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UNFC Compliant Resource Assessment of Combined Production of Thermal Energy and Minerals from Geothermal Brines

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INTRODUCTION

Open-loop deep geothermal energy systems may produce brines with potentially commercial concentrations of 'critical' minerals, e.g. lithium. Committee for Mineral Reserves International Reporting Standards (CRIRSCO, 2024)-compliant resource assessments for minerals under the **United Nations Framework Classification for Resources (UNFC)** (UNECE, 2019 and 2021) informs investors about project viability and maturity across three dimensions: environmental-socio-economic viability, technical feasibility and degree of confidence in the estimate.

Industry and stock-markets require CRIRSCO-aligned assessments as basis for investment in minerals activities, but the European Commission expects a UNFC-based resource classification UNFC for strategic purposes. After an earlier 2015 version, the 2024 updated 'bridging' document developed by CRIRSCO and the United Nations Economic Commission for Europe (UNECE) aligns the two systems (UNECE/CRIRSCO, 2024).

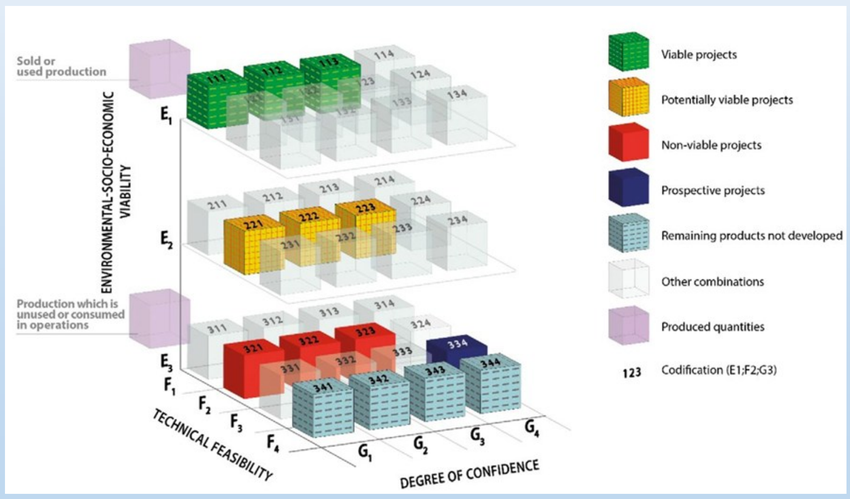
At the same time, UNECE and the International Geothermal Association (IGA) agreed to develop a globally applicable harmonized standard for reporting geothermal resources. Specifications for the application of UNFC to geothermal energy resources first became operational in 2016, with an update issued in 2022 (UNECE/IGA, 2022). Geothermal developments are currently seeking incremental value from minerals co-production.

While the UNECE provides separate specifications for the application of UNFC to minerals and geothermal energy, there is no explicit guidance on the combined production of thermal energy and minerals from brines.

A conceptual approach to integrated UNFC classification is proposed to align reporting markets.

UNFC

1. A universal system for classifying and reporting minerals, energy, and other resources.
2. Developed and maintained by the UNECE Expert Group on Resource Management, with support of stakeholders from governments, industry, academia and civil society .
3. Based on three fundamental criteria of **environmental-socio-economic viability** (E), **technical feasibility** (F), and **degree of confidence in the estimate** (G).
4. Classification shows maturity of E-F-G aspects and their impact on project development.
5. Aligns with Sustainable Development Goals.
6. Aligns with international codes and standards (e.g. CRIRSCO for minerals) via bridging documents.
7. Supports decision-making and investors' confidence.
8. Enables consistency, transparency, and sustainability in resource management.



KEY RECOMMENDATIONS

1. Integrated Project Description

Project developers should, using Qualified Experts, develop an integrated description of the combined geothermal energy and minerals project so that there is a consistent basis for the UNFC classification. This should cover technical, process, economics, environmental and social aspects. Key elements would be:

1.1 Comprehensive Conceptual Model: A conceptual model that encompasses all relevant processes. This model should facilitate the delineation of the 'energy' and 'minerals' classification components that will have to be assessed according to the respective UNFC guidance documents.

1.2 Detailed Materials and Energy Flow Assessment: A detailed analysis of all material and energy flows within the system, including potentially harmful mass flows (e.g., hazardous chemicals and waste streams). Such modelling will likely be required for environmental impact assessments and permitting procedures.

1.3 Specification of Reference and Intermediate Points: Clearly define intermediate nodes (UNFC geothermal guidance) resp. reference points (UNFC geothermal and minerals guidance) for each product stream to ensure clarity in what the reported quantities represent within the integrated project.

1.4 Process Interdependencies: Energy and mineral value extraction will likely be intertwined and influence each other. For instance, pre-treatment steps before heat extraction may give rise to solid precipitates (scales) containing valuable minerals.

2. Internal Energy Utilisation

The UNFC classification should reflect both commercially sold energy and internally utilised energy. Classification should account for geothermal energy that may not be sold as a product but instead used to e.g., power mineral extraction processes and be an important aspect of project economics. This would be E3.1 category.

3. Project Lifetime

The overall UNFC classification of the integrated project must account for the implications of different depletion rates between heat and mineral resources in. For example, for the geothermal part, there may be uncertainty on how the temperature will be sustained over time, while for minerals there may be uncertainty on how concentration in brine will evolve over time – with the 'recharge' processes being different.

4. Technical Viability

The technological readiness may be different for the two components: for example, geothermal lithium extraction technology is only starting to be demonstrated at commercial scale, while some types of geothermal energy extraction can be regarded as more mature technology. This would impact on the F category assessment. Where the technical readiness of one commodity may impact the economics of the whole project or another commodity, that impact needs to be addressed also in the E category of the impacted commodity.

CONCLUSIONS

A conceptual approach to UNFC classification of the combined production is proposed that considers existing guidance for the minerals and energy components, while acknowledging the unique challenges, interdependencies and synergies within the integrated project.

Such approach aims to provide the basis for aligning reporting of both minerals and energy components to investment markets.

These considerations suggest that the UNFC assessment needs to be based on:

a) a conceptual model that encompasses all relevant processes, and
b) a detailed materials and energy flow assessment for the whole system.

This allows consistent delineation of the 'energy' and 'minerals' components, which can then be assessed according to their respective UNFC guidance.

Acknowledgement and Disclaimer

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