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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

RECYCLING OF COATING AND ADHESION PRODUCTS

Benchmark

FINAL REPORT

EXPERTISES

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ABSTRACT

Chemical products are subject to an extended producer responsibility (EPR) scheme since 2012. Significant quantities of coating and adhesion products such as adhesives, paints, polyurethane foams, varnishes, and coatings are placed on the market. Today, a large proportion of used products from this sector is not recycled but incinerated - with or without energy recovery.

The French public authorities would like to see the EPR system for chemical products tend more to the recycling of certain products in order to promote a circular economy approach. The Ministerial order of 1 December 2020 imposes in the specifications of the Product Responsibility Organisation in charge of the EPR scheme, an experiment on the recycling of coating and adhesion products (categories 4 and 5 of the Ministerial order of 16 August 2012). This approach is supported by some of the French stakeholders in the sector.

Considering these facts, ADEME wanted to conduct an international search, particularly in other industrialised countries, for existing solutions or initiatives for recycling these products. This international review aims to provide an overview of the spectrum of potentially recyclable products and to draw up a non-exhaustive inventory of the solutions currently in place and their levels of maturity.

The international review adopts a multi-criteria approach and presents for 5 recycling initiatives the regulatory context, the technical aspect (technologies, maturity, etc), the economic aspect (including markets for recycled products), and the actors involved.

The study identified mature recycling initiatives for water-based paints (some including water-based wood stains, varnishes, and oils) and for polyurethane foams. The recycling of solvent-based paints is technically feasible with the same type of processes as for water-based paints but is not widely practised for economic reasons (additional regulatory, technical and market constraints). Recycling initiatives identified for other types of used coating and adhesion products (adhesives, sealants, coatings...) only concern production waste for the moment.

The study identified the key success factors for initiatives that could inspire the development of such scheme in France (collection channels and level of service to the waste holder, selectivity of flows at the collection or recycling level, information sharing within the sector, existence of funding, end-of-waste, final outlets, quality control to develop SDS, etc.).

Within the EPR scheme, this report could be used to guide and support the reflections of public authorities and stakeholders towards increasing and improving the recycling of chemical products. This work could also contribute to future experiments and the development of recycling industrial solutions that are still emerging.

1. Background and objectives of the study

The French public authorities would like to see the EPR system for chemicals tend more to recycling, which rouses some industry players' interest. An international review of coating and adhesion products recycling initiatives provides information on good practice for increasing recycling in France.

1.1. Background

Chemical products are subject to an extended producer responsibility (EPR) scheme since 2012. The products included in the scope of this scheme mainly concern the DIY, decoration, maintenance, and gardening sectors. Significant quantities of coating and adhesion products such as glues, paints, varnishes, and coatings are placed on the market. The complete list established under article R.543-228 of the Environmental Code is detailed in the Ministerial order of 16 August 2012 listing the chemical products that may present a significant risk to human health and the environment (modified by the Ministerial order of 1 December 2020).

Today, a large proportion of the post-consumer waste products from this sector are not recycled. Incineration - with or without energy recovery – thus remains the main treatment solution available.

The French public authorities would like to see the EPR system for chemical products tend more to recycling of certain products to promote a circular economy approach. Indeed, recycling chemical products has many environmental advantages. It allows to preserve natural resources, to save energy and raw materials and to reduce the production of final waste.

This desire was confirmed following the publication of the Ministerial order of 1 December 2020 (TREP2026615A), which imposes in the specifications of the Product Responsibility Organisation[1] in charge of the EPR scheme, an experiment involving the recycling of coating and adhesion products (categories 4 and 5 of the Ministerial order of 16 August 2012).

This approach is supported by some of the French stakeholders in the sector.

1.2. Objectives

Considering these facts, ADEME wanted to conduct an international search, particularly in other industrialised countries, for existing solutions or initiatives for recycling these products. This international review aims to give an overview of the spectrum of potentially recyclable products and to draw up a non-exhaustive inventory of the solutions currently in place and their levels of maturity.

The international review adopts a multi-criteria approach and aims to present the following elements:

- the regulatory context,
- the technical aspect (technologies, maturity, etc.),
- the economic aspect (including markets for recycled products),
- the actors involved.

Within the EPR scheme, this assessment could be used to guide and support the reflections of public authorities and stakeholders towards increasing and improving the recycling of chemical products. This work could also contribute to future experiments and to the development of recycling industrial solutions that are still emerging.

[1] To date, for the products covered by this study, there is only one Product Responsibility Organisation in France, the company ECO-DDS

2. Methodology

ADEME has entrusted this work to RDC ENVIRONMENT. The study was conducted between July 2021 and June 2022.

The methodology was carried out in 3 phases, according to the work plan below.

Table 1: Work plan

Phases	Means
Phase 1 - Identification of initiatives	
1.1. Appropriation of the French situation	Interviews with French industry actors
1.2 Identification and characterisation of recycling initiatives	Literature review of recycling initiatives in OECD countries Interviews with industry stakeholders Summary of identified projects, including research projects
1.3. Selection of the 5 initiatives for in-depth analysis	Pre-selection based on the selection criteria Decision by ADEME after opinion of the Steering Committee
Phase 2 - In-depth analysis	
2.1. In-depth analysis	Interviews with stakeholders of each initiative Review of documents made available by stakeholders
Phase 3 - Transversal analysis	
3.1. Transversal analysis	Evaluation criteria (see phase 1.1)
3.2. Analysis of the transposition to the French framework	

2.1. Appropriation of the French scheme

The actors of the French scheme who were interviewed are :

- AMORCE, the national association of local authorities, associations, and companies for the management of heat, energy, and waste networks,
- CIRCOULEUR, paint recycling company,
- FIPEC, association of the paint, coating, and varnish industries (SIPEV), of printing inks (AFEI), of colours for art, leisure, and education (AFCALE), of glues, adhesives, and sealants (AFICAM) and of products for wood preservatives (SPB),
- CHIMIREC, a group specialised in collection and treatment of hazardous and non-hazardous waste,
- PENA Group, waste collection and treatment group,
- FNADE, the National Federation of Waste Management and Environmental Services (FNADE),
- SYPRED, Union of professionals in recycling, recovery, regeneration, and treatment of hazardous waste.

2.2. Categories of products concerned

Table 2: Coating and adhesion products in the scope of the French EPR system Chemical Products

4. Adhesion, sealing and repair products	
Sealants (including glazier's sealants, adhesive sealants, sealants for joints)	Glazier's sealants: ≤ 5 kg Other sealants : - in can packaging: ≤ 0.3 l - other types of packaging: ≤ 5 kg
DIY adhesives	Water-based adhesives: ≤ 5 kg Solvent-based adhesives: ≤ 1 kg Reactive adhesives: ≤ 500 g
Adhesives for school use and multiple use glues / fixing or small decorative fixing, solvent-free	Any weight ≥ 80 g
Adhesives for other uses such as floors, walls, and tiles	Wall and floor adhesives: ≤ 25 kg Tile adhesives: ≤ 25 kg
Polyurethane foam-type resins / expanding foams regardless of the application method	Aerosols ≤ 1 l
Resins not packaged as aerosols	≤ 25 l and ≤ 30 kg
5. Material treatment and coating products and surface preparation products	
Treatment products for non-wood materials	≤ 25 l and ≤ 30 kg
Wood treatment products	≤ 25 l and ≤ 30 kg
Paints, varnishes, wood stains and related products (including lacquers, undercoats, surface water and oil repellents), regardless of the method of application	≤ 25 l and ≤ 30 kg
Paints and products used to control the growth and settlement of fouling organisms	≤ 2,5 l
Pigments, colours, tints and other additives for decorative paints and coatings, excluding products for tinting machines	≤ 1.5 kg
Mineral and organic interior/exterior coatings for walls or floors: decorative coatings, repair, filling, levelling, finishing, jointing and smoothing coatings, adhesive mortar, various mortars	Dough: ≤ 25 kg Powder: ≤ 25 kg

According to ECO-DDS, 622 kt of category 4 products and 724 kt of category 5 products were put on the market in France in 2020.

2.2.1. Adhesion, sealing and repair products

2.2.1.1. Sealants

Sealant is an elastic cement paste, which is used in various ways.

Composed of calcium, carbonate, linseed oil, wax, resin, and brick powder, it is mainly used to fill holes and to make objects stick together. Putty is also widely used by glaziers. In this case, the material is slightly different, composed only of linseed oil and chalk. Sealant is used to insulate a door or room, preventing air from entering, by fixing the glass panes to the windows. It is also a good way of ensuring that a surface is watertight[2] .

2.2.1.2. Glues and adhesives

Adhesives are either polymers that take on their adhesive properties by evaporation of the solvent (water or organic), or monomers that polymerise.

There are many different chemical families in today's glues and adhesives tapes. The main ones are as follows:

- Vinyls (white wood glue)
- Neoprene or contact adhesive (high strength assembling adhesive)
- Epoxy (wood, metals)
- Urethane (mainly used in industry)
- Cyanoacrylate ("glue")
- Acrylic (polystyrene or other porous materials)

There are also glues made from natural materials (used by children).

2.2.1.3. Polyurethane foams

Description of the product category

The PU foam-type resins in the scope of the EPR scheme are non-aerosol resins ≤25l/30kg and aerosols ≤1l.

Expanded polyurethane foams are used for their thermal insulation properties and for the sealing of cracks [3] .

Expanded polyurethane foams (urethane polymer or PU) are the product of the chemical combination of two or more elements:

- polyols of the alcohol family,
- isocyanates,
- a stabilising catalyst,
- a propellant.

This mixture reacts with ambient air and humidity to form a compact and light foam. The gas released during application causes an increase of 40 to 45 times the initial volume contained in the aerosol. Polymerisation occurs during application and is not reversible.

There are several families :

- Single component expanding foams : This is a product with a high expansion potential, the most widespread and the least expensive. Single component or universal expanding polyurethane foam is used to seal cracks and on thermal or sound bridges in general.
- Two-component expanding foams: Its expansion is moderate. Two-component expanding PU foam is used for cold conservation or insulation and for moisture protection. It is a product recommended for work on boats, cars, and for the professionals in the refrigeration and building industries.
- Expanding foam adhesives: These are low expansion foams used to combine sealing and thermal break. Adhesive polyurethane foams are very popular in the construction sector, particularly for the assembly of polystyrene plates and other thermal insulation materials.
- Fire-fighting foams: Certified by the M1 anti-fire standard, this foam delays fire for two hours or more. It is often used in collective buildings to create fireproof construction joints.
- Outdoor foams: Also known as winter polyurethane foams, they can be used outdoors even at temperatures below zero. This type of material hardens in contact with humid ambient air. They are recommended for outdoor locations exposed to very low temperatures.

[2] Source: Futura-sciences
[3] Source: Manomano.fr

2.2.2. Material treatment and coating products and surface preparation products

2.2.2.1. Paintings

Description of the product category

A paint is a chemical mixture of four main types of ingredients:

- Pigments (15-25%) are natural or synthetic and are used to tint the paint (clays, silicas, calcium carbonates, calcined clays, barium sulphate, etc.) or to provide physical properties (anti-corrosion, film hardness)
- The mineral filler (10-15%) increases the volume of the paint, reinforces its structure, and makes the paint more opaque (diatomaceous earth, talc, lime, barite, clay)
- Binders and film-formers (25-30%); these are polymer resins (acrylic, polyurethane rubber, polyesters, vinyl acetate/ethylene (VAE), silanes, alkyds, epoxy resins or sunflower or linseed oils, glycerophthalic resin) which provide properties such as gloss, adhesion, durability, resistance, flexibility.
- Thinners / solvents (45-50% by mass): They are used to facilitate the application of the paint by reducing its viscosity during application and are highly volatile so they can be dispersed in the ambient air and make the paint film appear.
- Additives (5%): In small quantities they are used to modify the flow properties (viscosity modifier), the stability of the pigments (UV filters), the surface tension (adhesion), to prevent freezing, to control foaming, to favour the dispersion of the pigments (for a more uniform paint)

Water-based/acrylic paints use a water-based thinner. Oil-based or solvent-based paints use an organic thinner: dichloropropane, toluene, xylene, acetone, etc. Oil-based paints and vegetable oil paints are solvent-based paints.

It is the binder/pigment ratio that determines the finish: matte (more pigments and mineral filler than resins), gloss (same amount of pigments as of resins), satin (intermediate).

Oil-based paints generally have a higher content of volatile organic compounds (VOC) than water-based paints (compounds directly toxic to human health and precursors of fine particles). They dry more slowly than water-based paints and have better water resistance (cleanable). They tend to have better covering power.

Oil-based paint is in decline compared to acrylic paints which have improved in terms of formulation to tend to be similar to the level of finish of the oil-based paints (smooth aspect).

The undercoat or primer is a type of paint even if it has a different name. Often more liquid than paint, it is enriched with components that allow it to smooth the surface, to "block" it so that it does not absorb the finish paint, and even to adhere to complex surfaces[4] . There are also water-based and oil-based undercoats. A water-based undercoat can be used under an oil-based paint.

Water-based paints have sub-families depending on their binder :

- Acrylics
- Latex
- Acrylics - latex
- Vinyls
- Lime
- Tempera
- Silicate
- Silicon

Oil-based paints have sub-families depending on their binder :

- Glycerophtalic
- Polyurethane
- Chlorinated rubber
- Epoxy
- Alkyd

In Europe the term acrylic paint and in North America the term latex paint are sometimes misused to refer to all water-based paints.

[4] Source: L'universdupeintre.com

2.2.2.2.Wood stains

A wood stain (the term dye is used in Quebec) is a protective or decorative product for porous materials (wood, concrete, etc.) that does not cover the material with an opaque film. It differs from paint or varnish because it has little or no binder and no filler.

The small proportion of binder dissolved in the solvent is the main difference between a wood stain and a varnish. After the solvent has evaporated, the film obtained is microporous, which allows the material to breathe without removing the film.

The difference with wood treatment products is that wood stains do not contain biocide.

A wood stain is composed of the following elements:

- Solvent (water, white spirit, etc.) - 50%-70%. Wood stains are presented in the form of solvent or aqueous phases (polymers are sometimes larger and therefore less penetrating)
- Binder
    - oil-based wood stains: linseed oil, castor oil, baked-on or not,
    - polymeric wood stains: acrylic, alkyd, alkyd-urethane.
- Pigment (0-5% by volume), typically very fine and transparent iron oxides, which, in addition to colour, provide the wood with UV protection. Micronized titanium dioxide, which is almost transparent in the visible range, also provides good UV protection but makes the surface slightly more opaque.
- Additives: may contain siccatives or hardeners.

There are acrylic and oil-based wood stains.

2.2.2.3.Varnishes

Varnish differs from paint because it does not contain an opacifying mineral filler. Otherwise, like paint, it contains a natural or synthetic resin/binder, a solvent and additives and may also contain pigments.

There are water-, oil- and alcohol-based varnishes.

The binding resins are urethane-based, acrylic-based or hybrid.

Acrylic or urethane-oil varnishes are water-based. Urethane or polyurethane varnishes are oil-based.

2.2.2.4.Wood treatment products

Oils and saturators are products used to treat wood that differ from paints, varnishes, and wood stains because they do not create a film when drying. This mainly changes the finish (more natural look and less satin/gloss) and maintenance (less durability but can be reapplied without sanding).

Oils are composed of oils and possibly pigments.

Saturators also include acrylic or alkyd polyurethane resins for waterproofing and rub resistance.

They can have a water or oil base.

Water-based saturators include emulsifying agents (to avoid water/oil separation).

Products commonly referred to as "wood treatment products" are wood stains containing biocides. Biocides are substances regulated at the European level (Biocides Regulation (EC) No 528/2012).

2.2.2.5.Coatings

Coatings or plasters have different functions: decorative, repair, filling, levelling, finishing, jointing, smoothing, adhesive mortar (tiling), etc.

Coatings are composed of mineral or organic binders, mineral fillers and mixed with water. They are pasty. There are different categories of coatings:

- mineral coatings
    - Mixture of sand and hydrated or hydraulic lime,
    - Mixture of lime and plaster,
    - Mixture of flax shives, quarry sand and lime.
- organic coatings: coatings composed of a siliconized acrylic resin, additives, fillers, and polymers
- organo-mineral coatings based on silicates or silicone and mineral fillers.

Organic coatings are waterproof, thin, and elastic and can be applied to all types of surfaces but are more expensive than mineral coatings. Mineral coatings are more breathable than organic coatings (avoid

condensation) but can crack. Organic-mineral coatings have properties of resistance to micro-organisms and pollution.

2.3. Selection of 5 initiatives for in-depth analysis

The objective of this phase was to select 5 projects for the in-depth analysis.

Based on the set of recycling initiatives identified in OECD countries, 9 initiatives were pre-selected and contacted to test their compliance with the selection criteria. Projects that were stopped or remained at the R&D stage were not considered at this stage. In the United States and Canada, given the number of initiatives, only certain structuring EPR-type initiatives were pre-selected, as most of the other actors are linked to these schemes.

The following 9 initiatives were selected:

- PDR
- PLANET PAINTS
- AKZO NOBEL
- ECO-PEINTURES
- PRODUCT CARE
- PAINTCARE
- RESENE PAINTWISE
- COMMUNITY REPAINT
- PAINT 360

The selection criteria used to identify the 5 initiatives finally selected are :

- The country of the initiative: European countries are favoured for selection due to closer regulatory and market contexts.
- The date of the initiative: older initiatives, which have more experience and feedback, are favoured.
- The maturity of the collection channel: initiatives with a high density of collection points are favoured.
- The annual quantities collected by the initiative reflect the scale of the scheme and the possibility of achieving economies of scale in recycling.
- The annual quantities recycled by the initiative reflect the maturity of the recycling scheme.
- The recycling rate in relation to the collected waste volume, knowing that the recycling rate is not comparable between different products.
- The nature of the recycled products: closed-loop recycling is favoured, at least for the part of the collected stream that has sufficient quality.
- The market in which the recycled products evolve: the national market is favoured over the international market when export is carried out for reasons of lack of outlet / quality at local level.
- The existence of an EPR scheme: initiatives linked to an EPR scheme are encouraged so that the benchmarking can provide information on the relationship between the Product Responsibility Organisation and the recycling scheme and the way in which recycling is organised within the sector.
- Lack of hazardous waste classification: countries that do not have a hazardous waste classification for products such as water-based paints have a context more comparable to France.
- Social economy: initiatives that promote job integration or initiatives that aim to sell paint at fair prices are favoured.
- Availability of information: initiatives with low availability of information are automatically excluded for phase 2

Based on the selection criteria, the initiatives selected for Phase 2 are as follows :

- PDR
- PAINT 360
- PRODUCT CARE
- PAINT CARE
- AKZONOBEL-INTERCHEM

3. Appropriation of the French situation

The results of the interviews with French stakeholders were transcribed in the form of a SWOT analysis.

Table 3: SWOT analysis on the development of coating and adhesion products recycling in France

Strengths	Weaknesses
A well-developed collection channel for household waste and for some chemical waste, collection systems from distributors (Rekupo system[5]), open to households and professionals **Existence of recycling processes in operation in France** (set up by the producers for unsold goods and production loss, and existence of the CIRCOULEUR recycling initiative for post-consumer waste) **Products with a relatively short lifespan**[6] allowing a relative adequacy between the composition of the waste stream and the regulation to put them on the market (except for destocking practices)	**Lack of communication between actors** within the EPR Chemical Products scheme **Lack of involvement of the Product Responsibility Organisation ECO-DDS** with the identified recycling actors **Waste stream varies widely** (quantities, composition, physical state, contamination) **Difficulty in accessing the content** for certain products (sealants, adhesives) due to the packaging used and the nature of the products (separation of container/content) **Some waste classified as hazardous waste** **Feasibility of recycling to be assessed** (technical feasibility and economic profitability) **Collection still poorly developed for professional chemical waste** excluding paints[7,5] **No consensus amongst** the operators of the scheme on the procedure for considering certain used **water-based paints** as **non-hazardous waste**[8]
Opportunities	**Threats**
Producers who are in favour of increasing recycling[9] **Increased savings for manufacturers** (outlet for manufacturing waste, lower disposal costs for non-compliant products) **Positive change in consumer attitudes** towards recycled products **Potential growth in collection of chemical waste via the EPR for Construction Products and Materials of the Building Sector (PMCB),** which will offer additional collection channels for professionals; this should make it possible to manage packaging outside the scope of ECO-DDS.	**Manufacturers' reluctance to share information on composition** **Evolution of the product regulation** that could lead to the prohibition or restriction of the use of an increasing number of substances that will nevertheless be found in the waste stream temporarily **Regular changes in the composition of products** which require the adaptation of recycling processes **Risk of fragmentation of the flow** between non-EPR and EPR flows and between flows concerned by PMCB EPR and those concerned by the Chemical Products EPR. Risk of fragmentation of the flow between several recovery outlets if coordination is not effective and PMCB

[5] Among the coating and adhesion products, the Rekupo system accepts paints and coatings but not polyurethane foams.
[6] Compared, for example, with **Construction** Products and Materials of the Building Sector
[7] Since 2021, chemical waste of professionals covered by the Ministerial order on products can be accepted at waste disposal centres.
[8] Representatives of producers indicate that water-based paints could be exempted from the hazardous waste classification, and this, based on a sorting at the collection point. Representatives of the hazardous waste treatment operators indicate that since paint waste has mirror entries in the European waste classification (20 01 27* and 20 01 28), methods must be implemented to assess the hazardous character of the waste. Also, as the information on the container is not sufficient to judge the hazardous character, a prior characterisation is necessary to establish an adequate simplified method of assessing the hazardous character. DGPR confirmed to SYPRED that the characterisation data on the chemical waste stream is too poor to judge whether a visual sorting is sufficient to classify a chemical stream container as non-hazardous waste.
[9] FIPEC's will to develop recycling, ongoing projects on characterisation of the waste stream to identify recyclable flows

Synergies with the PMCB EPR for recycling, particularly if the actors cooperate and have a coherent operation mode between the two schemes **Experimentation of environmental labelling on paints** which can highlight the benefits of incorporating recycled material in paints	EPR does not move towards recycling. **Competition of recycling with energy recovery and RDF production**

4. State of play of initiatives in OECD countries

This chapter provides a summary of all the initiatives identified in the OECD countries, followed by a more detailed analysis of the R&D projects and finally an in-depth analysis of 5 initiatives selected for this study.

4.1. Summary of identified initiatives

Of all the product categories surveyed, only paints (about 30 initiatives) and, to a lesser extent, polyurethane foams are subject to chemical mixture recycling initiatives in OECD countries (2 initiatives). Wood stains, varnishes and water-based wood treatment products are included in some paint recycling initiatives. The initiatives identified for the other product categories (adhesives, sealants, etc.) only recycle the container while the content is used to produce energy. These are also the only products for which research projects or papers have been identified.

About 40 recycling initiatives could be identified, the vast majority of which focus on water-based decorative paints[10] (latex, acrylics).

4.1.1. Paintings

Types of recycling

There are different types of paint recycling, depending on the type of paint (water-based or solvent-based) and its quality.

Water-based paints (acrylic or latex) can be recovered in several ways:

- Closed-loop paint recycling. It should be noted that sometimes, only white paint is recycled. In addition, recycled paint can be mixed with virgin paint before being put on the market, depending on the incoming and target quality.
- Material recovery of paint waste in the production of cement or concrete blocks (replacing mixing water or latex[11]). This solution can be used in addition to recycling when the quality of the paint does not allow for recycling into paint or reuse. It is studied in several research articles.[12]

Solvent-based paints are recycled either into new paints or through a regeneration process of the solvent, which can then be reused for different purposes (including the manufacture of new paints). Recycling of solvent-based paints is less developed than recycling of water-based paints because it requires high quality paint waste , specific skills, and authorisations (waste management and hazardous products) and because the waste stream is more complex (various solvents) and decreasing.

Lastly, recycling sometimes is complementary to the reuse of paints, for example at COMMUNITY REPAINT NETWORK in the UK, PRODUCT CARE in Canada and RESENE PAINTWISE in New Zealand.

[10] Decorative paints are paints used by both private individuals and professionals to decorate interior or exterior surfaces. They differ from industrial paints, which are used for example for coating cars or other products.

[11] Said A, Quiroz O. Recycling of waste latex paint in concrete: a review. *MOJ Poly Sci*. 2018;2(2):52-54. DOI: 10.15406/mojps.2018.02.00047

[12] De Souza Tavares EC, Barbosa TTN, Filho JN de O, Meneses CGR, Reuse of Waste Water-Based Paint, 2014.

Location of initiatives

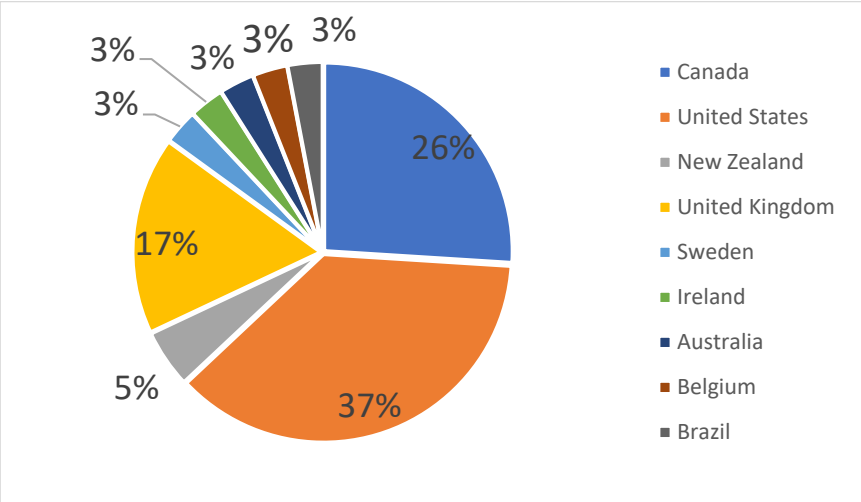

Figure 1 : Number of initiatives (research, pilot or operating) identified per foreign country

The initiatives identified are mostly located in North America (United States and Canada). This can be explained by the existence of EPR schemes in most of the states and provinces in these territories, the first of which was established in 1994 (British Columbia).

Initiatives also exist in Europe (in particular in Belgium, France, Ireland, the Netherlands, and the UK). These are generally more recent[13] , and some are still in the experimental stages (Ireland). In the past, some recycling initiatives have faced problems of economic viability which prevented them from continuing their activities (the Netherlands and Belgium). However, recycling initiatives led by the paint manufacturer AKZONOBEL seem to be developed in several European countries (Belgium, France, UK). To finish, in Sweden, several university studies (feasibility study and research paper on the recycling of pigments in paints) have been carried out recently. [14,15]

Paint recycling organisations operate in Australia and New Zealand. However, in Australia, , recycling project holders seem to face problems of access to the waste stream via the EPR PAINT BACK scheme, which exists but does not have a recycling obligation. Nevertheless, producers do not wish to recycle. PAINT BACK prefers to direct solvent-based paints to energy recovery, while water-based paints are mainly used as co-products in the industry.

Finally, in South America, no initiatives have been identified on an industrial scale. A research paper on the material recovery of paints for the manufacture of 'soil-cement' bricks has been published in Brazil.[16]

No results were identified in Asia.

[13] One of the first initiatives, NEWLIFE PAINTS, which has now stopped, started in 2008.
[14] E. Brattsell Bukowski, Introduction of a Paint Reuse Program in Stockholm, Sweden, KTH Royal Institute of Technology, 2020.
[15] M. C. F. Karlsson, Recycling of TiO2 Pigments from Waste Paint: Process Development, Surface Analysis, and Characterization, Chalmers University of Technology, 2018.
[16] De Souza Tavares EC, Barbosa TTN, Filho JN de O, Meneses CGR, Reuse of Waste Water-Based Paint, 2014.

4.1.2. Polyurethane foams

Type of recycling

The type of recycling is discussed in detail in the chapter describing the PDR initiative.

Location

A recycling initiative for polyurethane foams has been identified in Germany (PDR). Germany has set up an EPR scheme for this waste.

Recycling of this type of product has not been found in other countries.

In Switzerland, research papers were published in 2014 by the company Sika for the recycling of polyurethane adhesive production waste but no operating projects could be identified. [17]

4.1.3. Wood stains, varnishes, oils, and wood treatment products

Initiatives

No recycling initiatives specifically targeting wood stains, varnishes or oils were identified. PAINT 360 (UK) recycles wood stains and PAINTCARE (United States) recycles wood stains, varnishes, and oils, but it is marginal compared to the quantities of water-based paints (mixed with water-based paints for PAINTCARE). The quantities collected are much smaller.

4.1.4. Other coating and adhesion products

Initiatives

No recycling initiatives targeting these product categories have been identified. The recycling initiatives that have been studied in-depth discard these products for energy recovery.

4.2. Summary of R&D projects

The literature review did not identify many R&D articles on the subject. Two potential causes can be suggested to explain this:

- The coating and adhesion product recycling projects identified are first driven by companies, either the producers themselves or via independent initiatives e.g., led by start-ups. The research and development associated with these projects is therefore not necessarily published because it may be a competitive area.
- The recycling of paints does not involve advanced technologies as it relies on widespread industrial processes such as quality control, sieving, mixing, reformulation. Thus, the kind of academic research that is useful for its development is not necessarily published.

However, this section analyses the few R&D projects identified.

Concerning the recycling of white pigments

Mikael Karlsson published a PhD thesis in 2018 on the recycling of TiO_2 pigments (white) from paint waste, funded by the Swedish agency for innovative systems, AKZO NOBEL and STENA METALL.

The research is driven by the energy intensity required to produce TiO_2 pigments, which prompts the industry to look for alternatives to virgin pigments.

Commercial TiO_2 pigments are coated with aluminium oxides, silicon, or zirconium to reduce the sensitivity to light of paints, to improve its durability, and to improve pigment dispersion. The recycling of the three types of pigments has been tested.

The recycling process consists of a pyrolysis at 500°C with nitrogen to remove the volatile organic fraction. The pyrolyzed residues are then oxidised by the air at 500°C to eliminate the organic content and the carbon black. After this step, the inorganic fraction is contaminated by ionic salt residues which come from the decomposition of the paint ingredients. A step of washing of residues with an ion-exchanger resin then results in a pure TiO_2 product.

Among the three pigments studied, it was shown that a pigment coated with a combination of silicon and aluminium oxides was more likely to be eliminated during the recycling process than pigments coated with a combination of aluminium oxides and zirconium or those only coated with aluminium oxide.

[17] T. C. M. Corbiere, S. Ketch, Recycling of Polyurethane Adhesive Residues, Sika Technology AG, 2014

The virgin pigment was entirely replaced by the recycled pigment to test the influence on the properties of the product. The paint containing recycled pigments has a lower covering capacity and makes the surface slightly less opaque compared to the paint containing virgin pigments. No significant influence on whiteness, pH or viscosity was identified. However, surface defects due to poorly dispersed and aggregated pigments led to a decrease in the gloss of the paint film. Making the grinding of the pigments before reincorporation more efficient could probably improve this parameter.

The study concludes that although the recycled pigment product has inferior properties compared to the virgin one, it would be suitable for uses such as low gloss formulations and ceiling paints. A recycled pigment/virgin pigment blend would also be feasible.

In addition, the study recommends that the pigment industry coordinate with the paint and recycling industries to ensure better recyclability of pigments by working on the coating. This could be achieved either by facilitating the deterioration of pigment coatings during recycling to facilitate the coating of recycled pigments, or on the contrary by producing stronger coatings. The critical point is to avoid the inhomogeneity of the recycled pigments which creates aggregates.

Comments on this study: The thesis does not analyse the environmental impacts of such a recycling process in comparison to the use of virgin pigment or to the recycling by mixing paints as practiced by the in-depth initiatives (see below). The energy consumption for pyrolysis, the emissions related to the thermal degradation of organic compounds (CO_2 , pollutants) and the treatment of waste from ion exchange are strong potential limits to this alternative.

Concerning the recycling of polyurethane (PU) adhesives

SIKA has presented a research project with the aim of evaluating means to manufacture intermediate products from uncured 1K PU production waste, which can be stored and reused at any time for the preparation of any PU system.

The recycling concept consists of preparing either a non-reactive liquid-paste filler or a highly reactive filled prepolymer from a mixture of chemically pre-treated adhesive waste.

The chosen approach was to quench the PU adhesive with NCO reactive liquids[18] under appropriate process conditions. In this way, it is possible to produce an intermediate filler / liquid-paste plasticizer. This intermediate product, made from 1K PU adhesive-sealant waste of Sikaflex® , can be used in the production of a new adhesive. It can be stored without effort nor special precautions (exclusion of moisture) and reused at any time for the preparation of any PU or hybrid PU system in the same plant.

The feasibility could only be demonstrated by using PU production waste or PU adhesives that have passed their expiry date – and were previously disposed of.

Comments on this study: The article includes only an abstract, and therefore does not provide further information on the perspectives and limitations of this work.

Concerning the material recovery of paints for construction use

Tavares et al. from POTIGUAR University published a research paper in 2014 about the material recovery of production waste from water-based paints for the manufacture of 'soil-cement' bricks.

'Soil-cement' brick is a low-cost building material resulting from the homogeneous mixing and pressurisation of soil, cement, and water in appropriate proportions, which do not require a heating process. Usually, this final product has shown good resistance, waterproofing, and durability. In addition, its manufacturing process does not require high-temperature sintering and the use of wood as fuel, inducing deforestation.

Different formulas of brick have been made with :

- For solids 8% by mass of Portland cement, 0 5 10 and 20% of water-based paint residues and the rest of soil (72 to 92%),
- 12 to 15% of water by volume.

Pressurisation was done at 20MPa.

The addition of paint residues compared to paint-free formulas shows :

- An increase in resistance,

[18] Presumably amides, although this information is not specified in the text

- A decrease in water absorption (better waterproofing).

The properties of ‘soil-cement‘ bricks exceed the Brazilian standards used as a reference.

Comments on this study: The binding properties of paint residues are clearly noticeable through the improvement of the brick properties with the levels of paint residue. However, the formulas tested suggests a substitution of soil by paint residues and not a substitution of cement by paint residues. According to the authors, the main aim is to find a solution for the recovery of paint residues that would still be directly released into the environment, and the possibility of substituting cement is not put forward. However, the formulations could be optimised to reduce the need for cement.

Other works

Emma BRATTSELL BRUKOWSKI's master thesis at KTH in 2019 studies the feasibility of setting up a paint recycling system in Sweden like the programmes developed in the US and the UK (discussed in detail below). The study analyses the challenges of such a roll-out (end-of-waste, REACH, quality control). The study first recommends quantifying the waste volume, to study the public acceptance for the purchase of recycled paints and for the sorting gesture and to set up a small-scale experiment to better understand the stakes of a roll-out.

