3 and F3 for the E and F axes. This is due to the speculative nature of resources and the non-active project status. If there currently is no active operation to provide the basis for environmental, social, economic and technical evaluation, it is uncertain if the estimated quantitates can be put into production in foreseeable future. In the UNFC-2019, it is stated that "In accordance with the definitions of E1, E2 and E3, environmental-socio-economic assumptions shall be based on current conditions and realistic assumptions of future conditions" (UNECE 2020).

The UNFC classification and terminology (UNECE 2020) should not, in any circumstances, be changed or altered by individual evaluators outside of the official UNECE Expert Group on Resource Management (EGRM) process (an UN Expert Group

that meets once a year in Geneva where it reports its yearly activities and can approve requested changes in the UNFC guidelines). For example, terminology such as 'proven and probable resources' are not to be used for reporting as it conflicts with the CRIRSCO-template (where the correct terms are 'Probable Reserves' and 'Proved Reserves'), as it confuses and misleads the reader.

Alignment with CRIRSCO–UNFC Bridging Document

The Bridging Document between the CRIRSCO Template and the UNFC (UNECE 2015) should be followed when mapping quantities and grade information reported in accordance with the CRIRSCO Template into UNFC-2019. According to the criteria for bridging between CRIRSCO and UNFC, the non-CRIRSCO compliant "historical estimates" should not be classified into UNFC categories described in Figure 2, except the 'Exploration Target' category of the CRIRSCO. Principally, these would not be aligned by the Bridging Document.

In closed mines, there may be anything from 221 to 334 or even 344 category resources. There must be strong evidence to support mapping quantities for closed mines into 221, 222 or 223, as these essentially need a CRIRSCO-compliant resource reporting. The project must be active, and the current holder must have confirmed the quality of the latest resource data or published a new resource. Resources in an abandoned closed mine are E3, F3–4.

<table>
<tr><th colspan="2">CRIRSCO Template</th><th colspan="3">UNFC-2009 "minimum" Categories</th><th>UNFC-2009 Class</th></tr>
<tr><td rowspan="2">Mineral Reserve</td><td>Proved</td><td rowspan="2">E1</td><td rowspan="2">F1</td><td>G1</td><td rowspan="2">Commercial Projects</td></tr>
<tr><td>Probable</td><td>G2</td></tr>
<tr><td rowspan="3">Mineral Resource</td><td>Measured</td><td rowspan="3">E2</td><td rowspan="3">F2</td><td>G1</td><td rowspan="3">Potentially Commercial Projects</td></tr>
<tr><td>Indicated</td><td>G2</td></tr>
<tr><td>Inferred</td><td>G3</td></tr>
<tr><td colspan="2">Exploration Target</td><td>E3</td><td>F3</td><td>G4</td><td>Exploration Projects</td></tr>
</table>

Figure 2. *The CRIRSCO Template classification mapped into UNFC Classes and Categories. The bridging (UNECE 2015) describes the "minimum" Categories used for Prospective, Potentially Viable and Viable Projects. Note that the UNFC-2009 classes are the same as in the UNFC-2019 guidelines (UNECE 2020).*

When mapping any resource to UNFC, the evaluator should always avoid making predictions on mineral project's economic viability, geological and technical confidence (e.g., data coverage, mining, processing, metallurgical factors) of a mineral deposit. These assumptions are made by the commercial operator when considering the economic viability through technical feasibility studies before production, at least when resources are classified into categories which can be mapped into CRIRSCO categories. The assumptions made on technical feasibility and economic viability should have a reasonable basis, be clearly defined, and should reflect the level of information and stage of development of the mineral inventory at the time.

UNFC modification according to specific commodity

No commodity-specific 'modification' is needed for the primary UNFC classes as such by the evaluators. This applies to old reports, a GIS analysis, prospectivity mapping, and any other way to get information used for assessments. Different projects are still operating in the same business environment where mining is feasible when profits exceed the costs or in other ways benefit the large-scale infrastructural environment within the value chain. Therefore, the basic principles of EFG categories can be equally applied for, e.g., energy minerals, metal ores, industrial minerals, aggregates (be they crushed bedrock or originally loose materials such as gravel and sand), limestone, or any other bulk material. However, some adjustments on definitions and how to move between the sub-categories may become relevant. Nevertheless, the specific modifications proposed should be communicated through the Technical Advisory Group (TAG) and the Minerals Working Sub-Group that develops the specifications, guidelines and best practices for UNFC.

