Sustainable SoluTions FOR recycling of end-of-life Hydrogen technologies

Deliverable D6.4

Analysis of replicability: Permitting aspects and authorisation assessment

Document Details

Due date	31/12/2023
Actual delivery date	21/12/2023
Lead Contractor	HRD
Version	V1
Prepared by	Anna Marchisio
Input from	HRD
Reviewed by	Envipark

Document Details

X	PU - Public
	CO - Confidential, only for members of the consortium (including the EC)

Clean Hydrogen Partnership

Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Abbreviations

ADEME	French Environment and Energy Management Agency
AVV	Abfall-Verzeichnis-Verordnung
CRM	Critical Raw Materials
EFTA	European Free Trade Association
EOL	END of LIFE
EU	EU Commission
EWC	European Waste Code
HDV	Heavy Duty Vehicle
HSE	Health, Safety, & Environment
ICE	Internal Combustion Engines
JIVE	Joint Initiative for Hydrogen Funding Europe
LoW	List of Waste (of the European Union)
MEA	Membrane Electrode Assembly
MS	Member State
M1	Passenger Cars classification
N1	Light Commercial vehicles classification
NIP	National Innovation Programme (Germany)
PFSA	Perfluorosulfonic acids
PEMFC	Proton Exchange Membrane Fuel Cell
PGMs	Platinum Group Metals

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

Contents

List of figures

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

1 Executive Summary

Within Task 6.3.1 of BEST4Hy project (M21 to M36), an analysis of authorization for upscaling has been planned under responsibility of Hensel Recycling (HRD).

In this task, permitting and authorization aspects to effectively implement and upscale BEST4Hy recycling processes will be analysed by HRD to be compliant with local authorities' regulations and to be integrated in existing recycling facilities. This document therefore analyses the German case study specifically, with some consideration on possible applicability at EU level, on the basis of common legislation and regulations. However, each Member State implements EU Directives in local national legislation, which might include additional requirements.

RINA and ENVI have supported HRD in the assessment of hazardous/HSE (Health, Safety and Environmental) impact risks. A replicability analysis of the development of the system has been produced by HRD with the close involvement of Hensel Recycling USA.

2 Legal Background in the EU

Waste plays a crucial role of EU policy. A framework of different regulations and directives aims in fact to better the management of waste both in the EU as well as in EFTA countries. EU policy has chosen to separate the different streams according to product, such as the ELV Directive, discussed in this chapter, but also the WEEE Directive or the Battery Directive, to only mention a few. A coverage of the relevant EU Directives, Acts and Regulation has been provided in deliverable D6.2 "BEST4Hy Regulatory and Standardisation Assessment".

The product related waste regulation is subordinate to the general waste regulation, such as the Waste Framework Directive or Waste Shipment Regulation, and treatment related legislation (e.g. Landfill Directive, Waste Incineration Directive).

An important principle of product specific regulation is that a given product can not fall under the jurisdiction of two separate directives at the same time. For instance, the lead acid battery in an end-of-life vehicle is covered under the ELV Directive, whereas a lead-acid battery being a replacement part during life cycle of the vehicle is subject to the Battery Directive.

The European Union environmental policy is largely based on directives, which represent the basic requirements and allow for adaptation to the regulatory necessities and systems of the European Member States (MS). As a result, the transposition often varies country by country around Europe. Once a given MS has approved its national law, it must notify the EU Commission (EC) of its regulation. If a MS violates the provisions in its national transcription, the EU Commission may ask the authorities in the given MS to make the necessary changes and it could even launch an infringement procedure against the country.

With implementation reports at regular intervals, the EU Commission is supervising the correct implementation of the ELV Directive in the markets of the EU.

Clean Hydrogen Partnership
Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

Since 1998 Hensel Recycling has been dealing with the professional recovery of platinum group metals (PGMs) from spent auto catalytic converters and other End of Life materials (EOL) such as diesel anti particle filters, pharmaceutical catalysts, stationary catalysts coming from biogas plants, oxygen sensors etc.

