Design-for-recycling (D4R) – State of play

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Building Partnerships for a Sustainable Infrastructure
ENVIRONMENTAL PROTECTION made in Germany

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Global Project
"Support of the Export Initiative for Green Technologies" (BMU)
Köthener Str. 2
10963 Berlin / Germany
T +49 30 338 424 646
E markus.luecke@giz.de

Collaborative Action for Single-Use Plastic Prevention
in Southeast Asia (CAP-SEA)
193/63 Lake Rajada Office Complex, 16th Fl.
New Ratchadapisek Road, Klongtoey
Bangkok 10110 / Thailand
T +66 65 2400266
E christoffer.brick@giz.de

More information
https://www.giz.de/en/worldwide/78869.html
www.exportinitiative-umweltschutz.de

Authors:
Clara Löw
Andreas Manhart
Siddharth Prakash
Mirja Michalscheck

Layout:
kippconcept gmbh, Bonn

Photo credit:
Title: © Meaw_stocker – stock.adobe.com

Freiburg, February 2021

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

In cooperation with Öko-Institut e.V.

Contact
info@oeko.de
www.oeko.de

Head Office Freiburg
P. O. Box 17 71
79017 Freiburg

Street address
Merzhauser Straße 173
79100 Freiburg
Phone +49 761 45295-0

Office Berlin
Borkumstraße 2
13189 Berlin
Phone +49 30 405085-0

Office Darmstadt
Rheinstraße 95
64295 Darmstadt
Phone +49 6151 8191-0

Table of Contents

List of Abbreviations . . . 2

Executive summary . . . 3

1 Background . . . 5

2 Setting the scene . . . 6

3 Introduction into the concept . . . 9

3.1 Definition, prerequisites and assumptions . . . 9

3.2 Interrelation to recyclability . . . 12

3.3 Material choices . . . 13

4 The state of play: Existing D4R guidelines . . . 14

4.1 EU Circular Plastic Alliance and JRC Study to support D4R of plastic products . . . 14

4.2 Selected D4R guidelines . . . 15

4.3 Global initiatives and non-plastic sectors . . . 16

4.4 Analysis of existing experiences with (mandatory) design-for-recycling requirements . . . 17

5 Implementation . . . 18

5.1 Implementation through standards and criteria – technical perspective . . . 18

5.2 Embedding of guidelines in a legal framework or policy initiative . . . 19

5.3 Options for action . . . 20

6 Limitations and improvement of the concept . . . 22

6.1 Focusing problems . . . 22

6.2 Knowledge on waste management . . . 22

6.3 Level of specification . . . 24

7 Trade-offs . . . 25

8 Key implementation aspects . . . 26

List of References . . . 27

Annex . . . 28

List of Abbreviations

ASEAN	Associations of South-East Asian Nations
BMU	German Federal Ministry for the Environment
CAP SEA	Collaborative Actions for Single Use Plastic prevention in South East Asia
CEN	European Committee for standardisation
CENELEC	European Committee for Electrotechnical Standardization
CPA	EU Circular Plastic Alliance
D4R	Design-for-recycling
EEE	Electronic and Electrical Equipment
EPR	Extended Producer Responsibility
EPS	Extended Polystyrene
EPU	Economic Planning Unit (Malaysia)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
HDPE	High density polyethylene
ID	Indonesia
ISO	International Organisation for Standardisation
JRC	Joint Research Centre of the European Commission
LCA	Life cycle assessment
LDPE	Low density polyethylene
MOEF	Ministry of Environment and Forestry (Indonesia)
MY	Malaysia
PCD	pollution control department (Thailand)
PE	Polyethylene
PET/rPET/PETG	(recycled) Polyethylenterephthalate
PP	Polypropylene
PS	Polystyrol
PVC	Polyvinylchlorid
PVDC	Polyvinylidenchloride
SIRIM	Standard and Industrial Research Institute of Malaysia
SUP	single-use plastic
TH	Thailand

About the Export Initiative for Green Technologies

The GIZ global project **"Support of the Export Initiative for Green Technologies"** contributes to solving key environmental problems on behalf of the German Federal Ministry for the Environment (BMU). The **BMU Export Initiative** aims to export know-how available in Germany and support sustainable development worldwide. It includes topics such as poor waste management, air and water pollution or supporting infrastructures for sustainable urban development. Partner countries are Egypt, Jordan, India, Thailand, Malaysia, Indonesia and Ukraine. Project measures focus on building up technical and institutional know-how as well as laying the groundwork for the introduction and use of environmental and climate protection technologies "Made in Germany".