4.3. In-depth analysis of five initiatives

4.3.1. PDR (Germany)

4.3.1.1. Overview

General	
Country / region of action	Germany
Starting date	1993
EPR scheme	Yes
Amount of the EPR fee	Approximately 0.30 EUR / can or about 3% of the product price. PDR would thus collect about 6 million EUR of EPR fees per year.
Description of the waste stream	
Nature of waste collected	Polyurethane (PU) foam in metal cans, 1k (80%) and 2k (20%)
Origin of waste collected	Individuals (20%) and professionals (80%)
Collection	
Collection system	Collection points: DIY shops, professional shops, waste disposal centres. Mailing service (very limited) and on-call collection (professionals).
Quantities collected (/year)	1,770 t/year (2020) or approximately 8 million cans (220 g/cartridge)
Collection rate	Not available, estimated appr. 40% (2020) of the products placed on the market
Cost of collection	Approximately 6 million EUR [19]
Recycling	
Nature of waste recycled	Recycling of propellant and packaging: "1k" and "2k" PU foam. Recycling of unused product: "1k" PU foam only.
Quantity of waste recycled and reused (/year)	1 411 t/year of which • Content (36%) : 428 t PU prepolymer, 79 t propellant • Packaging (64%) : 722 t tinplate, 100 t recycled cardboard, 22 t reused cardboard, 7 t plastic films, 1 t mixed plastics[20]
Recycling rate and reuse	81% (1% reuse) in total, about 70% on content
Cost of recycling	Gross cost: 4 MEUR / year[21] Net cost (with material revenue): close to 0
Outlets	
Nature of recycled products	Recycled prepolymer mixed with MDI[22] , propellants, aluminium, tinplate, plastic, and cardboard

[19] This would imply a collection cost of about 3 400 EUR/tonne, knowing that PDR estimates that it is less than 2 000 EUR/tonne. The inconsistency between the data may be due to an exceptionally low collection rate in 2020 (COVID crisis). PDR did not want to give precise figures. Thus, the data should not be used to establish costs per tonne.
[20] PDR also reports a PU foam can waste stream of 156 t recycled at 36%.
[21] Product weight and packaging
[22] Diphenylmethylene diisocyanate, mixing with virgin increases product stability

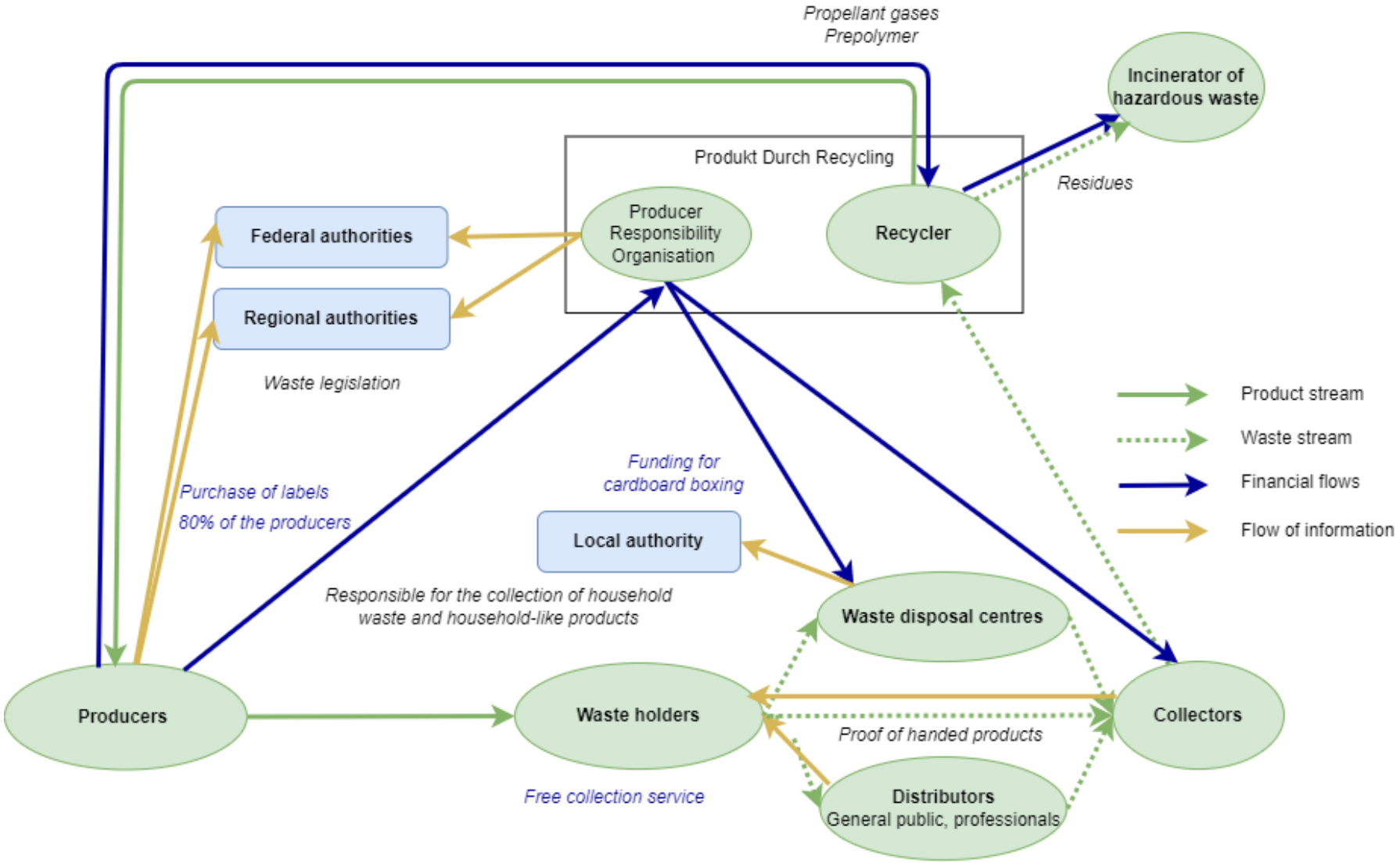

Figure 2 : How the PDR PU foam recycling initiative works

PDR Recycling GmbH + Co KG is a profit-making recycling company whose capital is held by 9 current or historical PU foam producers (shareholders): BOSTIK (Germany), TREMCO CPG (the Netherlands), DOW CORNING (Germany), HENKEL (Germany), ORION (Poland), RAMSAUER (Austria), SOUDAL (Belgium), TKK (Slovenia) and HANNO (Austria). No shareholder has more than 50% of the capital. The votes in the Board of Directors are not linked to the share in the capital: each member has one vote.

Any profits of PDR are redistributed to the shareholders according to their share in the capital. It should be noted that PDR's shareholders have approved the company's HP cartridge recycling business, even though they are not those who place these products on the market , as it is a technically feasible and profitable business.

PDR also acts as a Product Responsibility Organisation of the scheme. PDR has 12 contributing members who pay EPR fees directly to PDR (no financial intermediary). Most of the shareholders are also contributing members (all those who are still producers today, but some shareholders are no longer producers and are therefore not required to contribute). Some contributing members are not shareholders.

PDR commissions companies to collect, store and transport PU foam.

PDR operates a single recycling centre based in Thurnau, Bavaria. The site also recycles HP ink cartridges.

INTERSEROH is a large recycling company that also acts as a Product Responsibility Organisation for the PU foam packaging scheme. INTERSEROH employs 2,300 people in 7 countries. PU foam packaging is not the core business of INTERSEROH, which also has a licence for the Dual system for non-hazardous packaging and is developing broader take-back and recycling solutions for packaging in several countries. INTERSEROH does not recycle the content of PU foam packaging. According to PDR, INTERSEROH's members for the PU foam packaging scheme are rather small, cost-oriented companies (lower EPR fees than PDR's ones).

PDR estimates that about 80% of the volume of PU foams put on the market in Germany (professionals and individuals) goes through the PDR system and that the remaining 20% goes through the competing system INTERSEROH. The share of free riders is relatively insignificant and would concern a few online traders. These values are estimates, as the market shares are confidential and unknown to the PDR management. The members of PDR tend to be large companies, which choose PDR in particular because of the possibility of communicating on the recycling of the content of PU foam packaging.

4.3.1.2. Context and evolution of the scheme

Context of creation :

- PDR was created in 1993 by PU foam manufacturers in anticipation of an EPR obligation that was published in the waste legislation in 1994 and came into force in 1996.
- According to the VerpackungG law, the extended responsibility of packaging producers covers all household and non-household packaging, including hazardous waste packaging, but the latter cannot be included in the Dual system that operates for non-hazardous packaging.
- Therefore, to fulfil their obligations, the manufacturers of PU foams who also put packaging on the German market have decided to set up a take-back and recycling scheme for end-of-life cans.
- Manufacturers have decided to recycle the remaining substances in the cans as well, although they are not obliged to do so by the regulation[23] . Recycling PU foams allows them to communicate in their sustainability reports and to access secondary materials that they can integrate into their products. Public authorities consider this choice as environmentally ambitious.

[23] Confirmed by an exchange with the UBA

Key stages of development/modifications:

- After initially recycling only 1k foam packaging waste, the scheme later integrated the recycling of 2k PU foam packaging and propellants.
- PDR had a collection activity before choosing to delegate it to logistics companies for reasons of economic efficiency.
- Between 2010 and 2015, the market for PU foams with a low MDI content (Methylene 4,4'-diphenyl diisocyanate, a hazardous substance in PU foam cans) developed strongly in Germany because the free sale of PU foams with a content of more than 0.1% MDI was restricted. In practice, it became mandatory to offer low MDI foams (<0.1%) to continue to offer unrestricted sales on the DIY market, although these products were more expensive and less efficient than conventional foams. PDR separated these cans and recycled them separately to also market the finished products separately. After the end of the restriction on the sale of conventional PU foams in 2015, consumers have shifted to conventional foams again, the market for low MDI foams declined and PDR has since stopped stream separation and separate recycling.
- PDR also receives PU foam cans from the Benelux countries and Italy, and considers at the Swiss, Austrian and French markets.

Perspectives:

- PDR plans to reinvest in the process for almost 2 million EUR on the summer of 2022 to modernise the facility. This will result in a one-month shutdown.
- PDR advocates with public authorities to ensure that the recycling targets concern not only the packaging, but also the content.
- The introduction of a mandatory deposit system could increase collection rate. The members of PDR who place products on the markets do not want to join a deposit system by fear of losing market share to the members of the competing Product Responsibility Organisation INTERSEROH.
- No further changes of the system are considered.

4.3.1.3.Technical description

4.3.1.3.1. Market entry

Product characteristics:

PU foams are used in the DIY and construction market for their adhesion and insulation properties, especially for the installation of windows. The industry produces finished products such as PU foam insulation boards, which are outside the scope of the study[24] , and markets expansive PU foam in cans, which can be used for sealing, caulking, filling holes and generally insulating small areas. There are few competing products in this market segment for expansive PU foam.

There are different types of expansive PU foam, the most relevant distinction for recycling being the one between one-component (1k) foams, which represent about 80% of the market, and two-component (2k) foams, which represent about 20% of the market.

- One-component foam (or 1K foam) is usually used in aerosol cans. It is stirred to mix the ingredients and then applied to the area concerned. The prepolymer reacts with the moisture in the ambient air - this is called foaming - causing the material to grow before a drying time.
- Two-component foam has polyurethane as its main ingredient, together with cross-linking agents or hardeners which are in an inner container of the can. Before use, the 2K must be activated, i.e., the inner container is opened by a mechanism. By shaking the cans, the two components are mixed and should be applied within approximately 10 minutes. The difference in technical properties compared to 1K foam is that 2K foam hardens very quickly and homogeneously, the foam does not tend to sag and achieves a very high resistance.

PU foams contain a base of diphenyl methane diisocyanate (P-MDI), polyether polyol and polyester polyol and additives. MDI is irritating and may cause cancer.

Low MDI or MDI-free foams are used partially for the DIY market. They contain higher proportions of cross-linked diiosocyanate dimers or trimers (i.e., the MDI monomer has already partially reacted). They developed in Germany between 2010 and 2015 when the unrestricted sale of PU foams containing more than 0.1% MDI in DIY shops was banned[25] . This market still exists based on consumer preferences but has decreased as these products are rather more expensive and less efficient. These foams are indeed less reactive and are not used in the professional market.

[24] In France they are part of the PMCB EPR and not of the Chemical Products EPR

[25] Prohibition that was no longer valid when the hazard phrase R40 became H351 following the entry into force of the new CLP labelling

Standard PU foams are not developed to reduce MDI content, as MDI emissions during use are low (below detection limits according to SOUDAL) due to the rapid reaction of the substance during use.

It should be noted that there are also PU foams designated by their application (fire fighting, adhesives...) which are part of the definition of PU foams in this work and which are recycled by PDR (belong to the 1k or 2k families).

Packaging characteristics :

PU foam packaging is relatively standardised with two main sizes:

- A small size of 650mL, for about 500 mL of product (void volume for the gas phase), which weighs about 580 g when it is full
- A large size of 1L, for 650-800 mL of product, which weighs approximately 1.1 kg when it is full

Standardisation is not driven by design for collection and recycling but by economies of scale in the manufacture of packaging suitable for pressurisation. The packaging is sold in standard-sized boxes, which facilitates collection operations.

This standardisation also concerns the French market.

Market entry :

Polyurethane foams are available in DIY shops and specialised stores [26] .

Approximately 25 million cans are sold each year in Germany. PDR does not monitor the quantities placed on the market as there is no monitoring requirement for this data and no collection target that would indirectly require monitoring this data or a waste stream data. PDR covers about 80% of the market, or about 20 million cans.

The points of sale shall give consumers the necessary information for collection and recycling of PU cans, in accordance with the regulations.

Relationship between producers and the EPR system :

Those who place products on the markets pay their EPR fees through the purchase of labels affixed to the cans. The frequency of payment therefore depends on the frequency of supply of labels. To demonstrate compliance with the EPR, producers must justify to the public authorities that their volumes sold correspond to the volumes of labels purchased.

As part of the conditions for participation in the PDR system, the producers are expected to provide information on the composition of the products to PDR. Each year PDR receives information from the producers. Safety Data Sheets are shared. In addition, producers notify significant changes to PDR. If producers refuse this condition, they cannot participate in the EPR system. Information on product composition is kept confidential and is not shared with other members or even shareholders.

4.3.1.3.2. Collection operations

Type of holders: individuals and professionals

Properties of the incoming waste :

- Cans which have reached the end of their life weigh on average 220 g (large and small)
- 80% of the cans are 1k cans and 20% are 2k cans
- The composition of used cans is as follows

[26] Throughout Europe, PU foams sold in DIY shops must be sold with gloves to avoid skin contact (§ 56 of Annex XVII of the REACH Regulation).

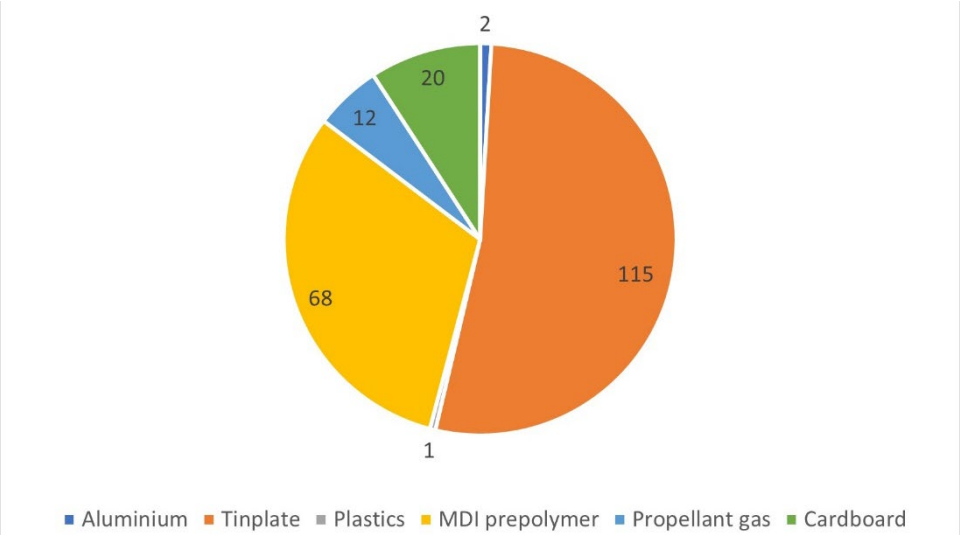

Figure 3: Composition of incoming PU foam can waste (in g)

- Used cans are collected approximately 1 to 3 years after manufacture (expiry date after 2 years)

Level of service for holders :

- PDR provides collection material, communication material for collection points (posters, stickers for containers for waste managers, collection cupboards for shops) and boxes, free of charge.
- Types of collection points :
    - Voluntary drop-off points in DIY shops, specialised professional shops and waste disposal centres.
    - Free collection service for professionals from 72 cans (6 boxes of 12) via a phone or online request.
    - In areas without a good collection network, PDR can provide free return labels by post from 6 boxes.

- Network :
    - More than 3,000 public points throughout Germany in shops and waste disposal centres, and more than 15,000 professionals are served.
    - The law states that collection must be close to the user but does not require a grid. PDR estimates that the collection point is located within 10km of every point in Germany, except in some sparsely populated areas or on islands. The postal return system is intended to provide a solution for the holders concerned, but PDR is trying to reduce the share of this service.
- Free of charge: the service is always free of charge, with acceptance criteria. If the acceptance criteria are not met, the service is not performed, there is no billing.

Acceptance criteria :

- All PU aerosol foams are accepted at the collection points (list below). These variations in terminology specify the more precise functions fulfilled by PU foams, which implies some variations in formulation (more or less expansion or adhesion properties)
    - PU foam
    - Building foam
    - One-component foam (1k)
    - Two-component foam (2k)
    - Fire fighting foam
    - Well foam (waterproof)
    - Insulation foam
    - Foam for door and window frames
    - Foam for windows
    - Construction foam
    - Setting adhesive (especially for bonding PU foam insulation boards)
    - Perimeter foam
    - PU foam gun

- Only cans with the PDR label on the product (identification of members paying EPR fees to PDR) can access the PDR collection points:

Figure 4: Label on the cans of PDR member brands

- Rusty cans should be excluded at source as they are not guaranteed to be waterproof: they can introduce water into the system which interferes with recycling (see below).
- If the intermediate collection containers contain mixed waste, collection is refused.
- Only cans that are upright, sealed (either with a cap or hardened PU foam) and in taped boxes which are protected from the weather are accepted.
- Collection points must comply with the same thresholds and collection conditions as large waste producers (≥ 6 boxes).

Operation mode with the distributors :

- Waste collection is not overseen by the distributors. It takes place in a waste collection area that is usually dedicated to the collection of many waste streams.
- Sometimes containers are wrongly used as collection points for mixed waste. In this case collection is refused (see acceptance conditions).

Operation mode with the waste disposal centres:

- Collection of PU foam packaging is usually part of the services offered by the municipalities, often with two bins: one bin for PU foam with PDR labelling and one bin for PU foam with INTERSEROH.
- Those who go to waste disposal centres put PU foam cans in the 240l container. The local authority in Hof reports that users also put cans from brands which are not members of PDR in the containers, despite the PDR acceptance conditions. No complaints have been received by the local authority about the presence of non-member cans in the system as PDR accepts up to 10% non-member cans in its service policy. The drop-off is usually overseen by the officers of the waste disposal centres.
- Municipalities accept both households and professionals. The municipality of Hof, for example, does not have a threshold for the professionals' waste volume.
- PDR has a contract with most German municipalities to provide a free collection container and to put the municipality in contact with the collector chosen by PDR. The municipality directly solicits the collector to define collection times.
- Municipalities can also choose to work with independent waste management companies without going through PDR. Many municipalities work with both PDR and INTERSEROH. PDR and INTERSEROH have entered negotiations to plan a mechanism for collection of mixed cans from their members and a system of financial compensation between them depending on the volumes collected. These negotiations have not been successful. The Product Responsibility Organisations therefore provide in their conditions with the municipalities for a physical separation of the flows depending on the labels.
- Collection is only done after the cans have been packed, which allows compliance with the conditions of ADR chapter 3.4 (dangerous goods packed in limited quantities, see regulations below). PDR tries to convince the municipalities to pack themselves in exchange of a financial support (confidential amount). If the municipality does not want to pack, the collector does so before collecting.
- Municipalities are not compensated for the collection infrastructure (no full cost coverage). The municipality of Hof sees this as a point of improvement for the system.

Traceability: each box collected is labelled to indicate where it was collected. Proof of the number of cans handed in is provided to the collection point when the collectors take them, and to professionals when they hand them in at the collection point (certificate of disposal enabling professionals to demonstrate that they are managing their waste correctly).

Organisation of collection operations :

- PDR divides the German territory into 10 collection areas, which do not correspond to the Länder borders but to areas which are coherent to be served from a logistical point of view with intermediate storage facilities.
- For each area, PDR has assigned the collection market to a collection service provider via a bidding process. The contracts are not renewed at a predefined frequency but according to the needs identified: PDR wishes to maintain long-term relationships with its collection service providers to preserve the quality of service.
- The selected collection service providers are logistics companies that are not particularly specialised in waste initially, but rather in the transport of parcels for example. They need a permit to transport waste but do not need a permit to collect hazardous waste (see regulations below). PDR trains the selected operators in their collection requirements.
- The selected companies collect with small standard delivery trucks (typically 7-10 m³ of load area) which allows smooth circulation in the cities and easy access to all collection points and reduces infrastructure costs.
- Rounds are organised to collect both the professionals who use the collection service and collection points. On-call collection takes place within 2 to 6 weeks.
- Proportion collected per collection channel
    - 10% in DIY shops
    - 10% at municipal waste disposal centres
    - 60% from on-call collection by professionals
    - 20% from sales outlets for professionals

  Thus, PDR estimates that about 20% of the quantities come from households and 80% from professionals.
- The collected cans are collected in one or two intermediate storage points per collection area, owned or rented by the selected collection provider. These warehouses can store hazardous waste.
- No collection accidents have been reported in the last 10 years.

Organisation of transport operations :

- Transport from the intermediate storage areas to the PDR site is carried out by entities providing road transport services that are authorised to transport hazardous waste.
- Transport is in accordance with ADR regulations.

Satisfaction: According to a survey conducted by PDR, 99.3% of users are satisfied or very satisfied with the free return and recycling service in 2021 (712 participants from DIY shops, waste disposal centres and professionals). 98.2% of collection logistics partners are also satisfied with the system. The municipality AZV HOF (10 waste disposal centres, 95,000 inhabitants), which was interviewed as part of the study, was also satisfied with the service.

4.3.1.3.3. Recycling operations

Description of the recycling process :

- Key steps :
    - The boxes are opened and the 1k cans are separated from the 2k cans manually. The prepolymer in the 2k cans cannot be recycled because the PU foam has hardened.
    - Cans in poor condition (rusty, smashed) are discarded and not recycled (10-15% of the waste stream) to avoid water entering the recycling process, which activates the formation of PU foam and requires cleaning of the entire installation.
    - Boxes that are in good shape are reused; the rest is recycled.
    - PDR mechanically grinds the cans in an inert and dry atmosphere to avoid contact with water, and in a closed reactor to avoid the emission of dangerous propellant gases. The propellant is drawn in during the grinding and liquefied under pressure and at low temperature.
    - Two separate crushers are provided for the 1k and 2k cans. In the case of 1k cans, the liquid components fall into an acetone bath (solvent). The resulting PU/solvent mixture is filtered several times, goes through a distillation process that extracts the PU and regenerates the solvent. For both types of cans, a solid residue is generated and is then sorted:
        - a metal separator sorts out the cleaned and dried aluminium and tinplate,
        - the plastic caps, mainly made of PP (white and red), are crushed. The mixed material is sold to a recycler who collects it,
        - the residue, containing 2k foam in a solid state and the result of regular cleaning operations, is incinerated in a hazardous waste incinerator or sent for CSR (Refuse-Derived Fuels) manufacture to facilities authorised to manage hazardous waste.
    - PDR and its customers agree on quality criteria that are regularly controlled during production and before sale. A written quality reporting comes with each batch of finished product.
- Innovative aspect: it would be the only installation in the world that carries out this recycling process. The patents governing the process have expired and can therefore be used by competitors.
- Replicability: PDR believes that the knowledge and experience accumulated in can management over the last 30 years is difficult to replicate in the short term.
- Technical barriers to recycling: presence of water (managed by acceptance criteria).

Secondary raw materials (81%) :

- Pre-polymer (PREPUR®) - 25%.
- Propellant gas (TRIGAS ®) - 5%.
- A mixture of PP/PE plastics - 0.1%.
- Tinplate boards (containing tin) - 41
- Recycled (6%) and reused (1%) packaging boxes
- Decommissioned cans - recycled portion - 3%.

Waste: (19%)

- Mixed PU waste - 9%.
- Decommissioned cans- non-recycled portion - 6%.
- PU waste containing isocyanates - 2%.
- Residual waste - 1%.

Traceability: Annual reports are submitted to the regional statistical agencies of the Land of Bavaria and to the Bavarian Environmental Agency on collection and recycling performance of the scheme, by Land and on an aggregate basis for Germany. The performance is also reported to the member producers so that they can use it to demonstrate compliance with their EPR obligations. The performance of the scheme is reported as an average, no statistics are made for individual brands.

All collected cans are recycled at PDR's facility in Bavaria. Despite the associated transport costs, Germany does not generate sufficient quantities for PDR to consider building a second economically viable recycling facility. PDR estimates that a plant can be built for an annual flow of over 20 million cans to be recycled. The PDR facility still has remaining processing capacity[27] and is therefore looking to attract material from neighbouring countries.

[27] Operates with only one shift, sometimes two and is allowed to operate with three

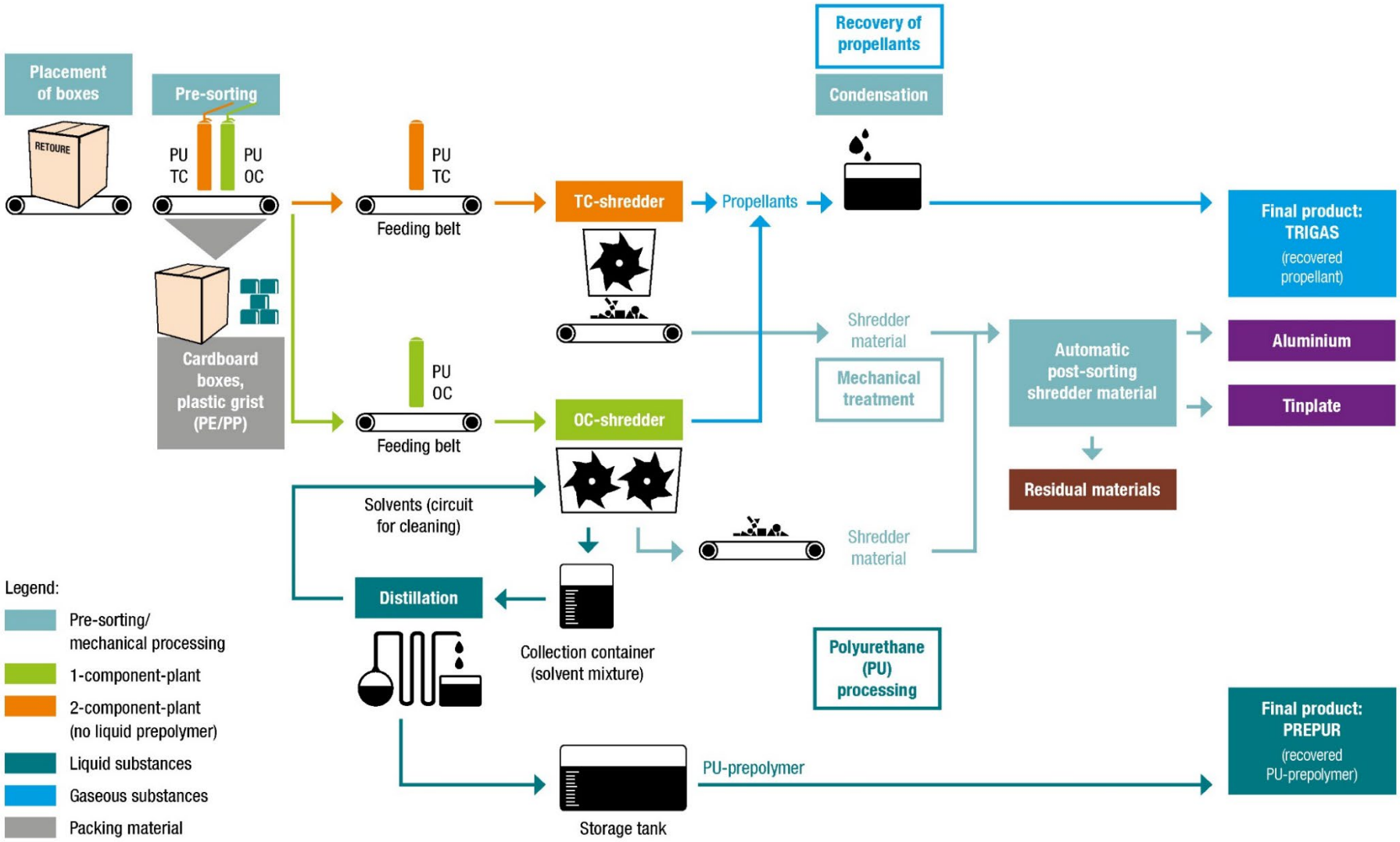

Figure 5: Graphic of the recycling process of PU foam cans by PDR

4.3.1.3.4. Finished products

Description of the finished products and applications:

PREPUR PU prepolymer (base diphenyl methane diisocyanate (P-MDI), polyether polyol and polyester polyol) can be used in various PU construction applications such as adhesives, foams, lacquers, fillers, and binders. It is a brown liquid.

- Viscosity: 10,000 - 24,000 mPa·s
- Free isocyanate (NCO): 11.0 - 13.0 % by mass
- Classified as dangerous according to CLP Regulation. The product sheet mentions the hazard phrase H332: harmful to health.

The PU prepolymer is only available when it is mixed with MDI (in a 1:1, 1:2 or 1:3 recycled to virgin ratio). Different mixtures are also produced on demand.

TRIGAS® propellant is a mixture of different dry propellants with a low acetone content. The components are dimethyl ether (DME), isobutane, propane, n-butane and in decreasing quantities refrigerants R134a (1,1,1,2-Tetrafluoroethane) and R152a (1,1-Difluorethane). The exact quantities of the different components are tested by gas chromatography (GC) and supplied with the product as a certificate of analysis.

It is used for PU foam cans, solvent cleaning sprays, sprays with a grease dissolving effect, double chamber sprays and other applications.

- Form: liquefied gas under pressure, colourless
- Vapour pressure: 5-7 bar at ambient temperature
- Acetone content ≤3.5%.
- Water content: 0%.
- Classified as hazardous according to CLP Regulation H220: extremely flammable gas - the product is supplied with a Safety Data Sheet which only mentions this hazard phrase.

SOUDAL does not use TRIGAS® as a propellant for its PU foam cans because the technical tests were not satisfying.

The PE/PP plastic mixture is a shred of the cartridge covers. It is used in the plastics industry.

The metals (tinplate and aluminium) are recycled.

Marketing strategy :

- Pure or blended: In the past, pure recycled prepolymer was put on the market. However, the properties of the material are better when the recycled material is blended with the virgin material : it is stronger, more resistant to temperature changes and can be transported, filled, and stored with fewer temperature precautions than pure recycled prepolymer (especially in winter). As manufacturers requested, PDR has therefore decided for the last 6 years to market only blends given its responsibility in terms of safety.
- Display of recycled content: Until 3-4 years ago, the presence of recycled material in the manufacture of new cans was not shown to the final consumer. Indeed, brands thought that consumers would have prejudices about the quality or costs of the process and that the willingness to pay for recycled products would be lower than for virgin ones. For the past 3 or 4 years, some producers have used the incorporation of recycled material as a commercial argument without changing their pricing policy. Four brands display the use of recycled prepolymer on the product with a dedicated logo, encouraged by PDR.

Quality assessment :

- Price: finished products are cheaper than their virgin equivalent (confidential value)
- Market in which the products evolve: almost exclusively EU (some sales in Turkey, Russia), for the manufacture of adhesives and PU foams
- Users' motivations for using finished products :
    - PDR has seen a growing interest in the PDR scheme from the sustainability managers of producers.
    - According to the producer SOUDAL, customer interest in incorporating recycled materials is very limited. Therefore, the choice of incorporating recycled materials is not based on the image sent to the consumer but rather by a company's sustainability policy. The customers, mainly professionals, are firstly interested in the performance of the products,

and then in the price. SOUDAL receives little feedback from customers on the use of recycled materials in its adhesives.

- Return of a secondary material user (incorporator) :
    - SOUDAL considers that it is not possible to incorporate more than 25% of recycled prepolymer due to the variability of properties. However, at this level, the limited factor is the supply (waste stream from the non-consumed part, therefore necessarily limited) and not the demand.
    - SOUDAL, a member of PDR, uses PREPUR for the manufacture of urethane adhesives. The use of PREPUR for the manufacture of PU foams was discarded several years ago due to a lack of compatibility with SOUDAL's formulations. Negative customer feedback was linked to a lack of stability of the product (impossibility to remove the foam from the packaging after several months of storage). Technical stability tests are realised on new formulations to allow PREPUR to be used again in the formulation of PU foams.

4.3.1.4.Economic performance

Economic assessment: PDR is a for-profit company whose profits are distributed to the producers/shareholders. The company is profitable overall, thanks to the HP ink cartridge and PU foam packaging waste recycling activities. The balance sheet for each of the activities is confidential. Estimates of revenues and costs per activity and per cartridge were estimated from the amount of EPR fees, the distribution of cost and revenue per activity, and the mass balance, assuming a break-even balance for the PU foam recycling activity. PDR did not wish to confirm or deny these estimates.

EPR support: The average EPR fees collected per PDR represent on average 30 ct EUR / cartridge:

- 41 ct EUR for large formats of about 1L
- 23 ct EUR for small sizes < 650 mL

Differentiation in the amount of EPR fees is only based on the product characteristics aforementioned (e.g., not on the 1k or 2k nature of the foam).

The average EPR fee collected by INTERSEROH is 19 ct EUR / can.

Revenue : Revenues are about 1.25 ct EUR/cartridge collected (10 million EUR/year):

- about 75 ct EUR/cartridge collected (60% of the revenue) comes from EPR fees - 30 ct EUR/cartridge put on the market,
- About 50 ct EUR / collected cartridge comes from material resales (40%). Most of this revenue comes from prepolymer, followed by propellant.

Costs: The gross costs of collection and recycling are approximately 1.25 ct EUR/cartridge collected (10 million EUR/year):

- Approximately 6 million EUR/year for logistics (financing of collection and transport service providers) - estimated cost is therefore approximately 75 ct EUR per cartridge collected (60% of costs)
- Approximately 4 million EUR/ year for recycling (including disposal costs) - estimated cost is therefore 50 ct EUR per cartridge collected (40% of costs)

Waste disposal centres and municipalities do not receive support for their collection facilities as they have a take-back obligation. Some municipalities are compensated for the packaging of cans when they are not willing or able to do it themselves, but the amounts would not be significant in the PDR balance sheet. The scale is confidential.

PDR employs approximately 60 employees excluding support services, of which 12 are for PU foam recycling (the rest being for the cartridge recycling activity), i.e., 150 tonnes processed / operational FTE.

PDR estimates that a cost-effective recycling facility can be established on the PDR model for a market of 20 million cans.

Revenue and costs should not be used to calculate costs per tonne as the data do not match.

Involvement of the social economy: German companies are obliged to employ a certain number of people with a disability. 5 out of 60 people employed by PDR are disabled, which exceeds these legal obligations. This is possible especially for operations at the warehouse. The organisation does not use any special aids for their employment and pays them on the same scale as people without disabilities.

4.3.1.5.Environmental performance

Collection rate: no precise information, estimated at 40% of the waste volume (or of the products put on the market)[28] from the mass balance (2020).

Recycling rate: 81% based on quantities of packaging and contents collected (2020), recycling rate of about 70% on contents alone

Material demand: The recycling process does not have a significant direct material consumption. The solvent (acetone) used to extract and separate the PU is regenerated by distillation. The process also consumes nitrogen to inert the working atmosphere.

Energy demand: The energy demand of the process is also relatively limited. The energy consumption corresponds to electricity and fuel oil consumption, particularly for conveying the cans, pressurising the installation, sucking, and cooling the propellants, regenerating the solvent by distillation, and drying the finished products.

Quantity and fate of waste: 19% of incoming quantities[29] are waste (2020). The waste produced is incinerated in energy recovery plants, less in hazardous waste incineration.

Environmental indicators (GHG, LCA, etc.) :

An important environmental issue in the management of PU foam cans is to ensure that the propellant gases are captured and not released into the atmosphere, as the older ones contain potent greenhouse gases (e.g., the refrigerant R134, which is less present in the waste as it must be progressively replaced according to EU Regulation No. 517/2014. This practice is adopted by PDR and INTERSEROH, that respectively recycle and eliminate the gas . Leakage is not considered significant. The PDR plant has also installed a thermal waste air treatment system to reduce fluorine emissions, which is maintained by combustion of propane[30] .

An environmental assessment commissioned by PDR and carried out by PE International (SPHERA)[30] compared the PDR system with a system that recycles only the packaging (INTERSEROH). The study analyses the environmental impacts of the PDR's can collection and recycling system and accounts for the benefits of the recycling system. For the comparison with the competing system that recycles only the packaging, the logistical system of collection, propellant capture and packaging recycling were considered identical to the PDR system. The prepolymer and propellant were accounted as incinerated in a hazardous waste incinerator and the benefits of energy recovery and (packaging) recycling were recorded.

The standardised comparative analysis compared to the impacts of an average European is presented in Figure 7. The conclusions of the comparative analysis are as follows: "In the PDR system, higher environmental costs are required in the impact categories of acidification, eutrophication and greenhouse effect (see non-normalised results on the right of Figure 6) to recycle material flows than in the competing system. Figure 6 In the PDR system, higher environmental costs are required in the acidification, eutrophication, and greenhouse impact categories (see un-normalised results on the right below) to recycle material flows than in the competing system. However, this disadvantage is largely offset by the higher benefits [Note from RDC: the benefits of recycling]. In the photochemical ozone creation impact category (summer smog potential), the PDR system is also superior. Not only are the costs lower than in the competing system, but the benefits are higher. The PDR system is also much more beneficial to the environment in terms of primary energy consumption (see un-normalised results on the left of Figure 6).

Sensitivity analyses showed that even parameters that have a large influence on the final result do not change the final result when they vary. The ecological advantage of the PDR system over the competing system is so great that the result of the study does not change with this variation."

In terms of optimisation, the study recommends that PDR focus on optimising the transport of cans to PDR.

[28] The calculation is based on the number of cartridges and on a market that does not vary much over time; the result is therefore equivalent when it is based in on the waste volume or the products put on the market.

[29] The balance sheet was calculated based on incoming quantities because the incoming and outgoing quantities are not equivalent due to a stock phenomenon. There is no energy recovery or release of material on site, so the quantities of incoming and outgoing material must be equivalent.

[30] PE International for PDR (2013) Life cycle assessment for the recycling of polyurethane foam boxes according to the PDR process. A critical review of the study was carried out by DEKRA. The collection and recycling model has not changed significantly since 2013 and the conclusions are still valid a priori.