PGMs are critical raw materials, and the EU Commission underlined their fundamental importance in the European Critical Materials Act (March 2023), where it "identifies a list of strategic raw materials, which are crucial to technologies important to Europe's green and digital ambitions and for defence and space applications, while being subject to potential supply risks in the future."

The Regulation comprises both the critical and strategic raw materials lists in EU law and gives clear targets for domestic capacities along the strategic raw material supply chain and to diversify EU supply by 2030[1]:

- At least 10% of the EU's annual consumption for **extraction**,
- At least 40% of the EU's annual consumption for **processing**,
- At least 15% of the EU's annual consumption for **recycling**,
- **Not more than 65%** of the Union's annual consumption of **each strategic raw material at any relevant stage of processing** from a single third country.

About 90% of the total waste input of Hensel Recycling derives from automotive origin (passenger cars, mainly), and the legislation outline we refer to dates to 2000, while the EU Commission made an updated proposal in July 2023.

The ELV Directive was implemented in 2000 and it was the first harmonised EU framework designed to ensure that vehicles reaching the end of their life and considered as waste be treated in an environmentally responsible manner. The Directive set out provisions on the collection and depollution of ELVs, it restricted hazardous substances in new vehicles and set targets on reuse and recycling (85%) and on reuse and recovery (95%), based on the average weight of ELVs per vehicle and year. Since its adoption, the legislation has not been substantially amended.

Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661

With the approval of the Directive on End-of Life Vehicle 2000/53/EC, the concept of Extended producer responsibility was introduced for the very first time in an EU waste directive by the EU Commission.

The directive aimed at reduction of waste arising from end-of-life vehicles. The scope of the directive covers passenger cars classified as M1, light commercial vehicles classified as N1, and three-wheel motor vehicles as defined in the previous Directive 92/61/EEC but excludes motor tricycles[2].

The directive contemplates aspects along the life cycle of a vehicle as well as aspects related to treatment and recycling operations. As such it aims at:

- preventing the use of certain heavy metals such as cadmium, lead, mercury and hexavalent chromium,
- collection of vehicles at suitable treatment facilities,
- de-pollution of fluids and specific components,
- coding and/or information on parts and components
- ensuring information for consumers and treatment organisations
- achieving reuse, recycling and recovery performance targets

With these targets set, the directive involves four major stakeholders, the producer, the recycling industry, the last holder and the authorities.

[2] Other vehicles, such as buses with more than 9 seats, motorcycles, commercial vehicles for the transport of goods with a maximum mass of more than 3.5 tons, trailers and other vehicles (e.g. trains, boats, and airplanes) are not covered by the ELV Directive.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