The project component CAP SEA, which stands for Collaborative Action for Single-Use Plastic Prevention in Southeast Asia, focusses on the prevention of single-use plastic (SUP) and reusable packaging systems in Thailand, Malaysia, and Indonesia.
For more information on CAP SEA project activities, please download the factsheet **here**.

Executive summary

- There are upstream and downstream measures, addressing waste prevention and waste management respectively. Applying the preferable options of the waste hierarchy at the early phases of the material life cycle, e.g. design, manufacture, is what so-called upstream measures seek to achieve. The concept of design for recycling (D4R) is one of a full bouquet of upstream measures and the scope of this pre-study, see the details in chapter 2.

- Design-for-recycling is a design principle addressing the recyclability of all sorts of items and therefore including end-of-life considerations at an early life cycle stage. A broad understanding of recyclability also includes considering the prevailing collection, sorting and recycling system. E.g. in Germany, a packaging may be described as recyclable if a collection infrastructure exists, if the material is identified in the commonly applied sorting schemes, if the recycling is possible at industrial scale, if the material has a high content of recyclable material, and if there are no so-called recycling system incompatibilities such as laminates or certain chemicals. These guidelines shall ensure compatibility with the waste management systems but are not an implementation measure for downstream measures, they do not offer any legal certainty and should therefore only be understood as a recommendation, see details in chapter 3.

- There exists over 100 different D4R guidelines. In Europe, a mainly industry-led process has started to evaluate and harmonise these guidelines for the reasons of effectiveness, see details in chapter 4.

- The starting point for the implementation of D4R is a parallel way forward with a policy and a technical "track". The former has the aim to bundle guidelines or criteria sets under a legal umbrella and propose a method how new guidelines can be added to the framework; the latter focusses on the technical requirements for a certain material or product, see chapter 5.

- Low-hanging fruits for which recyclability could most easily be enhanced were identified for Europe, these products can also be the starting point for policy and technical standardisation in the considered context, Thailand, Malaysia and Indonesia in this case, see chapter 5.3. The easy-to-follow design principles can be followed:

Figure 1-1: Easy-to-follow design principles

- Mono-materials should be chosen instead of a polymer mixture or composite materials.
- Labels made of the same material as the packaging or, alternatively, water-soluble adhesive for paper labels schould be preferred over labels based on PVC.
- Pigmented polymers, coloured printings and opacifier may hinder automated sorting and not be recyclable to the same degree and quality as transparent polymers.
- Caps and lids of bottles and boxes from plastic should be easily and completely removeable to fully separate the material streams.
- The variety of D4R guidelines for materials, specific products and packaging is high. Some of the above-mentioned examples could be used as a basis for own reflections.

Source: (Sharma 2019)

- Limitations, improvement possibilities and trade-offs are elaborated in chapters 6 & 7.

- In compiling this paper, some important concrete aspects have emerged that should be considered when implementing D4R. They are listed here as “key implementation aspects” in the last chapter and include amongst others these elements:
  - A design-for-recycling guideline for a plastic item is developed for a specific product made from a specific polymer or other materials. It can additionally be sector-specific, if needed;
  - The variety of D4R guidelines for different products can be used as a blueprint for own, context-specific developments;
  - It is advised to implement D4R in combination with recycled content targets, possibly through the means of Ecodesign;
  - Recommendations from current European undertakings teach us to avoid different guidelines for the same products and/or polymers, to ensure regular updating and to establish a testing process to asses recyclability and to demonstrate compliance with the guidelines, see chapter 5.3;
  - Focus on the domestic recycling sector, hence, the mistake of using well-sorted imported plastic for recycling should not be made. Inputs for plastic recycling should be domestically sourced;
  - Upstream and downstream measures have to be implemented in parallel.