CRIRSCO-compliant resource reporting from non-active projects

Evaluator's competence is required when mapping problematic cases. When active project turns into a non-active project the defined classes and categories also change in respect to project viability. Such change may come from, e.g., company goes bankrupt, collapse in commodity prices, or project development is put on hold for any environmental, social or governmental effects (ESG). Thus, categories 111,112, 221, 222 and 223 must be re-mapped to reflect the CRIRSCO Template Reasonable Prospects for Eventual Economic Extraction (RPEEE) aspects. The G-axis values do not change as different modifying factors (e.g., economic, environmental, social, governmental) have generally no effect to geologic confidence. On the other hand, E- and F-axes must be re-classified to communicate the new project status.

Criteria for aggregate, industrial mineral and industrial rock resources classification

Despite the differences between aggregate, industrial mineral and industrial rock (such as limestone), and metal deposits, the technical feasibility and environmental-social aspects (EFG assumptions) are very similar. Different or 'modified' criteria should not be used for different commodities when defining UNFC categories. The operator (mining company) needs to follow legislative instruments and permitting depending on the jurisdiction they operate in. For example, the categories 111, 112, 221, 222, 223 should only be used in active project developments, not for scenario-based estimations.

If resource potential is modelled (GIS methodology) using a predictive model (scenarios) and classified in accordance with UNFC-2019, categories E3 and F3-F4 should be used. Within these categories the probability estimates (P10, P50, P90) should be used to communicate the likelihood of different scenarios, and the estimation methods used must be described in the reporting. The confidence levels in the classification itself should not be used, *per se*, to reflect the probability in the scenarios.

National or regional aggregation: data only from areas where mining is permitted; categories for 'exclusion zones'

National aggregation should include all resources of a country, no matter if a piece of land is designated for mining or for something else. If a resource, known or assumed, is in, e.g., a protected or a built area, it still is a resource and should, hence, be included into the national aggregated information. Also see Simoni *et al.* (2021) on national aggregation. In situations where an 'exclusion zone' prevents the project going further, the sub-category E3.3 emphasizes that the environment-socio-economic future conditions are not favourable and E3.3 category is to be used.

Also, no matter whether there is a current exclusion zone or not, and regardless of the quality of the mineral resource, if there really is information on technical characteristics of the resource from that location, then the F-axis cannot have the value 4. For example, if some technical testing has been done, which also means that the geology is known to some extent, the category E3.3, F3, G3 might be accurate for a resource in an 'exclusion zone'. In any case, the categories F4 and G4 should not be used as a default for all resources within 'exclusion' zones.

Resources in built land, road and railway lines, etc

Any resource in built land, road and railway zones, tunnels and other underground structures, harbours, and areas designated to similar uses, is in an area with potential for further building and construction. Construction always requires mineral resources, especially aggregates. It is, hence, important to know all the possible mineral resources in such areas. Never ignore these resources, never exclude them from the national resources accounting.

National or regional aggregation: confidential data

It is understood that national legislation and/or the company policies may not allow public or even protected access to the resource data. Such lack of transparency inherently means lower reliability of public information, and the matter must be disclosed in reporting national aggregated data, just like any other data gap. Combination categories, such as [111+112+221+222+223] (resources and reserves known to exist) and [221+222+223] (resources only) for an active project, can be used safely if the confidential data is available for the national database holder, and if such combinations can be published. For non-active projects, depending on data density, the category range is from 331 to 344; the same also holds for active projects if even the combined reserve + resource data is not allowed to be published.

For the case the confidential information not being available beyond the company holding the data, the national deposit database holder must rely on its own assessment (by its evaluator) on existing resource information. Such assessment can be based on historic

resource data (if any exists) and/or probabilistic examination of resource potential in an area or locality. These quantities are not true estimated quantities based on information from the current operator and, therefore, the basis for estimation must be disclosed in the mapping report. This means also that the UNFC categories to be used cannot be any better than E3, F3. The G-axis values might still range from 1 to 4, but the realistic range is in most cases just from 3 to 4. If G-axis values 1 or 2 are used, then the safe way is to use combination categories, such as 331+332+333. This however means that there really is high geological data density for at least a part of a deposit. Finally, if there is not even a historic resource nor any probabilistic assessment of a resource grade and tonnage, then no UNFC category can be given, even if there is an active mine.

If the operator (project owner) has not disclosed tonnage or grade information, no UNFC category can be given at mineral deposit level within confidence of 111,112 or 221, 222 and 223. This might be the case when company has not yet published its updated resource quantities after material change (e.g., extensive drilling campaign).