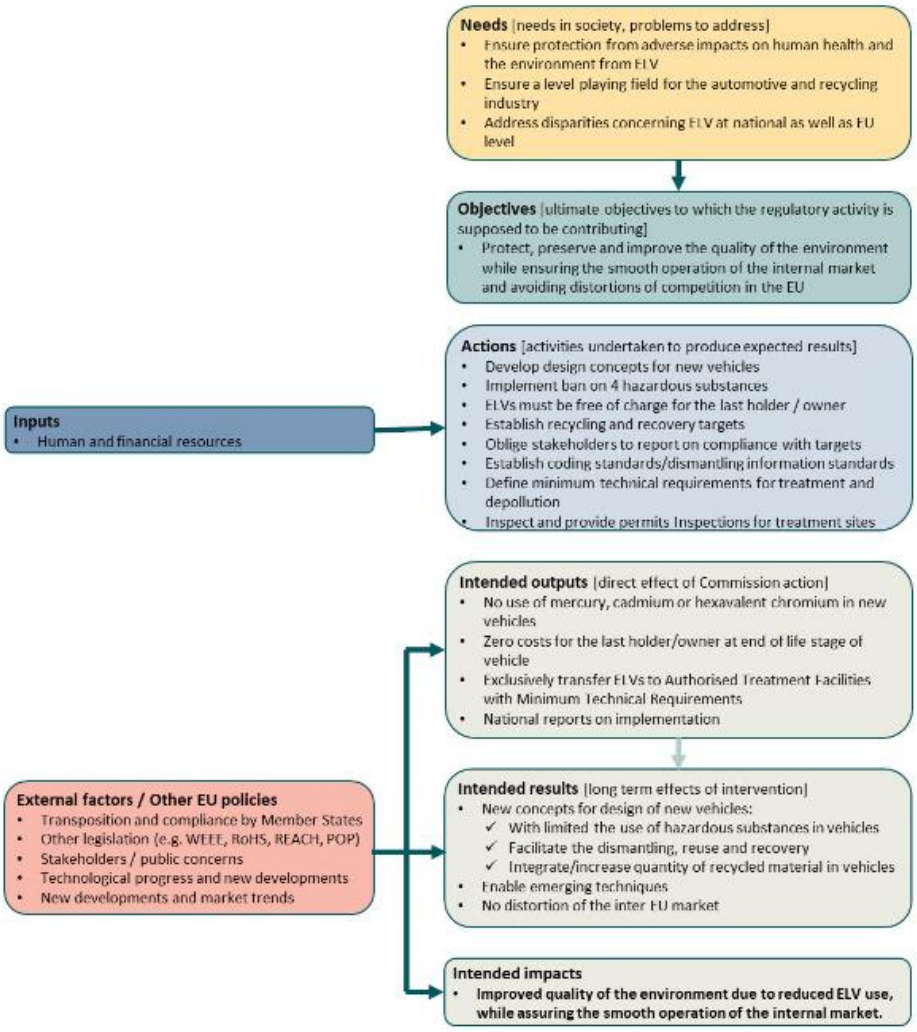

Figure 1. The intervention logic showing the intended functioning, desired results, and overall rationale of the Directive.

Since 2000 the Directive has stayed unchanged. In the new proposal advanced in July 2023, the Commission referred to the “The European Green Deal […] which aims to ensure by 2050 a climate neutral, clean, and circular economy, where the management of resources is optimised, and pollution minimised. The circular economy action plan and the new industrial strategy for Europe lay out the roadmap for the European industry to meet the objectives of the Green Deal. The action plan contains a commitment to review the legislation on end-of-life vehicles (ELVs) with the aim to 'promote more circular business models by linking design issues to end-of-life treatment, consider rules on mandatory recycled content for certain materials, and improve recycling efficiency'. The EU action plan “Towards Zero Pollution for Air, Water and Soil' also stressed the need for the Commission

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

to propose new measures to address the EU's external environmental footprint linked to the export of ELVs and used vehicles"[3].

Hensel Recycling refers to the German implementation of this EU Directive[4] as far as the collection of spent auto catalytic converters on domestic ground is concerned and to the various MS applications in each MS where a subsidiary of the Group is present.

Furthermore, spent auto catalytic converters are classified as dangerous waste in Germany, according to the *Abfallverzeichnis-Verordnung (AVV)*, which relies on the European List of Wastes (LoW). This list contains so-called EWC (European Waste codes), which are six-digit codes used to identify the waste as listed in the LoW. They are formatted as three pairs of numbers, i.e., 16 08 01, and identify and classify waste into categories according to how these have been produced, adequately describing the waste being transported, handled, or treated.

2.1 Possible Scenarios with EoL FCH and WE systems

The classification of a waste is the first step to ensure that its management can be appropriately regulated. The whole value chain of waste treatment uses the EWC as a basis for the authorization of its transport, handling, storage and treatment. It is expected that any hydrogen device or parts of it, such as stacks, becoming waste will be impacted by the waste legal framework. At the moment, there is not a specific waste category corresponding to the items. This section analyses some possible codes that could be used instead of (or while waiting for) a dedicated entry.

According to the Technical Guidance issued by the European Commission[5], once clarified that an item is waste, the first consideration must be if the waste has one or more hazardous properties listed in Annex III of the EU's Waste Framework Directive, Directive 2008/98/EC on waste. It is plausible that EoL stacks, MEAs and water electrolysers (WE) will be classified as **hazardous waste**, given the

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

[3] https://eur-lex.europa.eu/resource.html?uri=cellar:8e016dde-215c-11ee-94cb-01aa75ed71a1.0001.02/DOC_1&format=PDF

[4] Altfahrzeug-Verordnung, before 2000 known as „Altauto-Verordnung".