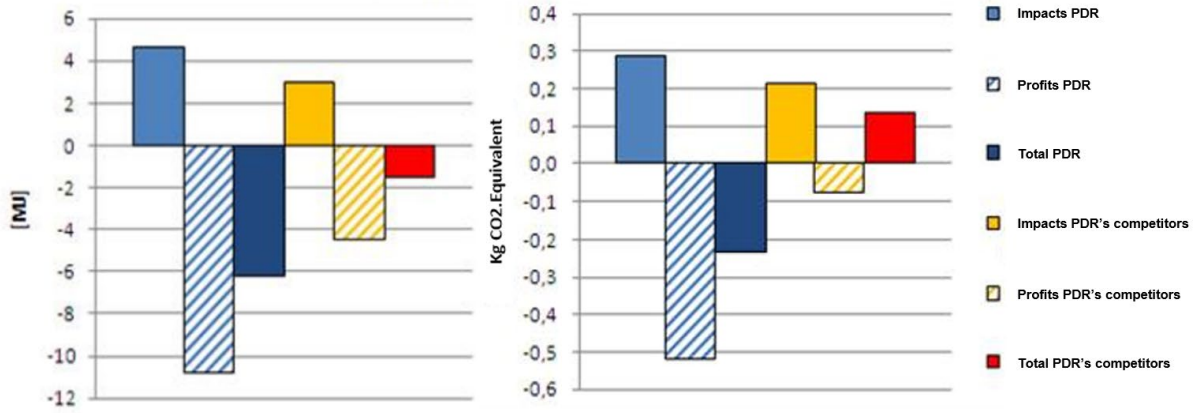

Figure 6 : Comparative life cycle assessment between PDR and the competing system expressed for one cartridge (primary energy in MJ on the left, climate change impact according to Global Warming Powers at 100 years in kg CO2 equivalent on the right)

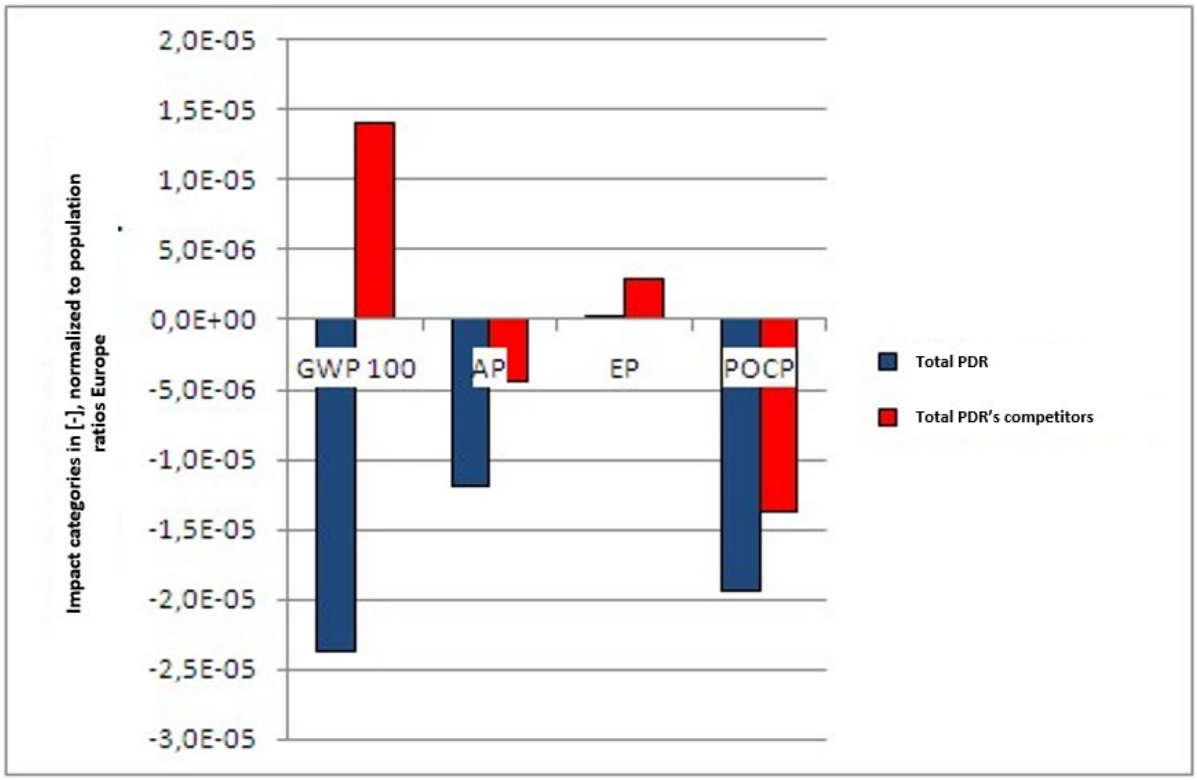

Figure 7 : Comparative life cycle assessment between PDR and the competing system - normalised results for one cartridge (GWP 100 climate change impact based on 100-year Global Warming Potentials in kg CO2 equivalent on the right, AP: acidification potential, EP: eutrophication potential, POCP: photochemical ozone creation potential)

Certifications: The recycling site is certified by ISO 9001, 14 001 and BS OHSAS 18001 (health and quality management system) which ensures good practice in terms of :

- handling and storage of hazardous waste
- storage of flammable gases and fluids

PDR is a specialist waste management operator and a licensed facility for collection, storage, treatment, and recovery of the relevant types of waste.

4.3.1.6.Regulation and standards

4.3.1.6.1. EPR scheme

Overview: The German EPR regulation covers PU foam packaging and specifies targets for collection and recycling of packaging. However, there are no obligations regarding the end-of-life of unused contents. Recycling of the contents is therefore a voluntary process carried out by the producers.

The law concerning the packaging (VerpackG[31]) of July 2017, last amended in July 2021, introduces an EPR scheme for many types of packaging placed on the German market, including PU foam packaging.

Most non-hazardous packaging placed on the German market is covered by the Dual system under Article 7 (DUALES SYSTEM DEUTSCHLAND), which is administered by the Central Agency for packaging registration (ZSVR). PU foam packaging is excluded because it is hazardous and largely of professional origin, according to UBA.

Article 15 includes EPR schemes for other types of packaging, including packaging containing toxic substances. Article 3(7) defines packaging containing harmful substances, which includes "packaging containing mixtures of 4,4'-diisocyanate diphenylmethane (MDI), the precursor of polyurethane foam".

Article 15 also defines the obligations of producers and distributors of such packaging of hazardous products in the context of EPR, which PDR meets. Producers are obliged to **take back, free of charge,** used packaging, empty of any residue[32] , of the same type, shape, and size as the one that they put on the market, at the **actual place of supply or in the immediate vicinity.** If take-back is not possible at the point of sale, take-back is possible at a **central collection point** if it is within a reasonable distance of the actual place of return for the person entitled to do so and is accessible during the distributor's normal business hours. This condition was used by PDR to define its network of collection points. There is no quantitative target for the distance to the collection point.

For final distributors, the take-back obligation shall be limited to packaging of the products which the distributor offers. For final distributors with a sales space of less than 200 square metres, the take-back obligation shall be limited to packaging from the brands which the distributor offers in its range of products.

The final distributor of the packaging shall inform the final consumers by clearly visible and readable signs at the point of sale and, in the case of mail order, by other appropriate measures, of the possibility of returning it.

Producers must demonstrate to the authorities in each Land that they have an EPR system in place for all quantities placed on the market that complies with the obligations under the Packaging Act. There is no approval system by the public authorities.

Article 16(5) specifies that priority in treatment is given to preparation for reuse or recycling. Article 16 also specifies **material-specific recycling targets which apply only to the packaging part (not to the contents):**

- 80% by mass for aluminium; 90% by mass from 1er January 2022,
- At least 90% of plastics must be recovered (by mass). A minimum of 65% and, from 1er January 2022, 70% of this recovery rate must be achieved through mechanical recycling.

The type of recycling is not regulated by law. These targets are easily met by the PDR scheme (for the packaging part). There is currently no obligation or effective incentive to recycle the contents of packaging in the regulations. PDR is lobbying public authorities to have targets for the recycling of packaging contents, arguing that this has an environmental benefit. This would increase recycling by covering the whole market.

The EPR scheme does not have collection targets.

The law states that information on the achievement of recycling targets must be provided by producers to the Land to which they belong, on request. In practice, PDR provides information on the quantities collected and recycled (average, not brand-specific statistics) to the public authorities in each Land to demonstrate compliance with the packaging targets, and members do not have to provide this information themselves.

The order on industrial waste management (GewAbfV[33]) of April 2017, last amended in July 2021, provides in Article 3 (paragraph 8) that if similar waste is hazardous waste according to the European Waste Register Regulation, it must be collected and treated in accordance with national legislation, i.e. separated from other

[31] https://www.gesetze-im-internet.de/verpackg/

[32] The UBA specifies that it is not necessary for the packaging to be completely empty to be considered as a part of the framework, it is sufficient that the emptying of the contents is planned in the normal / intended use of the packaging, which is the case here.

[33] https://www.gesetze-im-internet.de/gewabfv_2017/GewAbfV.pdf

waste, stored, collected, transported and treated in such a way that it is recovered or eliminated in a proper manner. The details are not precise.

4.3.1.6.2. Waste status

Article 5 of the KrWG law transposes End of Waste in Germany. The government can specify with a ministerial order how products can cease to be waste .

In practice, the authorities do not require PDR to ask if the products can cease to be waste. PDR considers that the general conditions are met (existence of a demand, a market, compliance with technical specifications and product regulations, absence of overall harmful effects on the environment and human health) for all its secondary raw materials. For the metal and plastic fractions, it is common practice in the industry to consider that secondary raw materials have ceased to be waste.

4.3.1.6.3. Hazardous product / waste classification and labelling

The PU foam cans are classified as hazardous products at European level due to the presence of isocyanate (MDI), with the mentions H334 "Respiratory sensitiser" and H351 "Suspected of causing cancer". SOUDAL specifies that the tests carried out on consumer exposure to isocyanate indicate a respiratory exposure below the detection limits.

European regulations require that professional users of PU foams containing more than 0.1% MDI must be trained in the use of these products (European Regulation (EU) 2020/1149 of 3 August 2020 amending Annex XVII of REACH) from August 2023, with compulsory information on the packaging from February 2022.

The order concerning the hazardous goods (GefStoffV) introduces definitions, hazard criteria, labelling and packaging requirements and requirements for safety data sheets and risk assessment. New cans are hazardous products, as is the recycled prepolymer. Used 1k and 2k cans are considered hazardous waste.

4.3.1.6.4. Supervision of collection operations

Distributors are obliged to offer a take-back service for PU foam packaging (see paragraph on EPR), at least for the brands they market in their small outlets.

Municipalities are obliged to offer a collection service for households' hazardous waste. This is required in the Article 20 (paragraph 2)[34] of the law on circular economy and is also regulated at the level of the Länder[35] . However, the level of service and the grid is not defined by the regulation.

Collection of PU foam cans is exempted from the regulations on collection and transport of hazardous waste in the Regulation on the notification and authorisation procedure - AbfAEV §12.6[36] .

The waste is still considered hazardous, but collection operators need a licence for waste collection (KrWG §53), and no specific licence for hazardous waste collection (KrWG §54).

Collection and transport comply with the ADR regulations according to Chapter 3.4 (limited quantity regime)[37] . Chapter 3.4 requires pressurised gas packaging to have a valve protection cap, which could not be guaranteed for the collected packaging waste. PDR therefore requested a safety declaration from BAM (the federal agency for materials research and testing), which confirmed that the provisions of Chapter 3.4 could be applied under several conditions:

- The cartridge has its own cap (usually unopened cans) or is sealed with cured PU foam,
- The cans are transported upright,
- The packaging prevents the risk of falling by transporting in the original cardboards or in the 4G-approved cardboards mentioned in chapter 3.4,
- The cardboards are not smaller than the cans to avoid pressure.

[34] "Public authorities are obliged to collect the waste generated by private households in their territory separately (...) from hazardous waste; public authorities in charge of waste management shall ensure that hazardous waste is not mixed with other waste during collection."

[35] In Bavaria, for example, the Bavarian legislation on waste requires it - section 3: "The authorities in charge of waste disposal are obliged to collect, transport and eliminate waste from households separately from other waste which, because of its content of harmful substances, requires separate disposal in order to safeguard the welfare of the community. This also applies to small quantities of comparable waste from commercial and service enterprises, as they can be eliminated together with the waste mentioned above "

[36] https://www.gesetze-im-internet.de/abfaev/__12.html "Collectors and transporters of hazardous waste who collect or transport waste as part of parcel post, courier and express services, as they take into account in their transport conditions the legislation adopted for safety reasons with regard to the transport of hazardous goods".

[37] These elements could not be confirmed by the UBA services that responded to our survey.

PDR has therefore requested that operators fill in waste tracking slips.

Traceability of collection operations must be ensured to enable producers to demonstrate compliance with the extended producer responsibility requirements (this responsibility lies with the producers and not with PDR as a Product Responsibility Organisation, as there is no approval procedure).

4.3.1.6.5. Supervision of recycling operations

The recycling site has an environmental licence from the competent authority (Landratsamt, equivalent of the prefecture) of the county (Landkreis) in which it is located. The site is classified as Seveso low threshold and subject to the Industrial Emissions Directive. PDR complies with a quality management system for its recycling operations (Entsorgungfahrbetrieb) which must be reviewed every 3 years. This includes measures of employee training.

PDR must track all waste movements and report to the local authorities (Landkreis) every year, so that they can verify the data. A more detailed audit is carried out on site every 3 years.

The law on labour protection (ArbeitsschutzG) requires that the employer determine whether employees are engaged in activities involving hazardous substances or hazardous substances are present, can be produced or released. If so, the employer must consider any resulting risks to the health and safety of workers. The aspects to be considered are listed in the order on hazardous goods (GefStoffV) article 6 (danger, exposure, substitution, preventive measures, occupational health examinations, risk assessment...). Health, fire, and explosion aspects are taken into account. Hazards must be assessed separately and interactions between substances should be assessed.

In practice, PDR regularly checks for the presence of isocyanate in the air (suspected to be carcinogenic). Every year, the occupational medicine carries out analyses on a part of the staff to identify the presence of isocyanate in blood and urine. Procedures have been developed to ensure safe handling. Training courses are held every year. The workers in charge of sorting have individual protective equipment (glasses, gloves). There is no requirement to wear breathing masks (except for COVID masks). The entire plant is under vacuum to avoid gas escaping to the outside. It is extremely rare, but PU foam cans can explode; this has happened twice in 10 years without injury to personnel.

4.3.1.6.6. Finished product

There are no standards for the quality of finished products. Finished products must comply with REACH and CLP. Safety data sheets are produced for the propellant and the prepolymer.

PDR is not required to register recovered substances under REACH and reports annually to ECHA that it uses the exemption under Article 2.7. d) of the REACH Regulation. The arguments advanced by PDR are that:

- All waste comes from products that have been placed on the market in the EU,
- Producers and members of PDR provide information on the composition of their formulas to PDR (kept confidential between members) as part of their membership obligations.

Länder authorities are responsible for checking the REACH registration obligations at German level.

Since June 2021[38], medium-chain chlorinated paraffins (MCCPs), which are part of PU foam formulations, are considered as substances of very high concern according to the REACH Regulation, on the list of candidates for authorisation[39] . This means that MCCPs are still allowed and are not subject to a threshold for their use, but that obligations of information on value chain are activated from a share of 0.1% by mass in the formula. Producers are gradually substituting these substances in new products put on the market. The recycling issue is known to PDR customers who are also members and producers. The MCCP content in recycled products currently exceeds 0.1%, which activates obligations of information for downstream users, but it is decreasing year by year and PDR anticipates that this issue will disappear in the next few years. It would be difficult to extract these materials within the recycling process.

The REACH restriction introduced by Regulation 2020/1149 provides for mandatory training for professional users of PU foams, which includes a part on the management of empty packaging, to improve the management and therefore the collection rate.

[38] https://echa.europa.eu/documents/10162/af3efea2-1518-3bbe-0bf5-3867131c2f4c Inclusion of substances of very high concern in the Candidate List for eventual inclusion in Annex XIV (Decision of the European Chemicals Agency 23.06.2021)
[39] https://echa.europa.eu/fr/substance-information/-/substanceinfo/100.323.845 Information page on MCCP

Banning isocyanate (as discussed for a while by ECHA) would challenge the economic model of recycling (the prepolymer is the source of a large part of the revenue excluding EPR fees). The use of MDI is increasingly restricted, but no ban is currently envisaged.

Some customers who buy the finished products want to use them to market products in Turkey or Russia. PDR is not responsible for the associated procedures. Similar registration exemptions exist in these countries.

The transport of recycled end products is subject to ADR regulations (European Agreement on the Transport of Dangerous Goods by Road). The storage of pressurised cans is subject to the TRG 300 standard.

4.3.1.6.7. Cross-border transfer

Waste of cans imported from other European countries are subject to a notification procedure.

Secondary raw materials are exported as a product without any special procedure within the EU.

4.3.1.7.Overall assessment

Strengths	Weaknesses
The PU foam market has **few competing products** on the market, which makes it possible to implement a relatively expensive voluntary system without jeopardising sales. PDR has precise information on the **composition of the products** placed on the market, which allows it to adapt its recycling process and to justify the possibility of using the exemption from REACH registration with ECHA under article 2.7. d) of REACH. PDR **recycles both the packaging and the contents,** which is an advantage for the marketers' image compared with its competitor INTERSEROH, as well as an environmental advantage. PDR offers a **high level of service** for waste holders with a large network of collection points and a postal service for the most remote areas. PDR was able to benefit from the ADR **limited quantity regime** and **avoid the requirement for a hazardous waste collection licence** for the cartridge collection phase. These provisions depend on the collection method chosen, which allows it to call on logistic service providers and presumably reduce collection costs. The **system of paying EPR fees** by paying stickers is **simple** and replaces the declaration of quantities placed on the market.	**Low transparency** of the sector on the annual sales figures of PU foams and the quantities collected, which makes it more difficult for the public authorities to monitor the system. The **costs of collection and transport are high** (significant geographic coverage, relatively small waste volume, only one facility in the country). The **composition of the recycled prepolymer is variable** (within a given range) due to the variability of the incoming waste stream (formulation variability). **Recycling of contents is not mandatory**. Competition from INTERSEROH members for whom content is not recycled. **Low consumer awareness of** the benefits of recycling the contents. Not part of the purchase criteria (or marginally).
Opportunities	**Threats**
PDR is considering **processing cans from other countries**, or if the waste volumes allow it, setting up additional recycling units. The introduction of content-based **recycling targets** would oblige all producers to join a system with an environmental performance equivalent to that of PDR. The introduction of a mandatory **deposit system** could increase the collection rate. The producers who are members of PDR do not wish to join the system by fear of losing market share to the members of the competing Product Responsibility Organisation INTERSEROH. The **mandatory training for professional users** of PU foams (REACH restriction Regulation 2020/1149) includes a section on the management of empty packaging which could be an opportunity to improve the management and therefore the collection rate.	The **presence of SVHC** in the waste stream can be problematic **in a transition phase**. However, the delay between placing on the market and collection is relatively short (1-3 years) so the problem disappears in a few years in case of substitution, and the information available for recyclers is sufficient during the transition period. No substance is therefore a problem in the medium term. **Banning isocyanate** (discussed for a while by ECHA) would challenge the economic model of recycling (the prepolymer is the source of a large part of the revenue excluding EPR fees). The use of MDI is increasingly restricted, but no ban is envisaged at this stage. Increasing **market share of MDI-free or low-MDI solutions** could affect the process or the economic model of recycling (need for separate treatment).

Replicability to France

Collection

- Necessary adaptation of the collection system to collect professionals: Only PU foams from private individuals are currently collected by the ECO-DDS system (1k and 2k foams) at waste disposal centres, as professionals are not accepted in all the waste collection centres throughout the territory. In addition, the Rekupo system for professionals, particularly craftsmen, excludes aerosols. Access to

the professional waste stream is essential because it represents 80% of the quantities collected in Germany.

- Adaptation of the collection system to remove PU foam cans from the aerosol stream in which they are currently collected and move towards separate collection. Collecting waste cans in bulks or in boxes may influence the regulations applied to collection. In this regard, collection channels for professionals and craftsmen have priority over the waste disposal centres because they represent the overwhelming majority of the waste volume.
- Necessary articulation with the collection schemes that will be set up under the PMCB EPR is also key.
- Probably higher collection costs due to a density about twice as low as in France, requiring a larger network. Adapting the thresholds for the number of cans to be collected may enable to contain costs, but attention must be given to the level of service.
- Transport costs probably similar but dependent on the location of the recycling units.

Recycling

- Technically replicable process
- Potentially necessary separation of low MDI foams: The market for low MDI foams is more developed in France now due to a later withdrawal of the ban on the free sale of conventional foams in DIY shops (from 2010 to April 2021[40] in France, until 2015 in Germany). This could require a possible recycling facility to separately process low MDI foams, which is technically feasible and has been done by PDR for some years. This need may decrease in the coming years if sales of low MDI PU foams decrease.
- Similar recycling costs if there are sufficient economies of scale (deployment of a facility to process also the waste streams of neighbouring countries or shipment of the waste stream to Germany). The choice of capacities should be coordinated at European level and at least with neighbouring countries to avoid overcapacity, as several countries are currently interested in collecting for recycling this stream.

Regulation

- Application of the obligation to have a hazardous waste licence and application of the limited quantity regime: If the regulation is applied in France, the type of collection equipment and provider would be more constrained, and costs would increase. Public authorities should check the relevance of these derogations regarding the physical and health risks involved.
- Waste status of prepolymer and propellant gas to be clarified: today, the fact that finished products cease to be waste could take place within the framework of the Ministerial Order of 22 February 2019 which sets the criteria for the chemical products or regenerated objects to cease to be waste. This interpretation should be clarified with the DGPR**.**

Focus on the Belgian scheme project

VALIPAC, the Belgian Product Responsibility Organisation in charge of industrial packaging, and DETIC, the trade union representing PU foam producers for Belgium and Luxembourg[41] , which is a member of VALIPAC, are considering the creation of a collection and recycling scheme for used PU foam cans for Belgium, in conjunction with the Netherlands and France. They are still thinking about the organisation of the system and modelling its impacts, so the system could take several years to emerge.

The Belgian market represents about 5 million PU foam cans according to DETIC estimates. PU foam packaging sold to professionals is already under the responsibility of VALIPAC in Belgium, which collects EPR fees for all industrial packaging. VALIPAC finances the selective collection of several industrial packaging waste streams via a system of bonus to packaging waste producers. PU foam cans are not part of the collection systems currently financed by VALIPAC, as the scheme focuses on the largest flows to achieve the collection and recycling targets imposed on it. This stream is largely collected with mixed construction waste (uncertainty about its current fate).

Some VALIPAC members who put packaging on the market have expressed their interest in the creation of a collection channel for the recycling of PU foam cans, based on the German PDR model, which has motivated the current reflection.

This is based on two axes:

[40] Decree No. 2021-395 of 6 April 2021 adapting the public health code to European Union law concerning the rules applicable to chemical products

[41] Among others, DETIC also represents the producers of adhesives, sealants, cosmetics, detergents, aerosols, and biocides

- How can PU foam packaging be collected? Consideration is being given to the collection of flows from professionals, particularly from construction sites. Collection could, for example, be based on the system set up by VALIPAC for the collection of plastic films for recycling, via a system of bonus for waste producers. Flows from households could join the system via collection at waste collection centres but do not constitute the core of the system (outside the scope of VALIPAC's responsibility).
- How to recycle the collected waste? VALIPAC was not aware of the remaining capacity of PDR and therefore had plans for a new recycling unit. Coordination with neighbouring countries is desired to limit transport distances and achieve economies of scale.

The need for a collection channel to make the recycling unit emerge, and vice versa, leads to slowing down the effective emergence of the project. The optimisation of the system costs is also a key point, as the PDR system is perceived as expensive, and VALIPAC considers it necessary to compensate the waste producer with bonus to encourage sorting, which the German system does not do.

4.3.1.8. Contacts

Organization	Role	Name	Function
PRODUKT DURCH RECYCLING	Product Responsibility Organisation Recycler	Thomas HILLEBRAND	Operational Director
SOUDAL	Producer	Luc THYS	Marketing & R&D Director
ABFALLZWECKVERBAND STADT UND LANDKREIS HOF (Waste Management Association of the City and District of HOF)	Local authority	Hermann KNOBLICH	Head of Sector
UBA (Umweltbundesamt)	Environment Agency	Ines OEHME	Head of Plastics and Packaging Section
DETIC	Federation of Producers in Belgium and Luxembourg	Françoise VAN TIGGELEN Sikdar SOHELY	Secretary General Chief Scientific Advisor

Representatives of distributors and collectors did not wish to respond to our requests.

4.3.2. AKZONOBEL - INTERCHEM (Netherlands)

4.3.2.1. Overview

General	
Country / region of action	The Netherlands
Starting date	2020
EPR scheme	No
Amount of the EPR fee	Not applicable
Description of the waste stream	
Nature of waste collected	Water-based and solvent-based post-consumer paints in their plastic or metal containers.
Origin of waste collected	Individuals and professionals (construction companies, interior designers, and paint producers).
Collection	
Collection system	The Netherlands: waste disposal centres and door-to-door. INTERCHEM: waste disposal centres and professionals (directly or via a third-party waste collection and transport company), AKZO /INTERCHEM initiative: waste disposal centres only
Quantities collected (L/year)	INTERCHEM total: about 1.8 million [42] Of which water-based decorative paints: 0.15 million[42] (25% of this collected paint is for the initiative with AKZONOBEL)
Collection rate	Information not available
Cost of collection	Between 0.06 and 0.07 EUR per kg[43]
Recycling	
Nature of waste recycled	As part of the AKZO NOBEL initiative: mural water-based paints for interior decoration.
Amount of waste recycled (L/year)	INTERCHEM total (solvent-based and water-based paints recycled as part of the initiative and other recycling initiatives): 300,000
Recycling rate	INTERCHEM total (solvent-based and water-based paints recycled as part of the initiative as well as other recycling initiatives): 16%
Cost of recycling	Confidential information
Outlets	
Nature of the recycled products	Water-based paints for interior decoration with 35% recycled paint.

[42] Estimate based on information provided by INTERCHEM: 3 million kg collected per year (including packaging); 20% of the weight corresponding to packaging; considered density of 1300 kg/m³.
[43] only the logistical costs of transport

The following flow chart shows the link between the different actors in the scheme involved in the AKZONOBEL and INTERCHEM partnership initiative.

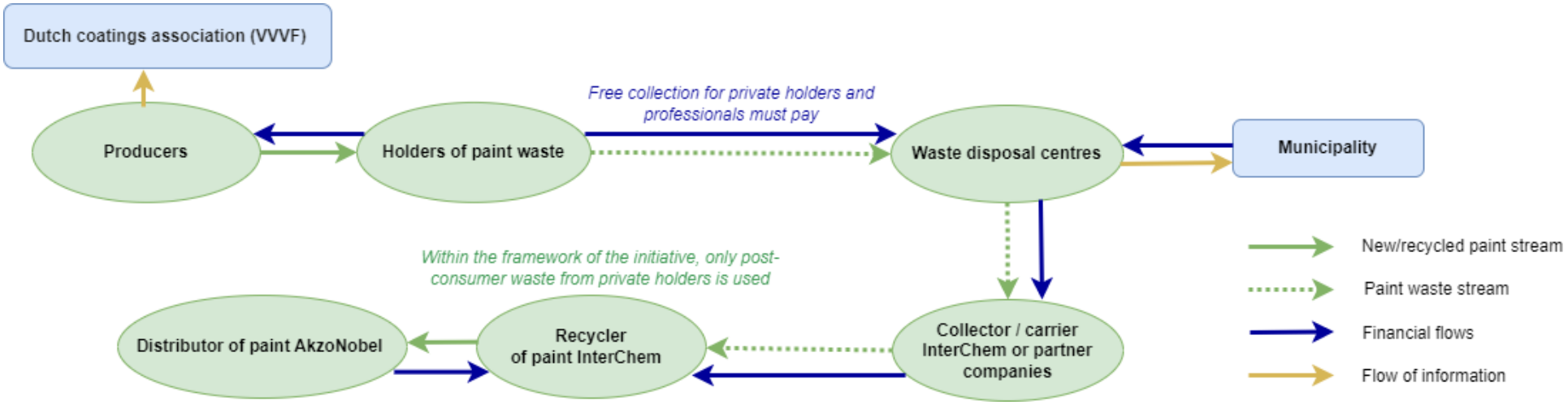

Figure 8: Flow chart of the paint waste treatment scheme involved in the AKZONOBEL and INTERCHEM partnership initiative (green are the actors directly involved and blue the secondary actors)

INTERCHEM is an international company specialising in collection, treatment, and recycling of mainly hazardous waste. In addition, INTERCHEM manufactures solvents, paints, and coatings for the manufacturing and other industries. AKZONOBEL is an international company specialising in the manufacture of paints and coatings.

INTERCHEM is responsible for the collection, transport, sorting and recycling of paint waste and AKZONOBEL is responsible for product development and distribution.

The Dutch association of paint and printing ink manufacturers (VVVF) represents the those who place products on the market, including AKZONOBEL. Apart from this sectoral representation role, the association has no direct connection with the initiative. The VVVF has around 75 member companies, employing a total of around 4,250 people. The association represents about 95% of the paint and printing ink industry in the Netherlands. The association supports recycling initiatives.

4.3.2.2. Context and evolution of the scheme

Creation context: The initiative started in 2020 with the partnership between the companies AKZONOBEL and INTERCHEM in the Netherlands.

As a collector of hazardous waste (including paint waste) INTERCHEM had knowledge of the quantities and quality of paint waste it collected from its customers (including AKZONOBEL). INTERCHEM became aware of the opportunities for recycling paint waste. AKZONOBEL had already set up a paint recycling initiative in the UK[44] and wanted to have a new source of recycled paint for the Benelux. The combination of these two interests explains the genesis of the initiative.

Key stages of development/modifications :

1. Feasibility study and production of the first test batch of recycled paint
2. Organisation of the production at an industrial scale
3. Analysis of the legal aspects of the initiative
4. Production of the pilot batch for marketing
5. Scaling up and marketing.

Prospects: The partners will continue to develop their initiative; however, they note that the future of the initiative is strongly dependent on the evolution of consumer perception of recycled paint and on the evolution of classification rules under the CLP Regulation (Classification, Labelling, Packaging)[45] , in particular regarding classified substances. Indeed, a more restrictive Regulation could reduce the volume of paint waste acceptable for recycling by the initiative.

4.3.2.3. Technical description

4.3.2.3.1. Market entry[46]

The paints are sold in DIY shops or specialist shops.

Between 2016 and 2020 on average, 110,000 tonnes of paint were placed on the Dutch market each year (about 85 million litres). The country also exports paints, on average about 50,000 tonnes of paint per year (about 40 million litres). The distribution of the market by sector is as follows:

- 40% for the construction sector (including the interior design sector),
- 30% corresponds to direct sales to individuals (DIY sector),
- 30% corresponds to sales to the industrial sector (naval, automotive, etc.).

According to the industry association VVVF, for some years now the industry has been confronted with a low availability of virgin raw materials while demand has been growing. The combination of these two factors leads to higher raw material prices. The reasons for the low availability of raw materials include

- the growing demand in China,
- a reduction in the supply of ocean freight from Asia to Europe (especially during the COVID period between 2019 and 2021).

4.3.2.3.2. Collection operations

In this section, the collection of paint waste in the Netherlands in general is presented, followed by the specifics of how the collection of paint by INTERCHEM, a partner in the AKZO NOBEL recycling initiative, works. Some of the paint collected by INTERCHEM is not destined for recycling (see below).

[44] Dulux Trade - link: https://www.akzonobel.com/en/media/latest-news---media-releases-/akzonobel-launches-recycled-paint-to-help-close-loop-on-waste

[45] CLP refers to Regulation (EC) No 1272/2008 of the European Parliament on classification, labelling and packaging of chemical substances and mixtures. Updates to the harmonised classification are made annually via Adaptations to Technical Progress (ATP).

[46] Source: VVVF annual report

Collection of paint waste in the Netherlands

Type of holders: individuals and professionals.

Properties of incoming waste: post-consumer waste from water-based and solvent-based paints.

Service level for holders :

- There are two types of collection services for households and businesses that can be assimilated to households:
    - Paint waste can be placed in waste disposal centres[47] where individuals can put their paint waste (see more detailed information below).
    - Paint waste is collected directly door-to-door; a truck collects all small chemical waste (KCA - Klein Chemisch Afval); the truck passes through the neighbourhoods of a municipality and collects this waste. However, it should be noted that individuals must go to the truck to give their waste and that this is an occasional collection whose frequency varies according to the municipality.

  For both types of collection, collection is usually done in such a way that water-based and solvent-based paints are collected separately.
  Non-assimilated companies must hire collection companies at their own expense.
- **Access conditions:** Collection services for household and similar waste are available only to residents or businesses registered with the municipality.
- **Geographical coverage:** there are approximately 170 collection points at waste disposal centres.
- **Free of charge:** Free for resident individuals; assimilated companies must pay.

Acceptance criteria: paints must be in their packaging.

Organisation of collection operations at the waste disposal centre: Holders bring their chemical waste, including paint, to a specific collection point at the waste disposal centre. This collection point is dedicated exclusively to small chemical waste (KCA). Holders place their waste on a counter (see photo below), the waste collection operator takes the waste and places it in the container dedicated to each stream (e.g., lead acid batteries, asbestos, water-based paint, etc.). It is at this stage that water-based paints are separated from solvent-based paints and other waste.

Figure 9: Collection point for small chemical waste, called KCA in the Netherlands.

Organisation of transport operations: generally speaking, at national level, for transport between collection centre and the treatment facility, there are two configurations depending on the volume of waste collected.

- A waste truck collects the different waste streams in separate containers (water-based paint, solvent-based paint, sealants...) but in the same truck. The waste streams are transported to a gathering centre where the different waste streams are checked and sorted in case of mis-sorting (e.g., solvent-based paint in the water-based waste stream) and then gathered. Once there is enough water-based paint waste to fill a whole truck, it is sent to the recycling facility.
- If the volume is sufficient or if it is economically feasible, the waste truck can carry out the transport directly from the waste disposal centre to the treatment facility.

[47] Called 'Milieustraten' in Dutch.

Collection of paint waste by INTERCHEM

INTERCHEM offers a hazardous waste collection service. As part of this service, the company collects paint waste.

As regards the paint collection operations managed directly by INTERCHEM, the paint waste collected selectively from waste disposal centres (according to the methods described above) or from companies (if these are not comparable to households) is transported, either directly by INTERCHEM (60% of the volume collected managed by INTERCHEM), or by partner collection companies (40% of the volume collected managed by INTERCHEM). INTERCHEM charges a gate-fee when accepting paint waste.

4.3.2.3.3. Recycling operations

Properties of the incoming waste for the AKZONOBEL - INTERCHEM recycling initiative: post-consumer waste from water-based paint.

Acceptance criteria and sorting steps: As part of the recycling initiative, AKZONOBEL and INTERCHEM have defined a list of paint brands that can be accepted for recycling. The idea is to only accept paint brands that have been analysed beforehand and that meet the limits for the presence of controlled substances . Once the accepted brands have been sorted, the recycler carries out a visual inspection of the contents of the cans to determine whether the paint inside is in good condition. In addition, only :

- water-based paints with a specific composition (in practice this is a list of accepted brands and types of products),
- full cans (cans with a content of more than 25% of the volume of the packaging are considered full),
- cans suspected of being less than 10 years old (visual sorting).

Paint cans that do not meet these criteria are either recycled in other INTERCHEM partnerships/initiatives for paint recycling or incinerated if the acceptance criteria of the other initiatives are not met neither.

Description of the recycling process :

- Key steps: After sorting, the paint cans are mixed in intermediate containers; in a second step, additives and virgin paint are added to the mixture to obtain the desired final product. Once the final paint is obtained, quality control is carried out, particularly to check the quality of the final product. Quality control is carried out per batch of product; the parameters checked are colour, viscosity, microbiology, drying, covering capacity, pH, and the presence of lumps.
- Innovative character: No, the paint recycling process is mainly manual and similar to the processes implemented by other initiatives.
- Replicability: yes, no obstacles to the transfer of this type of recycling process in France have been identified.
- Technical barriers: The main barriers to recycling are the quality of the incoming waste and the regulations on the content of regulated substances which limit the use of certain waste paints. This is managed through the acceptance criteria.

Finished products: 16% of incoming paint (solvent or water-based) is recycled into paint; AKZONOBEL-INTERCHEM were unable to provide an estimate of the proportion of paint recycled as part of their initiative.

4.3.2.3.4. Finished products

NB: This paragraph focuses on recycled paints sold by AKZONOBEL. The characteristics of finished products sold by other recycling initiatives associated with INTERCHEM are not known.

Description of finished products and applications: Sikkens Alpha Recycle Mat is a water-based paint for interior surfaces, suitable for use on walls and ceilings, with high opacity, white colour, composed of 35% recycled paint. At this stage, only the white colour is produced by the initiative. The finished product can be made in light colours via point of service (POS) tinting.

Strategy for market entry :

- Pure or mixed: virgin and recycled mix.
- Display of recycled content: yes.

Quality assessment :

- Price: the price of recycled paints is comparable to the price of virgin paints (depending on the market, between €11.75 and €13.50 per litre before tax)
- Market in which the products are evolving : recycled paints are sold via different brands in the Benelux under the "Sikkens" brand and in France and the UK under the "Dulux" brand.

- Motivations of users to use the finished products: information not available
- Perception of quality compared to virgin by the different actors (producers, consumers, and recyclers): the perception of quality depends on the national markets and is evolving. According to a survey conducted by AKZONOBEL, in the Netherlands, consumers trust recycled paint.

4.3.2.4. Economic performance

Economic balance: Economic information is confidential. Given the lack of financial support from an EPR and the price charged for recycled paint under the initiative, the activity is probably profitable.

EPR support: none.

Involvement of the social economy: none.

Key success factors: Firstly, the complementarity of the partners, with INTERCHEM's expertise in paint waste management on the one hand and AKZONOBEL's expertise in the development, production, and marketing of paint on the other. Another success factor was INTERCHEM's prior knowledge of paint production. Indeed, in addition to its hazardous waste management business, INTERCHEM manufactures solvents and coatings for the manufacturing and other industries. This prior knowledge facilitated exchanges between the partners and the development of the initiative.

4.3.2.5. Environmental performance

Collection rate: information not available at the level of the initiative

Recycling rate: The recycling rate for Sikkens Alpha Recycle Mat production is relatively low (16%) because the acceptance criteria for paint waste are very restrictive.

Material demand: the recycling operation, which consists of mixing waste paint (previously selected and controlled) with virgin paint and additives, does not involve a major consumption of material.

Energy demand: The recycling operation does not involve major energy consumption.

Quantity and fate of waste: waste produced during recycling and paint streams that cannot be recycled are sent for energy recovery (84%). Metal and plastic waste from paint cans is recycled in the respective channels.

