Repository

Section 15 - Hydrogen, Sustainability & Circularity

Topic 104 – Material Consumption & Cycles

Dissemination Level: Public

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1. Repository Introduction

This document is part of the H2VE Repository, a structured collection of learning resources and materials developed to support Centres of Vocational Excellence (CoVEs) and training providers in delivering high-quality, up-to-date hydrogen education. The thematic clusters and sub-topics covered in this repository were jointly compiled by all H2VE project partners as part of Deliverable D5.1 - Educational Training Material Specification Document. Each document corresponds to a specific sub-topic within a broader thematic cluster and follows a standardized structure comprising a document header, learning context, core content, curated digital tools, and assessment guidance, where applicable. The aim is to provide trainers and educators with general resources as well as modular content that can be integrated into existing curricula or adapted to specific training contexts. A list of underlying resources and sources is provided at the end of each document to allow for further exploration and verification of the material presented.

2. Topic Overview

Critical raw materials such as platinum group metals and nickel are central to the scale-up of hydrogen technologies, particularly in electrolyzers and fuel cells. This topic examines material flows across the hydrogen value chain, including extraction, processing, use, and recovery, and discusses supply risks associated with critical raw material dependency. Learners gain an understanding of why material circularity is a strategic priority, including considerations around resource scarcity, geopolitical supply concentration, and environmental impacts of primary extraction. These material-level considerations connect directly to the broader circular economy and recycling strategies covered elsewhere in this thematic cluster.

3. Learning Resource Overview

1. Learning Context	**Prerequisites:** • Completed Topics 99–103 • Basic knowledge of H_2 technology types (PEMWE, alkaline, SOEC, PEMFC, SOFC) and their key component materials
2. Content	• **Critical Raw Materials Across Hydrogen Technologies** Material demand varies significantly by technology: PEMWE relies on iridium and platinum catalysts with ex-

	treme supply concentration; PEMFC uses platinum with lower iridium dependency; alkaline electrolysis avoids platinum-group metals in favour of nickel electrodes, though nickel supply is still geographically concentrated; SOEC/SOFC systems depend on zirconium, lanthanum, and manganese; and balance-of-plant/storage components rely on titanium and carbon fibre. • **Supply Risk and Geographic Concentration** More than 70% of global platinum-group-metal mining is concentrated in South Africa, meaning supply disruptions there could have cascading effects on hydrogen technology scale-up timelines worldwide. • **EU Critical Raw Materials Act (2024)** The Act sets 2030 targets of 10% domestic extraction, 40% domestic processing, and 25% recycling for strategic materials, directly shaping how the hydrogen sector must plan its supply chains. • **Closed-Loop Strategies** Reducing catalyst loadings (the DOE roadmap targets under 0.1 g platinum per kW by 2030), developing iridium-free anode catalysts, and improving PGM recycling yields are the main levers for reducing material criticality. The FCH-LCA Tool's material criticality indicator, developed by Forschungszentrum Jülich, allows this risk to be scored quantitatively for any modelled system. • **Social Dimension of Material Hotspots (S-LCA)** Material hotspots frequently overlap with social hotspots: South Africa's platinum belt, for instance, is associated with acid mine drainage, water security concerns, and community health risks, a link that can be explored using Social LCA databases such as PSILCA or SHDB alongside standard material flow data.
3. Digital Tools	• FCH-LCA Tool, Material Criticality Indicator (SH2E): The FCH-LCA Tool includes the CRM criticality indicator developed by Forschungszentrum Jülich (SH2E D3.1). Allows quantitative CRM risk scoring for any modelled H_2 system. • PSILCA v4.0, Social Risk Screening of CRM Supply Chains: Use PSILCA's mining sector indicators (child la-

	bour, forced labour, occupational safety, community water access) for the countries supplying Pt, Ir, and Ni to H_2 manufacturers.
4. Assessment Guidance	**Assessment Methods** • Comparative table exercise: students fill in a blank material intensity table for PEMWE, alkaline electrolysis, and SOEC, then rank by supply risk using IEA data. • Policy analysis (500 words): how does the EU Critical Raw Materials Act's 25% recycling target for strategic materials interact with the current state of PGM recycling from fuel cells? **Sample Questions** 7. List three critical raw materials used in PEM electrolysers and identify the primary supply risk country for each. 8. Compare the material criticality profile of PEMWE with alkaline electrolysis. Which technology has higher supply risk and why? 9. The EU Critical Raw Materials Act sets a 25% recycling target for strategic materials. Is this target currently achievable for iridium from PEMWE? Justify your answer. **Evaluation Criteria** • Accuracy of CRM identification and supply risk data (40%) • Quality of technology comparison using material intensity data (35%) • Policy contextualisation and critical analysis of achievability (25%)
5. References	• IEA. (2024). Global critical minerals outlook 2024. International Energy Agency. https://www.iea.org/reports/global-critical-minerals-outlook-2024 • IEA. (2023). Critical minerals market review 2023. International Energy Agency. https://iea.blob.core.windows.net/assets/c7716240-ab4f-4f5d-b138-291e76c6a7c7/CriticalMineralsMarketReview2023.pdf • European Commission. (2024). Critical Raw Materials Act. https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en

	• Iglesias-González, S., et al. (2024). Life cycle sustainability assessment of the platinum supply chain in the EU. Sustainable Production and Consumption. https://www.sciencedirect.com/science/article/pii/S2352550924000782 • Zapp, P., & Schreiber, A. (2021). D3.1 Material criticality indicator. SH2E - Clean Hydrogen Partnership. https://sh2e.eu/downloads/

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