[5] Commission notice on technical guidance on the classification of waste (2018/C 124/01) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018XC0409(01)

presence of PFSA (Perfluorosulfonic acids), which belong into the EU POPs Regulation[6], being harmful for human health and the environment.

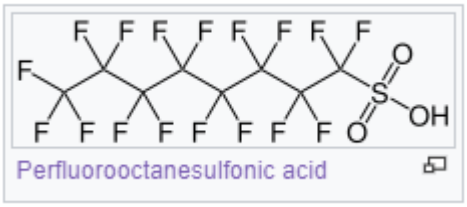

Figure 2. Example of Perfluorooctanesulfonic acid chain.

Similarly, also waste streams of the above-mentioned devices and components deriving from different production line (obsolete, defective, test items etc.) are very likely to be classified as **hazardous waste**.

Regardless of being EOL or production waste streams, these items show as principal characteristic that of being catalyst, i.e. capable of catalytic action and owing catalytic properties.

For this reason, a possible EU waste code could be **16 08 07***[7]. This code corresponds to "Spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium, or platinum **contaminated with dangerous substances"**.

Code 16 08 07* is the mirror entry of 16 08 01 "Spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium, or platinum"[8].

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

[6] https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX%3A32019R1021

[7] European Waste Catalogue (EWC) Code 16 08 07* describes waste that as spent catalysts contaminated with hazardous substances and is classed as a Mirror Hazardous code.

[8] Some wastes are not automatically hazardous or non-hazardous - they are called mirror entry wastes. These wastes have a hazardous waste entry (or entries) marked with an asterisk (*), and an alternative non-hazardous waste entry (or entries) not marked with an asterisk.

It could be argued that whole stacks, where all components are under high pressure and safely contained inside the metallic envelope as depicted in picture 3, might be classified under the above non-dangerous code 16 08 01. This because the PFSA components are not environmentally threatening in this case, being sealed inside the system, which needs to be disassembled and treated first. This option could also be used by waste management companies, who have the faculty of undertaking the classification of the waste they transport, handle, store or treat.

Figure 3. Whole stack coming from an EOL hydrogen passenger car (M1).

Another possible waste classification code is 16 02 15*, which describes waste as hazardous components removed from discarded equipment and is classed as an absolute hazardous code. This other code could be considered fit by the legislator in cases such as whole stacks and modules, where often cables and remaining electrical components such as wire and similar are still mounted on the item. HRD has authorisations to handle, transport and stock this kind of waste too.

However, each MS can also issue guidance about how to classify waste and to determine the nature of the waste with a certain discretion, regardless of what the basis directive indicates. This has already been the case with spent auto catalytic

Clean Hydrogen Partnership

Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

converters, which are classified as non-hazardous in different EU countries[9] and hazardous in others[10].

Furthermore, MSs typically recognize each other's sovereignty to classify the waste, however, for instance, France has deemed that all spent catalytic converters shall be classified as hazardous, including those imported from Countries which traditionally classify them as non-hazardous. The heterogeneity of the single country classification may add some complexity to possible transboundary shipments of waste in the future.

2.2 Domestic Collection in Germany

Considering the case study of Hensel Recycling, hence domestic (German) collection, HRD is a certified waste management company in accordance with §56 of the German Closed Substance Cycle and Waste Management Act (KrWG)[11], and the German law on emission protection (BlmSchG)[12]. HRD possesses all authorisations and permits for the transport, handling, storage and treatment of certain waste codes, including 16 08 01 and 16 08 07*.

Furthermore, HRD is certified according to DIN EN ISO 9001, DIN EN ISO 14001, and DIN EN ISO 45001, i.e., quality, environmental and occupational health and safety management systems respectively.

Hence, alongside the authorisations linked to the waste management regulations, HRD owns all the permits linked to the operation of the plants, e.g. on control of emissions.