Environmental indicators (GHG, LCA...): An LCA study has been carried out for Sikkens Alpha Recycle Mat. Based on this, AKZONOBEL has produced an Environmental Product Declaration (EPD).[48]

Certifications : INTERCHEM, which oversees collection and recycling operations, is certified according to standards NEN-EN-ISO 9001 (quality management system) and 14001 (environmental management system).

4.3.2.6. Regulation and standards

4.3.2.6.1. EPR scheme

At this stage, there is no EPR system for paint waste in the Netherlands.

4.3.2.6.2. Waste status

Water-based paint waste is considered as non-hazardous waste (under a EURAL code 20 01 28). However, it is often collected and transported with hazardous waste. Thus, in practice collection and transport of water-based paint waste is often treated as hazardous waste from a logistical/regulatory point of view.

End-of-waste as provided for in Article 6 (paragraphs 1 and 2) of the Waste Framework Directive was transposed in 2011 into the Dutch law on environment[49] . Water-based paint waste can cease to be waste after recycling.

The finished product of the AKZONOBEL-INTERCHEM initiative is no longer considered as waste; this is achieved through self-monitoring of compliance with the conditions of end-of-waste.

4.3.2.6.3. Hazardous product / waste classification and labelling

Water-based paint waste is not considered hazardous. The finished product of recycling is considered a hazardous product.

[48] Link: https://www.mrpi.nl/epd/akzonobel-decorative-coatings-b-v-sikkens-alpha-recycle-mat/
[49] Artikel 1.1 zesde lid van de Wet Milieubeheer. stb 2011, 103, https://zoek.officielebekendmakingen.nl/stb-2011-103.html)

4.3.2.6.4. Supervision of collection operations

Water-based paint waste is mostly not considered as hazardous in the Netherlands, but it is collected with waste that is considered as hazardous. Consequently, collection of water-based paint waste is considered as a collection of hazardous waste (e.g., for ADR transport, see below).

Facilities that collect industrial or hazardous waste must have a collection licence; they must apply for a licence to the Ministry of Infrastructure and Water Management.[50] . This applies to the following waste: waste oil, vessel waste and small hazardous waste (KCA), including water-based and solvent-based paints. Specifically, the small hazardous waste covered by the collection licence belongs to 6 categories, one of which is waste resulting from the application of paints, varnishes, wood stains and other similar liquid and pasty agents.

In addition, collection points for small hazardous waste should follow the PGS 15 manual. This manual refers to the publication Hazardous Substances 15:2011 version 1.1 (December 2012) "Storage of packaged hazardous substances". PGS 15 provides guidance on the method of temporary storage of packaged hazardous substances for fire, occupational and environmental safety.

Companies that transport (by road, rail, or waterways) industrial or hazardous waste on a professional basis or organise the disposal or recovery of waste on behalf of third parties must be registered on the Dutch list of waste collectors, transporters, and brokers (VIHB list). The Minister of Infrastructure and Water Management has designated NIWO as the authority responsible for processing applications for inclusion in the VIHB list.[51] As elsewhere in Europe, the law in the Netherlands requires that collection and transport of hazardous goods/waste should be carried out in accordance with the ADR rules, as defined in the ADR 2017. This may also apply to water-based paint, which is often transported with hazardous waste.[52]

Operators collecting and transporting hazardous waste (which includes water-based paints) must report the quantities of waste collected/transported to the Ministry of Infrastructure and Water Management. This reporting is done via the national waste reporting point (LMA - Landelijk Meldpunt Afvalstoffen).

4.3.2.6.5. Supervision of recycling operations

An environmental licence is required for every company that handles waste[53] . As a collector, transporter, and manager of waste, INTERCHEM has an environmental licence.

INTERCHEM respects the legal requirements in terms of monitoring and review its HSE management system. This involves monitoring incidents and accidents and implementing control measures.

Hazardous waste treatment facilities (including water-based paints) are obliged to report the quantities of waste treated to the Ministry of Infrastructure and Water Management via the national waste reporting point (LMA - Landelijk Meldpunt Afvalstoffen).

4.3.2.6.6. Finished product

In terms of compliance with REACH , the paint waste comes from a list of paint products that have been certified as REACH compliant, and the proportion of recycled paint is therefore considered by the producer to comply with REACH requirements. To confirm this list, the partners have selected trusted, well-known brands that are marketed in the Netherlands.

As REACH is constantly evolving, the partners plan to periodically analyse the composition of post-consumer waste. In addition, the list is being closely monitored as the market and regulations are changing rapidly. In particular, the partners plan to test the biocides content to comply with the CLP regulation and nonylphenolethoxylates under REACH (list of substances SVHC, CAS 9016-45-9). These tests are scheduled on a quarterly basis and are carried out by an external partner (Tüv Süd).

The product is placed on the market with an SDS which is based on the chemical analysis of the finished product. This is also because post-consumer paint waste still contains quite high amounts of methylisothiazolinone (a biocide).

[50] Besluit inzamelen afvalstoffen (Bia) - Link: https://www.ilent.nl/onderwerpen/inzamelen-afval/aanvragen-inzamelvergunning-bia
[51] Link: https://www.niwo.nl/pagina/112/aanvragen/afvalstoffen/vihb_registratie.html
[52] Link: https://business.gov.nl/regulation/transport-dangerous-goods-road/
[53] Decree on the activities (Activiteitenbesluit milieubeheer). Link to the website: https://wetten.overheid.nl/BWBR0022762/2021-07-01/#Hoofdstuk1_Afdeling1.1_Paragraaf1.1.1_Artikel1.2

4.3.2.6.7. Cross-border transfer

There is no cross-border shipment of paint waste under this initiative. These are collected and treated in the Netherlands and are no longer considered as waste after recycling. At the national level, there are no specificities with respect to the EU regulation on cross-border transfer.

Finished products are not considered as waste. The regulations on cross-border transfer of waste do not apply. The Netherlands does not require End of Waste recognition from the importing country in case of export.

4.3.2.7. Overall assessment

Strengths

The initiative **did not require external funding** from, for example, an EPR-type mechanism. This can be interpreted as a sign of current or expected future profitability.

The initiative counts with a **certification** according to ISO 9001 (quality management system) and 14001 (environmental management system).

There is a very **good control of incoming waste** which implies a good control of the composition of the recycled paint. To keep control of incoming waste, the paint waste accepted is registered in a list of paint products that have been certified as REACH compliant.

In the Netherlands, **solvent-based paint and water-based paint are collected separately**, and any sorting operations to separate the two fractions are less consistent, since an initial sorting is already carried out at source.

The **complementarity of the partners**, on the one hand INTERCHEM's expertise in the management of paint waste and on the other AKZONOBEL's expertise in the development, production, and marketing of paint. INTERCHEM had prior knowledge of paint production. As a reminder, in addition to its hazardous waste management activities, INTERCHEM manufactures solvents and coatings for the manufacturing and other industries. This prior knowledge facilitated exchanges between the partners and the development of the initiative.

Weaknesses

The incorporation rates of recycled material are relatively low. Indeed, the recycled paint content of the final product of the initiative is 35%, which is relatively low compared to the other initiatives studied. This is partly due to the very limited choice of used paint brands that can be used to produce the recycled paint, which implies that little is available for recycling. This choice is explained by the stakeholders' desire to keep a tight control on the incoming waste stream.

Opportunities

Consumers currently have a positive perception of recycled paint.

Overall, the **stakeholders** in the scheme who were consulted (representatives of producers, representatives of waste management companies, waste collection companies) are **very favourable to the development of paint waste recycling**.

Threats

Due to the **regulations**, especially the REACH obligations, AKZONOBEL and INTERCHEM restrict the **scope of acceptable paint waste**. This is to maintain good control over the composition of the final product. Thus, if the regulations become more restrictive, so will the scope of acceptable waste for recycling. Since the volume of acceptable paint waste would be smaller/limited, the incorporation rate of recycled material could further decrease.

The **change in consumer perception of the quality of recycled paint**; today it is rather favourable, but the actors perceive that this could change.

Replicability to France

The model is replicable to France (similar initiatives such as CIRCOULEUR are already operating in France). However, it should be noted that the water-based paint waste used by AKZONOBEL - INTERCHEM is

collected separately. In France, the separate collection of water-based paints is currently unusual and is only done on the professional waste stream via the Rekupo system. This system of mixed collection of solvent-based and water-based paints should be changed to facilitate the development of recycling initiatives such as AKZONOBEL - INTERCHEM, or a sorting should be set up afterwards.

From a regulatory point of view, the regulatory framework is broadly consistent with that applicable in France for most of the relevant requirements (licences, classification of hazardous waste and product). However, to promote recycling, recycled paints should cease to be waste. In France, unlike in the Netherlands, a self-assessment of operators of the general conditions set out in Article 6 of the Waste Framework Directive is not sufficient[54] ; the conditions established by Ministerial Order on end-of-waste must be met. Such a Ministerial Order should be developed so that end-of-waste is applied in France.

Moreover, the control of the composition based on a list of incoming brands with known composition is not sanctioned as non-compliant by the authorities. French authorities would need to accept this approach.

4.3.2.8. Contacts

Organization	Role	Name	Function
AKZONOBEL	Recycler	Katrien CLOU	Technical Support Manager Benelux
HVC	Collector	Chiel LANDMAN	Product Manager
INTERCHEM	Recycler	Erik WEGH	Commercial Manager
INTERCHEM	Recycler	Ria DERKS	Product & Safety Coordinator
Vereniging Afvalbedrijven	Association of Waste Management Companies	Rutger MAAS	Project Officer
VVVF	Association of producers	Jeroen HAGMAN	Project leader sustainability

[54] For more information on the differences in the transposition of end-of-waste between countries see :
(1) ADEME/ RDC Environment (2017) Guide pratique d'évaluation d'une Sortie de Statut de Déchet - Benchmarking http://www.rdcenvironment.be/guide-pratique-ssd/
(2) RECORD / RDC Environment (2014) Sortie du statut des déchets. Transposition et pratiques dans les différents Etats-membres de l'Union Européenne https://librairie.ademe.fr/dechets-economie-circulaire/3255-sortie-du-statut-des-dechets-transposition-et-pratiques-dans-les-differents-etats-membres-de-l-union-europeenne.html

4.3.3. PAINT 360 (United Kingdom)

4.3.3.1. Overview

General	
Country / region of action	United Kingdom
Starting date	2013
EPR scheme	No
Amount of the EPR fee	Not applicable
Description of the waste stream	
Nature of waste collected	Water-based paints, wood stains / dyes
Origin of waste collected	Individuals and professionals (construction companies, interior designers, and paint producers)
Collection	
Collection system	UK: non-selective collection of paints at waste disposal centres, between 4 and 7% of waste disposal centres have set up a selective collection system PAINT 360: no dedicated system, from private individuals (via waste disposal centres) and professionals (directly or via waste managers)
Quantities collected (L/year)	Between 1.3 - 1.4 million (collected by PAINT 360)
Collection rate	PAINT 360 (the largest recycler in the UK) collects between 2 and 2.5% of the estimated volume but is not the only player.
Cost of collection	Ad hoc selective collection (e.g., on a construction site): 216 EUR per container or ~1.8 EUR per litre collected. [55] Scheduled selective collection (e.g., at a waste disposal centre): 168 € per container, i.e., ~1.4 EUR per litre collected.
Recycling	
Nature of waste recycled	Post-consumer water-based paints in their packaging, only decorative paints, and wood stains / dyes.
Amount of waste recycled (L/year)	1 million (recycled by PAINT 360)[56]
Recycling rate	~80 %
Cost of recycling	0.9 EUR/L collected; 1.09 EUR/L recycled
Outlets	
Nature of the recycled products	Recycled paint that contains a minimum of 65% recycled content.

[55] Estimate based on information from Reconomy and PAINT 360: cost £140-180/container; average 100 cans of paint/container, average 1.2L of paint/can. A €/£ exchange rate of 1.2 was used.
[56] Estimate made by RDC based on information provided by PAINT 360 (20,000 l of paint recycled/week by PAINT 360 and 55 ML of paint waste generated in the UK). Considered density of 1300 kg/m³.

The following flow chart shows the link between the different actors in the sector involved in the PAINT 360 initiative.

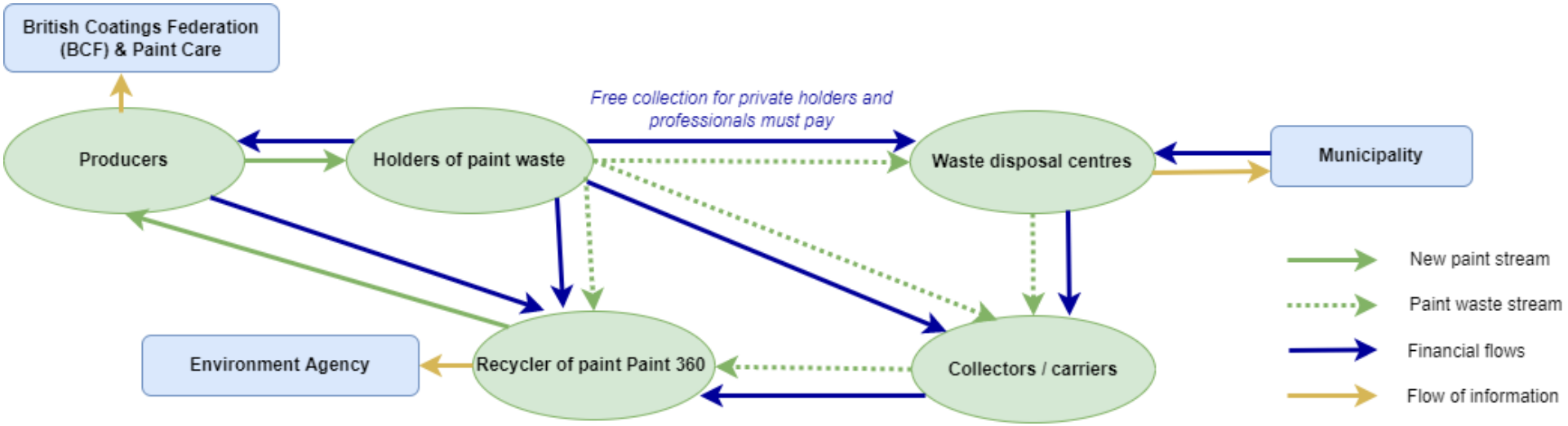

Figure 10: Flow chart of the paint waste treatment scheme involved in the PAINT 360 initiative (in green the actors directly involved and in blue the secondary actors)

4.3.3.2. Context and evolution of the scheme

Context of the creation of the initiative :

PAINT 360 is a private company created with a double objective: to employ people who have difficulty to find a job and to give a second life to household paint waste. This initiative was born from the realisation that households were storing paint waste that could be recycled and that by recycling it, jobs could be created.

Key stages of development/modifications :

1. The company was launched at the end of 2012 and started operations in 2013. The first year of the initiative was spent learning and refining the business model. Initially, PAINT 360 sold the recycled paint to professionals, including decorating companies. These early partnerships with professionals, who were clear and transparent about quality expectations, allowed PAINT 360 to improve the quality of their products. Their recycling centre was built in Birmingham.
2. In 2018, the company created an account on an e-commerce platform so that it could sell directly to individuals.
3. The company starts discussions with several paint producers, with the aim of supplying them with recycled paint for their products.
4. From 2020 onwards, PAINT 360 creates its own website and starts a partnership with a retailer specialised in paint to market its products.

Perspectives:

- The company is developing a new brand, 'Paint Savers', for individual consumers.
- The company will open a second paint recycling centre in Wales.
- PAINT 360 wants to increase the automation of its recycling process, especially for the emptying of paint cans, and to be able to double its processing capacity for the same number of workers.
- The company also wants to increase the number of paint colours it offers (from a dozen to around thirty).
- More generally, UK waste management regulations are undergoing significant change. As part of their circular economy strategy, public authorities are aiming to reform and extend EPR schemes and implement a waste stream tracking system for paint waste[57] . The possibility of establishing an EPR scheme for paints is discussed at a government level. Producers, led by the British Coatings Federation (BCF), want to establish a voluntary management system instead of a mandatory EPR. The federation launched the PAINTCARE initiative about ten years ago, which aims to design and study the feasibility of a paint waste management system. The management system, as imagined at this stage, aims to set up around 2,000 collection points (50% in the country's waste disposal centres and 50% in paint shops/distributors) and the construction of 10 to 15 recycling centres. PAINTCARE's objective is to recycle 70% of paint waste by 2030 (compared to a performance of about 2% today).

4.3.3.3. Technical description

4.3.3.3.1. Market entry

The paints are sold in DIY shops or specialist shops.

Approximately 700 million litres of paints and coatings are produced each year by the UK industry, 30% of which is exported. Taking imports into account, approximately 650 million litres of paints and coatings are sold in the country each year.[58]

Decorative paints and coatings are the largest market with almost 70% of the volume produced. Paints and coatings used in industry (automotive, shipbuilding, packaging) make up the remaining 30%. [59]

Concerning interior decorative household paints, 340 million litres are sold each year in the UK[60] .

[57] A Green Future: Our 25 Year Plan to Improve the Environment.
[58] BRITISH COATINGS FEDERATION - Statistics 2019. Link : https://www.coatings.org.uk/Statistics/Industry_Statistics_public.aspx
[59] EUROPEAN COATINGS. Link to the website: https://www.european-coatings.com/articles/2021/04/five-facts-about-the-british-coatings-market
[60] PAINTCARE. Link: https://www.paintcare.org.uk/wp-content/uploads/2021/11/PaintCare-2021-Trade-and-Consumer-Research-Report-Digital-1.pdf

4.3.3.3.2. Collection operations

National waste stream: Approximately 55 million litres of decorative paint waste are generated in the UK each year[61] . Most of the paint waste collected in the UK is water-based paint, accounting for about 90% of the market. Solvent-based paint accounts for about 10%; for these paints, the most common treatment is energy recovery.

Type of holders: individuals and professionals.

Properties of incoming waste: The incoming waste at collection points is post-consumer waste of water-based and solvent-based paints.

Service level for holders :

- Collection channels: There are two main collection channels at national level, also used by PAINT 360:
    - 70% comes from waste disposal centres or household waste recycling centres (HWRC).
    - 30% comes from collection of professional waste from professional sites on the one hand (mainly construction sites); and from paint retailers (distributors) who have set up take-back systems for unused paint on the other.
- Access conditions: waste disposal centres that accept paint waste but have not set up a selective collection system ask holders to mix the paint with sand or sawdust before bringing it to dry the paint and put it with residual household waste. Waste disposal centres with a selective collection system do not impose any special access conditions.
- Geographical coverage: Of the 1,000 or so waste disposal centres operating in the UK, between 30 and 40 collect paint waste selectively. At these sites, water-based and solvent-based paints are collected separately.
- Free of charge: free for individuals and professionals must pay

Organisation of collection operations: collection is done in such a way that water-based paints are collected separately from solvent-based paints. Regardless of the collection channel, the operational process of the selective collection of paints is the same:

1. First, the waste collector sets up a container for water-based paint waste at the site (waste disposal centre or professional site). The collection company asks the representative of the site to put only water-based paint waste (in its packaging) in the container. In practice, some solvent-based paints end up in the container. It should be noted that companies like RECONOMY manage several waste streams. It is therefore possible that several containers are set up by the same collection operator on the building site or at the waste disposal centre (if the sites do not already have their own) for other waste streams such as aerosols, sealants, etc.
2. A waste truck collects the different waste streams (water-based paint waste, solvent-based paint waste, sealants, etc.) in the same truck; the waste streams are collected in an orderly manner and separated by container in the same truck. The frequency of collection depends on the site's waste production flow. It can vary from 1 collection per month to once every 6 months.

Organisation of transport operations: transport is carried out by waste management companies. Collected waste streams are transported to a gathering centre where the different waste streams are controlled and re-sorted in case of mis-sorting at collection point (e.g., solvent-based paint in the water-based paint waste stream) and then stored. Once there is enough water-based paint waste to fill a "paint only waste" truck, it is sent to the recycling facility (such as PAINT 360).

In addition, PAINT 360 offers a door-to-door collection service via collection partners or with the company's own vehicle[62] ; this service is intended for professional holders such as interior design companies.

Barriers to collection operations :

- In the UK, there is a decentralisation of the management of waste disposal centres, which are the responsibility of municipalities. For example, the set up of separate collection containers must be negotiated with each municipality. This will make it more difficult to roll out a selective collection of paints at a national level and therefore limit the recyclable stream.
- The UK's waste disposal centres do not have sufficient space, which negatively impacts on the possibility of setting up a selective collection of paints for recycling.

[61] Source PAINTCARE.
[62] PAINT 360. Link: https://www.paint360.co.uk/waste-paint

4.3.3.3.3. Recycling operations

Properties of incoming waste: the incoming waste in the PAINT 360 facilities is water-based paint waste in metal or plastic containers. PAINT 360 only recycles decorative paints and wood stains / dyes. Finishes, fillers, clear coatings, etc. are not recycled because their volume is marginal.

Acceptance criteria and sorting steps: only water-based paint waste that is less than 20 years old and in its original container is accepted; to meet these conditions, a manual and visual sorting is carried out. The contents are checked visually to confirm the absence of contaminants (various objects, pieces of wood/plastic, etc.). In addition, the company has a regulatory obligation to eliminate any paint containing lead or mercury.

Description of the recycling process :

- Key steps: After sorting and quality control, the paint waste is emptied into intermediate storage containers by colour and is stored until there is enough of a colour to start production. To sort and group the colours, they use a photo spectrometer, a light table, and a gloss meter. Once there is enough, the paint waste is decanted, disinfected with biocides, and filtered. The 360 paint retains the original colours or modifies them to produce different shades.
  Concerning quality control of inputs, it starts at the sorting stage, by separating the different types and colours of paint into groups. Each can is then opened to check for foreign objects such as brushes, sand, etc. before deciding whether the paint waste can be treated. Then the paint, when it is in the can, is stirred to see if the material is pliable to check its rheology.
  In terms of quality control of recycled paint, batches of paint are currently tested for 3 main parameters, namely pH, opacity, and presence of lumps. In addition, PAINT 360 has recently made a commitment with a local university to develop a testing protocol to determine VOC levels while detecting traces of lead and formaldehyde, which is expected to be completed in the second quarter of 2022.
- Innovative character: no
- Replicability: yes
- Technical barriers to recycling: According to the representative of PAINT 360, the main barrier is the reluctance of consumers, whether professional or private, to buy paint with recycled content. In addition, professional paint consumers show resistance to changing their consumption patterns. The demand for recycled paint, and therefore recycling, is thus restrained.

Finished products: PAINT 360 offers 10 different products based on recycled water-based paint. The table below shows the names of the products and the proportion of recycled water-based paint content. The products differ in their function[63] (fungicide, abrasion resistant paints, etc.) and the additives added.

Product name	Recycled content	Hazardous product label
Void Contract Emulsion	50%	No
Eggshell	50 %	No
Tungsten	Discontinued	No
Tungsten Anti-Bac	Discontinued	Yes
Hoardings Paint	90 %	No
Masonry Paint	50 %	No
Silk Paint	50 %	No
Mould Resistant Paint	50 %	Yes
Eggshell Mould Plus	50 %	Yes
Nicotine Blocker Paint	Discontinued	No

[63] Description of functions available: https://www.paint360.co.uk/paint-and-sundries

4.3.3.3.4. *Finished products*

Description of finished products and applications: recycled paint that contains a minimum of 65% recycled paint.

Strategy for market entry: PAINT 360's products are mainly sold to professionals of decoration of buildings. The company also sells recycled paint to paint manufacturers who add the recycled content to their respective products. To a lesser extent, it sells to individuals via an online sales platform and via a UK paint distributor.

- Pure or mixed: virgin and recycled mix.
- Display of recycled content: yes.

Quality assessment

- Price: the price of recycled paints is comparable to the price of virgin paints (i.e., between 7 and 30 € per litre); the price will depend on the finished product and the final outlet of the market entry (professional market with relatively lower prices compared to the private market)
- Market in which the products evolve: 70% is sold on the local market and 30% is exported.
- Motivations of users to use the finished products: for professional users, PAINT 360 products are put forward during negotiations with project managers as a commercial argument, particularly in the specifications which include social and/or environmental selection criteria. No information available for private users.
- Perception of quality compared to virgin by the different actors (producers, consumers, and recyclers): information not available.

4.3.3.4. Economic performance

Economic balance:

The table below shows average costs per final litre recycled or ranges of values for data where average values are not available. These values were estimated by RDC Environment from discussions with PAINT 360.

Cost	Value
CAPEX	0.01 €/L recycled
OPEX	1.03 €/L recycled
General expenses	0.05 €/L recycled
Total	**1.09** €/L recycled

Concerning revenue, the initiative charges a gate-fee (see gate-fee paragraph below) to companies and municipalities sending in their water-based paint waste, and Paint 360 generates income from sales of their recycled paint products.

EPR support scale: none (there is no EPR for paints in the UK).

Gate-fee: PAINT 360 receives financial compensation for each container that enters its recycling facilities. The gate fee is € 114[64] per container. Each container contains an average of 100 cans of paint. This means that the gate fee amounts to approximately €0.95/L[65] .

Involvement of the social economy: PAINT 360 has a mission to contribute to the social economy by hiring individuals in professional reintegration. They do not receive any public or private financial support for this mission. Nevertheless, they value their mission of contributing to the social economy when the specifications of their professional clients impose social criteria for the award of contracts.

Key success factors: the availability of a sufficiently high level of initial capital, especially to communicate and publicise the recycling initiative and the strategic partnerships between paint recyclers and paint manufacturers to facilitate the commercial breakthrough of recycled paints[66] .

[64] 95 £ with an exchange rate of 1.2.
[65] Each can of paint contains on average 1.2 litres of paint according to PAINT 360.

4.3.3.5. Environmental performance

Collection rate: The volume of water-based paint collected is not tracked by the recycling company. In fact, it only counts the number of containers that enter its facilities. From discussions with PAINT 360, it is estimated that they collect between 1.3 and 1.4 million litres per year. Compared to the volume of paint waste produced each year in the UK (55 million litres), the volume collected by PAINT 360 would represent between 2 and 2.5% of the total.

Recycling rate: According to PAINT 360, the recycling rate varies according to the origin of the paint waste. Indeed, the household paint waste stream contains more undesirable substances than that of professionals of construction and interior decoration.

- For waste from households, 75-80% of waste is recyclable.
- For waste from professionals, 85-90% of waste is recyclable.

The rate of rejection from sorting therefore varies from 10 to 25%.

Material demand: the recycling operation does not involve major material consumption; two types of inputs are used, additives and virgin paint.

Energy demand: The recycling operation, which consists of decanting, filtering, and mixing paint waste, does not involve major energy consumption.

Quantity and fate of waste: The waste from the recycling operation is paint waste that is not considered recyclable (see section 4.3.3.3.3) as well as empty plastic or metal paint cans. Paint waste that is not recycled as part of the initiative (e.g., solvent-based paints) is sent for energy recovery. The plastic cans are dried, then shredded, dried a second time, and finally sent to a plastic recycler. The metal cans are sent directly to a metal recycler who melts the material down and makes, among other things, new paint cans that PAINT 360 uses for its finished products.

Environmental indicators (GHG, LCA...): the company carried out a comparative analysis between paint with recycled content and virgin paint. It was estimated that using paint with recycled content instead of virgin paint avoided 1.3 kg of CO_2 per litre of paint. The study was carried out in collaboration with a UK university[67] .

Certifications: In 2021, the company sought to certify to ISO 9001 (quality management system) and 14001 (environmental management system).

4.3.3.6. Regulations and standards

4.3.3.6.1. EPR scheme

At this stage, there is no EPR scheme for paint waste in the UK. Discussions are underway at government level on the possibility of establishing an EPR for paints. The producers, led by the British Coatings Federation (BCF), wish to create a voluntary management system instead of a mandatory EPR.

4.3.3.6.2. Waste status

End-of-waste as set out in Article 6 (paragraphs 1 and 2) of the Waste Framework Directive has been transposed into UK national law and is still in force[68] . The waste must have been recycled or otherwise recovered and meet the general conditions of the Framework Directive to be classified as non-waste (existence of a demand and market, compliance with technical standards and product regulations, absence of overall harmful effects on the environment and human health).

Once they are no longer classified as waste, waste controls no longer apply. Products usually cease to be considered as waste at the end of the recycling or other recovery process, when the material can replace the "new" material/product.[69]

The Environment Agency has established quality protocols formalising end-of-waste criteria for 13 categories of waste. There is no quality protocol for paint waste[70] .

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[66] According to the representative of PAINT 360.
[67] Bath University.
[68] Environment Agency. Link: https://www.gov.uk/guidance/check-if-your-material-is-waste
[69] Source : https://www.gov.uk/guidance/check-if-your-material-is-waste#when-a-material-has-not-become-waste
[70] Quality protocols converting waste into non-waste products. Link: https://www.gov.uk/government/collections/quality-protocols-end-of-waste-frameworks-for-waste-derived-products

PAINT 360 considers that the recycled paint they produce is no longer waste as it complies with the general conditions. The Environment Agency, when asked about this issue, did not provide a clear explanation regarding the implementation of End-of-waste.

4.3.3.6.3. Hazardous product / waste classification and labelling

According to the European framework, water-based paint waste is mostly considered as non-hazardous waste. However, if it contains hazardous additives such as heavy metals or fungicides, it may be considered hazardous depending on the concentrations. In the UK, water-based paint waste is not considered hazardous in practice.

Recycled water-based paint is not considered a hazardous product; however, some products containing recycled paint may be considered hazardous due to certain additives (e.g., fungicide). Recycled paint must comply with UK regulations on product classification and labelling.[71] PAINT 360 has its SDS produced by third party companies based on material analysis of their finished products by independent laboratories. They produce SDS for all their products. Sampling and subsequent analysis is done by batch. As a first phase, for a new product, sampling is done by batch of 200 litres. As a second phase, sampling is done in batches of 1,000 litres (because the production of the new product ramps up). The method used for material analysis is a standard method generally used by paint manufacturers, both virgin and recycled[72] .

In addition, PAINT 360 is developing a testing protocol internally, with the support of a local university[73] , to determine the possible presence of VOCs, formaldehyde, and lead in recycled paint.

However, it should be noted that at national level there are two sectors of paint recycling: a professional sector that includes actors such as PAINT 360 and a more informal sector that includes local initiatives for the reuse and recycling of paint waste. The professional sector shall ensure that it complies with regulations on product classification and labelling, while the informal sector has a less rigorous approach[74] .

4.3.3.6.4. Supervision of collection and transport operations

Collection operators must register with the Environment Agency. This is defined by the Controlled Waste (registration of carriers and vehicles) Regulations 1991[75] . The Environment Agency makes the list of registered collectors available to the public free of charge. In addition, paint holders (private or professional) who request door-to-door collection are obliged to contact only registered collectors.

In general, companies that transport waste professionally or transport construction or demolition waste that they have produced must register as Upper Tier waste carriers and be listed on the Agency's public register.

Companies that transport their own waste (other than construction and demolition waste) on a normal and regular basis must be registered as Lower Tier carriers and will appear on a separate public register; Lower Tier registration is much simpler.

Regardless of the type of business, if it transports waste beyond an occasional trip to a disposal site, it must be registered.

Water-based paint waste is not considered hazardous, but as it is often collected along with potentially hazardous waste, truck drivers must hold an ADR licence. To become a driver of a hazardous goods vehicle, the person must :

- undertake technical training sessions and sit examinations to obtain an ADR driver card
- undergo any additional training, depending on the hazardous goods the driver wants to transport.

Depending on the type of waste transported, waste transporters must have

- a duty of care transfer note for non-hazardous waste
- a consignment note for hazardous waste

For water-based paint waste, a duty of care transfer note is required. A duty of care transfer note is a legal document that companies transporting waste are legally required to have. This document covers the company and the owner under the law on environmental protection of 1990. It proves that the company or owner eliminates its waste in a legal and responsible manner. The document is valid for a period of one year and must be preserved by the owner or company for a period of two years after its expiration date.

[71] Link: https://www.gov.uk/product-labelling-the-law
[72] The representative of PAINT 360 did not give any further details about the name and stages of these material analyses.
[73] The name of the university was not given.
[74] Source : PAINTCARE
[75] Link: https://www.legislation.gov.uk/uksi/1991/1624/made

The duty of care transfer note is completed and signed by both parties and should include[76] :

- the type of container in which the waste is stored,
- the time and date of the waste transfer,
- where this transfer took place,
- the names and addresses of both parties,
- the categories of the two authorized persons,
- details of the parties' certificate of registration, including the number of the certificate and the name of the issuing council,
- if one or both parties have a waste licence, the number of the licence and the name of the issuing council,
- the reasons for an exemption from the obligation to register for a licence.

4.3.3.6.5. Supervision of recycling operations

Recycling operators must obtain an environmental licence from the Environment Agency. This is set out in law in Section 5.4 of the Environmental Permitting (England and Wales) Regulations 2016[77] . There are exemptions from licences if the recycling operator processes up to 5 tonnes per week of non-hazardous paint waste for reuse. This is formalised in the UK regulations by a low-risk waste position (LRWP)[78] . PAINT 360 is not covered by this exemption.

Waste treatment operators (with or without an environmental licence) must complete waste declarations (reports on waste input/output) to inform the Environment Agency about the waste they have received or removed from their site.[79]

The Environment Agency uses this information to

- monitoring a site's compliance with its environmental licence conditions,
- compile national statistics on waste.

4.3.3.6.6. Finished product

Most recycled water-based paints are non-hazardous products[80] . However, some water-based paints may contain hazardous substances such as fungicides or other hazardous additives (e.g., « Mould Resistant Paint » of PAINT 360) in which case these may be labelled as hazardous.

In addition, the VOC content of paints and auxiliary products is regulated by Regulation 2012:1715 on volatile organic compounds (VOCs) in paints, varnishes and vehicle refinishing products. These cover the decoration and vehicle refinishing sectors. They require that the VOC content of the ready-to-use products does not exceed the VOC limits applicable to the relevant product category[81] . The labels of finished products must indicate the VOC content of the actual product and the category limit.

4.3.3.6.7. Cross-border transfer

In the UK, the rules, and procedures for the cross-border transfers of waste are set out in the Waste Shipments Regulation EC No 1013/2006 , as amended by :

- the International Transfers of Waste (Amendment) (Exit from the EU) Regulations 2019
- The International Transfers of Waste (Amendment of Regulation (EC) No 1013/2006) Regulations 2020.
- the International Transfers of Waste (Amendment) (Exit from the EU) Regulations 2021.

Within the framework of the PAINT 360 initiative, paint waste is collected and processed within the national territory. Finished products are not considered as waste. The regulations on cross-border transfer of waste do not apply. The UK does not require that products cease to be waste for exports.

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[76] Source : https://www.businesswaste.co.uk/

[77] The Environmental Permitting (England and Wales) Regulations 2016.

[78] Source : https://www.gov.uk/government/publications/low-risk-waste-positions-paint/treating-up-to-5-tonnes-a-week-of-non-hazardous-waste-paint-for-reuse-lrwp-7

[79] Source : https://www.gov.uk/guidance/national-operator-waste-returns

[80] Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1021051/Waste_classification_technical_guidance_WM3.pdf

[81] The limits per paint category are available: https://www.coatings.org.uk/vocproductregulations.aspx

4.3.3.6.8. *Transversal remark*

Using post-consumer waste paint implies uncertainty about the composition of the inputs and therefore the recycled products. Controlling the final composition to comply with product regulations[82] generates significant costs, putting the brakes on recycling.

4.3.3.7. Overall assessment

Strengths The initiative is profitable and does not require external funding from, for example, an EPR-type mechanism. The level of the gate-fee and the income from the sale of the paintings are sufficient for the initiative to be profitable. The initiative is being certified according to ISO 9001 (quality management system) and 14001 (environmental management system). The incorporation rates of recycled material are relatively high and can be as high as 90% recycled material. Recycled paint products are placed on both national and international markets. This reflects a diversification of markets and therefore a reduction in the risk of a shock in the demand in one of them. However, it should be noted that the initiative is more dependent on the national market (70% of the market). Initiative with a social economy orientation valued at the commercial level. PAINT 360 has a mission to contribute to the social economy by employing individuals in professional reintegration. In addition to playing a beneficial role from a societal point of view, they value their mission of contributing to the social economy when the specifications of their professional clients impose social criteria for the award of contracts.	**Weaknesses** At national level, there is a lack of infrastructure for collection and recycling of paint waste. The selective collection service for holders (especially for private individuals) is very poorly developed, with only between 4 and 7% of waste collection centres collecting paint selectively. There is also little recycling capacity. The sorting and selection of paints before recycling is done by PAINT 360 in a manual and visual way. It relies only on the experience of the sorters and has therefore a greater probability to resulting in sorting errors than a more formal procedure where a list of accepted brands/products is established. A poorly developed culture among individuals in terms of bringing paint waste to the waste collection centre. This is concomitant with the fact that the collection service (selective or not) is poorly developed. The combination of these two factors results in the fact that individuals tend to store their paint waste instead of bringing it to the waste collection centre.
Opportunities The interest shown by producers to structure and develop a voluntary take-back system for paint waste with a view to recycling it. Discussions are underway at UK government level on the possibility of establishing an EPR for paints. The producers, led by the British Coatings Federation (BCF), want to set up a voluntary management system instead of a mandatory EPR. Environmental and social procurement criteria (public or private). Recycled paint products can allow users to gain points in the awarding of contracts. Indeed, more and more of these criteria are included in the awarding of contracts, thus favouring the use of PAINT 360 products. Public policy on waste management that favours the recovery of paint waste instead of landfilling. The ban on landfilling of liquid waste and the increasing cost of landfilling due to higher taxes, favour the fact that	**Threats** In the UK, there is a decentralisation of the management of waste collection centres which are under the responsibility of the municipalities and there is no obligation to implement selective collection. For example, the implementation of a selective collection must be negotiated with each municipality. This will make it more difficult to develop a national selective collection for paints and will therefore limit the recyclable streams. UK waste disposal centres do not have sufficient space, which has a negative impact on the possibility of implementing a selective collection of paints for recycling.