National or regional aggregation: regional estimates

Speculative resource assessments are informative and well-suited in regional-scale studies and help to create a more realistic regional-scale aggregated resource for a commodity. This is important especially when the aim is to estimate "how much there is in the ground" – something that is important for national resource accounting and mineral policy formulation. However, classification into UNFC categories should not be given a higher confidence than E3 and F3–F4. The G-axis can be communicated through estimated scenarios based on probabilistic methods (P10, P50, P90).

3.2 Suggestions and recommendations on how to solve axis-specific issues

E-axis

- If information on permitting does not exist, the E-axis category is E3. The class E2 is possible if *there are reasonable prospects for environmental-socio-economic viability in the foreseeable future* (UNECE 2020).

- Grade information is related to the G-axis and has no effect on the E-axis. The economic viability of a mineral project is determined through technical feasibility and degree of geological confidence in G-axis (e.g., grade continuity and geological continuity). The grade or other quality information alone is not enough to support any UNFC classification, if the resource tonnage or volume is not reported.

- No mining permitting means that the E-axis category cannot be 1, even where the area is designated for mining. In the latter case the value for E is 2.

F-axis

- A resource "inside legal (or *de facto*) ban", within an 'exclusion zone', as expressed in some of the case studies: Prohibition of mining in a particular area. Exclusion zones should be considered as E category matters, be classified as E3.3, and have nothing to do with the F-axis. They do not, for example, outright result into the value F4. No permit may, of course, mean that not much of technical feasibility is done, but may also mean a case of F1, if all is economically and technically set for mining, just the permitting not received.

- The Sub-class “Development pending” may be due to “Application pending” and could mean E2 or E3, whereas the project maturity regards to technical feasibility of a project can be, at the same time, anything from F1 to F3. Probably not F4, as if an extraction permit is applied for, the operator certainly knows something about technical feasibility of the resource. E1 can only exist when all permitting is in place – permit applied for is not such a case.

- Built land, road and railway lines: For built land, roads, railways, harbours, and areas designated to such uses, it is essential to keep in mind that they are areas with potential for further building and construction. Such activities demand mineral resources, and the best resource for the needed aggregates, especially, may very well be within that same area. It is hence important to know the quality of the mineral resources of such areas, even when such an area is legally designated as an ‘exclusion zone’. Hence, we strongly recommend not to map any resource within such area as no-go zones, and in any case not outright F4 (unless, of course, no technical work is reported).

- If F-axis confidence were defined based on proximity to “markets” and quantities with a spatial distance (e.g., <30 km) to markets were automatically defined as F4, this approach is assuming that technical feasibility and economic viability can be classified based on artificial boundaries even without current operation in the area. Therefore, this classification should be regarded as predictive modelling of prospective future resources quantities, rather than potential or commercial sources. Regional commodity assessment work can be used as informative source amongst decision makers, regional and infrastructure planning authorities, and mining companies. Also, this is a good basis for getting aggregated commodity information for a municipality, province or a country.

- The F-category should, in the first place, be assessed by the operator when moving forward with the project and should not be an unsubstantiated assumption by the evaluator. External evaluators (especially a government authority/entity like a geological survey) should only define the category which describes/reflects the project maturity the best.

- Rating into F4 “as no mining project is under consideration”: This statement tells nothing about technical feasibility. If it was meant that there is no information on technical feasibility of the deposits, then F4 is the correct category. If the information available is that technical studies have been done but results not known, or minor studies done and results known, the respective resource gets the category F3. There might even be parts where more than basic technical studies have been done in the past. For such localities, F2 might be appropriate for aggregates.

- The F-axis categories F1 and F2 should only be used for Active Projects with a high confidence in technical feasibility, and not for, e.g., non-active projects with historical estimates. We recommend, that values F1 or F2 should not be used in the latter cases, as these classes indicate high confidence in technical feasibility (e.g., estimated resource quantities for Life of Mine approximation, positive metallurgical and processing studies, positive Net Present Value (NPV) derived from operating expenses and capital investments).

- Mining and other permitting in place means E1 but has no effect of F-axis values.

G-axis

- Similar to F-axis, an exclusion zone (e.g., building land, environmentally protected areas, cultural areas) has nothing to do with the G-axis value(s) of a resource.

- A G-axis value cannot be based on current distance from the location of the utilisation of the resource. This is essentially a F-category issue by assessing the economic feasibility of the commodity in relation to the transportation distance. It has no effect on G-axis, nor on E-axis.