Analogously to the collection of other waste kinds that HRD manages, EOL stacks and WEs will be picked up from scrap yards, OEM dealerships, and other

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

[9] Italy, Spain, Portugal, Belgium, the Netherlands, to mention a few.
[10] France, Germany, the UK (even before the Brexit).
[11] https://enb.iisd.org/consume/closed.html
[12] https://hpc.ag/en/success-stories/federal-immission-control-act-of-germany-the-hpc-as-translator/

recycling centres by means of trained personnel driving authorised vans and HDVs.

The stacks and other materials from hydrogen devices will be collected upon the issuing of an official certificate where it is stated that the material will be recovered, and an environmentally friendly recycling is ensured (*Genehmigungsbescheid*).

By issuing the document the company (HRD) declares to be authorised to collect, transport and stock the waste and to dispose of the necessary authorisations to treat such material in order to recover CRM and other elements. This ensures the chain of custody of the waste (Duty of Care).

With regards to the environmental permitting, HRD can operate (i.e. disassemble and treat the small quantities of FCH waste being collected at the moment) under current authorisations for the time being. Should however a pilot plant scaling up being implemented (passing for instance to a 50-litre reactor) an extension of HRD present authorisations will be needed. In this case, factors as HSE and water and ground protection issues will be taken into consideration and presented to the local Authorities for approval of the new operation.

Since HRD do not forecast to implement any incineration process, and even in the scaling up all steps should be performed mechanically and hydrometallurgically or by means of alcohol dissolution, no extra (i.e. different) permits are to be requested. This is also a business-driven choice.

2.3 Collection in other EU Countries

HRD co-owns or fully owns 7 subsidiaries located in the EU and outside its boundaries. Some of these entities are just office and warehouse facilities, while others are operative units where waste materials are stocked and treated.

As the business of recycling of FCH and WEs materials grows, these branches will be able to perform operations as collecting, stocking and partially decanning/disassembling, based on the mother company model.

Collecting materials in scrap yards or collection centres in other countries will require the adoption of local regulations and possibly the extension of present permits according to national rules.

A possible business model could imply that the recovered material will be either:

- sent to Germany to be treated by HRD; or
- treated locally by a company licensed by HRD or by the same subsidiary, properly licensed.

In the case that the material were sent to Germany, a transboundary shipment of waste would be taking place.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