[82] The Volatile Organic Compounds VOC in Paints, Varnishes and Vehicle Refinishing Products Regulations 2012:1715.

paint flows are going towards recovery (including energy recovery). However, it should be noted that these public policy elements also favour energy recovery.	

Replicability to France

The business model is replicable in France as there are no innovative aspects to the process that cannot be replicated. However, it should be noted that the water-based paint used by PAINT 360 is collected separately. Currently in France, collection of water-based paints is unusual and is only done on the professional stream. This system of mixed collection of solvent-based and water-based paints should change to facilitate the development of recycling initiatives such as PAINT 360, where a sorting system is set up after collection.

From a regulatory point of view, the regulatory framework is broadly consistent with that applicable in France for most of the relevant requirements (licences, hazardous waste, and product classification). However, the possibility for recycled paints to cease to be waste is very important to promote recycling. In France, a self-assessment of operators of the general conditions is not sufficient, the conditions established by Ministerial Order on end-of-waste must be met. It is therefore necessary to develop such an order. The control of the composition of the finished product based on sampling is not sanctioned as non-compliant by the authorities. French authorities would have to validate this approach.

4.3.3.8. Contacts

Organization	Role	Name	Function
ENVIRONMENT AGENCY	Public Authority for England and Wales	Cathryn JONES	Advisor - Hazardous waste
PAINT 360	Recycler	Lee COLE	Managing Director
PAINTCARE	Branch of the British Coatings Federation(BCF)	Dr Steve SNAITH	Consultant
RECONOMY	Waste collection	David Seal YATES	Commercial Director

4.3.4. PAINTCARE (United States)

Preliminary notes:

- Each state has its own legislation, and the organisation may be different, so we have based this chapter mainly on the feedback from Oregon, California, and Colorado (the most mature states).
- The figures provided are for 2019 (as 2020 was a special year due to the pandemic with closures of sites)

4.3.4.1. Overview

General	
Country / region	11 US states: Washington, Oregon, California, Colorado, Minnesota, New York, Vermont, Maine, Connecticut, Rhode Island, District of Columbia
Starting date[83]	Oregon (2009-2010), California (2010-2012), Colorado (2014-2015)
EPR scheme	Yes
Amount of the EPR fee	Between 0.31 EUR and 1.75 EUR per packaging, depending on the size of the packaging. This represents a contribution of between 0.11 and 0.14 EUR per litre sold. Packages of less than 280 mL are exempt from contributions.
Description of the waste stream	
Nature of waste collected	Interior and exterior **« architectural » paints**[84]: latex, acrylic, water-based, alkyd, oil-based, enamel (including textured coatings). Primers, wood stains, coatings, undercoats, shellacs, varnishes, polyurethane (single component), waterproofing and rustproofing are also accepted. The packaging must be closed and labelled and must not exceed 18.92 L in terms of capacity. Main exclusions: **aerosol paints (spray cans),** paints for uses other than "architectural" painting such as **industrial maintenance coatings**[85] **and workshop/industry application coatings**[86] **.**
Origin of waste collected	Collection is intended to households and small businesses. Some large companies also take advantage of collection sites or dedicated collections. The nature of the collected and accepted paints differs between households (water-based and solvent-based paints), small private producers (water-based and solvent-based paints below a certain production and storage threshold), and large producers (only water-based paints) due to regulatory constraints on hazardous waste.
Collection	
Collection system	• Permanent collection points: municipal hazardous waste collection points[87] and paint distributors • Temporary collection points organised by municipalities during hazardous waste-related events[88] . • Waste treatment or transfer sites • Door-to-door collections: on demand above certain volumes (775L), recurrent or

[83] 1st date: law; 2nd date: start of the initiative
[84] The terminologies used are those of the US EPA, the California Air Resources Board, and other state and local architectural and industrial maintenance rules.
[85] Coatings exposed to extreme environmental conditions in industrial, commercial, or institutional use (immersion in water or chemicals, exposure to corrosive or acidic agents, exposure to high temperatures, abrasion)
[86] also called Original Equipment Manufacturing
[87] waste disposal centres or specific sites for hazardous household waste
[88] trucks set up for one day

<table>
<tr><td></td><td>occasional. Some of these collections can also be carried out as part of a more global collection of hazardous waste.</td></tr>
<tr><td>Quantities collected (/year)</td><td>
<table>
<tr><th></th><th>Total (million L)</th><th>Water-based paints</th><th>Solvent-based paints</th></tr>
<tr><td>Oregon</td><td>2,97</td><td>80 %</td><td>20 %</td></tr>
<tr><td>California</td><td>15,07</td><td>82%</td><td>17%</td></tr>
<tr><td>Colorado</td><td>2,81</td><td>78%</td><td>22%</td></tr>
</table>
</td></tr>
<tr><td>Collection rate [89]</td><td>• Oregon: 8.5 %
• California: 5.6 %
• Colorado: 5.4 %</td></tr>
<tr><td>Cost of collection</td><td>no specific information</td></tr>
<tr><td>Reuse</td><td></td></tr>
<tr><td>Promotion of reuse</td><td>PAINTCARE pays shops selling or providing paint (water-based and solvent-based) for reuse at a rate of 0.37€/L reused. The content level of the cans is not always conditioned[90] .</td></tr>
<tr><td>Reuse rate[91]</td><td>
<table>
<tr><th></th><th>Water-based paints</th><th>Solvent-based paints</th></tr>
<tr><td>Oregon</td><td>6 %</td><td>9 %</td></tr>
<tr><td>California</td><td>4%</td><td>3%</td></tr>
<tr><td>Colorado</td><td>4%</td><td>3%</td></tr>
</table>
</td></tr>
<tr><td>Recycling</td><td></td></tr>
<tr><td>Nature of waste recycled</td><td>Only the water-based paint is recycled for material recovery.
Paint containers are also generally recycled, although it is more difficult to recycle plastic paint cans (paint residues).</td></tr>
<tr><td>Quantity of waste recycled (/year)</td><td>
<table>
<tr><th></th><th>Water-based paints (millions of L)</th><th>Packaging (tonnes)</th></tr>
<tr><td>Oregon</td><td>1,52</td><td>Metal: 37.7
Plastics[92] : 3.5</td></tr>
<tr><td>California</td><td>8,67</td><td>2 216</td></tr>
<tr><td>Colorado</td><td>1,75</td><td>301</td></tr>
</table>
</td></tr>
<tr><td>Recycling rate[93]</td><td>• Water-based paint
○ Oregon: 64%.
○ California: 76%.
○ Colorado: 82%.</td></tr>
</table>

[89] Calculated as a proportion of the stream, if the number of boxes reaching the end of life is equivalent to the number sold in the same year.
[90] However, California states that the cans must be more than 75% full.
[91] Quantities of paint reused / quantities collected
[92] Exports of packaging to China have stopped, and some of it is no longer recovered.
[93] Volumes recycled / Volumes collected

<table>
<tr><td></td><td>• Packaging: no data</td></tr>
<tr><td>Cost of recycling</td><td>The data provided by some recyclers allows us to estimate the cost of recycling at between 3 and 6 $/gallon or between 0.7 and 1.4 EUR/ L.</td></tr>
<tr><td colspan="2">Outlets</td></tr>
<tr><td>Nature of recycled products</td><td>• Mainly water-based paint
• Other opportunities are cited by recyclers as minor:
o Decorative ground cover (<1% latex paint in California)
o Material recovery in cement - paints are a filler (5% in California)</td></tr>
<tr><td>Energy recovery</td><td>
<table>
<tr><th></th><th>Water-based paints</th><th>Solvent-based paints</th></tr>
<tr><td>Oregon</td><td>/</td><td>91 %</td></tr>
<tr><td>California</td><td>12%</td><td>55%</td></tr>
<tr><td>Colorado</td><td>/</td><td>39%</td></tr>
</table>
</td></tr>
<tr><td>Elimination</td><td>
<table>
<tr><th></th><th colspan="2">Landfill</th><th colspan="2">Incineration</th></tr>
<tr><th></th><th>Water-based paints</th><th>Solvent-based paints</th><th>Water-based paints</th><th>Solvent-based paints</th></tr>
<tr><td>Oregon</td><td>30%</td><td>/</td><td>/</td><td></td></tr>
<tr><td>California</td><td>7%</td><td>/</td><td>/</td><td>42%</td></tr>
<tr><td>Colorado</td><td>14%</td><td>/</td><td>/</td><td>58%</td></tr>
</table>
</td></tr>
</table>

The following flow chart shows the link between the different actors in the scheme involved in the PAINTCARE initiative.

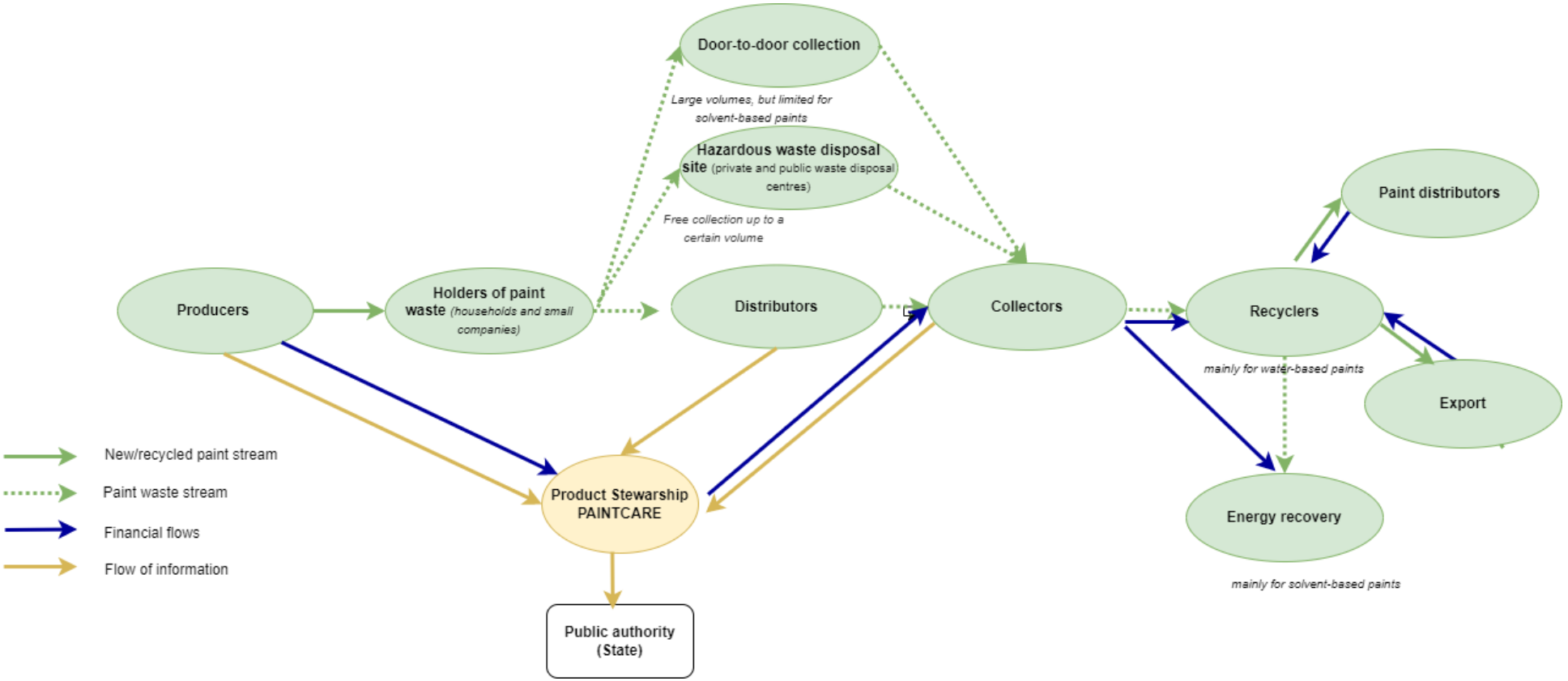

Figure 11: Organisation of the PAINTCARE recycling initiative

The originality of the EPR system is based on a payment to the collectors, called carriers in the United States, who are responsible for finding the recyclers themselves, according to the principle of the waste hierarchy, and for giving them an amount of this financial support. The carriers are selected by the Product Responsibility Organisation. Depending on the country, transparency regarding the amounts paid to the various actors of the chain is not assured.

The Product Responsibility Organisation does not cover the structural costs of collection on the sites but provides specific waste collection trucks and boxes and trains the staff.

In conclusion, EPR can be considered operational for collection and financial for treatment.

4.3.4.2.Context and evolution of the scheme

Context of creation :

The creation of the EPR scheme began in 2009 in Oregon and was inspired by the Canadian PRODUCT CARE initiative (see below). EPR was initiated by local hazardous waste program managers (local governments), who had the largest volumes of paints and the largest costs associated with their treatment. Therefore, they wanted to cover the costs of managing end-of-life paints by the paint manufacturers.

The manufacturers, and in particular the AMERICAN COATINGS ASSOCIATION, which initiated PAINTCARE, wanted a visible contribution that would make the entire value chain involved, up to the consumer (the producer charges the distributor who charges the consumer)[94] . According to PAINTCARE, this visibility limits the risk of free riders[95] and thus ensures a sufficient scale of manufacturers to mutualise costs.

PAINTCARE is a non-profit organisation that ensures that paint producers meet their obligations in terms of paint management in states that have adopted them. PAINTCARE is present in all 11 states that have adopted these regulations and encourages households and companies to return their paint waste to collection sites for reuse, recycling, or elimination.

Key stages of development/modifications :

The first regulation was passed in 2009 in Oregon, then gradually several states followed: California (2012), Colorado (2015), Connecticut (2013), Minnesota (2014), Rhode Island (2014), Vermont (2014), the District of Columbia (2016), Maine (2015), and more recently Washington (2021) and New York (2019). The main developments achieved by PAINTCARE are:

- Changes in the structure of contributions, which changes according to collection rate. As this rate is difficult to establish at the beginning of the programme (estimating the quantities of paint residues is difficult[96]), these contributions can go up or down. In 2022, several states have changed the structure of contributions (general decrease in California and the District of Columbia and addition of an intermediate group of packaging for several states).
- Financial audits of PAINTCARE are now systematically requested by the authorities during the renewal of the programmes in the States.

Perspectives: Federal regulations require collection of paint waste (as a household hazardous waste) only for small generators (households or companies), with a volume limitation. For solvent-based paints, companies must be considered exempted producers under the federal regulation on hazardous waste producers and therefore meet certain thresholds[97] . In practice, it is difficult to verify this requirement and some companies benefit from PAINTCARE without complying with the regulations. PAINTCARE would like to see a regulatory review to harmonise regulations and practices. Contracts with collectors will gradually introduce recycling targets. At this stage, PAINTCARE does not have regulatory recycling targets, but it reports its figures annually to the various states.

[94] This visible contribution is present on the invoices between paint suppliers and distributors and may also be visible on the consumer's purchase receipt.
[95] The visible effect also makes offenders more visible and therefore encourages manufacturers to comply with their obligations.
[96] PAINTCARE uses average data from feedback in Canada and other states when starting a new initiative.
[97] Exemption under Article 40, Section 262.14 of the Code of Federal Regulations.

4.3.4.3.Technical description

4.3.4.3.1. Market entry

The market entry of paints meets the requirements of both federal and state regulations. To be allowed to sell paints, manufacturers must participate in the PAINTCARE programme or set up their own programme.

The PAINTCARE programme targets architectural paints sold in cans of less than 18.92 L. These are subject to a contribution. The table below shows which paints are subject to contributions and which are excluded:

Accepted paints: architectural paint	Exclusions from EPR and from the collection system
• Interior and exterior architectural paints: latex, acrylic, water-based, alkyd, oil-based, enamel (including textured coatings). • Terrace coverings, floor paints (including elastomers) • Primers, coatings, undercoats • Dyes • Shellac, lacquers, varnishes, urethanes (single component) • Waterproofing and repellents for concrete/masonry/wood (not tar or bitumen based) • Metal coatings, rustproofing • Paints for lawns and fields	• Thinners, mineral spirits, solvents • **Aerosol paints (spray cans)** • Paints for the automotive and marine sectors • Art and craft paintings • Caulking, epoxy, glues, adhesives • Paint additives, dyes, wood stains, resins • Wood preservatives (containing pesticides) • Restore and repair of roofs • Asphalt, tar, and bitumen products • 2-component coatings • Terrace cleaners • adhesives, • Paints used for circulation and road markings • **Industrial Maintenance Coatings ("IM")** • **Workshop / plant application coatings**

Table 4 : List of paints in the scope of the EPR in the US

Manufacturers, whether they sell paint directly or indirectly in a state with a PAINTCARE programme, must register with PAINTCARE. They are provided with notices and examples of possible exemptions so that they can check whether their products are contributors or not, and the documents they need to provide to justify this. PAINTCARE makes public the list of manufacturers and brands sold by state. In 2022, the number of participating manufacturers by state is shown below:

Status	California	Colorado	Connecticut	District of Columbia	Minnesota	Maine	Oregon	Rhode Island	Vermont	Washington
Number of manufacturers	215	149	142	114	151	131	169	131	139	102

Table 5: Number of manufacturers per state (source: PAINTCARE)

These lists allow distributors to know whether the product they are going to place on the market is registered or not.

Distributors are responsible for passing on PAINTCARE fees in the selling price of products covered by the program and for selling only products registered with PAINTCARE. These responsibilities apply to all paint distributors, including paint and hardware shops, online retailers and shops that sell reused/recycled paint. The contribution is made visible on invoices[98] .

In some states, distributors must have backups of certain information for 3 years (e.g., in California: manufacturer's name, date of purchase and sale).

[98] At least between manufacturers and distributors, and it is also possible on consumers' bills.

The EPR fees are based on the volume of the containers. The contributions range from **0.31 EUR to 1.75 EUR per package**, depending on the size of the packaging. Products packaged in containers of less than 280 mL are exempt from contributions.

In relation to the volumes placed on the market for 3 States, the contribution represents between **0.11 and 0.14 EUR per litre sold.**

The level of contribution varies to match the price level of the products according to the size of the packaging. The level of contributions does not vary according to recyclability or the incorporation of recycled paint (no eco-modulation).

The change in contributions depends on the collection results compared to the initial projections. A reduction has been proposed for California and the District of Columbia for 2022.

4.3.4.3.2. Collection operations

Type of holders: households and small businesses.

Properties of incoming waste: water-based and solvent-based architectural paints. However, solvent-based paints are restricted to small-scale producers of hazardous waste in accordance with the regulations.

PAINTCARE plans to conduct a study on the average age of collected paints. The experience of one recycler (METROPAINT) indicates that the average age of the paints handed in for recycling is between 3 and 5 years. According to this recycler, there is a negative relation between the maturity of the programme and the age of collected paints, due to destocking at the beginning of the programme (in the first years one can find paints older than 10 years, sometimes even 50 years).

Note: In practice, it is difficult for collection points to verify compliance with the regulations for companies, which may be required to accept larger volumes than required by law.

Level of service for holders :

- Types of collection points: there is a wide variety of collection procedures with four main types
    - Permanent collection points: municipal household hazardous waste collection points[99] and paint distributors
    - Temporary collection points organised by municipalities during hazardous waste-related events
    - Other sites also accept paint residues: waste treatment/transfer sites.
    - Door-to-door collections: on demand above certain volumes (775L), recurrent or occasional. Some of these collections can also be carried out as part of a more global collection of hazardous waste.
      Distributors accept products from residents and companies, while hazardous waste disposal sites sometimes restrict access to companies (site-specific decision).

  The ventilation of the volumes collected between the different collection points differs from state to state. The two main types of collection in terms of number of sites and volumes collected are collection from distributors and collection from municipal hazardous waste collection sites.

- Network: network is measured through 2 indicators required in the EPR regulation; each state can define its own indicators:
    - the geographical distribution of collection points: 90-95% of residents, depending on the region, must be within 24 km of a permanent collection site,
    - the density of collection points for urban areas (1 site per 30,000 inhabitants in Oregon and Colorado, 1 per 50,000 in California)

  For areas not covered by fixed collection points, regulations often require the possibility of at least 1 collection event per year (non-fixed site).

- Free of charge: Free collection service is offered to households, and depending on the site, to small companies. The accepted limit is generally between 5 and 20 gallons per visit and is site-specific. Generally, large companies must pay (sometimes above a certain volume).

Acceptance criteria: All paints in the programme are accepted at collection points, except for large producers (no solvent-based paints, to meet regulatory requirements).

Distributors accept paint waste from residents and companies, while hazardous waste disposal sites are limited or sometimes not accessible for companies.

[99] Waste disposal centres or points dedicated to the collection of hazardous waste depending on the situation

The cans must be closed and labelled and must not exceed 18.92 L in terms of capacity.

Unlabelled or leaking products are not accepted by distributors or at occasional sites, but hazardous waste facilities may accept them, outside the PAINTCARE programme. Indeed, in sites that also accept other hazardous waste (waste disposal centres), a wider possibility of collecting paints is offered; only a part of the products is directed to the PAINTCARE programme and the containers provided for this purpose (cf. Table 4 p.69). Therefore, the programme relies, to a great extent, on these actors, as it is easier for a waste holder to bring all his paint waste to one place.

Organisation of collection operations: the person in charge of the programme carries out the following control actions: inspection of the packaging, verification of its acceptance and placement in the ad hoc bins provided by PAINTCARE.

PAINTCARE requires that collection sites comply with the regulations, especially for storage.

Staff at the various collection sites must be trained. The topics covered in the training are (example from Colorado):

- identification of PAINTCARE products,
- acceptable containers,
- persons accepted for collection,
- procedure for producers of very small quantities of solvent-based paints (companies),
- storage,
- procedures and reporting,
- training,
- planning a pick-up,
- administrative documents required and registration obligation

Reporting is usually required from collection sites. For example, in Minnesota, the following information is requested: employee training, shipping documents with the PAINTCARE carrier, and information from producers of very small quantities bringing in solvent-based paints.

PAINTCARE finances collection containers and training. Clean-up kits in case of accidents are also provided to sites. A variety of containers are used:

- 0.76 m³ containers in which the paint packages are placed (the most used)

Figure 12: Example of a cubic container (source: PaintCare New York Webinar)

- 213 L drums
- 15 m³ containers

PAINTCARE can also provide ad hoc support for collection facilities (investments, improvements).

Generally, retailers collect paints on a voluntary basis. This is an approach that allows them to develop consumer traffic in shops.

Organisation of transport operations

Carriers contract with PAINTCARE who selects and pays them directly. These collectors/carriers are either actors operating in the waste management sector (and for authorised transport of hazardous waste) or recyclers.

The carriers are responsible for delivering the empty containers to the collection points and for collecting the PAINTCARE containers of used paint. They provide the data on delivery to the treatment facilities. They are free to choose the recyclers they want, who must meet certain criteria. Carriers must make their choice in accordance with the waste treatment hierarchy and PAINTCARE checks their declarations on a quarterly basis. In the future, PAINTCARE will also check that they are meeting their recycling targets as set out in their contracts.

PAINTCARE's reasons for contracting with collectors are that they have employees who can audit, screen, and monitor the operations of treatment facilities to ensure compliance and continuity of service. In addition, they can ensure that they meet the regulatory requirements for the transport of hazardous waste, which is an assurance to PAINTCARE.

4.3.4.3.3. Reuse

PAINTCARE pays shops that provide paint for reuse at 0.37€/L. There is no requirement on the level of content of the cans (except in California, where the cans must be at least 50% full). Sites must estimate the actual volume of paint using an internal method (weighing, visual, etc.).

The paint is sold as they stand, without emptying the cans.

Note: Reuse shops are also collection points, allowing the paint to be sold directly.

4.3.4.3.4. Recycling operations

Properties of incoming waste: The acceptance criteria correspond to the PAINTCARE regulations. Wood stains, varnishes and saturators are also collected. The staff check the labels and manually separate solvent-based paint from water-based paint. Non-compliant products are also removed. The containers are emptied into 207 L drums.

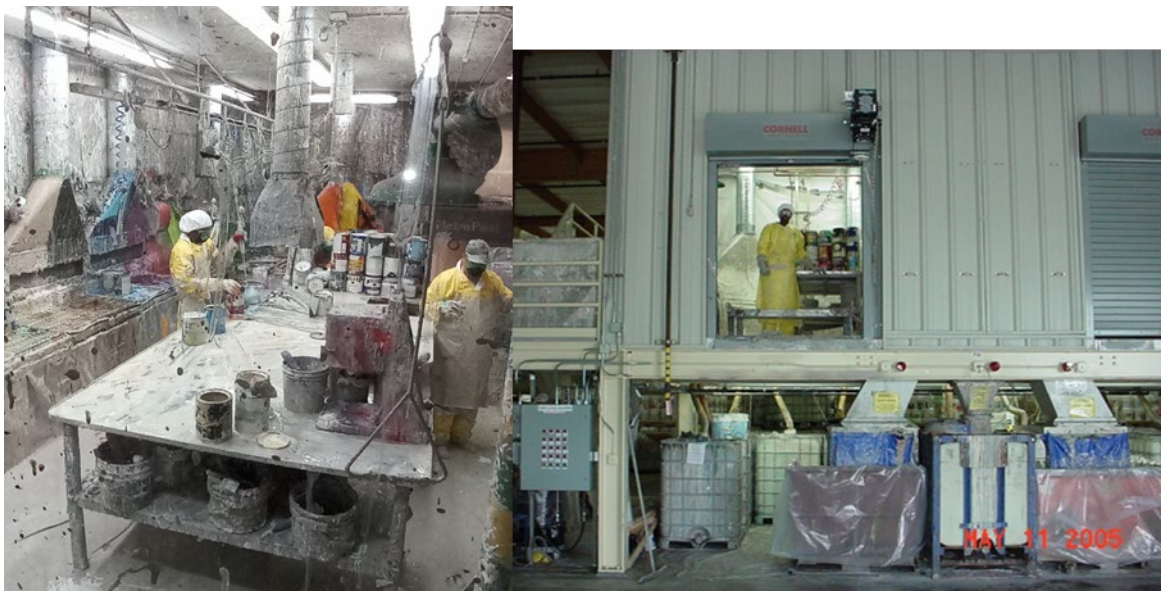

Figure 13: Photographs of some of the recycling steps ; Left: checking and opening the jars; Right: batching (source: MetroPaint)

Description of the recycling process :

- Key steps :
    - Separation of products to be recycled (water-based paints and 20% of varnishes, wood stains and saturators, which represents 1% of the volume collected[100]) from the others and

[100] These water-based products are then mixed with water-based paints. If the flows were larger, they would probably be treated separately.

removal of products that do not comply with the programme by checking the composition via the label
- Opening of lids, in some installations automatically
- Removal of low-quality products (pasty, dry, dirty, with mould).
- Emptying into 207L drums, then according to colour (visual check) then 1000L tanks
- Between 15 and 25 different colours are processed (some colours are split into three shades (light, medium and dark)
- Mixer and automatic filtration
- Scraping the pots to remove dry paint residue and make the pots recyclable
- Use of a compactor for metal pots
- Laboratory tests to control various parameters. Depending on the recyclers, 5 to 10 parameters are generally controlled, including
  - Weight,
  - pH,
  - VOC content,
  - drying capacity,
  - film thickness,
  - opacity,
  - bacterial, fungal and mould growth,
  - the colour to ensure homogeneity (if necessary, addition of a little dye/pigments)

  METROPAINT uses the parameters defined by the Master Paint Institute Standard and the Greenseal certification[101] .
- Addition of certain additives to ensure certain properties:
  - preservative to prevent mould and make the paint more liquid,
  - thickening agent (alcohol to increase the pH),
  - biocide to prevent bacterial growth,
  - deodorant.

  Note: sometimes it is also necessary to use virgin dyes (depending on the recycler, only 3-7% of virgin products are added to recycled paints).

- **Innovative character:** little innovation, but in recent years some recyclers are investing in more automation (opening of jars); however, sorting must remain manual to ensure good initial separation (reading of labels, appreciation of poor-quality products and colours).
- **Replicability:** there are no difficulties with the replicability of recycling a priori.

Technical barriers to recycling: there do not appear to be any major technical barriers at this stage.

One limitation identified is the need for huge storage capacities, as colours are imposed by the waste input, and are only changeable/mixable within a certain range during recycling. As a result, the number of colours can be considerable. Due to the cost of storing the different batches of paints per colour, destocking (for colours in low demand) is usually practised for colours that are less in demand on the domestic market (bright colours).

On the opposite, some colour inputs are limited in quantity (e.g., white).

4.3.4.3.5. Finished products

Description of the finished products and applications:

The finished products are 100% paint. Recyclers have different market positions and different sizes of product range.

METROPAINT places about 12 water-based paint colours on the market. The number of colours has been reduced compared to the start of the initiative. The recycled paint is usually resold as interior paint.

ACRYLATEX has developed Tag-out anti-graffiti paint for public customers (municipalities), which represents 10% of volumes, and "Montage Signature" paint (large quantities) for 18 to 22 colours or "Limited Edition" (when volumes are more limited) for about 30% of volumes. The part sold directly is put back into cans. For ACRYLATEX, 30% is sold to other manufacturers and distributors, who buy the recycled paint in large containers (drums).

[101]Greenseal GS-43 Recycled Latex Paint (https://www.greenseal.org/files/shares/Standard%20PDFs/GS43-1.1-Standard-2013.pdf)

Strategy for market entry:

- Pure or mixed: mixed,
- Display of recycled content: display of recycled origin but no information displayed on recycled content,
- Distribution channels: There is no single marketing model. Recyclers use different channels:
    - sales on site (30% for METROPAINT) or via their own brand (70% for ACRYLATEX)
    - sales through distributors' shops, such as MILLERPAINT in Oregon and Washington State (60% for METROPAINT, 30% to manufacturers and distributors for ACRYLATEX).
    - In Colorado, some recyclers work with associations such as HABITAT FOR HUMANITY, which helps low-income households renovate their homes. Note: HABITAT FOR HUMANITY is also an actor in reuse.

  The share between the different channels varies between recyclers.

Quality assessment :

- Technical tests: recycled paint is subject to numerous tests (see paragraph 4.3.4.3.4 p. 72). The tests carried out on the paints are generally the same as for virgin paints. Therefore, the quality is comparable (mid-range interior paint). Some tests may be more difficult to pass (opacity of white paints for example). For METROPAINT, the paint must meet the requirements of the Master Paint Institute and Greenseal Certification[102] .
- Warranties : Paint is usually sold with a 3-year warranty, ACRYLATEX offers a 10-year warranty on recycled paint. There is no warranty on reused paint. Sellers of reused paint make customers sign a release form explaining that the paint is taken back as it stands, with no guarantee of quality or content.
- Price of recycled paint in 3.75 L cans: lower than virgin
    - 1 to 4 EUR / L recycled paint sold ex works on the domestic market
    - 0.3 to 0.6 EUR/L recycled paint sold for export
    - 3.4 - 7.0 EUR / L recycled paint sold at the distributor[103]
    - 6.4 -14.0 EUR / L virgin paint
- Market in which the products evolve :
  A large part of the products is sold on the domestic market (70-90%).
  However, between 10 and 30% of the sales of the recyclers surveyed are sent for export. Export sales are used to limit storage and to evacuate paints with colours that are not in sufficient demand on the domestic market (China, Romania, Cuba, El Salvador, Guatemala).

- Users' motivations for using the finished products :
  In the United States, there is certain difficulty in matching the supply of recycled paint colours with demand. Paints entering recycling facilities are coloured. However, the most popular colour is white. Indeed, consumers tend to choose their own tints and are increasingly buying white paint, which they tint in the shop by adding pigments. Moreover, when consumers use white paint in certain rooms, they generally store it to adjust, and as a result the residual quantities collected are smaller.
  The main motivation for users to buy recycled paint is the advantageous conditions (sale via discount sites).
  One recycler has relied on public sector actors who have sustainable purchasing obligations but regrets not identifying stronger demand from public buyers despite regulatory requirements (integration of environmental clauses in public procurement contracts). They also regret the lack of monitoring of compliance with these requirements.

- Perception of quality compared to virgin by the different actors (producers, consumers, and recyclers): There is no real data on the subject. The recyclers consider that recycled paint meets the average range of interior paints.

4.3.4.4.Economic performance

Economic balance:

PAINTCARE communicates on two main figures:

- the total contributions collected from producers, which for the three countries studied represent

[102] Greenseal GS-43 Recycled Latex Paint (https://www.greenseal.org/files/shares/Standard%20PDFs/GS43-1.1-Standard-2013.pdf)

[103] The margin achieved by the distributors seems to be comfortable. Also, one recycler is considering increasing its selling price.

- between 0,11 and 0,14 EUR/ L sold
- between 1.68 and 2.05 EUR/L of paint collected

- financial support provided to reuse shops (0.37 EUR /L of reused paint sold)

Based on the data provided in the reports, PAINTACARE's total expenditure ranges from 1.38 EUR to 1.96 EUR per litre collected.

Note: Expenditure and income are not equal; the balance between income and expenditure is used for investments and reserves. PAINTCARE's policy regarding its financial reserves[104] is to set a level of 100% reserves in relation to the expenditure programme, with a minimum of 75% and a maximum of 125%. When this reserve appears to be too high on an aggregate basis, the contributions requested from producers are reduced. This is what happened in 2022 for California.

The distribution of PAINTCARE's expenditure shows that the largest share is allocated to treatment support (56% on average). Administrative costs (staff, overheads, and contributions to governments of about 1-2%) represent 14% of expenditure on average.

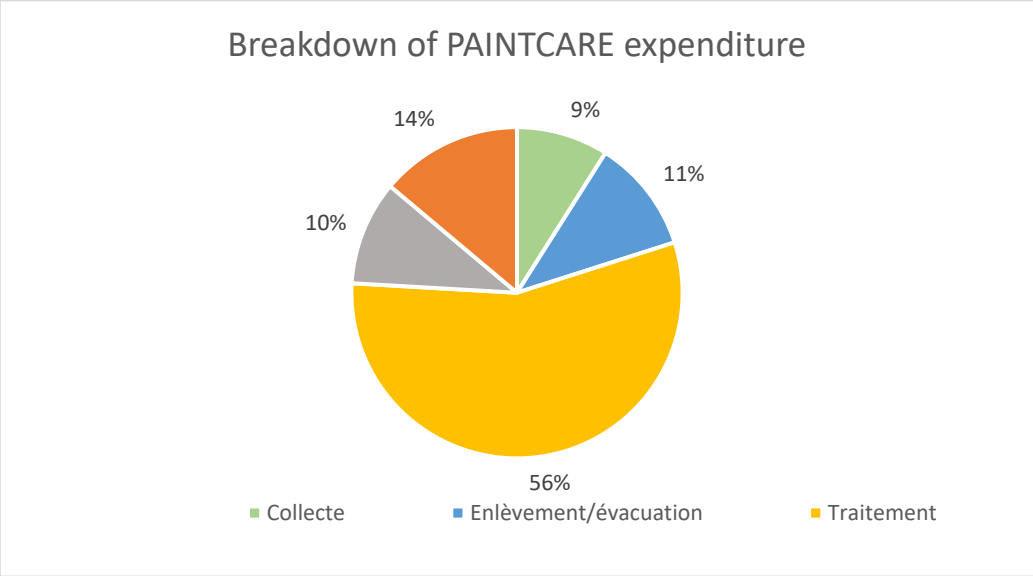

Figure 14: Distribution in percentage of PAINTCARE's expenditure by major item (PAINTCARE California and Colorado 2019 reports)

The data available in the reports also allowed to estimate support for each outlet:

	Share of the activity in PAINTCARE's expenditure related to treatment	Amount in EUR/L oriented in each outlet
Recycling	60 %	1,15-1,28
Energy recovery	21 %	1,14-1,28
Incineration	4-8%	1,18-1,28
Landfill	5-6%%	1,15 -1,28
Reuse	1 %	0,36

[104] Reserves represent the accumulated surplus or net assets (cash and investments) of the programme. The reserves are needed to sustain the programme in case paint collections are higher than expected (higher expenditure), paint sales are lower than expected (lower revenue), or a combination of both.

Table 6: Details of support by outlet (source: PAINTCARE California 2019 and 2021 reports)

This table shows that there is no really differentiated support by type of treatment.

Recycling costs: Based on data from recyclers, production costs are estimated around 0.7 and 1.4 EUR / L collected. Expenses are divided between staff (50 to 70%) and machines and rent (30 to 50%).

Material resales: Material resales on the domestic market represent between 0.5 and 1.5 EUR / L; export sales between 0.17 and 0.56 EUR / L.

Without the support of PAINTCARE, stakeholders say that recycling would not be profitable.

The METROPAINT recycler reports that it has experienced greater losses since the health crisis due to the closure of the facility and high absenteeism, which has resulted in no revenue.

Involvement of the social economy: Staff are generally low-skilled and employed at minimum wage ($15/hr in California). However, the facilities need slightly more skilled staff to handle blending, laboratory testing, and some sales force staff.

The staff of the facility can be people on professional integration. METROPAINT, which used to hire temporary staff (no social benefits[105]), has encountered many difficulties (absenteeism, turn over, addictions, etc.). The trend is to recruit permanent staff.

In addition, the sale of reused paint through PAINTCARE support makes the purchase of paint affordable for some households.

Key success factors :

- Collection of paints relies on pre-existing structures in the sector: paint distributors and hazardous waste collection facilities.
- It relies on the selected collectors who choose the recyclers according to the hierarchy of the waste treatment methods.
- Recyclers tend to value paints at a domestical level and use export as an opportunity to decrease stocks and colours poorly demanded in the domestic market.
- Some recyclers have developed ranges of products and niche products that allow the paint to be used by different users (individuals, public authorities).
- Reuse is encouraged and rewarded, but at a lower level than recycling.