- The UNFC category 224, albeit possible, is most probably not realistic anywhere. If technical feasibility has been worked on in any extent, the geological data density most probably is better than G4. While it can be anything from G1 to G3, it is unlikely G4, which is defined as "*Product quantity associated with a Prospective Project, estimated primarily on indirect evidence*" (UNECE 2020).

- Volume estimates and spatial area (km^2) coverage without tonnage and grade information and cases with only commodity grade without resource volume (tonnage): Such resources should not be given UNFC classes at all; that is, no data on quantity or quality means no UNFC category.

- There should not be statements that 'geology is well known', and work consisted of x amount of drilling and 'therefore G1 is suitable'. This unless you are the project owner and responsible of reporting the quantities to public domain. The category G1 means a high confidence on the data, typically at 90 % certainty level.

4 SUMMARY

All the case studies in MINTELL4EU are extremely informative and useful. They present many breakthroughs in the use and application of the UNFC. All case studies also indicate how very different types of geological resources can be mapped into UNFC categories.

Another benefit from the MINTELL4EU case studies is that they indicate a number of issues still existing in the use of the UNFC. Harmonization of the resource data within a country and between countries can only be done as soon as the issues in data gaps and in challenges described in this report are both understood and resolved.

Our conclusion, based on the MINTELL4EU case-study reports, and also from other discussions, is that extensive workshop-type training, based on real-life case examples, is needed in every country where the UNFC is to be used. The most important is that this training covers all experts working on deposit databases and resources accounting in public organisations, such as national and state geological surveys, mining inspectorates or directorates. Of major importance is also to include the extractive industries sector, particularly where the national mining law requires them to report any resources according to the UNFC. Also elsewhere, the private sector will benefit from understanding the UNFC system, even if the companies have no reporting obligations under the mining law, if they report according to the CRIRSCO or any other code, or if they are dealing with other types of resources such as geothermal energy or anthropogenic resources.

In detail, we also stress that:

- The ***Governmental Organisations producing aggregated mineral inventories mapping into UNFC-2019 need access to basic permitting information*** (e.g., exploration and mining license and environmental permitting and confidential mineral resource information) to carry out correct aggregation for all axes of the UNFC. This information can be used in combination with estimated quantities based on, e.g., predictive modelling to maintain UNFC mineral inventories and derive aggregated national mineral UNFC estimates.

- It is recommended to first consider the current project status (active and non-active projects) of specific quantities under assessment. All active mineral projects must follow the country-specific legislation related to land-use planning, environmental requirements, and exploration and mining permitting. All mining companies are managing risks through different technical studies and geological information (degree of confidence in estimation). This information may be publicly disclosed in company reporting, open only to authorities, or not disclosed beyond the company. ***If this information is not available, only speculative resource quantities can be estimated*** by the national body mapping resource data into UNFC categories.

- The ***speculative resource assessments and different predictive models*** are informative and well-suited in regional-scale studies. We are very much in favour

for such work aiming to assess the full resource potential of a region, a country or a continent. But classification according to the UNFC ***should not be given a higher confidence than E3 and F3–F4***. The G-axis can be communicated through estimated scenarios based on probabilistic methods (P10, P50, P90).

- Regardless of scale and type of reporting of UNFC, the classification should include a definition of what information and data information is available for the evaluator.

- The ***terminology must be consistent with UNFC-2019 and, if applicable, also with the CRIRSCO-templates*** (UNECE 2013, 2015, 2020). For example, 'proven resources' or 'probable resources' should not be used as it conflicts with CRIRSCO-template (Probable Reserves and Proved Reserves) and may confuse and mislead the reader. This calls for a dedicated guidance on how to bridge (translate) between CRIRSCO and UNFC.
- Issues we have detected are many and often not simple to understand. Hence, ***to achieve harmonised data, it is necessary to have a permanent, Pan-European instrument of training everybody mapping national resources data according to the UNFC.***

ABBREVIATIONS

CIM	The Canadian Institute of Mining, Metallurgy and Petroleum
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
ESG	Environmental, Social and Governmental assumptions
GIS	Geographic Information System
GSO	Geological Survey Organization
GTK	Geological Survey of Finland
IRT	International Reporting Template (CRIRSCO)
JORC	Australasian Joint Ore Reserves Committee
NI43-101	National Instrument for the standards of disclosure for mineral projects within Canada
QA/QC	Quality Assurance and Quality Control
PERC	Pan-European Reserves and Resources Reporting Committee
REE	Rare earth elements
SAMREC code	The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves
TAG	Technical Advisory Group
UNECE	United Nations Economic Commission for Europe
UNFC	United Nations Framework Classification for Resources
UNRMS	United Nations Resource Management System

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