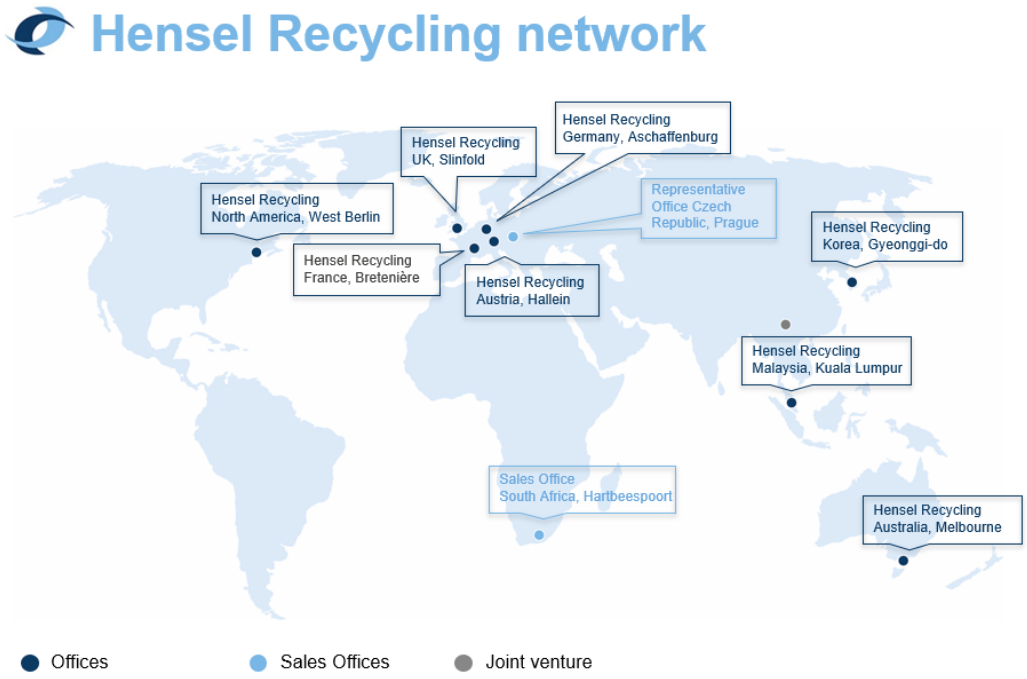

Figure 4. Hensel Recycling Network all over the world

2.4 Transboundary Shipment of Waste

Regardless of the waste status (hazardous or non-hazardous), in order to move waste from one country to another, the waste producer and the consignee must comply to the 1013/2006 Regulation about transboundary shipments of waste[13] - regulation first approved in 2006 and updated in 2021.

Depending on the classification of waste (16 08 01 non-hazardous and 16 08 07* hazardous) the shipment may follow different paths.

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1013-20210111

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

Non-hazardous waste follows the so-called “Green path”, being accompanied by a tracking document commonly called “Annex VII”, where all details are given concerning:

- Origin and waste generator
- Person who ships the waste
- Consignee
- Data about weight, volume, and nature of the waste (EWC)
- Data about the company who is responsible for the transport
- Date of shipment
- Date of arrival
- Data confirmation by the receiver
- Treatment or laboratory performance

The companies responsible for the transport and logistics must be authorized to carry non-hazardous waste in all countries interested by the itinerary and, of course, in the countries of the collection and delivery respectively.

In case the material has been classified as hazardous, a similar tracking document is issued, but being the material under the Amber List of the Basel Convention[14] stricter measures will have to be adopted.

While the raw data are the same, in the case of hazardous waste shipments all parties (sender and receiver) must notify their local Authorities, who might allow (or not) a given volume of such waste streams for a period which cannot exceed 3 years of time. After this time, a new notification process must be put in place again.

In the case of hazardous waste streams, a certain itinerary must be agreed upon with alternatives by the parties making the arrangements and, similarly as with non-hazardous waste transport, only certified companies can do the transport, after being listed and approved of by the Authorities.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.

[14] https://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx

Furthermore, this kind of operation is more costly not only because the carriers will apply higher tariffs than regular goods carriers, but also because a bank-guarantee is requested by the Authorities in order to prevent any kind of unwanted cost arising due to non-compliant practices or unforeseen events..

This makes the whole process complex and costly, but HRD is excellently equipped to overcome all hindrances, being familiar with these practices.

3 Conclusions

The EU legal framework has not yet contemplated a set of rules specifically applicable to EOL FCH and WE systems, starting from a dedicated entry in the EWC. However, the existing set of regulations seems to be fit and flexible enough for the management of this kind of waste treatment. This, in turn, means that it is possible to manage according to existing regulations the small volumes of waste arising from hydrogen devices currently being disposed of.

As for any waste, it is important that hydrogen technology related waste be classified in such a way that only authorised companies and entities be allowed to collect, transport, and treat it. The case of HRD in Germany shows that such businesses exist already and are companies technically well equipped and respecting regulations and standards that decision makers and Authorities foresee, e.g. they operate under permits and authorisations that can be either extended to cover any new requirement or added on (with some business risk).

There is a point of attention regarding fact that this kind of waste might contain PFSA compounds, which need appropriate treatment as they are highly harmful to nature and humans.

The regulatory framework should take into account the risks and the technical requirements necessary to treat or to recover this material efficiently (pending the entry into force of the ECHA PFAs ban and its possible effects) so as to secure that this product be taken care of by professionals.

Hensel Recycling considers that its facilities may easily be adjusted to handle this kind of material safely and efficiently, to secure the recovery of the CRM as forecasted, and this might be true for other players in the same line of business.

Clean Hydrogen Partnership

Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007216.