1 Background

In an ideal circular economy, no primary resources shall enter production processes, but only recycled material. As a precondition, products must be dismantlable and components must be recyclable. The transition towards circular economy includes the rethinking of product design to include considerations for end-of-life treatment and recyclability. As a means to steer the behaviour at the end-of-life in an early stage of the product's life, the design phase, various initiatives have developed design-for-recycling guidelines for specific polymers and plastic applications.

Efforts to introduce the design-for-recycling (D4R) principle in locally manufactured plastic products represent a major element of the German government-funded[1] project "Collaborative Actions for Single Use Plastic prevention in South East Asia" or short "CAP SEA". The project is one component of a global export initiative to reduce plastic waste and focusses on single-use plastic (SUP) prevention and preparation for reuse options. It is being implemented in Thailand (TH), Indonesia (IN) and Malaysia (MY) and executed by in the Pollution Control Department (PCD, TH), collaborating with the Ministry of Environment and Forestry (MOEF, ID) and the Economic Planning Unit (EPU, MY). It started in 8/2019 and will run until 2/2023.

One of the outcomes shall be the 'improvement of the design of specific products from plastic-consuming branches for better resource efficiency'. This is in line with the findings of the Circular Economy and Plastics Gap-Analysis in ASEAN Member States. In this analysis, the "plastics choice optimisation" and "design principles for a circular economy of plastics" were identified as being able to address the analysed gaps. (European Commission; ASEAN 2019) This report has been prepared to support the CAP SEA partners in their work on design-for-recycling concepts.

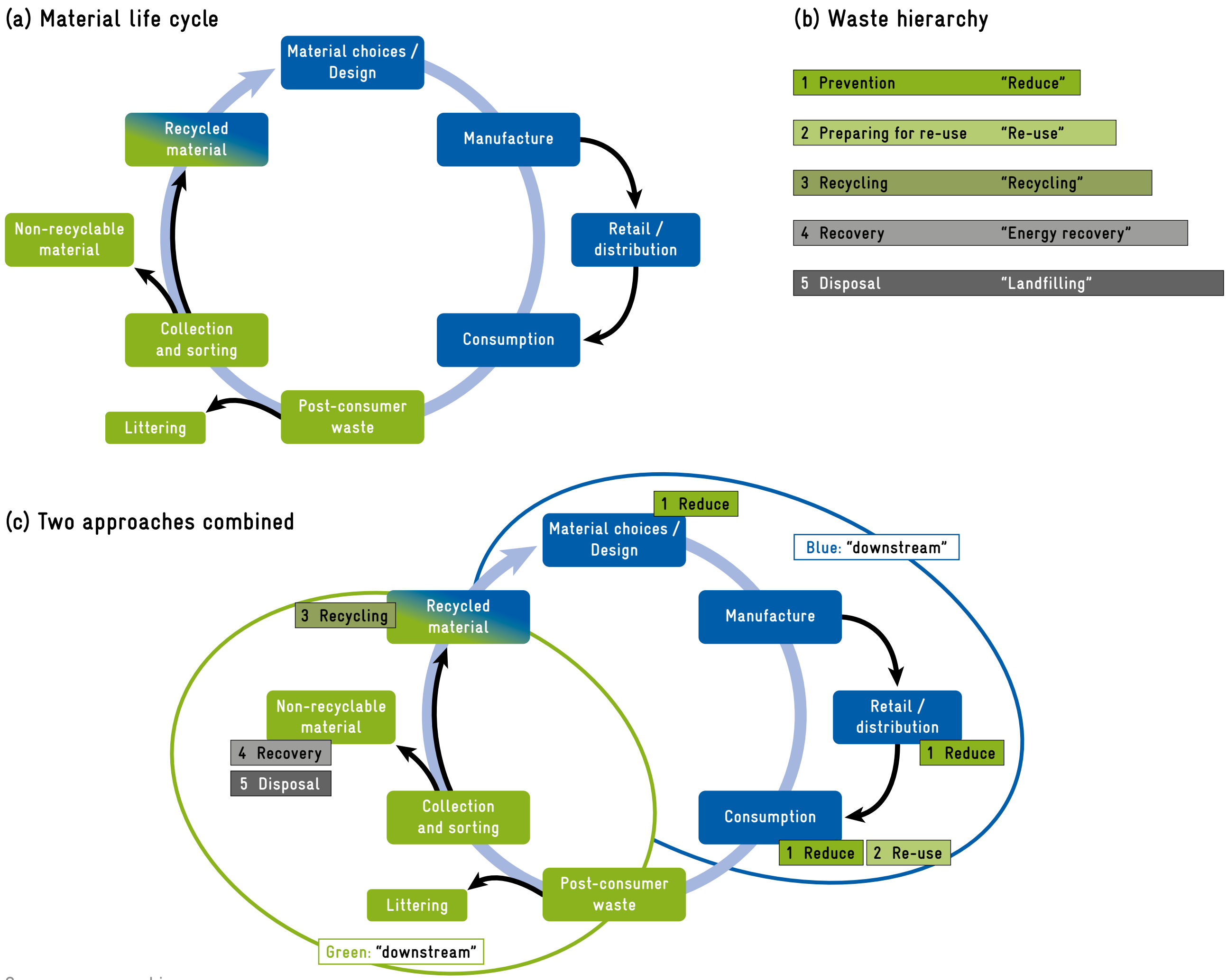
1 CAP-SEA is part of the GIZ global project to "Support the Export Initiative for Green Technologies" funded by the German Federal Ministry for the Environment.