4.3.4.5.Environmental performance

Collection rate: 5-12% of the products placed on the market depending on the state

Recycling rate: target of 70% for latex paint (generally achieved)

Material demand: The recycling process does not have a significant direct material consumption. Some pigments/preservative additions may be required, but these represent less than 3% of the final composition.

Energy demand: The recycling operation, which consists of decanting, filtering, and mixing paint waste, does not involve major energy consumption.

Quantity and fate of waste: Paint waste that cannot be recycled (especially solvent-based paints) is sent for energy recovery or incineration depending on the State. Some is also still sent to landfill (water-based paints only).

The plastic cans are dried and then sent to a plastic recycler. According to the recyclers, the recycling of black paint cans is sometimes a problem and not all are recycled. The recycling rate is not a directly monitored indicator, only the tonnages recycled are known. The metal cans are compacted and sent to a recycler.

Environmental indicators (GHG, LCA...): no data available

Certifications: Some recyclers use product certifications such as GREENSEAL for recycled water-based paints[106] . This label sets out certain performance requirements of the Master Painter Institute[107] as well as recycled content and limit values for VOCs, aromatics or bans on certain substances (halomethane, phthalate esters, heavy metal formaldehydes, certain aromatics, or VOCs).

[105] social security, insurance, holidays, ...
[106] https://greenseal.org/wp-content/uploads/GS-43-Standard-Ed-1.2-04.2021.pdf
[107] https://mpiinfo.org/store/usd/Publication_Standards.asp?page=standards

4.3.4.6.Regulations and standards

4.3.4.6.1. EPR scheme

The regulations adopting PAINTCARE Product Stewardship are different in each state[108] ; but the general framework is the same. The law defines the principle of Product Stewardship, some objectives, and modalities of operation between PAINTCARE and the administration. PAINTCARE must then suggest multiannual plans and draw up annual reports which are checked and validated by the administration of each State. The main differences between States are the type of data to be reported annually and the collection targets.

The regulations generally set **targets for collection coverage** (90% to 95% of the population within a certain distance[109] or even a minimum number of collection sites available for an urban population).

There is generally no **regulatory quantitative target for collection**. The reason given by PAINTCARE is that it is difficult to assess the quantities of residual paint in the cans (which should be minimised) and therefore to set targets.

There is generally no **regulatory quantitative target for recycling and other treatment methods,** but the principle is to follow the waste hierarchy. The recycling rate (paint recycled/paint collected) is defined in PAINTCARE's contracts with carriers for some states (Rhode Island, New York, and Washington).

Some indicators are monitored in the annual reports such as :

- Criteria for the distribution of collection sites and density (regulatory) and their typology
- Collection rate (paint collected/paint placed on the market). These ratios allow to monitor developments, but not directly the performance of the programme. At the beginning of the programme, it is necessary to estimate the forecast collection rates to calibrate the EPR fees. PAINTCARE uses data taken from feedback: routine programme with a collection rate of around 7% and launch with a collection rate of 5%[110] .
- The recycling rate (recycled paint/collected paint),
- Orientation towards different outlets for water-based and solvent-based paint
- Economic data (allocated income and expenditure per PAINTCARE's item, reserves)

PAINTCARE reports further information in the reports, for example, for Oregon :

- the list of participating manufacturers and brands covered by the programme
- How the programme will manage waste (collection, removal, reuse, recycling, and other post-consumer processes including energy recovery and elimination)
- the principles and organisations in place to ensure environmental management practices including for collection
- collection arrangements and the list of facilities accepting paints
- their amount of compensation to service providers for collection, reuse, recycling, transport activities (not always detailed)
- how to reduce post-consumer paint generation, promote reuse and respect the waste treatment hierarchy
- volumes sold and collected
- communication to various stakeholders and evaluation of its effectiveness
- the third-party audit report of the programme and the demonstration of sufficient funding to support the programme in a fair and sustainable manner,

Finally, PAINTCARE defines its reporting requirements and the associated frequency to the different stakeholders, for example in Oregon:

- Producers: sales data by month
- Collection points :
    - Distributors, private collection points: quantities reused per type of paint per month
    - Public collection points: quantities reused by type of paint per month, transport, and recycling services per month
- Carriers :

[108] In Oregon the law is House Bill 3037. In California, Chapter 5 of Division 30 of the Public Resources Code establishes the Architectural Paint Recovery Program. In Colorado the law establishing the Paint Stewardship is Senate Bill 14-029, also called the Architectural Stewardship Act.
[109] less than 24 km in general
[110] However, some states have higher results (e.g., Minnesota 12%).

- monthly billing report covering all services (containers, transport, quantities collected per site),
- quantities of non-PAINTCARE products collected per site per month
- volume by type of paint, installation, and outlet each quarter

The PAINTCARE regulation is also associated with the regulation on hazardous waste collection (see chapter 4.3.4.6.4 p.78)

4.3.4.6.2. Waste status

The Code of Federal Regulation Title 40 §260.3 clarifies the applicable framework[111] regarding products which cease to be waste. Materials that have been recovered but still need to undergo further recovery processes before being used must apply to cease to be waste. This means that in the case of full recovery, no application for licence is required. Hazardous secondary materials that cannot be distinguished from a product or an intermediate do not need to apply for a licence to be considered a waste but can do so §260.3. The criteria used by the administration to decide if a product can cease to be waste are :

- Treatment of secondary materials as a product (positive price or contract),
- The physical and chemical identity is comparable to a commercial product or intermediate,
- Market capacity ensures that secondary materials are used within a reasonable timeframe and that there is no disposal,
- The hazardous substances do not generate higher than normal risks in the production process (emissions to air, water, and soil),
- Further evidence that secondary materials are not being abandoned.

In conclusion, recycled water-based paints and recycled solvent-based paints are not considered as waste this without a special request to the federal authorities. A formal application can be requested for (hazardous) solvent-based paints.

After discussions with the State of California, it appears that paints, as product residues, are not considered as waste in the case of reuse. When recycled, paints have the waste status but become products again after recycling. There is no need to apply for a specific product status. If the paints were solvent-based and required special labelling when first used, then the recycled paint should have the same type of labelling.

4.3.4.6.3. Hazardous product / waste classification and labelling

According to the Code of Federal Regulation title 40 § 261, end-of-life solvent-based paints are considered hazardous waste. When transported in a mixture with water-based paints, the whole is therefore considered a hazardous waste.

The Federal Hazardous Substances Act requires labelling on all packages of hazardous substances, i.e., toxic, corrosive, irritant, highly sensitising, flammable, or combustible, pressure generating upon decomposition, heating or otherwise and which may cause serious bodily injury or illness during or as a result of any ordinary or reasonably foreseeable use, including ingestion by children.[112]

4.3.4.6.4. Supervision of collection operations

To use the PAINTCARE program for solvent-based paints, a company must be qualified as an exempt producer under the federal law (40 CFR § 262.14) or other state law on hazardous waste and be considered a Very Small Quantity Generator (VSQG)[113] meeting the following thresholds:

- generate less than 100 kg (25 gallons) of hazardous waste per month
- accumulate less than 1000 kg of hazardous waste (220 gallons)

In California, according to Health and Safety Code § 25217.2.1, collection of solvent-based paint with water-based paint may be performed under these conditions:

- a person generating solvent-based paint as the owner or person in charge of the maintenance of a household
- if he/she is a small quantity producer " exempt under conditions" (production threshold of less than 1000 kg)

[111] https://www.law.cornell.edu/cfr/text/40/260.30; also clarified by the EPA
[112] US Code, title15, §1261

In practice, these conditions are difficult to control at the drop-off points. They are easier to verify in the case of door-to-door collections.

Some states require licences for the collection of hazardous waste from households. In this case, employees must meet the requirements of the Occupational Safety and Health Act section 1910.120 and receive training in at least the following topics: general operations of hazardous waste, operations according to Resource Conservation and Act (treatment, storage, and disposal facilities), and emergency response. PAINTCARE provides training for the collection of paints, particularly from distributors.

In California, permanent sites must be licensed and receive an authorization from CUPA (Certified Unified Program Agencies). This permit application includes the expected volumes, an indication of whether small producers waste will be accepted, a description of the facility...

For door-to-door collection: see paragraph 4.3.4.6.7 below.

4.3.4.6.5. Supervision of recycling operations

According to the Code of Federal Regulation Title 40 § 260 to 270, there is a licence requirement under the Resource Conservation and Recovery Act for facilities processing, storing, and disposing of large quantities of hazardous waste.

In Colorado, the requirement to be qualified as a recycling facility is to demonstrate that 75% of the volumes are treated on site on a rolling three-year average[114] .

4.3.4.6.6. Finished product

Federal regulations on hazardous substances (chemical substances inventory of the Toxic Substances Control Act (TCSA)) must be followed. Section 8 (b) of the Toxic Substances Control Act (TSCA) requires EPA to compile, maintain and publish a list of each chemical substance manufactured or processed, including imports, in the United States for uses subject to TSCA. Any chemical not included in the inventory is considered a "new chemical". Mixtures are not considered chemical substances. Thus, the formulation of products (e.g., paints) from the mixture of chemicals, where no chemical reaction occurs, is not considered to result in a new chemical substance.

In conclusion, a paint placed on the market only must comply with the TCSA regulation if it uses a substance that is not listed in the inventory or for which the use "paints" is not listed.

As paints from recycling are very similar to virgin paints[115] and no new substances are added, there is no specific registration requirement for recycled paints and their composition.

At this stage, public authorities do not register the ingredients that constitute recycled paint. However, tests are carried out on recycled paints before they are put on the market to ensure compliance with the requirements for certain substances (heavy metals: lead, mercury, or VOCs). The only tests carried out upstream by some recyclers are the verification of the composition via the information available on the label, and in case of doubt, their removal from the recycling process.

4.3.4.6.7. Transport

The transport of hazardous waste is regulated according to the quantity of hazardous waste produced. The greater the quantity, the higher the level of requirements is.

A hazardous waste carrier is subject to several regulations under the Resource Conservation and Recovery Act, described in Title 40 of the Code of Federal Regulations (CFR), Part 263, including meeting the EPA's hazardous waste manifesting requirements, which is the equivalent of a hazardous waste tracking slip, above a waste generation threshold of 1000 kg.

EPA's hazardous waste manifesting system is designed to track hazardous waste from the time it leaves the producer's facility where it was generated, until it reaches the off-site waste management facility that will store, treat, or dispose of the hazardous waste. Manifesting responsibilities vary depending on the mode of transport (road, water, rail, or air).

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[114] Code of Colorado Regulations, 6 CCR 1007-2 Part1

[115] Indeed, according to one recycler (METROPAINT), the paints are on average 3 to 5 years old and contain on average no hazardous products in terms of regulations or in extremely diluted quantities (estimate drawn from several hundred tests over 23 years of practice).

Except for certain wastes from VSQG[116], a carrier can only accept hazardous waste from a producer if he receives a properly prepared manifest. Regulatory requirements could therefore be less strict for small quantities.

In practice, the public authorities interviewed indicate the need for the manifest for carriers.

ACRYLATEX states that it meets the requirements of the Hazmat Endorsement. This is a Hazardous Materials Endorsement Threat Assessment Program for any driver wishing to obtain a reference to hazardous materials on a state-issued commercial driving licence. The transportation of these materials requires labelling of vehicle under the Department of Transportation's hazardous materials regulations.

4.3.4.6.8. Cross-border transfer

Paint waste is not sent abroad as such but recycled. Exported paints are considered as products and therefore do not have to undergo procedures related to cross-border transfers of waste. The US does not require that all products are recognised as having ceased to be waste by importing countries for exports.

NB: Unites States have not signed Basel Convention on waste transboundary shipments.

4.3.4.7.Overall assessment

Strengths	**Weaknesses**
An **already established collection network** that facilitates the delivery of paint cans (hazardous waste drop-off points, distributors). A **simple recycling process.** Some **recyclers also produce virgin paint**, which allows the use of a network for the distribution of recycled paint. **Niche markets** adapted to recycled paints (e.g., anti-graffiti paint). **Quality recycled paint** with possible warranties. **Support for reuse** that promotes real reuse actions.	**Difficulty to calibrate EPR fees** due to the random behaviour of paint users (purchasing the right amount of paint, and sorting gesture). An **unprofitable recycling process**, with little opportunity to reduce cost in the short term (high labour costs). A **lack of transparency** on the establishment of downstream support scales and their link with actual treatment costs. Risks of **stocks of recycled paint** due to the diversity of the materials collected (colour in particular). **Regulatory obligations** on the transport of hazardous waste which puts the brakes on the acceptance of solvent-based paints at collection or generates practices not aligned with the regulations. The EPR fee scale which does not encourage producers to incorporate recycled paint (no eco-modulation).
Opportunities	**Threats**
Possibility of **automating the recycling process**, especially for emptying the pots The possibility of **diversifying certain outlets** by relying on public clients (requirements for a percentage of recycled material in the specifications)	**Difficulty in meeting the changing demand** for recycled paint (increasing demand for white tinting colour, while collection of white paint is very low) **Public procurement is not very controlled** in terms of its obligations to integrate environmental criteria into its purchases
Replicability to France • **Collection points**: support from existing actors for collection is possible (waste disposal centres, distributors) and exists for some EPRs • **Collection**: reliance on collectors without contracting with recyclers is generally not the approach of	

[116] https://www.epa.gov/hwgenerators/hazardous-waste-generator-regulatory-summary

EPRs in France, which prefer to establish agreements with recyclers directly

- **Support scales :**
    - The downstream support scale lacks transparency and does not ensure that the costs of the different stages are covered at their fair value; there is no great difference in support depending on the outlet.
    - The upstream support scale does not encourage producers to engage in eco-design. It does not respect the minimum obligations imposed by the Waste Framework Directive and French regulations.
- **Recycling:** the process is replicable
- **Regulation :**
    - EPR regulations in France are more demanding and generally impose targets on Product Responsibility Organisations directly, particularly in terms of reuse and recovery rates (here only collection density issues are required).
    - The regulations on hazardous waste are essentially the same as those in France, the case of simplified procedures for transport slips is possible for small volumes.
    - the waste status regulations are simpler for the US and favour recycling.
    - the control of the composition based on the label and tests for some substances is not sanctioned as non-compliant by the authorities. The French approach would be more demanding in the absence of characterisation data.

4.3.4.8. Contacts

Organization	Role	Name	Function
PAINTCARE	Product Responsibility Organisation	Fred GABRIEL	Director of Operations
ACRYLATEX	Recycler and carrier (California)	Brian BRITTAIN	President
METROPAINT	Public recycler (Oregon)	Andrew STAAB	METROPAINT Program Manager
LOOP	Recycler in Ontario, Canada but participant in the State of Maine	Josh WIWCHARYK	President
CalRecyle California Department of Resources, Recycling and Recovery	California Public Authority (in charge of monitoring the PaintCare programme)	Victoria PLUIM	Manager legislation
Colorado Hazardous Materials and Waste Management Division	Public authority State of Colorado	Wolf KRAY	Unit Leader Materials Management Unit

4.3.5. PRODUCT CARE (Canada)

Preliminary notes:

- Each province has its own legislation, and the organisation may be different, the report is mainly based on the feedback of British Columbia, the oldest province in the EPR.
- The figures provided are for 2020 as they were available on the PRODUCT CARE website. It should be noted that 2020 was a special year due to the pandemic with closures of site and could reduce the performance of the scheme.
- 1 Canadian dollar: 0.69 EUR (February 2022)

4.3.5.1. Overview

Name of the initiative	
Country / region of action	8 Canadian provinces[117] : British Columbia, Saskatchewan, Manitoba, Ontario, New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland and Labrador
Starting date	1994 in British Columbia
EPR scheme	Yes
Amount of the EPR fee	Between 0.1 and 2.48 EUR / L sold, depending on the volume of the packaging.
Description of the waste stream	
Nature of waste collected	**Paints for residential use:** interior and exterior water-based (e.g., latex, acrylic) and oil-based (e.g., alkyd, enamel) paints. Aerosol paints are accepted, for all types of sectors (automotive, industry, crafts). **Other coating and adhesion products:** Varnishes, coatings, primers, polyurethane (single component), terrace coatings and floor paints (including elastomer), wood protection oils[118] are accepted. **Main exclusions from EPR**: approved wood preservatives, thinners, industrial paint (except aerosols), two-component paints, wood stains and dyes.
Origin of waste collected	In Ontario, only household and small companies waste is accepted. In other provinces, industrial waste is also collected. Collection sites may have different acceptance thresholds for private and commercial waste.
Collection	
Collection system	**Permanent collections:** municipal sites, private service providers, paint distributors, beverage bottle depots **Door-to-door collections** for large volumes (more than 10 pots) **Occasional collection events**
Quantities collected (/year)	Collection in all provinces: 4.2 million L[119]
Collection rate	7% on average (between 3.5% and 9.7%) of products placed on the market
Cost of collection	Data not available
Reuse	

[117] There is another EPR program in Quebec (ECO-PEINTURES) and a government program in Alberta.
[118] except those registered under the Pest Control Products Act
[119] some provinces do not count aerosol paints in these figures

Promotion of reuse	Paint Share Programme: reusable paint is given free of charge to the public and NGOs to be used for its original purpose.
Reuse rate[120]	Between 0[121] and 4% depending on the province
Recycling	
Nature of waste recycled	Water-based paint waste mainly and to a lesser extent some solvent-based paints (small quantities)
Quantity of waste recycled (/year)	Information not available
Recycling rate	Water-based paints; between 68 and 90% depending on the province
Cost of recycling	Estimated 1.68 to 3.54 EUR/ L collected
Outlets	
Nature of the recycled products	• Architectural water-based paint mainly [122] • For dry paint waste, and some paint colours, the cement outlet (paint used as filler) exists but is minor according to the recyclers.
Energy recovery	• 100% solvent-based paint in British Columbia • 6 to 34% of all paints depending on the province
Elimination	• no landfill in British Columbia • 2-24% for other provinces

[120] Quantities of paint reused / quantities collected
[121] However, this value must be qualified in view of the year of measurement (2020) and the closures of reuse sites.
[122] In Ontario, alkyd paint is recycled

The following flow chart shows the link between the different actors in the scheme involved in the PRODUCT CARE initiative.

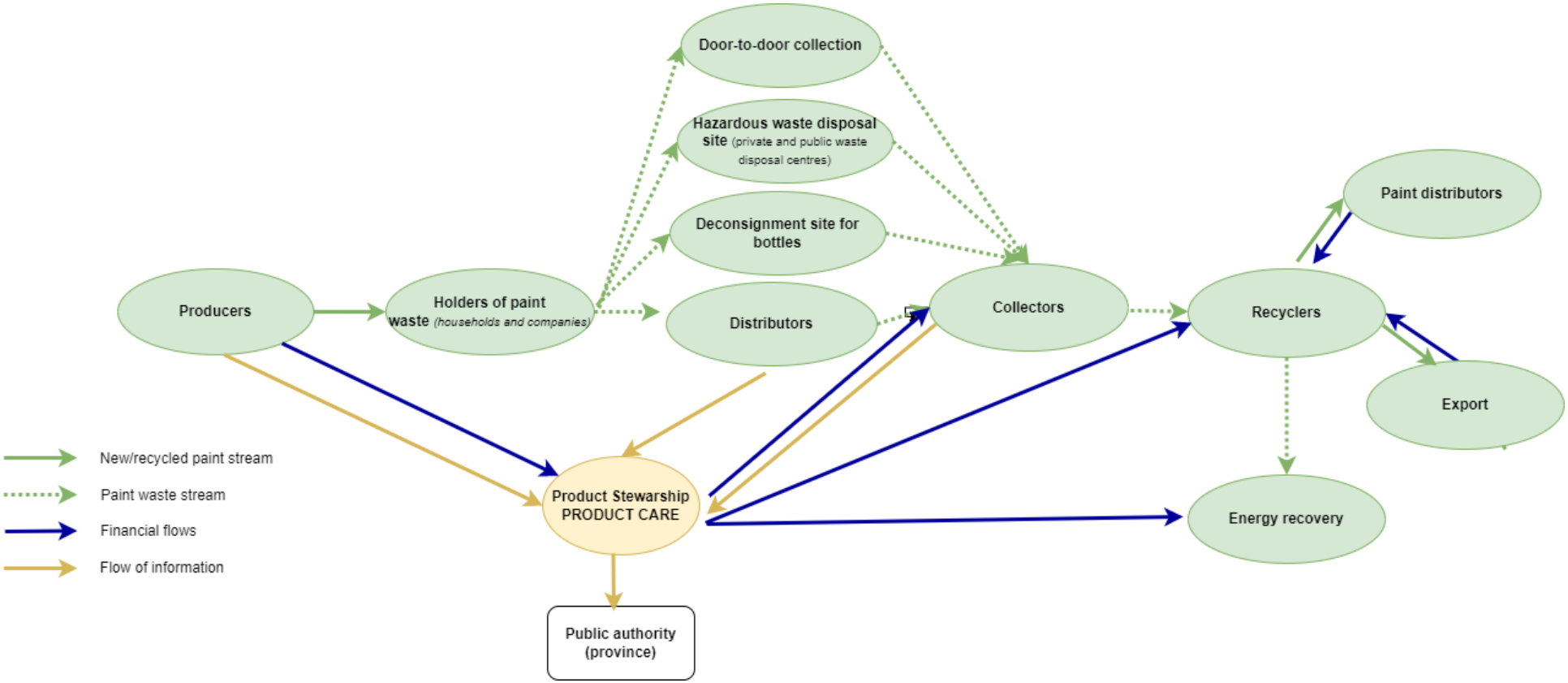

Figure 15: Organisation of the PRODUCT CARE recycling initiative

PRODUCT CARE is the Product Responsibility Organisation in charge of paints. It represents paint producers in their responsibility for managing the end-of-life of their waste, who pay EPR fees directly to it.

PRODUCT CARE relies on dedicated or pre-existing private[123] or municipal collection sites collecting hazardous waste or other types of flows. It generally provides the standardised collection containers (drum, 1m³ container). The Product Responsibility Organisation then generally calls on collectors (called "haulers")[124] who contract with it. The haulers are waste management companies. These actors are selected by the provinces according to different processes.

Recyclers can be companies created to develop the recycling activity or producers of virgin paint who have developed a recycling activity. Five recyclers operate in Canada: RENUE (Calgary), LOOP (near Niagara Falls on the US side), GFL (Hamilton), LAURENTIDES (Quebec and New Brunswick).

4.3.5.2. Context and evolution of the scheme

Context of creation :

The EPR system was established in British Columbia in 1994. The province introduced EPR regulations for paints, requiring paint producers to develop recycling systems for the end-of-life of their products. In response, producers came together in PRODUCT CARE, an organisation responsible for ensuring that its members meet their obligations under the various aspects of EPR.

Key stages of development/modifications :

Due to the success of collection and recycling programs, PRODUCT CARE has expanded to other provinces and other activities. PRODUCT CARE is a non-profit organisation that now runs other recycling programmes in Canada and the United States (hazardous products - pesticides, solvents, smoke detectors, light bulbs, etc.).

For painting, other provinces that have joined the program are Nova Scotia in 1996, Saskatchewan in 2005, Manitoba in 2006, New Brunswick in 2009, Prince Edward Island and Newfoundland and Labrador in 2012 and Ontario in 2015.

Perspectives: no information.

4.3.5.3. Technical description

4.3.5.3.1. Market entry

The PRODUCT CARE program targets residential paints sold in cans of less than 25 L for the professional and household markets. These are subject to contributions which varies according to the volume of the paint can and the province. The table below shows which paints are subject to contributions and which are excluded.

Accepted paints	Exclusions
Paints for residential use • Interior and exterior paints: water-based (e.g., latex, acrylic) and oil-based (e.g., alkyd, enamel) • Terrace coatings and floor paints (including elastomer) • Varnish and urethane (single component) • Concrete/masonry paint • Drywall paint • Coatings and primers (e.g., metal, wood) • Stucco paint • Paints for marine use (Except those registered under the Pest Control Products Act) • Wood finishing oil • Melamine, metal paint and rustproofing, colouring, and shellac • Pool paint (single component)	• Approved wood preservatives • Thinners • Industrial paint (excluding aerosols) • Two-component paints • Dyes and wood stains

[123] For example, in Saskatchewan, PRODUCT CARE has contracted with SARCAN for drop-off points, transportation to recyclers for some of the sites.
[124] In general, it seems that the number of carriers is limited (1 for some provinces or less than 10).

• Insulation paint • Textured paint • Fissure plug • Wood preservative (Except those registered under the Pest Control Products Act) • Wood, masonry, asphalt, or waterproofing coatings (tar-free or bitumen-based products) Aerosol paints of all types: products from the automotive, craft and industrial sectors Empty paint containers - metal or plastic	

Table 7: List of paints in the scope of EPR in Canada

Manufacturers, whether they are producers, importers, or distributors, must register with PRODUCT CARE. They sign a contract with PRODUCT CARE and must report their sales in a computerised system. In 2021, 145 paint manufacturers were registered.

They must pay a contribution (Environmental handling fee) per packaging put up for sale. Depending on the province, members can choose to make the fee visible to final consumers (e.g., on the bill). However, some provinces[125] have forbidden this to avoid confusion with a tax.

The table below shows the contributions requested by PRODUCT CARE by province:

Table 8: EPR fee by province and container in EUROS (Source: PRODUCTCARE) - reminder: 1 Canadian dollar = 0.69 EUR

Volume	British Columbia	Saskatchewan	New Brunswick	Manitoba	Ontario	Nova Scotia	Prince Edward Island	Newfoundland and Labrador
100-250 mL	0,2	0,1	0,2	0,1	0,1	0,2	0,3	0,1
251-1000 mL	0,4	0,2	0,3	0,2	0,2	0,3	0,5	0,2
1000-5000 mL	0,7	0,5	0,7	0,4	0,6	0,7	1,2	0,5
5-23 L	1,6	1,3	1,3	1,0	1,5	1,3	2,2	1,0
Aerosol	0,2	0,2	0,2	0,2	0,2	0,2	0,3	0,1

The contributions range from 0.07 to 2.48 EUR / L sold depending on the volume of the packaging. The contributions are not proportional to the volume of the packaging (this would be the case with a fixed contribution per litre) but tend to reflect the amount of paint left in the cans after use. Thus, per L of paint sold, large volume containers contribute less as these paints are generally used by professionals[126] and their use is more optimal and therefore the proportion of products becoming waste is lower.

Members authorise PRODUCT CARE to carry out audits and inspections on their sales, distribution, supplies and imports. Products that are repackaged but have already been sold are not subject to contribution.

[125] New Brunswick, Newfoundland and Labrador, Prince Edward Island and Ontario.

[126] A study conducted for Quebec more than 10 years ago provided data on residual paint levels in paint cans
-paint for households: 13% of residues
-Painting for professionals : 1%
-average : 7%.

There is no eco-modulation of the contributions to favour eco-design, or to penalise according to the difficulty of recycling paints. According to PRODUCT CARE, this last type of modulation is not necessary because the market tends to evolve towards more easily recyclable products (decrease of solvent-based paints in favour of water-based paints, easier to recycle).

Sales in all provinces amounted to 57 million L (some provinces do not count aerosol paints in these figures).

PRODUCT CARE is the only Product Responsibility Organisation for paints in the provinces where it is located. Its reputation is sometimes broader when it has other products for which it is responsible as a Product Responsibility Organisation.

4.3.5.3.2. Collection operations

Type of holders: households and companies (small companies only in Ontario)

Properties of incoming waste: water-based and solvent-based residential paints and other permitted coatings

Service level for holders :

- Types of collection points: there is a wide variety of collection arrangements with three main types of arrangements
    - Permanent collections: via municipal sites (some sites may have restrictions on daily volumes; acceptance of professionals is also variable), private service providers, paint distributors, and deconsignment sites (return of returnable beverage bottles)

Figure 16: Example of a deconsignment site(source: Chilliwack bottle depot)

    - Door-to-door collections for large volumes (more than 10 pots), on demand
    - Occasional collection events

In total, there are almost 1,000 permanent collection sites in the 8 provinces. The distribution of sites varies greatly from province to province. Thus, Ontario relies mainly on distributors and then municipal points, while British Columbia relies equally on the three systems (distributors, municipal points and deconsignment points).

PRODUCT CARE contracts with collection sites. PRODUCT CARE generally pays collection sites on a quantity basis ($/type/volume of collection container, generally set at the provincial level). In Ontario sites are paid per hour of service. PRODUCT CARE aims to establish as many contracts as possible with collection sites once the site comes forward and is ready to contract. There is no tender procedure to select sites, but rather a call for sites to come forward and meet a set of specifications.

- Networking: Some provinces set an accessibility target, such as British Columbia, which sets it at 95% of the population. According to this province, reasonable access is 30 minutes or less by car from home to the drop-off site in an urban area and 45 minutes or less in a rural area. Nova Scotia considers 30 km in rural areas and 30 minutes in urban areas.

- Free of charge: All users can drop off their waste free of charge.

Acceptance criteria :

Acceptance of professional waste can vary from site to site.

Cans must be less than 25 litres and 680 grams for aerosols. Unsealed can, cans without lids, or cans with unidentifiable or missing labels will be rejected.

At the drop-off sites, the staff check the above acceptance criteria.

Paint sold in bags is considered a PRODUCT CARE product and must also be accepted, if it meets the same requirements (lid, no leakage).

Organisation of collection operations[127] :

Collection containers vary from site to site. The most common are cardboard boxes, with a plastic film inside (Gaylord boxes), 205 L metal drums or plastic boxes (tubskid).

Figure 17: Example of a collection container (tubskid) (source: British Columbia Paint Collection Site Guidelines)

This equipment is provided by the collector who comes to collect the waste. Depending on the type of collection container chosen, different storage arrangements are required. Cardboard boxes should be stored indoors and on pallets. In confined spaces, drums or plastic boxes are more appropriate.

PRODUCT CARE provides guidance documents for the management of collection sites.

Water-based and solvent-based paints are not sorted at collection site. However, aerosol paints are stored separately.

Collection points contact the take-back contractor when the containers are filled to 80% of their volume.

Each month, the sites must submit a form to PRODUCT CARE summarising collections (type of collection packaging and estimated volumes).

Collection sites must have a Health and Safety Programme and an emergency plan. In addition, PRODUCT CARE reminds sites of brief rules for safety and management of hazardous materials. It also reminds procedures in case of paint spills and provides a kit to the sites (absorption equipment).

Collectors[128] are selected through a tender procedure or by simple negotiation by PRODUCT CARE. Contracts are generally long (several years). Collection sites contact the authorised collectors in the province to work with them. PRODUCT CARE pays the collectors based on quantities (in $/collection container and distance travelled).

Preparation for collection requires the application of a sticker on the collection container (either water-based and solvent-based paints or aerosol paints) and the filling in of a PRODUCT CARE slip. The collector must display signs on the sides of his vehicle.

4.3.5.3.3. Reuse

[127] Source: interview and guidance document British Columbia Paint Collection Sites Guidelines, Feb 2021 (https://www.productcare.org/app/uploads/2016/02/2021-BC-Paint-Collection-Site-Guidelines-Complete.pdf)
[128] Called transporters in Canada

PRODUCT CARE encourages sites collecting used paint cans to put aside products for reuse through a programme called Paint Share. This programme does not cover aerosol paints. Sites must then identify and segregate the cans in question and store them in a specific way.

Cans considered suitable for the Paint Share programme should be :

- in good condition and rust free
- with a capacity of more than 1 L
- more than half full
- the paint should still be liquid (but the collector should not open the container to check this).

The percentage of collection sites that are part of the Paint Share programme varies between provinces but can be as high as 85% (Saskatchewan). The reuse rate varies between 0 and 4% of the volumes collected.

The sites receive a fee for reuse. The amount is not disclosed.

4.3.5.3.4. Recycling operations

The recyclers contract with PRODUCT CARE. The recyclers interviewed are also producers of virgin paint, which allows them to use their network for the distribution of recycled paint.

Properties of incoming waste: Incoming waste meets the acceptance criteria for collection (see above).

Description of the recycling process :

- Key steps for recycling water-based paints

Note: Recycling is mainly for water-based paints.

  - In one facility, containers are directly weighed when they enter the site.
  - Staff check labels and manually separate solvent-based and water-based paints. The average distribution of incoming products is 80% water-based paints, 15% solvent-based paints, 5% emulsified alkyd paints (used as a substitute for solvent-based paints). The average age of the paints is 10 years based on sampling campaigns.
  - Non-compliant products are discarded (mainly recognisable by their shape): pesticides, glues. These errors represent 3% of incoming waste. Solidified paints are also set aside for dedicated treatment (filler for cements).
  - Solvent-based paints must be treated in a specific way in terms of health and safety.
  - One of the installations separates products very precisely, by use or composition/risk characteristics (e.g., LOOP sorts up to 30 to 40 types of paint: flammable, bituminous, exterior paint, etc.) and performs a relatively fine sorting of solvent-based paints (flammable, exterior paints, etc.) to ensure their recycling.
  - Paints of the same colour are mixed in 1000 L containers. Colour control is carried out to ensure consistency. Concentrated colorants and titanium dioxide (less than 1%) may be added.
  - The other quality controls carried out are the same as for virgin paint of equivalent quality (mid-range). The objectives are mainly texture, viscosity, odour, and colour.

According to one of the facilities, between 65% and 75% of incoming paints are recycled.

Note: there is no real difference in the recycling process between water-based and solvent-based paints. Solvent-based paints that are recycled (small quantities) require more chemistry skills (compatibility of products, VOC content).

Paint cans (metal and plastic) are also recycled, although black plastic paint cans are more difficult to recycle.

- **Innovative character:** little innovation, but in recent years some recyclers are investing in automation to reduce human handling; sorting, however, must remain manual (reading labels, judging poor quality products and colours).

- **Replicability:** The recycling technique appears to be relatively replicable.

Technical barriers to recycling :

For solvent-based paints, there are regulatory constraints (federal regulations) that impose strict VOC thresholds, which old solvent-based paints cannot meet. This makes it more difficult to recycle these solvent-based paints.

In addition, the chemistry of these paints also makes recycling difficult, as it is dangerous to mix them.

Finally, the reduction of the solvent-based paints market is reducing demand, which does not create an incentive for recycling.

For water-based paints, the major constraints are on the colours which can generate a significant need for storage space. When certain colours are no longer used on the domestic market, two alternatives are considered: export, or mixing these colours to obtain a brown/grey colour and supplying this paint as a useful mineral filler in the composition of certain cements.

4.3.5.3.5. Finished products

Description of the finished products and applications:

Most recycled products are paints.

In the domestic market, recycled paints are positioned as mid-range interior paints. Depending on the recycler, between 8 and 16 colours are offered.

Export is also used for less popular colours (pink, yellow, blue).

A small part goes into cement works (paints whose colours have been mixed due to lack of market, and low quality and dry paint) as filler, but without market value. These paints can also be used for asphalt renovators (in bitumen); a black pigment is sometimes added. There are fewer quality constraints in these applications.

Alkyl paints are used for primers for metal structures (anti-rust).

Strategy for market entry:

Different commercial strategies exist among recyclers

- Pure or mixed: mixed
- Display of recycled content: for LAURENTIDES, display of recycled origin but no information displayed on the recycled content,
- Distribution channels: LAURENTIDES sells recycled paint under its own brand (Boomerang) with many labels to justify its local manufacture:
    - LOOP sells to a discounter (GIANT TIGER),
    - Export is used for paints that do not find a local market (colour problems); this outlet may also have the advantage of requiring a lower level of quality.

Quality assessment :

- Technical tests: The requirements are the same as for a virgin mid-range paint, and tests are carried out on the following characteristics:
    - texture,
    - viscosity,
    - smell,
    - colour,
    - opacity,
    - ph.

- Warranties: In the past, Boomerang paint has received Canadian Ecolabel certification (Environmental Choice). [129] Boomerang paint has an Environmental Product Declaration (EPD)[130] .
  For white paints, some recyclers report that they still add a high percentage of virgin paint (between 20 and 50%) or titanium dioxide to meet opacity requirements.
  However, reused paint is not covered by the warranty. The paint is sold as it stands. There is no quality assurance. These elements are displayed on an orange sticker placed on the reused can, alerting the consumer to the general conditions of reuse. A transfer form is filled in by the customer, indicating the type of paint taken back and its nature (water or solvent-based). Containers can be returned if customers do not like the colour or quality.

[129] Environmental Choice program CCD-048 Surface Coating : recycled Water borne http://www.responsiblepurchasing.org/UserFiles/File/Paint/Standards/CCD_048_Recycled_Water_Borne_Surface_Coatings.pdf

[130] https://www.peintureboomerang.com/wp-content/uploads/2020/04/PL106_Laurentide_EPD_20112017.pdf

Figure 18: Presentation of the reusable paints and orange stickers (source: Product Care) (Message on the paper: Please do not abandon your paint here. Kindly let one of our staff inspect it)

- Price: The price of recycled paint depends on its destination.
    - Depending on the recycler, the value of recycled paint is between 25 and 50% of the price of virgin. One recycler indicates a value for the domestic market of between 0.77 and 1.54 EUR /L sold.
    - For exports the value is much lower: between 0.19 and 0.64EUR /L sold.

  Thus, even if the quantities exported are high (more than 50%), they do not represent more than 25% of one of the recyclers' turnovers.

- Market in which the products evolve: The export market share represents between 50 and 75% of the volume, depending on the recyclers interviewed, which is high. The countries in demand are the Caribbean, Africa, and Eastern Europe. For the share sold on the domestic market, the positioning focuses on low-budget projects (rental flats, student housing, second homes, etc.), which justifies the discount market.

- Users' motivations for using the finished products. The main motivation for users to buy recycled paint is the low price, according to one recycler. Difficulties related to lack of colour may exist (see arguments raised by recyclers in the PAINTCARE initiative, notably on white paint).

