Repository

Section 15 - Hydrogen, Sustainability & Circularity

Topic 102 - Secondary Use and Service Life Extension

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

Extending the service life of hydrogen technologies through secondary use is a key lever for reducing raw material demand across the value chain. This topic examines strategies such as repurposing decommissioned components for lower-demand applications, refurbishment programs, and maintenance-driven lifespan extension, using examples relevant to hydrogen storage tanks, electrolyzer stacks, and fuel cell systems. Learners gain an understanding of the technical, economic, and regulatory factors that determine whether a component is suitable for secondary use versus recycling or disposal. Service life extension is also situated within the broader R-strategy hierarchy, illustrating its role in delaying end-of-life material flows within the hydrogen value chain.

3. Learning Resource Overview

1. Learning Context	**Prerequisites:** • Completed Topics 99 - 101 or equivalent knowledge of sustainability and circularity design principles • Basic understanding of fuel cell system operation and degradation mechanisms
2. Content	• **Second-Life Applications**: Automotive fuel cell stacks, originally designed for roughly 5,000 operating hours,

can be repurposed for stationary backup power applications targeting 40,000+ hours at lower power density, a direct real-world instance of the R7 Repurpose strategy introduced in Topic 100.

- **Refurbishment vs. Remanufacturing:** Refurbishment involves cleaning, conditioning, and re-certifying a stack for continued use within the same application class. Remanufacturing goes further: full disassembly, component-level inspection, replacement of degraded parts (notably the MEA), and reassembly to original specification.
- **Lifetime Extension Strategies:** Predictive maintenance techniques such as impedance spectroscopy and voltage monitoring, alongside stack conditioning protocols and membrane hydration management, allow degradation to be tracked and slowed before a stack reaches end-of-life.
- **Business Models Enabling Circularity:** Product-as-a-service and leasing models, where the OEM retains ownership and end-of-life responsibility, together with take-back schemes under Extended Producer Responsibility, shift financial incentives toward designing for longevity and recovery.
- **Technical & Regulatory Challenges:** Barriers to wider second-life adoption include difficulty characterizing performance degradation, the need for safety re-certification in new applications, warranty gaps, and the current absence of dedicated standards for second-life fuel cell systems.
- **Industry Case Study: Honda (2025):** Honda, Tokuyama Corporation, and Mitsubishi demonstrated repurposing automotive fuel cell stacks to power a data center using by-product hydrogen, a real-world, industrial-scale confirmation of the Repurpose strategy.
- **Techno-Economic Viability:** Second-life deployment is generally justified when three conditions hold: stack performance remains above the threshold needed for stationary operation, refurbishment cost stays below the

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	combined cost of a new stack and the residual recycling value, and safety re-certification is achievable.
3. Digital Tools	-
4. Assessment Guidance	**Assessment Methods** • Decision-tree exercise: given a stack with known performance data (power degradation rate, operating hours), students must determine whether to choose R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, or R8 Recycle, with written justification. • Business model canvas: students design a service-based business model for a hypothetical FC stack leasing company. Must include end-of-life obligations. **Sample Questions** 1. What technical conditions must a used PEMFC stack meet to qualify for a stationary second-life application rather than being sent for recycling? 2. Explain the difference between refurbishment and remanufacturing in the context of fuel cell stacks, giving one advantage and one limitation of each. 3. Why do business models such as product-as-a-service or leasing support second-life strategies? What risks do they introduce? **Evaluation Criteria** • Accuracy of technical conditions for second-life eligibility (35%) • Correct distinction between refurbishment and remanufacturing (30%) • Quality of business model reasoning including EPR context (35%)
5. References	Honda Motor Co., Ltd. (2025, August). Stationary fuel cell power station using repurposed automotive fuel cells. Honda Global Newsroom. https://global.honda/en/newsroom/news/2025/c250801aeng.html Stanchev et al.(2025). Comparative techno-economic and life cycle assessment of stationary energy storage. Batteries, 11(10), 382. https://www.mdpi.com/2313-0105/11/10/382

	European Commission. (2020). Circular economy action plan. https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

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