A Web-Based Tool to Apply the UNFC for Anthropogenic Resource Recovery Projects

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Introduction

- The transition to sustainable energy systems requires **critical raw materials** for technologies such as **batteries, wind turbines, and solar panels**.
- Anthropogenic resources generated from **waste streams** (e.g., mining waste, slag and ashes, end-of-life materials) offer an opportunity to recover these materials aligning with **circular economy** principles.

Objective

- This project introduces a **novel web-based tool** developed within the **Horizon Europe project FutuRaM** (Future Availability of Secondary Raw Materials in Europe, futuram@eu).
- It supports the assessment of recovery projects and their classification according to the **United Nations Framework Classification of Resources (UNFC).**

UNFC for anthropogenic resources

The UNFC system uses a **three-dimensional classification matrix** to classify resource projects along three key axes; herein, 4 means low level and 1 means a high level of knowledge:

- **G (Degree of Confidence):** This axis focuses on the **reliability of data** regarding the product quantity and quality. It reflects the level of confidence in the potential recoverability of the quantities.
- **F (Technical feasibility):** This axis assesses whether **the recovery methods and technologies** are technically viable. It indicates the maturity of a project. It includes the Technology Readiness Level (TRL) and the status of the infrastructure.
- **E (Environmental and socio-economic viability):** This axis evaluates the project's **impact on the environment** and its potential **socio-economic benefits**. It considers the alignment of the project with regulatory requirements and its acceptability from a social perspective.

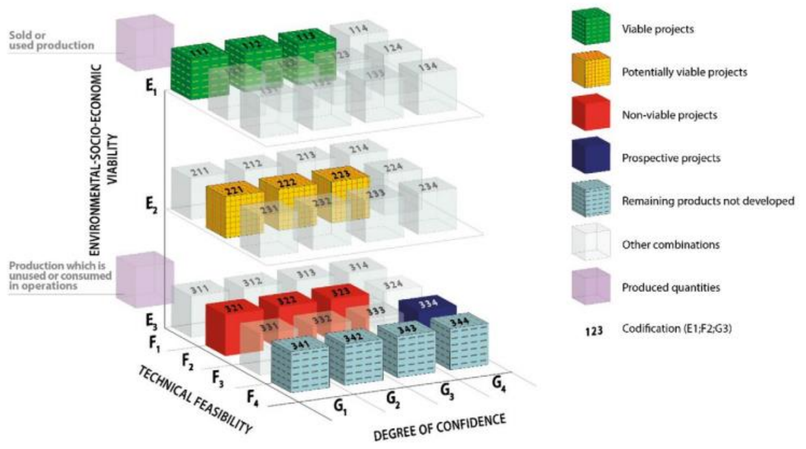

Figure 1: UNFC categories and examples of classes

(Source: UNECE (2019), United nations framework classification for resources, update 2019, United Nations)

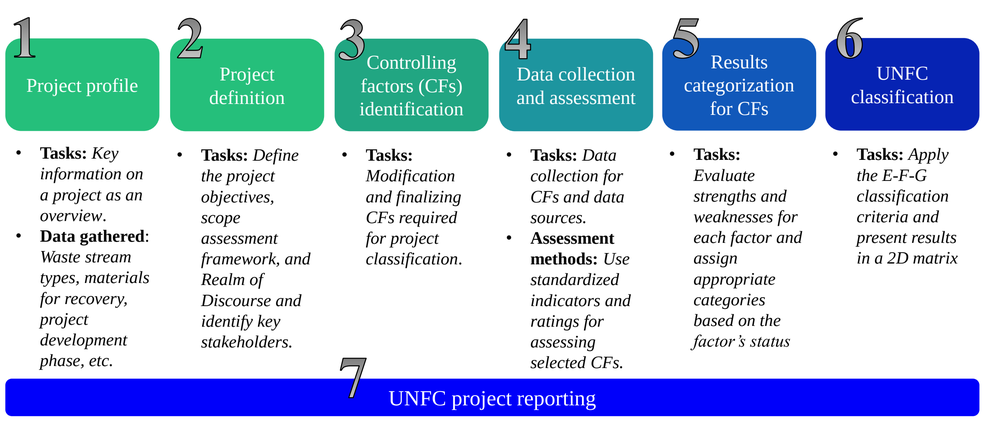

Figure 2: Seven-stage procedure to assess and classify a project

Seven-stage procedure for project classification

- The Seven-stage procedure is a **structured approach** developed to ensure a **thorough and standardized evaluation and classification** of anthropogenic resource recovery projects **in line with the UNFC**.
- It supports project developers from initial data collection to final project classification and reporting. It provides stakeholders with **a holistic view** of the project for **fact-based decision-making**.
- Each stage is designed to provide **clarity, consistency and transparency** in the assessment process.
- It ensures a **consistent assessment basis** for comparing projects and identifying the best recovery options.