- Perception of quality compared to virgin by the different actors (producers, consumers, and recyclers): There is no real data on the subject. The recyclers consider that recycled paint meets the average range of interior paints.

4.3.5.4.Economic performance

Economic balance:

PRODUCT CARE reports on the following data:

- Total contributions paid :
    - Between 0.1 and 2.48 EUR / L sold depending on the format
    - Or between 2.24 and 4.26 EUR / L collected
- The subsidies paid are available in the PRODUCT CARE reports by province: they represent a total of between 1.74 and 3.08 EUR per litre collected.
  Note: Expenditure and income are not equal, which suggests the constitution of reserves (PRODUCT CARE being a non-profit organisation).

The distribution of PRODUCT CARE's expenditure[131] by province is as follows:

Table 9: Details of support by outlet (source: PRODUCT CARE reports (2020))

	Share of the item in PAINTCARE's expenditure	Amount in EUR/L collected
Recycling	30 - 63 %	0,84-1,77
Collection points	9 - 21 %	0,24-0,37
Collection	9 - 37 % (Excluding islands: 9-15%)	0,17-1,14 (Excluding islands: 0.17-0.58)
Overheads	6 - 14 %	0,15-0,26
Communication	2 - 10 %	0,02-0,29

The item most funded by PRODUCT CARE is recycling, followed by collection points and collection.

- Recycling costs
  The recyclers did not want to provide precise data on their recycling costs.
  One of the recyclers indicated that 50% of the viability of his facility is ensured by material resales and 50% by PRODUCT CARE subsidies, which would give a range of recycling cost values between 1 .68 and 3.54 EUR/L collected.
  The most important expenses are staff and investments.
  Based on information provided by a recycler, the sales would be between 0.84 and 1.77 EUR/ L collected, i.e., between 1.20 and 2.52 EUR/ L sold.[132]

Involvement of the social economy: The employees who work at the installation can be in professional integration, but it is not the trend. Sorting tends to be automated, and the remaining functions require a good knowledge of the products.

Key success factors :

- Collection of paints is based on structures which existed before the creation of the scheme: paint distributors, hazardous waste collection facilities and deconsignment sites.
- The recyclers are waste treatment companies or paint manufacturers, which may allow them to position themselves in different stages of the chain (transport, recycling).
- Reuse is encouraged and many collection sites offer to reuse paint cans.

4.3.5.5.Environmental performance

Collection rate: 7% on average (between 3.5% and 9.7% depending on the province)

Recycling rate: 65% and 75% of incoming paints are recycled

Material demand: sometimes colourants are added to the paint (usually 3%), and for white paints, virgin paint may be added to ensure good performance (20-50%).

Energy demand: The demand is low and corresponds to electricity consumption of the automatic chain and lighting.

Quantity and fate of waste: 25 to 35% of incoming quantities are not recycled and are sent to energy recovery, incineration, or landfill, depending on the province.

The plastic cans are dried and then sent to a plastic recycler. According to the recyclers, the recycling of black paint cans is sometimes a problem and not all are recycled. The recycling rate is not a directly monitored indicator, only the tonnages recycled are known.

[131] Source: PAINTCARE 2020 financial reports for provinces excluding Manitoba and Ontario (and Saskatchewan which has an overall value of collection + transportation)
[132] However, these values seem to be higher than those reported directly by the recyclers - see the Finished Products section - (here the values are deducted from their statements on costs); this suggests a slight overestimation of the deficit of their activity.

The metal cans are sent to a recycler.

Environmental indicators (GHG, LCA, etc.) :

The LAURENTIDES company conducted a life cycle analysis for two products (a coloured and recycled paint and a white paint with 47% virgin paint added). The functional unit is the coverage of one square meter of surface in industrial and commercial buildings. This resulted in an Environmental Product Declaration (EPD)[133]. The results are not comparative with the performance of virgin paint and therefore do not allow conclusions about the value of recycling.

The environmental performance of recycled paints is likely to vary according to the type of outlet (export or local market). No quantitative information is available on the subject.

The VOC content of Boomerang paints is 43 g/ L which follows LEED standards.

Certifications : Boomerang paint has been certified by the Canadian Ecolabel (Environmental Choice)[134] in the past. The criteria were:

- contain more than 50% post-consumer recycled content,
- meet the requirements of the MASTER PAINT INSTITUTE (performance),
- not contain heavy metals,
- have a reduced VOC emission,
- not contain certain hazardous substances.

Boomerang paint also has two other labels that highlight its origin (local and recycled): “Well made” here (local label) and “Ici on recycle” (RECYCQUEBEC on waste management). According to LAURENTIDES, these labels play a role in educating consumers.

4.3.5.6.Regulations and standards

4.3.5.6.1. EPR scheme

The regulations adopting extended producer responsibility and the Stewardship programme (equivalent to the concept of EPR) are different in each province[135] .

In these texts, the principle of EPR/Product Stewardship is defined, as well as some objectives and operating procedures between the organisation in charge of Product Stewardship and the administration.

PRODUCT CARE must submit an Extended Producer Responsibility Plan to the provincial authorities, usually for a period of 5 years. This plan must be submitted for consultation and validated by the authorities.

In addition to this plan, an annual report is submitted to the authorities presenting the results of the scheme.

In Ontario the regulation sets certain targets from a regulatory perspective such as :

- networking (number of sites for small and large waste producers according to the density of the cities[136])
- the recycling rate of paints (70%)
- the maximum rate of orientation towards certain outlets such as cement or landscaping (15%).

In the other provinces, there are **no regulatory targets for grid, collection, or recycling.**

The plans define at least **the means implemented to organise the programme at provincial level** (collection, recyclers, communication, monitoring of certain annual indicators, etc.). In some cases, objectives are defined:

- collection network (in terms of the number of collection sites, or accessibility, generally defined by average travel times to a collection site in urban and rural areas137),

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[133] https://www.peintureboomerang.com/wp-content/uploads/2020/04/PL106_Laurentide_EPD_20112017.pdf

[134] Environmental Choice program CCD-048 Surface Coating : recycled Water borne http://www.responsiblepurchasing.org/UserFiles/File/Paint/Standards/CCD_048_Recycled_Water_Borne_Surface_Coatings.pdf

[135] In British Columbia it is the Recycling Regulation BC Reg 449/2004 https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/449_2004, in New Brunswick it is the Designated Materials Regulation of the Clean Environment Act (https://www.canlii.org/en/nb/laws/regu/nb-reg-2008-54/latest/nb-reg-2008-54.html), in Ontario it is the Waste Free Ontario act §S.O. 2016, c12- bill 151 (https://www.ontario.ca/laws/statute/s16012)

[136] For large producers: at least one collection site per 40,000 people in each locality with a population of 5,000 to 500,000, in localities with a higher population, at least 13 sites for the first 500,000 inhabitants, and 1 additional site per 150,000 inhabitants. For small producers: where there is a distributor, the number of collection sites is greater than or equal to 75% of these distribution sites.

[137] In British Columbia, this accessibility must be 95% with a travel time of less than 45 minutes in rural areas and 30 minutes in urban areas)

- recycling and disposal targets; in British Columbia: recycling target of 75% for latex (water-based) paints and 100% for pots, and 100% energy recovery target for solvent-based paints,
- collection targets and sales monitoring
- a target for the share of the population aware of the scheme; in British Columbia: 70%.
- end-of-life monitoring (mandatory waste composition audits)

The plan is subject to a broad consultation with stakeholders. In British Columbia these stakeholders are service providers (collectors, recyclers), regional governments, producers that are members of the programme, industry associations, indigenous communities, but also the public (internet consultation) and finally the provincial authorities (Recycling Council and Stewardship agencies).

Each year reports are produced presenting key indicators such as:

- sales of paint,
- collection rates,
- the grid and accessibility rates of collection sites (list of facilities),
- recycling rates and orientation to different outlets (usually distinguishing between water-based and solvent-based paints),
- the actors involved in transport and treatment,
- Financial data: contribution and expenditure of the Product Responsibility Organisation,
- a financial audit report.

Note: indicators are not fully harmonised across provinces.

4.3.5.6.2. Waste status

There are no regulations on end-of-waste in Canada.

According to LAURENTIDES, an opinion of the Quebec administrative tribunal has defined that when residual paint, used for recycling or reuse, is emptied from its initial container, and has undergone quality control, then it becomes a product. Canada does not require the importing country to verify if the products cease to be waste in case of export.

Reused paints are usually kept in the original packaging without even being opened, so they have the original labels.

4.3.5.6.3. Hazardous product / waste classification and labelling

Solvent-based paints are hazardous products due to the presence of hazardous substances.

Hazardous products are governed by federal regulations, specifically the Hazardous Products Act (SCR 198, c H.3). A manufacturer who sells or imports a hazardous product for recycling must keep the following documents up to date:

- hazard labels associated with possible risks (flammable, flammable aerosols, skin corrosion, skin irritation, serious eye injury, eye irritation, respiratory sensitizer, skin sensitizer, carcinogen, mutagen, reprotoxic),
- the safety data sheet of the hazardous product with the composition of the product,
- the names of any suppliers of the hazardous products and transfers of ownership.

Water-based paints are not considered hazardous waste and do not require a safety data sheet.

Concerning recycled products, recyclers did not mention any obligations for recycled solvent-based paints, which represent small quantities. The only tests carried out upstream by some recyclers are the verification of the composition on the label, and in case of doubt, their withdrawal from the recycling process. However, recyclers do carry out tests on the finished product before putting them on the market[138] to ensure the absence of prohibited substances. There is no mention of a dedicated control on the products but rather on the installations.

4.3.5.6.4. Supervision of collection operations

In British Columbia, for the collection of hazardous waste, non-household producers producing more than a certain quantity of hazardous waste and collection facilities must register.

Facilities collecting hazardous waste from households and storing no more than 25,000 kg or litres on site must be registered under section 42.3 (1) of the Hazardous Waste Regulation.

[138] It should be noted that for the PRODUCT CARE unit in British Columbia, the packaging of the recycled paint and its market entry is carried out by a company that is responsible for verifying compliance with regulatory requirements.

Producers generating hazardous waste above certain thresholds[139] defined by the Hazardous Waste Regulation over a 1-month period must also register.

The records include information on the quantities of waste generated/collected, the location of the sites, their plans, operational and emergency management plans, and financial elements on the relevance of the facilities.

PRODUCT CARE trains staff at the sites and audits them regularly.

4.3.5.6.5. Supervision of recycling operations

Waste recycling facilities must also be licensed by provincial authorities. In British Columbia, the Hazardous Waste Regulation[140] also regulates these facilities.

4.3.5.6.6. Finished product

Solvent-based paints have few outlets due to regulatory constraints on the transport of hazardous waste. Federal VOC regulations[141] require stricter limits on these emissions. These compounds tend to be at high levels in older paints, making it difficult to recycle solvent-based paints.

Normally, virgin paints require a safety data sheet providing the composition to be placed on the market. For recycled paint, which is made from mixtures, the precise composition is impossible to establish; there is a safety data sheet exemption for their market entry.

4.3.5.6.7. Transport

The transportation of hazardous goods is governed by the Transportation of Hazardous Goods Regulations (SOR/2001-286) (last amended 23/06/2021).

It includes responsibilities of the consignor and the carrier: the consignor must make notes about the risk of danger visible on each container of each good (or on the large container in which they are stored) and provide the carrier with the hazard notes. The carrier must ensure that the hazard information is in place and affix it to placards. A shipping document (equivalent to a waste tracking slip) must be drawn up and kept for two years by the shipper and the carrier.

Any person handling hazardous goods must have appropriate training which includes

- classification criteria
- regulation
- shipping document requirements
- hazard warnings
- safety rules
- emergency response plans
- a certificate of this training must be provided. Some US training documents (HazMat) are recognised.

According to LAURENTIDES, a licence for hazardous materials transport for paints is no longer required in all provinces. However, it is necessary for vehicles to have signs on their sides to identify the materials being transported.

4.3.5.6.8. Cross-border transfer

Paint waste is not sent abroad as such but recycled. Exported paints are considered as products and should not be subject to procedures related to cross-border transfers.

[139] These thresholds are defined according to the nomenclature of hazardous materials and their dangers.

[140] Hazardous Waste Regulation section 43 (https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/63_88_02#section43)

[141] VOC concentration limit for Architectural Coating Regulations (SOR /2009-264) https://laws-lois.justice.gc.ca/eng/regulations/SOR-2009-264/FullText.html

4.3.5.7.Overall assessment

Strengths	**Weaknesses**
An **already established collection network** that facilitates the delivery of paint cans (hazardous waste drop-off points, deconsignment, distributors). A **simple recycling process suitable** for solvent-based and water-based paints (more training required for solvent-based paints). Some **recyclers also produce virgin paint**, which allows them to use their network to distribute recycled paint. **Support for reuse** is part of the programme. Possible **accommodations for transporting paints** in some provinces (no licence) **Good governance** in the presentation of the plans by province	**No regulatory targets for recycling or collection** site coverage[142] An **unprofitable recycling** sector (excluding EPR support), with little possibility of reducing costs in the short term (high labour costs) A strong **need for stocks** of recycled paint due to the diversity of materials collected (notably colour), which generates a strong dependence on exports to sell them **Difficulties in ensuring good quality** levels for white paint (still a lot of virgin material added) There may be **conflicts between regulations**; the Recycling Regulation requires an increase in the collection network, which is relatively constrained by the Hazardous Waste Regulations.
Opportunities	**Threats**
The **possibility of automating** the recycling process, especially for emptying the cans.	**Difficulty in meeting the changing demand** for recycled paint (increasing demand for white tinting colour, while collection of white paint is very low)

Replicability to France

- **Collection:** support from existing actors for collection is possible (waste disposal centres, distributors) and exists for some EPRs
- **Recycling**: the process is replicable
- **Regulation :**
    - EPR regulations in France are more demanding and generally impose targets on Product Responsibility Organisations directly, particularly in terms of reuse and recovery rates (here only collection density issues are sometimes required).
    - Hazardous waste regulations are broadly like those in France, but some provinces consider less strict procedures for transport (exemption for hazardous materials licences).
    - Waste status regulations are simpler in Canada and encourage recycling.
    - the control of the composition based on the label and tests for some substances is not sanctioned as non-compliant by the authorities. The French approach would be more demanding in the absence of characterisation data.

4.3.5.8.Contacts

Organization	Role	Name	Function
PRODUCT CARE	Product Responsibility Organisation	Mark KURSHNER Mannie CHEUNG	President Vice President Operations
LOOP	Recycler in Ontario	Josh WIWCHARYK	President
LAURENTIDES	Recycler in Quebec	André BUISSON	CEO

[142] exception: Ontario

5. Transversal analysis of in-depth initiatives

Note: Three of the initiatives studied are EPR initiatives (PDR, PRODUCT CARE, PAINTCARE) while two are independent recycling initiatives run by a recycling company. The analysis carried out in these two cases focuses on different aspects. For the EPR-type initiatives, the governance of the scheme was studied, and in North America several recycling operators with different strategies were interviewed. For independent recycling initiatives, the strategy of the recycling company is at the core of the analysis, and the logic of partnerships with collection actors and producers is also studied.

5.1. Context of deployment of the initiatives

Table 10: Transversal analysis - Context of deployment of the initiatives

Initiative	PDR	AKZONOBEL - INTERCHEM	PAINT 360	PRODUCT CARE	PAINTCARE
Product	**PU foams**	**Water-based paints**	**Water-based paints***	**Water-based paints***	**Water-based paints***
Country	**Germany**	**The Netherlands**	**United Kingdom**	**Canada**	**United States**
EPR scheme	Yes	No	No	Yes	Yes
Date of creation	1993	2020	2013	1994	2009
Obligation of separate collection of the relevant stream	Yes	Yes	No	Yes	Yes
Collection target	No	No	No	Collection target in 1 province	Networking objective
Recycling target	No (packaging only)	No	No	No	No
Reporting of the scheme to public authorities	No (except for environmental permits and packaging scheme)	No (excluding environmental permits)	No (excluding environmental permits)	Yes, annual	Yes, annual

* *Mainly*

Recycling initiatives have emerged in two different contexts:

- The EPR scheme
- The voluntary initiative

The EPR scheme

The recycling initiatives led by PDR (PU foams), PAINTCARE and PRODUCT CARE (paints) have been developed because an EPR scheme has been set up and the separate collection of the stream has been imposed. These EPR schemes aim firstly to offer a waste collection solution covering many streams to all holders, and secondly to optimise the recovery of the waste collected by directing it towards recycling.

In the case of the PDR initiative, the EPR recycling initiative imposed the conditions for organising collection at all sites, without any influence on the pre-existing collection conditions. It should be noted that in the case of PDR, Germany has only imposed the establishment of an EPR scheme for the collection and recycling of PU foam packaging. It is the leading producers who have voluntarily decided to also recycle the contents for reasons of

brand image and to gain access to recycled raw materials. The sector does not have regulatory collection targets and its regulatory recycling targets only relate to the packaging component.

In the North American EPR systems, collection channels for hazardous wastes, of which paints were the major stream, already existed and the EPR systems relied on them. This constituted a valuable aspect for the roll-out of recycling.

In North American EPRs, the regulations generally establish the initiative and may provide some targets focused on collection performance (collection rate, or collection point coverage) or at least monitoring of indicators (collection rate, reuse rate, sales, recycling rate). Generally, no recycling performance is required. Collectors are asked to direct paint waste according to the waste hierarchy, but without quantified targets for directing it to these different outlets.

In all three cases, collection/recycling scheme would not be in balance without EPR subsidies, mainly due to the high costs of the collection system and the cost of recycling. The EPR system and the provision of support have therefore been necessary for the development of recycling.

The EPR schemes identified abroad have a lower level of transparency and supervision by public authorities than in France.

- In the case of the PDR initiative, given the voluntary nature of the recycling initiative, the federal public authorities do not have information on the quantities placed on the market, collected, or recycled. These are passed on to the Bavarian regional authorities for each Land and for the country. There is therefore no overall view of the scheme's performance at federal level. Economic information on the scheme is not transparent either.
- In the case of the PAINTCARE initiative, transparency is ensured for the upstream support scale, costs and support for reuse are public. However, the transparency of downstream support for the different actors of the chain (collection, removal, different treatment options) varies from country to country. Some reports give elements on the breakdown of costs for PAINTCARE in one country, but not the details of the remuneration of the actors. Contracts with collectors are the result of negotiation.
- In the PRODUCT CARE initiative, transparency is relatively like that of PAINTCARE. PRODUCT CARE costs per activity (collection, transport, recycling) are detailed in all reports. The downstream support scale, if any, is not public.

The voluntary initiative

In contrast, the AKZONOBEL-INTERCHEM and PAINT 360 initiatives have developed as voluntary recycling initiatives, without meeting regulatory collection or recycling targets. Both initiatives have positioned themselves in operational and market conditions that allow them to be profitable without external economic support (e.g., through EPR). They have had to adapt to pre-existing collection conditions in terms of channels and service levels but have defined their acceptance criteria in terms of accepted streams, which are implemented either at the collection point, at the gathering point or (exceptionally) at the beginning of the recycling process.

5.2. Organisation of the scheme

Note: The sector is not presented in chronological order of operations. Recycling is presented first because it is the core of the study and provides a better understanding of collection conditions and the relationships with marketers that facilitate the implementation of recycling.

5.2.1. Recycling

Table 11: Transversal analysis - Organisation of recycling

Initiative Country	PDR Germany	AKZONOBEL - INTERCHEM The Netherlands	PAINT360 United Kingdom	PRODUCT CARE Canada	PAINTCARE United States
Type of waste recycled	1k and 2k PU foams	Water-based paints for interior decoration	Decorative paints and water-based wood stains	Water-based paints and other water-based coatings (glazes, varnishes) Solvent-based paints in small quantities Aerosol paints	Water-based paints and coatings
Finished products	Prepolymer - for 1k foams only Propellants - 1k and 2k	Water-based paints for interior decoration	Water-based paints	Recycled paints Rust inhibitors Cement fillers or asphalt renovators (in bitumen - very small share)	Mid-range interior paints Anti-graffiti paints (niche market)
Share of recycled material in finished products	Prepolymer: 25 to 50%. Propellant gas: 100%.	35%	>65%	50%-80% white paint Up to 93% other paints	Up to 97%.
Finished product market	Europe (such as market entry)	Domestic and export	Domestic (70%) and export (30%)	25-50% domestic (North American) market 50-75% export	70-90% domestic market 10-30% export
Reuse rate (%)	1% (packaging)	0 %	0 %	0-4% depending on the	Water-based paints: 4 - 6 %

Initiative Country	PDR Germany	AKZONOBEL - INTERCHEM The Netherlands	PAINT360 United Kingdom	PRODUCT CARE Canada	PAINTCARE United States
				province	Solvent-based paints: 3 - 9%.
Recycling rate (%)	~ 70% (content only)	16% (for all paint waste recycled by INTERCHEM and not just their initiative with AKZONOBEL)	80 %	68 à 90 %	64 to 82% (water-based paints)
Energy recovery rate (%)	~ 30% (content only)	84 %	0 %	6 à 34 %	39 to 91% (solvent-based paints)
Disposal rate (%)	0%	0 %	20 %	2 à 24 %	7 - 30 % (water-based paints) 48 - 52 % (solvent-based paints)
Employment of people in professional integration / with disabilities	Yes (disability) Mandatory No support	No	Yes (professional integration) Volunteer No support	Not required No associated support Difficulty of actors employing workers in professional integration	Not required No associated support Difficulty of actors employing workers in professional integration
Social purpose of the sale of products	No	No	Yes	Yes: reused paint donation	Yes : A part is donated to NGOs to help low-income households to rehabilitate their homes

5.2.2. Collection

Table 12: Transversal analysis - Organisation of collection

Initiative	RDP	AKZONOBEL - INTERCHEM	PAINT360	PRODUCT CARE	PAINTCARE
Product	**PU foams**	**Water-based paints**	**Water-based paints***	**Water-based paints***	**Water-based paints***
Country	**Germany**	**Netherlands**	**United Kingdom**	**Canada**	**United States**
Type of collection points and % of quantities collected for the initiatives	10% DIY shop 10% waste disposal centres 60% professionals on call 20% professional shops	Waste disposal centres (100%)	Waste disposal centres Professionals (direct delivery or via waste managers)	Hazardous waste collection points for Distributors Deconsignment sites Occasional collections Door-to-door	Hazardous waste collection points (30-50%) Distributors (37-52%) Occasional collections (1-6%) Door-to-door (4-6%)
Waste accepted at collection point	All 1k or 2k PU foams in metal cans with PDR logo (10% non-PDR acceptance)	Water-based and solvent-based paints	Water-based and solvent-based paints	Interior and exterior water-based and solvent-based residential paints Aerosol paints (including industrial)	Interior and exterior water-based and solvent-based architectural paints and associated coatings
Rejected waste	Rusted or open cans	-	-	Pesticides, industrial paints (excluding aerosols)	Solvent-based paints from large producers, Aerosol paints Paints for industrial equipment and on-site painting (workshop)
Origin of waste collected (professional / private)	Individuals (20%) and professionals (80%)	Individuals	Individuals and professionals	Individuals and professionals (no limit)[143]	Individuals and professionals (accepted professionals must produce and store

[143] Except Ontario

Initiative	RDP	AKZONOBEL - INTERCHEM	PAINT360	PRODUCT CARE	PAINTCARE
Product	**PU foams**	**Water-based paints**	**Water-based paints***	**Water-based paints***	**Water-based paints***
Country	**Germany**	**Netherlands**	**United Kingdom**	**Canada**	**United States**
					volumes below a certain threshold)
Training of collection points by the recycling initiative	Yes	Yes	No	Yes	Yes
Network of selective collection	1 collection point approximately every 10 km, i.e., 1 public collection point for 28,000 inhabitants 15,000+ professionals served	1 collection point per 100,000 inhabitants	1 collection point per 1.6 million inhabitants	1 collection point per 25,000 inhabitants 90% of the population between 30 and 45 minutes by car (or number of sites)	1 collection point for 31,000 inhabitants 90% to 95% of the population within 24 km
Free collection	Yes, for individuals and professionals	Yes, for individuals Fee for professionals	Yes, for individuals Fee for professionals	Yes, for individuals Variable for professionals	Yes, for individuals Variable for professionals or large volumes
Collection performance (%)	40% of the waste stream	< 1% of the market entry	< 1% of the market entry	7% of the market entry on average (between 3.5% and 9.7%)	5 to 12% of the market entry

* Mainly

Role of collectors :

- Under the PDR initiative, collectors carry out collections on PDR demand, which organises the service, and are financed by PDR. They can also deal with the packaging for the waste disposal centres. They take the cans to intermediate storage facilities before transporting them to the recycling facility.
- In the North American initiatives, these actors are selected by the EPR organisations. They carry out collection on collection sites demand and are funded by the EPR organisations. In the United States, they are the backbone of EPR as they are responsible for directing the paints to the treatment operators of their choice.
- For the European paint recycling initiatives, collectors transport the paint waste to waste disposal centres and, for PAINT 360, to professional sites (usually construction sites). The relationship between the initiatives and the collectors follows a free market dynamic.

5.3. Economic conditions for collection and recycling

Table 13: Transversal analysis - Economic analysis

Initiative	PDR	AKZONOBEL-INTERCHEM	PAINT360	PRODUCT CARE	PAINTCARE
Level of support	75 ct EUR /cartridge collected	No support	No support	1.74 and 3.08 EUR /L collected	Total expenditure of PAINTCARE between 1.38 and 1.96 EUR /L collected Support for collection: 0.28 EUR/ L collected Support for treatment:1.14-1.28 EUR/ L treated Support for reuse 0.36 EUR/L reused
Cost of collection	75 ct EUR /cartridge collected	0.09 EUR per litre collected (only transport costs)	Between ~1.4 and 1.8 EUR per litre collected. [144]	ND	ND
Cost of recycling	50 ct EUR/ cartridge collected	Confidential	0.9 €/L collected	ND	ND
Resale price of finished products	50 ct EUR / collected cartridge Resale price of finished products not available	Between 11.75 and 13.50 EUR per litre sold	Between 7 and 30 EUR per litre sold	1.20 and 2.52 EUR/ L sold	1 to 4 EUR / L recycled paint sold ex factory on the domestic market 0.3 to 0.6 EUR/L recycled paint sold for export
Profitable without support	No	Yes	Yes	No	No

[144] Estimate based on information from Reconomy and PAINT 360: cost 140-180£/container; average 100 cans of paint/container, average 1.2L of paint/can. A €/£ exchange rate of 1.2 was used.

6. Conclusions

Table 14: List of conclusions

Transverses	
Conclusion 1	**There is no interest in dissociating the flows of professionals from those of private individuals in terms of recycling (same composition).**
Conclusion 2	**In terms of collection, it is relevant to develop channels adapted to the waste of private individuals and those of professionals, and to rely on the existing system to ensure a sufficient level of service. Collection by retailers should be considered as a regulatory obligation.**
Conclusion 3	**Producers play a key role in the success of recycling by facilitating the sharing of information about composition to recyclers and by creating demand for recycled products.**
Conclusion 4	**No operational recycling solutions have been identified for used adhesives, coatings, and sealants** (post-consumer)
Paints: Recycling water-based paints is feasible, environmentally relevant, and efficient.	
Conclusion 5	**The recycling of solvent-based paints is technically feasible but more demanding than the recycling of water-based paints: it is not widely practised.**
Conclusion 6	**Recycling of water-based paints is technically feasible in France**
Conclusion 7	**Source separation targets for water-based and solvent-based paints are not necessary, at least not initially**
Conclusion 8	**The quality of recycled paints depends on how selective the acceptance criteria are, and on the post-consumer recycled content. It is a matter of strategic positioning.**
Conclusion 9	**The existence of paint recycling initiatives in the Netherlands and the United Kingdom indicate the likely economic feasibility of recycling water-based paints under certain conditions (access to a sufficient waste volume, input selectivity, and relatively more expensive competing outlets). However, the profitability of possible initiatives in France needs to be further studied. An increase in the EPR downstream support scale and additional outlets (paint use in concrete, export) are likely to be necessary to achieve high recycling / material recovery rates (lower selectivity).**
Conclusion 10	**The re-use of paints is not a profitable solution today but could be envisaged via the social economy or municipal waste disposal centres. An appropriate legal framework and more communication would be necessary for a deployment in France.**
Conclusion 11	**The recycling of water-based paints can be achieved within the current regulatory framework. To allow projects to emerge, several preconditions seem necessary (waste status, validation of market entry based on the label and some tests).**
Conclusion 12	**Recycling water-based paints provides environmental benefits**

PU foams: Recycling PU foams is feasible and environmentally relevant. It is less economically efficient than water-based paint recycling and requires an increase in the EPR downstream support scale. The fact that the producers are driving the process is in favour of starting the process.	
Conclusion 13	**Recycling the content of PU foam cans is technically feasible, for the prepolymer (1k foams only) and the propellant (1k and 2k foams).**
Conclusion 14	**The quality of the finished products is close to that of the virgin products, but lower and more variable, so formulation tests are necessary.**
Conclusion 15	**A French separate collection scheme for recycling PU foams would not be cost-effective and requires an increase in the EPR downstream support scale compared to the collection of aerosols for energy recovery.**
Conclusion 16	**The recycling of PU foams can be done within the existing legal framework, but a framework will have to be established so that the prepolymer and propellant both cease to be waste, a necessary condition to develop the market for these products.**
Conclusion 17	**The recycling of PU foams provides environmental benefits. However, the efficiency of this scheme needs to be studied (environmental benefits per unit cost). The fact that producers are favourable to a scheme argues in favour.**

6.1. Transversal

Conclusion 1. There is no interest in dissociating the flows of professionals from those of private individuals in terms of recycling (same composition).

There is no real technical logic to separating the professional and private streams in terms of recycling. The composition of these products is similar, it is mainly the packaging that changes. All the initiatives identified abroad mix these flows.

Conclusion 2. In terms of collection, it is relevant to develop channels adapted to the waste of private individuals and those of professionals, and to rely on the existing system in order to ensure a sufficient level of service. Collection by retailers should be considered as a regulatory obligation.

In terms of collection, it is relevant to develop appropriate collection channels for the two types of holders (frequented places, waste volumes accepted, synergies with waste collection channels that will be developed as part of the French EPR for construction materials and that are likely to collect household chemical waste). It will be possible by ensuring the articulation between waste disposal centres, distributors (DIY stores, specialised shops), on-site collection, and/or door-to-door collection on-call and/or occasional collection.

- Among the initiatives identified, on-call collection mainly concerns professionals (in Germany, the Netherlands, and the UK) but also concerns household waste in North America.
- The waste disposal centres are still part of the scheme because :
    - These actors were already collection actors before the introduction of recycling and the holders were already directing their flows to them.
    - This allows stakeholders to take all their household chemical waste to the same place (those not included in recycling programmes remain as hazardous waste).
    - It is a place for communication and awareness-raising among households and professionals about the act of sorting and the fact that their waste will be recycled.
    - As these places are places of communication, they can offer paint for reuse or even recycled paint.
- The proportion between the different channels varies greatly depending on the streams and the countries:
    - For example, waste disposal centres play a minor role (10%) for the collection of PU foams in relation to the low share of household waste in the total waste stream, whereas the collection of water-based paints in North America relies mainly on hazardous waste disposal sites (similar to waste disposal centres).

- The schemes in the Netherlands and the UK do not rely on distributors as there is no obligation to accept the streams, whereas distributors have a take-back obligation in Germany, the US and Canada. In North America, although there is a take-back obligation, a significant proportion of the stream (varying by state) comes from hazardous waste collection points.

The level of service for the waste holders is key to achieving a sufficient collection rate. This involves :

- free collection for all holders, sometimes subject to volume conditions (maximum volume in the United States, the Netherlands and the United Kingdom accepted in waste disposal centres, minimum volume in Germany for door-to-door collection).
- networking objectives, as in the United States, Canada, and Germany.
- on-call collections for large volumes (Canada, United States).
- one-off collection events (Canada, United States).
- a special service for waste holders in Germany – a free mailing service for waste holders who are far from collection points, collection service available by telephone.
- the possibility of delivering other waste streams and in particular paints not included in the programme in the case of a site collecting several waste streams (United States, Canada).

Conclusion 3. Producers play a key role in the success of recycling by facilitating the sharing of information about composition to recyclers and by creating demand for recycled products.

Table 15: Transversal analysis - Role of producers

Initiative	RDP	AKZONOBEL - INTERCHEM	PAINT360	PRODUCT CARE	PAINTCARE
Voluntary sharing of composition from producers to recyclers	Yes	No	No	No	No
Use of recycled products by producers	Yes	Yes	Yes	No incentive	No incentive

In the case of the PDR initiative, the strong involvement of producers is decisive for the success of the initiative. First, they started to recycle the content of the cans, and are shareholders of the Product Responsibility Organisation. Another key success factor is that producers share changes in the composition of their products with PDR in a confidential manner so that PDR can adapt its recycling process, if necessary, by being a few months ahead. In addition, many of the producers are also buyers of the recycled end products and therefore provide a market for the recycler.

For the European water-based paint recycling initiatives, two dynamics are observed: on the one hand the AKZONOBEL-INTERCHEM initiative where the producer AKZONOBEL is the main driver; on the other hand, the PAINT 360 initiative where producers do not play a driving role. It should be noted that PAINT 360 supports and shares with PAINTCARE UK, which is a voluntary collection and recycling initiative of the British Paint Manufacturers Association. Thus, for both initiatives, the producers are either directly driving or supporting recycling initiatives. In all cases, the representatives of manufacturers interviewed reported a favourable opinion regarding the recycling of water-based paints.

In North American EPRs, although there is no direct incentive to use recycled paint via a support scale, it is worth noting that many paint recyclers are also producers of virgin paint, which shows their involvement in the scheme.

In the water-based paint recycling initiatives, there is no active sharing of the composition of the paints, but recyclers can have access to the safety data sheets and the list of paints participating in the programmes. However, the data provided in the safety data sheets is partial and it could not be established that all compounds relevant for recycling have been identified to comply with French and European requirements. The lack of complete data in the SDSs means that additional testing is required at the beginning of the recycling process to overcome the uncertainty in composition.

Conclusion 4. No operational recycling solutions have been identified for used adhesives, coatings, and sealants (post-consumer)

6.2. For paints

Conclusion 5. The recycling of solvent-based paints is technically feasible but more demanding than the recycling of water-based paints: it is not widely practised.

Of the initiatives studied, only one actor recycles solvent-based paints. Solvent-based paints are generally separated either at source or at the beginning of the recycling process and destined for energy recovery.

However, solvent-based paints are technically recyclable through the same types of recycling processes as water-based paints. It is the lower economic potential that leads many recyclers to exclude these paints from recycling:

- Recycling of solvent-based paints requires additional skills and authorisations related to the handling of hazardous waste and substances, which increases the costs of recycling compared to the recycling of water-based paints.
- Recycled solvent-based paints must meet the same product regulations in terms of VOC (volatile organic compounds) content, which is not possible when recycling older solvent-based paints.
- The quantities of solvent-based paint waste collected are lower than the quantities of water-based paint waste, and these quantities are decreasing due to the regulations on VOC: the economic potential related to economies of scale is therefore more limited.
- There is a diversity of solvent-based paints that would require the creation of separate streams depending on the solvents used, which further reduces the volume per product recycled.

Conclusion 6. Recycling of water-based paints is technically feasible in France

From a technical point of view, recycling processes of water-based paints are mainly composed of a sorting stage of the paints with separation of non-recyclable paints (solvent-based[145] , dry, ...), then mixing by colour and filtration, as well as the addition of optional additives to improve the properties of the paints. Depending on the initiative, one or more colours are produced, and the product range can also be distinguished by the recycled content, the presence of biocides for certain applications.... Then, a quality control step for different parameters (pH, viscosity, brightness, colour, microbiology, drying, covering capacity, presence of lumps) is implemented per batch.

These processes are standard waste treatment and paint formulation processes, so there are no barriers to replication in France.

They require chemical expertise and laboratories for quality control, and storage space to store the result of the sorting before production, and after recycling, to store the pending colours to have sufficient quantities before marketing them.

The figure below summarises the different recycling processes carried out by the initiatives studied.

[145] some recyclers, in particular in Canada, indicate that they can recycle water-based and solvent-based products in separate streams

Recycling Process (water-based paint)

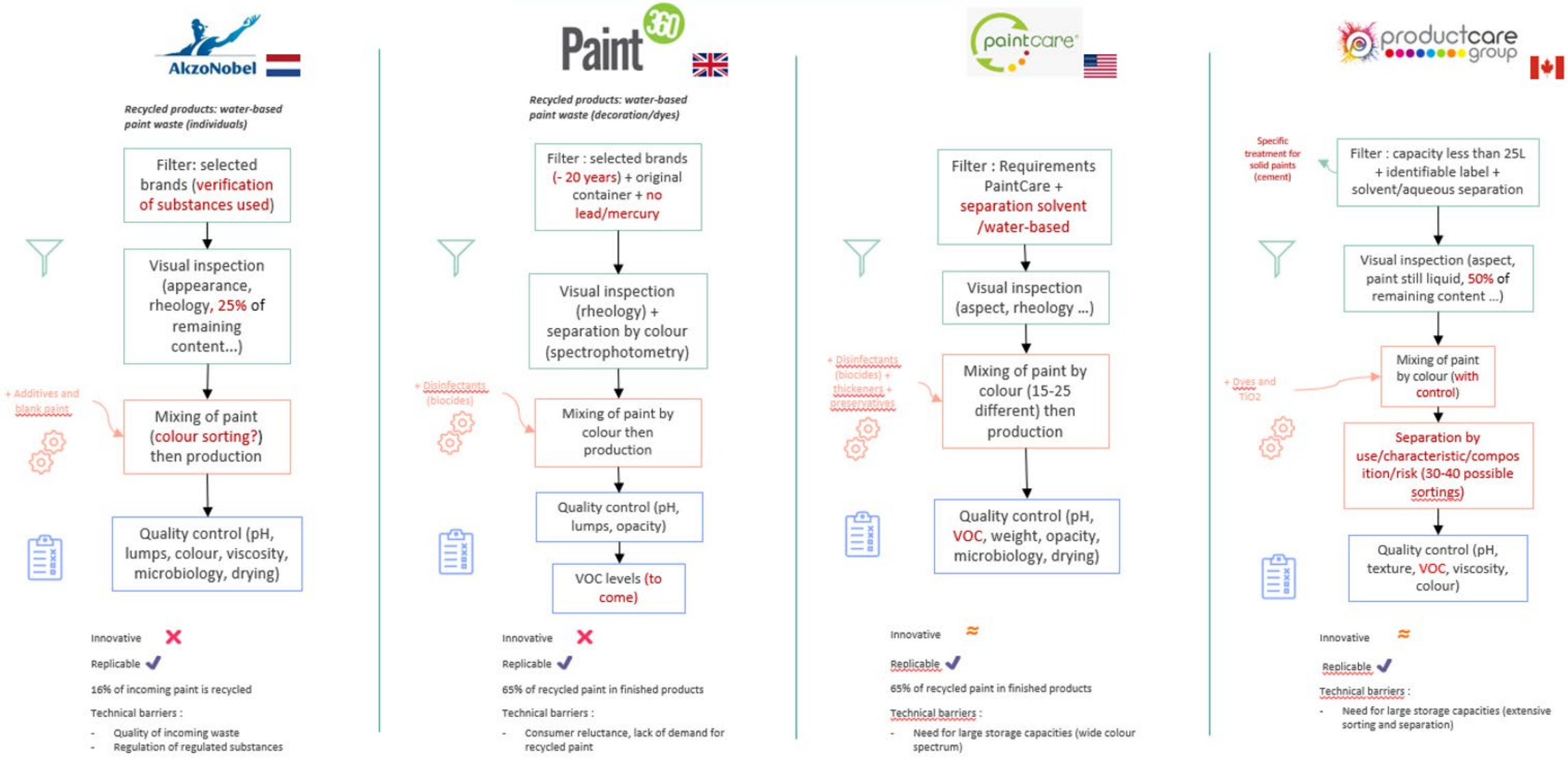

Figure 19 Water-based paint recycling process (key points in red)

Conclusion 7. Source separation targets for water-based and solvent-based paints are not necessary, at least not initially

To recycle water-based paints, a separation between water-based and solvent-based paints must be achieved at some point in the chain. Recycling initiatives identified abroad have shown that several operational arrangements are possible (separation at source, at the gathering point or at the beginning of the recycling process). The choice of when to carry out the separation should be made according to the economic optimum of the value chain. Separating water-based and solvent-based paints at source has three advantages:

- Sorting is carried out in part free of charge by the user of collection point.
- The cost of transporting solvent-based paints to the recycling plant and then transporting them back for energy recovery is avoided.
- ADR transport and associated costs can be avoided if water-based paints are transported alone (which is not often the case in practice).

However, these advantages must be nuanced. If recycling capacities are insufficient at national level or poorly distributed over the territory, generalised source separation may be useless in some places and may generate additional costs where the paint is not ultimately recycled. Separation at source should be encouraged first in areas with a large potential waste stream (densely populated) or close to recycling facilities to optimise logistics.

Thus, it seems appropriate to leave flexibility in the operational choices for separate collection, depending on local conditions. Recycling targets will be the policy instrument to drive the implementation of either separate collection or sorting of water-based paints.

Conclusion 8. The quality of recycled paints depends on how selective the acceptance criteria are, and on the post-consumer recycled content. It is a matter of strategic positioning.

For North American initiatives, quality defects can be explained by low input selectivity and high recycled paint incorporation rates (50 to80% for white paints in Canada, up to 93% in the US). The quality of recycled paints is considered lower than the quality of virgin paints.

For the European initiatives, the prices of recycled paints are equivalent to those of virgin paints. This can be explained by a higher selectivity and a lower incorporation rate of recycled paints (35% recycled for AKZONOBEL, 65% for PAINT 360). Recycled paints are considered to be of equivalent quality to virgin paints.

In general, all operators are implementing quality procedures (input and output controls), possibly backed up by certification.

Thus, the quality of finished products is a matter of strategic positioning of the sector: high recycling targets may lead to a reduction in product quality, but this can be compensated for by the addition of virgin products. The sector may also consider the loss of quality acceptable in view of the market segments targeted. Lastly, the user's perception may be different from the real quality of the product, due to image effects.

Conclusion 9. The existence of paint recycling initiatives in the Netherlands and the United Kingdom indicate the likely economic feasibility of recycling water-based paints under certain conditions (access to a sufficient waste volume, input selectivity, and relatively more expensive competing outlets). However, the profitability of possible initiatives in France needs to be further studied. An increase in the EPR downstream support scale and additional outlets (paint use in concrete, export) are likely to be necessary to achieve high recycling / material recovery rates (lower selectivity).

Recycling initiatives in the Netherlands and the UK operate without financial support from an EPR scheme or government, and without regulatory recycling targets. This indicates that it can be economically feasible to recycle water-based paints under certain conditions without additional costs compared to energy recovery. The UK initiative has been operating for several years and can therefore be considered cost-effective. The Dutch initiative is more recent, and its profitability cannot be guaranteed at this stage.

However, North American industries would not be profitable without financial support.

In reality, the way of operating of these initiatives is intrinsically different and the scope of the economic analysis is therefore not comparable:

- Voluntary recycling initiatives in Europe do not finance the treatment of non-recyclable flows (excluded brands, solvent-based paints) and focus on the profitable part of the waste stream (choice of profitable volumes via collection partners, choice of white paints for the Dutch initiative). Colours that are not in high demand are used for material recovery in concrete. It should also be noted that the initiatives operate in a national context where the alternatives for the treatment of paint waste (energy recovery or landfill) are relatively less competitive than recycling.
- North American initiatives fund collection and recycling of all streams, including colours in low demand and low-quality products, which are then destined for export or for use in concrete or energy recovery.

In conclusion, three conditions are necessary for the emergence of a recycling scheme without additional costs compared to current management:

- allow recycling initiatives to access a source of material currently destined for energy recovery.
- the use of public policy instruments for waste that make recycling more competitive than alternative treatment methods (taxation, regulation),
- selection of the most profitable volumes (collection points located near recycling units and possibly able to set up source separation) and with a domestic market (colours, composition). This makes it possible to guarantee a certain initial profitability, to develop R&D for other types of outlets, etc., and then to gradually expand to other products.

Nevertheless, to recycle a larger part of the available waste stream, it would imply :

- to seek out flows that are less profitable from a logistical point of view, which could lead to additional collection costs.
- to be less selective in terms of input to the recycling process, which would generate waste management costs for the part that cannot be recycled and would require the development of other outlets (material recovery for concrete use, export) for paints of lesser quality, or which have no domestic attractiveness due to colour trends. This would have to be studied on a case-by-case basis and according to the associated environmental issues (no data on paint use in concrete and export).

Conclusion 10. The re-use of paints is not a profitable solution today but could be envisaged via the social economy or municipal waste disposal centres. An appropriate legal framework and more communication would be necessary for a deployment in France.

Only North American EPR schemes encourage re-use. Paints are offered to users either freely or for a small fee, and this with no specific guarantee of quality. Re-use sites are usually municipal waste collection sites or sites run by NGOs with a social vocation (such as Habitat for Humanity in the US). These places seem to be relevant in practice, but in an unclear legal context concerning the quality framework.

To make this outlet more consistent, it would be useful to develop an evaluation of these paints to be re-used, as well as a guarantee assuring the final consumer of the quality of the re-used product. Another obstacle to re-use is the limited quantity of paint containers available. Communication should also be developed to generate more demand.

Conclusion 11. The recycling of water-based paints can be achieved within the current regulatory framework. In order to allow projects to emerge, several preconditions seem necessary (waste status, validation of market entry based on the label and some tests).

The table below lists the different regulatory characteristics of the initiatives studied.

Table 16: Transversal analysis - paint recycling - regulatory framework

Initiative Country	AKZONOBEL-INTERCHEM The Netherlands	PAINT360 United Kingdom	PRODUCT CARE Canada	PAINTCARE United States
Classification of used water-based paints as hazardous waste	No	No	No[146]	No
Authorisation of collectors	Yes	Yes	Yes	Yes, above a threshold
ADR transport	Yes	Yes	Possible exemption from certain requirements (licences) But obligation to indicate the substances transported	Obligation to indicate the substances transported
Environmental licences for recycling	Yes	Yes	Yes	Yes
Labour law regulations	Yes CLEAR	Yes CLEAR	Yes CLEAR	Yes Training requirement for collection sites, transporters, and recycling sites
Exemption for substances in finished products	Yes	Yes	Yes	Yes
Waste status of finished products	Yes (without specific criteria)	Yes (without specific criteria)	Yes (without specific criteria)	Yes (without specific criteria)
Safety Data Sheet or equivalent	Yes, voluntary	Yes, voluntary	Exempt for recycled products	Exempt for recycled products

The management of collection and recycling operations is similar to the French one (registration of operators, environmental licence for recycling facilities, waste tracking slips for hazardous waste, ADR transport when water-based paints are transported in the same truck as solvent-based paints, occupational health, and safety rules...). The regulations are not an obstacle to the implementation of water-based paint recycling. The need to develop less stringent regulations concerning the transport of water-based paints was not identified in the countries surveyed.

Although water-based paints are generally classified as non-hazardous waste in the countries surveyed (unless they contain biocides), the hazardous or non-hazardous waste classification of water-based paints did not emerge as a particularly key issue abroad, as water-based paints are often transported together with solvent-based paints and sorted at the gathering centre or recycling plant. Thus, hazardous waste management licences are largely required within the industry. If the French recycling industry wished to validate that water-based paint waste can be considered non-hazardous, to operate within the associated regulatory framework, the categorization as non-hazardous waste based on label sorting would not be possible. A representative characterisation would be

[146] Some products approved by the Pest Control Act (probably hazardous) are not accepted in the collection and recycling scheme

needed to demonstrate that waste from products that do not show any hazard pictogram on their label are indeed non-hazardous waste, and thus to validate or not the relevance of a label-based sorting.

The registration of recycled substances is not mandatory due to the possibility of benefiting from the exemption provided for in Article 2.7d) of the REACH Regulation.

The production of Safety Data Sheets is not mandatory for the market entry of most non-hazardous recycled water-based paints but has been implemented on a voluntary basis by the two European recycling initiatives. The sheet is produced from information on input waste (selection at the entrance of predefined brands) and analyses of composition on the finished product. Little information was obtained on the parameters monitored and the protocol. The validity of this protocol for the French authorities would need to be confirmed.

Recycled water-based paints cease to be waste in all the countries surveyed. Compared with France, the framework to receive end-of-waste is more flexible in studied countries in the sense that no application file was required but self-assessment was allowed. End-of-waste allows products to be transported and marketed without any constraints compared to virgin products. Additionally, in the absence of any dispute from importing countries on the waste status[147] , to lift the requirements related to waste transboundary shipment.

Conclusion 12. Recycling water-based paints provides environmental benefits

Recycling of water-based paints is superior to material recovery or energy recovery (CSR, incineration) in the waste treatment hierarchy.

The use of recycled paints in concrete should be considered as material recovery and not as recycling, as it involves reprocessing waste into secondary raw materials for engineering purposes in road and other infrastructure construction[148] . However, concrete incorporating recycled paints could also be considered a product itself. This interpretation will therefore need to be clarified by the French authorities when calculating any recycling targets.

The elements identified in the framework of this study provide elements to support the hierarchy of treatment methods:

- PAINT 360 conducted a life cycle analysis comparing the use of virgin paint versus paint containing recycled content (65-90%). The study concludes that recycled paint has a 1.3 kg lower CO_2 impact per litre of paint than virgin paint.
- Recycling of water-based paints saves virgin material by substituting virgin paints. Preliminary analysis of the European Ecolabel shows that about 50% of the impact of paints is due to the manufacture of raw materials and their procurement[149] . The substitution rate varies between initiatives: the more selective European initiatives claim a similar quality to virgin paint and therefore a substitution rate close to 1. In contrast, the North American initiatives claim a decrease in opacity and range for some recycled paints, suggesting the need to increase the quantities used to achieve equivalent characteristics to virgin paint.
- Recycling of water-based paints is energy and resource efficient, suggesting limited environmental impacts for the recycling phase. Residues that cannot be recycled go to incineration, which is the treatment method that would have been adopted anyway if the paint was not recycled.
- There is a significant volume of water-based paints that have reached the end of their life (between 10 and 20,000 tonnes with packaging), which allows to consider several recycling units on the territory, thus reducing the environmental impact of the logistics.
- The systems identified abroad allow for significant collection, recycling and even reuse performances
    - Collection: between 4 and 12% of the quantities placed on the market are collected by collection schemes in North America[150,151]

[147] According to Article 28 of Regulation 1013/2006 of 14/06/06 on shipments of waste "If the competent authorities of expedition and destination cannot agree on its classification as waste or not, the object of the shipment shall be treated as if it were a waste". This is adapted from the Basel Convention. In the countries surveyed there was no explicit verification of agreement by the competent authorities of the importing countries. France requests such verification.

[148] According to the Environmental Code Article L541-1-1, recycling is a "recovery operation by which waste (...) is reprocessed into substances, materials or products for its original function or for other purposes". Material recovery refers to any recovery operation other than energy recovery and fuel manufacture. It includes preparation for re-use, recycling, landfilling and other forms of material recovery such as reprocessing of waste into secondary raw materials for engineering purposes in road and other infrastructure construction.

[149] Source: Background report for the revision of EU Ecolabel, 2012

[150] A study conducted for Quebec more than 10 years ago provided data on residual paint levels in paint cans
-paint for households: 13% of residues
-painting for professionals 1
-average : 7%.

[151] The recycling initiatives studied in the UK and the Netherlands do not cover the whole country in terms of collection. Performance is therefore not relevant here.

- Recycling: between 64 and 90% of the quantities collected are recycled
- Reuse: 2-4% of the quantities collected are reused in North America (sufficiently full cans)

No specific data is available on the recovery of paints for export or the material recovery of paints.

6.3. For PU foams

Conclusion 13. Recycling the content of PU foam cans is technically feasible, for the prepolymer (1k foams only) and the propellant (1k and 2k foams).

The PU foam recycling process consists of crushing the cans to extract the propellant gas and drop the prepolymer into a solvent bath from which it is recovered by distillation. The packaging is also recovered (>80% recycling and re-use, 70% on the content alone). The prepolymer is reformulated with virgin materials into a blend, at different recycled content rates, depending on the users' needs.

In principle, this process can be replicated in France without any obstacles. It is a hazardous waste treatment process with specific operating conditions (under vacuum). It requires control of environmental requirements (avoiding propellant gas leaks) and safety requirements (preventing exposure to isocyanate, which is a carcinogenic substance). Capital requirements are higher than for water-based paint recycling.

The presence of water in the process must be avoided, as it leads to a hardening of the prepolymer, which reacts in the plant and causes costly cleaning of the recycling line. Therefore, rusty, or perforated cans, which potentially contain water, should not be accepted in the collection scheme and if collected, they should be discarded at the entrance of the recycling unit.

For 1k PU foams (single component), both the propellant and the prepolymer (which had not reacted) are recyclable. For 2k PU foams (bicomponent), only the propellant is recyclable, as the polymer is already formed and hardened it can only be used to produce energy. In practice, the 1k and 2k PU foam cans are manually sorted at the entrance of the recycling process and undergo separate shredding so that the polymer does not contaminate the prepolymer. The option of sorting at source was not chosen by PDR.

Conclusion 14. The quality of the finished products is close to that of the virgin products, but lower and more variable, so formulation tests are necessary.

The quality of the finished products is close to that of the virgin products but lower and more variable (within a given range), justifying a lower selling price and a mixing of the recycled product with virgin to avoid problems during storage and transfer of the prepolymer (cold thickening).

The prepolymer can be re-used for the manufacture of PU foams, or glues depending on the constraints of the manufacturers' formulations.

Conclusion 15. A French separate collection scheme for recycling PU foams would not be cost-effective and requires an increase in the EPR downstream support scale compared to the collection of aerosols for energy recovery.

In Germany, the material revenues only compensate for the recycling costs, and it can be assumed that separate collection of PU foams is more expensive than the collection with all aerosols. In Germany, collection for recycling has an additional cost of 11ct EUR/cartridge placed on the market compared to collection for energy recovery. Thus, any development of a recycling scheme in France would require the EPR scheme to provide funding for a dedicated separate collection, which is more expensive than the collection of mixed aerosols for energy recovery. Pooling the collection of PU foams with the French EPR scheme under development for construction materials could help contain costs.

Conclusion 16. The recycling of PU foams can be done within the existing legal framework, but a framework will have to be established so that the prepolymer and propellant both cease to be waste, a necessary condition to develop the market for these products.

The table below summarises the main features of the regulatory framework applicable to the PU foam recycling initiative carried out in Germany by PDR.

Table 17: Recycling of PU foams - regulatory framework

Initiative	PDR
Classification of waste as hazardous waste	Yes
Authorisation of collectors	Yes
ADR transport	No if the cans are sealed and packed
Environmental licences for recycling	Yes
Labour law regulations	Yes. Control the presence of isocyanate in the air and I n the employees' bodily fluids
Exemption for substances in finished products	Yes
Waste status of finished products	Yes (without specific criteria)
Safety Data Sheet or equivalent	Yes

The regulatory framework covering collection and recycling operations is similar to the French framework (registration of operators, environmental licences for recycling facilities, waste tracking slips for hazardous waste, occupational health, and safety regulations, etc.). These elements are not an obstacle to the implementation of PU foam recycling.

The registration of recycled substances is not mandatory due to the possibility of benefiting from the exemption provided for in Article 2.7d) of the REACH Regulation. This exemption is applied by PDR in Germany.

The recycled products (prepolymer and propellant) are subject to Safety Data Sheets. The sheet is produced from information on the incoming products (information from the producers) and a quality control on the finished product. Little information was obtained on the parameters monitored and on the protocol.

Prepolymer and propellant finished products benefit from an end-of-waste in Germany. The framework is more flexible than in France, insofar as no application file was required (self-assessment was allowed). This has made it possible to lift the requirements linked to waste transboundary shipment and to market the products without any particular constraint compared to virgin products.

The collection scheme receives the derogation of limited quantities within the ADR regulation if the cans are closed (by hardened foam or a cap for full cans) and packed vertically. This derogation enables a reduction of collection costs.

Conclusion 17. The recycling of PU foams provides environmental benefits. However, the efficiency of this scheme needs to be studied (environmental benefits per unit cost). The fact that producers are favourable to a scheme argues in favour.

Recycling of PU foams is superior to its energy recovery (incineration) in the waste treatment hierarchy. The elements identified in this study support this idea:

- Recycling of PU foams is resource and energy efficient (e.g., regeneration of the solvent used for extraction).
- According to an LCA carried out in 2013, the PDR system based on the recycling of the non-consumed content would avoid between 0.35 and 0.40 kg CO_2 eq. /cartridge collected compared to a system based on the energy recovery of the content, i.e., 3,500 tonnes CO eq_2 /year if 10 million cans were collected. This corresponds to the annual carbon footprint of 350 French people. The results are also favourable to recycling for the other environmental impact categories studied.
- Recycling of PU foams results in high recycling rates (81% for all packaging and contents).

It should be noted that the additional cost of collecting PU foams for recycling (0.11 EUR /can) is about 300 €/t CO_2 avoided, i.e., about the reference value of carbon recommended for France in order to judge the efficiency of public policies (250 €/t in 2030). The question of the efficiency of a separate collection obligation financed by PU foam producers arises. In principle, the costs and benefits should be further investigated before considering a separate collection obligation.

However, as most PU-foam producers are in favour of setting up this scheme at their own expense[152], it seems relevant and acceptable to launch the collection scheme for recycling in France.

[152] French producers are largely in common with PU foam producers who have set up a voluntary content recycling scheme in Germany, and with producers considering a similar scheme in the Benelux.

7. Recommendations

Table 18: List of recommendations

Organisation of the EPR	
Recommendation 1	**Ensure synergies between the EPR scheme for Chemical Products and the EPR scheme for Construction Materials. Ensure a coherence between the objectives applicable to both schemes and the associated collection channels.**
Recommendation 2	**Progressively implement recycling of water-based paints within the framework of the current recycling targets of the EPR scheme for Chemical Products and the planned experimentation, assess the waste volume, and then increase the ambition of the recycling targets and make them more specific to recyclable waste flows**
Recommendation 3	**Define specific recycling targets for PU foam cans after assessing the waste**
Recommendation 4	**As part of the EPR, foresee a dedicated downstream support scale for PU foam cans' collection for recycling**
Recommendation 5	**Integrate as part of the system of bonus/malus for EPR fees a criterion on post-consumer recycled content for water-based paints**
Recommendation 6	**Provide support to the scheme to develop outlets for recycled coating and adhesion products**
Recommendation 7	**Mobilise public purchasing on recycled paints**
Recommendation 8	**Study the feasibility of recycling products similar to water-based paints, considering the available volume**
Recommendation 9	**Encourage R&D for the recycling of other products (glues, sealants, coatings)**
Organisation of collection	
Recommendation 10	**Ensure the existence of collection channels for PU foam suitable for professionals, possibly with a deposit system or geographical coverage targets**
Organisation of recycling	
Recommendation 11	**Develop synergies with neighbouring countries for the recycling of small waste streams, while respecting the principle of proximity**
Regulation	
Recommendation 12	**For the collection of PU foams, investigate the relevance of applying the limited quantity regime of the ADR regulation and the exemption from the obligation to have a hazardous waste collection licence**

7.1. Organisation of the EPR

Recommendation 1. Ensure synergies between the EPR scheme for Chemical Products and the EPR scheme for Construction Materials. Ensure a coherence between the objectives applicable to both schemes and the associated collection channels.

The EPR scheme for Chemical Products only deals with chemical waste below a certain volume[153] . Above these volume thresholds, the EPR scheme for Construction Materials will take care of chemical waste[154] . The products covered by these two schemes may be conditioned in different types of packaging, or even used by different types of users, but their composition is similar, and they can therefore be recycled together.

In addition, some of the household-like chemical waste[155] are not currently covered by the collection systems set up by ECO-DDS for professionals (e.g., aerosols, including PU foams or paints, are not accepted in the Rekupo system). Household-like waste from professionals can be accepted at municipal waste disposal centres, but the question of how this service is implemented in practice, and whether it meets the needs of waste holders arises.

The texts relating to the EPR scheme for Construction Materials are still under discussion at the time of writing this report[156], so the framework that will apply is not yet stabilised. However, craftspeople will gradually have access to collection channels via the EPR scheme for construction materials, which could also receive chemical products (intentionally or as an error in the sorting procedure).

It is therefore important to establish communication between the Producer Responsibility Organisations in charge of the two schemes, which can be facilitated by the public authorities, if necessary, regarding the development of suitable collection channels, possible financial compensation, and synergies in terms of treatment.

Recommendation 2. Progressively implement recycling of water-based paints within the framework of the current recycling targets of the EPR scheme for Chemical Products and the planned experimentation, assess the waste volume, and then increase the ambition of the recycling targets and make them more specific to recyclable waste flows

In France, it will be difficult for the recycling scheme to emerge outside of the EPR scheme, which currently captures a significant part of the water-based paint deposit. A boost may therefore be needed to promote collection for recycling and the massification of EPR and non-EPR recyclable waste.

The existing recycling targets (1% of the content of categories 4 and 5 in the framework of the experiment to be carried out by 1er July 2022, and 5% of the quantities of chemical waste of categories 3 to 10 collected from 2023 onwards) constitute a boost, but they have not been reached to date. They are technically largely achievable given the large share of recyclable water-based paints inside the chemical waste volumes being collected and considering the recycling rates achieved by individual water-based paint initiatives assessed in this study (64-90% of the quantities collected[157]).

A gradual deployment of the scheme is preferable to initially favour the recycling of the most profitable flows (choice of collection points and types of waste entering the recycling process, etc.). This is possible within the framework of the current objectives. Such a deployment guarantees some initial profitability, gives some time to study the waste stream, to develop R&D for other types of outlets, and then to gradually expand recycling to other products. This should preferably be organised in coordination with the EPR scheme for Construction Materials to optimise flows and infrastructure development.

The need for a higher EPR downstream support scale for water-based paint recycling than for energy recovery is not proven by this study, as some initiatives are operating in other countries in a cost-effective and voluntary way. It is therefore relevant to set recycling targets that guarantee recyclers a quantity of waste collected for recycling and to let the Producer Responsibility Organisation organise itself to achieve this target. It might also be possible for public authorities to financially support particularly innovative projects whose benefits exceed the regulatory targets.

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[153] Sprayable products (paints and PU foams) are now accepted in the aerosol collection scheme.

[154] Decree No. 2021-1941 of 31 December 2021 on extended producer responsibility for construction products and materials in the building sector specifies that "mortars, coatings, paints, varnishes, resins, preparation and implementation products, including their containers, other than those mentioned in 7° of Article L 541-10-1", i.e., other than those concerned by EPR for chemical products, will be concerned by EPR for PMCB.

[155] List of the Ministerial order of 1 December 2020 establishing the list of chemicals mentioned in 7° of Article L. 541-10-1 of the Environmental Code

[156] The draft specifications currently under public consultation do not specify how chemical waste will be collected by the EPR PMCB http://www.consultations-publiques.developpement-durable.gouv.fr/IMG/pdf/projet_cdc_rep_batiment_consultation_public.pdf

[157] The 16% figure for the quantities collected by Interchem is not comparable with the others.

Once the recyclable waste stream has been assessed, recycling targets may evolve and become more specific to certain products such as water-based paints, varnishes, and water-based wood stains. In time, targets for products that are more difficult to recycle could also be added.

Recommendation 3. Define specific recycling targets for PU foam cans after assessing the waste

In Germany, it was the regulatory framework in place for packaging that led to a voluntary scheme to recycle the content of waste PU foam cans. However, the lack of common recycling targets for PU foam cans' content prevents recycling from covering the entire PU foam market.

In France, PU foam cans are already collected but are not destined for recycling. To develop the recycling of PU foams, specific targets for separate collection for recycling or for recycling of the PU foam stream will have to be developed. Indeed, PU foams will have a low contribution to the overall chemical waste recycling targets due to the quantities involved[158]. Specific recycling targets will therefore be needed to direct these streams towards recycling. In Germany, about 70% of the collected stream is recycled (content).

Recommendation 4. As part of the EPR, foresee a dedicated downstream support scale for PU foam cans' collection for recycling

The complete collection for recycling of PU foams is more expensive than the collection for energy recovery (about 11 EUR ct per can in Germany). The additional collection costs are not compensated by the material resales, which only compensate the recycling costs.

The downstream support scale must therefore be adapted to finance collection for recycling. This could be done by increasing the financial contributions for these products. It should be noted that this could be done with the support of the producers, who are for the most part common with the members of the PDR programme in Germany.

Recommendation 5. Integrate as part of the system of bonus/malus for EPR fees a criterion on post-consumer recycled content for water-based paints

The incorporation of recycled paint is not suitable for all market segments, due to a degradation of certain properties and a mismatch between the colours sold and the colours available as waste. A mandatory post-consumer recycled content could not be applicable to all producers depending on their positioning (quality, colours) and is therefore not a relevant instrument. The relevance of this instrument would have to be evaluated for the incorporation of recycled ingredients (e.g., binders, pigments) depending on the environmental relevance of this type of recycling, which remains to be assessed (see experimental project on TiO_2 recycling in the full report).

However, the introduction of a bonus / malus for water-based paints' EPR fees according to the post-consumer recycled content could provide an incentive for producers to experiment or generalise the incorporation of recycled paint in their products. Such an approach would have the advantage of :

- Encouraging an exchange between producers and recyclers on the composition of virgin and recycled products, allowing the sector to build capacity related to paint eco-design and recyclability.
- Encourage producers to think about the development of outlets and marketing for recycled paints.

Recommendation 6. Provide support to the scheme to develop outlets for recycled coating and adhesion products

Matching recycled products with market demand is challenging in terms of technical properties and image. Recycled paints have a different range of colours and properties which need to be considered in terms of market positioning. Recycled prepolymer from PU foam recycling requires compatibility testing with formulations of foam or adhesives that incorporate it.

The Producer Responsibility Organisation, public authorities, or professional federations (depending on the subject) should provide stakeholder support in order to remove the obstacles to the use of recycled products by producers and end consumers. This support could, for example, cover the following aspects:

[158] <1,000 tonnes of content collected in Germany with a mature scheme, compared to a waste stream ranging between 10,000 and 20,000 tonnes of water-based paints in France

- Highlighting the benefits of recycling: comparative life cycle analysis, development of arguments.
- Development of a label or logo or integration with existing logos/labels. For example, PDR has developed a logo for manufacturers incorporating recycled material. Recycled paints are more difficult to comply with the European Ecolabel today, according to AFNOR, because of the label criteria (e.g., supplier declarations of raw materials, audit of the purchasing process).
- Market research.
- Development of partnerships to ensure outlets.
- Industrialization tests.

Recommendation 7. Mobilise public purchasing on recycled paints

Public procurement has been a driver for the development of recycled paint markets for some recyclers in the US. Recycled paint can be relevant for indoor uses, or anti-graffiti paints used by local authorities.

Recommendation 8. Study the feasibility of recycling products similar to water-based paints, considering the available volume

Volumes of water-based varnishes, wood stains and wood oils are relatively small[159] but is growing in France (confidential figures).

Recycling of varnishes, wood stains, wood oils, etc. could :

- Either be organised in a similar way to water-based paint recycling with separation of similar products, mixing and sieving and quality control. The main obstacle according to PAINT 360 is the small volume of available material compared to water-based paints, which does not allow a critical volume of recycled products to be reached to develop a marketable range with sufficient volumes. Could other marketing models, such as those developed by the social economy for re-use, be envisaged to market recycled flows in reduced volumes? This could be explored.
- Or be mixed (in limited quantities) with the paints. This is the choice made by a recycler in Canada, given the small volumes involved.

Recommendation 9. Encourage R&D for the recycling of other products (glues, sealants, coatings)

No initiatives have been identified for these product categories.

7.2. Organisation of collection

Recommendation 10. Ensure the existence of collection channels for PU foam suitable for professionals, possibly with a deposit system or geographical coverage targets

Used expansive foam cans from professionals are not accepted by the French collection channels intended for professionals (Rekupo does not accept aerosols) but must be accepted at the municipal waste disposal centres, as it is the case for all household-like products. The effective use of municipal waste disposal centres by craftspeople is uncertain. Given that PU-foam cans professional waste volumes would represent 80% of the waste collected in Germany, it is essential to develop suitable collection channels for professionals to consider setting up a viable recycling scheme for PU foam. Collection of the professional waste stream could be organised via dedicated channels (on call, professional waste disposal centres) or via retailers, in addition to the municipal waste disposal centres.

The introduction of a deposit system is recommended by the German PDR initiative to improve collection rates. This could not be implemented in Germany because it would not have concerned the entire market (some producers are not part of the recycling scheme). It appears technically feasible because of the relative standardisation of packaging formats, which enables to envisage simple pricing for purchase and return.

[159] It represents 1% of the total collected disposal in the US.

Alternatively, it is necessary to ensure that the network of collection points is sufficient to provide an incentive for household and professional waste holders.

7.3. Organisation of recycling

Recommendation 11. Develop synergies with neighbouring countries for the recycling of small waste streams, while respecting the principle of proximity

According to PDR, an additional PU foam recycling facility is to be envisaged from 20 million cans to be recycled, which probably exceeds the full size of the French market. Other countries (Belgium, Netherlands) are working on a PU foam recycling project. It is necessary to ensure that recycling units are properly located to avoid overcapacity.

The same type of conclusions could be applied to small waste streams: glues, varnishes, coatings, wood stains, etc., for which the technical recycling options have yet to be developed.

These synergies must respect the principle of proximity of waste management methods, so that environmental impacts of waste transport remain limited.

7.4. Regulation

Recommendation 12. For the collection of PU foams, investigate the relevance of applying the limited quantity regime of the ADR regulation and the exemption from the obligation to have a hazardous waste collection licence

According to the German authorities, closed PU foam waste cans packed in cartons would not present a clear physical risk, which could justify the application of the limited quantity regime. The derogation reduces regulatory requirements for cans collection and thus reduce collection costs. Furthermore, Germany does not require collectors of waste PU foam cans to have a licence for the collection of hazardous waste.

The relevance of applying the limited quantities regime, and of lifting the requirement for a hazardous waste collection licence; should be studied by the French competent authorities to examine the risks and opportunities.

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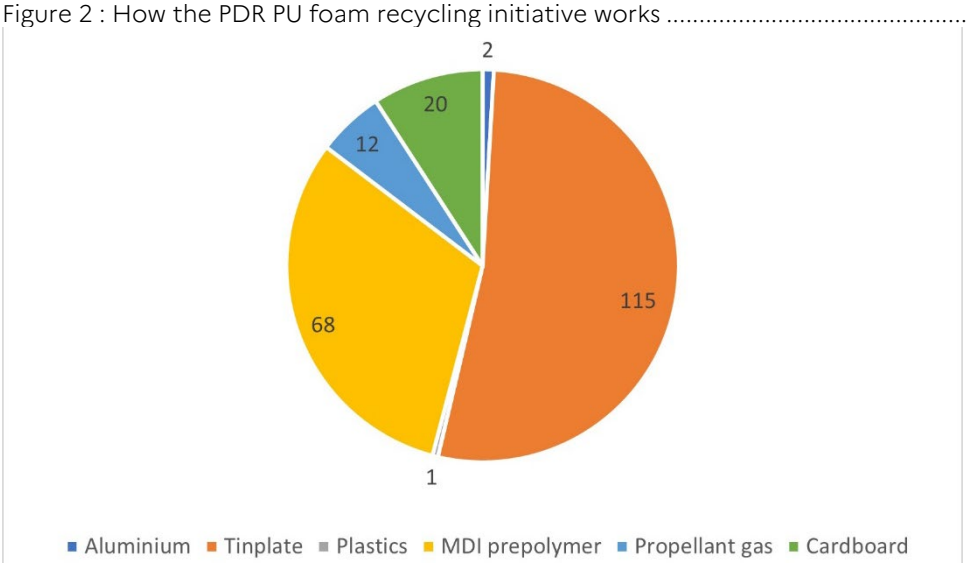

ABBREVIATIONS AND ACRONYMS

ADEME	Agency for the Environment and Energy Management
ADR	Agreement on the Transport of Dangerous Goods by Road
AFISE	French Association of the Detergency, Maintenance, and Industrial Hygiene Industries
AMF	Association des Maires de France
AMORCE	Association of communities, waste management, heat networks, local energy management
APCMA	Permanent assembly of chambers of trade and artisanal crafts
CAPEB	Confederation of Crafts and Small Building Enterprises
CNR	National Circle of Recycling
DGPR	Department for the prevention of risks at the French Ministry of Ecological Transition
ECO-DDS	Producer Responsibility Organisation approved in France for the management of municipal chemical waste
EPR	Extended Producer Responsibility
FCD	Trade and Retail Federation
FDMC	Federation of Building Materials Distributors
FEDEREC	Professional Federation of Recycling Companies
FFB	French Building Federation
FIPEC	Federation of Paints, Inks, Colours, Glues and Adhesives Industries
FMB	Federation of DIY shops
FNADE	National federation of decontamination and environmental businesses
FND	National Federation of Decoration
Jardineries & Animaleries de France	National Federation of Gardening Trades
PERIFEM	Technical Association for Trade and Distribution
PU	Polyurethane
REACH	Registration, Evaluation, Authorization, and restriction of CHemicals (REACH) - Regulation No 1907/2006 of the European Parliament and of the Council of the European Union, adopted on 18 December 2006
SDS	Safety Data Sheet
SNEFID	National Union of Waste Management Contractors
SYPRED	Union of professionals in recycling, recovery, regeneration, and treatment of hazardous

	waste
SYVED	Union for the recovery and disposal of waste
SWOT	Analysis of Strengths Weaknesses Opportunities and Threats
UFCC	French Union of Chemical Sales

ABOUT ADEME

At ADEME - the French Agency for Ecological Transition - we are firmly committed to the fight against global warming and degradation of natural resource.

On all fronts, we are mobilising citizens, economic players, and regions, giving them the means to move towards a resource-efficient, low-carbon, fairer and more harmonious society.

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EXPERTISES

RECYCLING OF COATING AND ADHESION PRODUCTS : BENCHMARKING

In France, chemical products have been subject to an extended producer responsibility (EPR) scheme since 2012. Significant quantities of coating and adhesion products such as adhesives, paints, polyurethane foams, varnishes, and coatings are placed on the market. Today, a large proportion of used products from this sector are not recycled but incinerated - with or without energy recovery.

The French public authorities would like to see the EPR system for chemicals become more oriented towards the recycling of certain products to promote a circular economy approach.
Considering these facts, ADEME wanted to conduct an international search, particularly in other industrialised countries, about existing solutions or initiatives for recycling these products.

Within the EPR scheme, this assessment could be used to guide and support the reflections of public authorities and stakeholders towards increasing and improving the recycling of chemical products. This report could also contribute to future experiments and the development of recycling schemes that are still emerging.

Mature recycling initiatives for water-based paints (some including water-based wood stains, varnishes, and oils) and for polyurethane foams has been identified.

The study identified the key success factors for initiatives that could inspire the development of such scheme in France (collection channels and level of service to the waste holder, selectivity of flows at the collection or recycling level, information sharing within the sector, existence of funding, end-of-waste, final outlets, quality control to develop SDS, etc.).