Development of the web-based tool

The web tool is designed to support users in classifying anthropogenic resource projects:

- **Front-end:** Developed using **HTML CSS, and JavaScript** to create a responsive and interactive user interface for data input, result visualization and report generation.
- **Back-end:** Developed using **Django** (Python web framework), ensuring scalability, flexibility and robustness.
- **Database:** Used **MYSQL** to store input data and project results, with several tables holding many-to-many relationships between waste streams, stakeholders, development phases and controlling factors.
- **Automated classification:** The tool uses built-in algorithms to automatically classify projects based on user input, providing instant feedback on **project viability**.
- **Detailed reporting:** The tool generates **UNFC-compliant reports**, including recommendations for stakeholders.

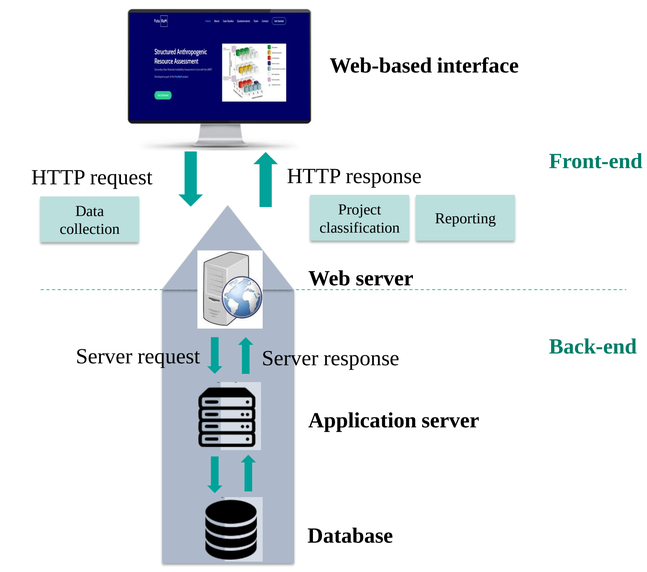

Figure 3: System architecture of the web-based tool

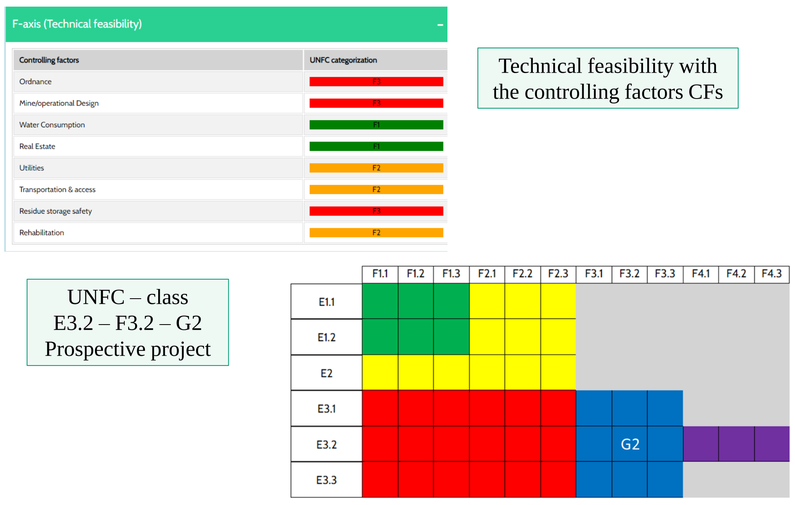

Figure 4: Result of categorization of the criteria and UNFC classification

Case study: Bollrich tailing storage facility

- **Project overview:** Located in Bollrich, this tailing storage facility contains significant quantities of **Cobalt (Co), Gallium (Ga), and Indium (In)**, vital materials for renewable energy technologies.
- **Classification of the project:**
  - ✓ **Degree of confidence (G2):** Moderate level of confidence in material quantities, based on exploration data.
  - ✓ **Technical feasibility (F3.2)**: Local studies indicate the potential for development but require more data acquisition.
  - ✓ **Environmental and socio-economic viability (E3.2):** Environmental-socio-economic viability cannot yet be determined due to insufficient information.

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