2 Setting the scene

With this chapter, we seek to provide the background for developing this paper and the mindset of upstream measures. First of all, it should be acknowledged that there are upstream and downstream measures, addressing waste prevention and waste management respectively. Applying the preferable options of the waste hierarchy (Figure 2-1b, steps 1 – 3) at the early phases of the material life cycle, e.g. design, manufacturing (Figure 2-1a), is what so-called upstream measures seek to achieve. The Figure 21 explains the terms "upstream" and "downstream" graphically.

Unlike downstream measures that are aimed at treating existing, generated waste, the upstream measures have the aim to reduce waste volumes, ensuring at an early stage of the product's life that a second life is possible and that products are easily recyclable. This is of importance because more than 80% of the environmental impact of a product is determined at the design stage (European Commission 2020b).

Figure 2-1: Two concepts to explain the terms "upstream" (blue in c) and "downstream" (green in c)



Source: own graphic

Examples for upstream measures[2] are:

- (Design for) Reuse shall extend the lifetime of products, e.g. reusable packaging for the distribution of food- and drinks-to-go, multi-use shopping bags, normed beverage crates with non-branded uniform bottles to be reused by various companies for refilling and for easy logistics, flat euro-pallets, etc. (Figure 2-2)
- Design-for-recycling (D4R), addressing the composition and make-up of products and requiring the compatibility with existing recycling infrastructure: e.g. deciding for a mono-material in the design of a product or packaging;
- Plastic consumption reduction measures such as products-as-a-service[3] business models, and other design options for environmental sound use which shall prevent littering, allow complete emptying or minimisation of chemical risk;
- Recycled content targets (see the pre-study on recycled content)

Figure 2-2: Designed for reuse

Source: Own photo (bowl), pixabay.com (beverage crate logistics, cotton bag), creative common license (euro pallets), pxhere (bag with oranges)

2 The four below mentioned measures are mentioned in the "four strategy elements to develop an Ecodesign for packaging projects" of the industry-led round table for ecologic design of plastic packaging hosted by the German Association for Plastic Packagings and Films (2019).

3 Selling the services and outcomes that a product can provide rather than the product itself. The product, however, remains in the ownership of the provider, costumers pay e.g. for using the product in a rental system.

So far, policy makers have often set a focus on downstream measures which have limitations due to product design aspects which hinder high quality recycling. Moreover, contrary to the opinion that waste management and segregation at source have to be fully established first; that further recycling capacities need to be built up; and that full recyclability of products is not yet important because *"as yet, not so much ends up in recycling anyway"* (colloquial term), upstream and downstream measures have to be implemented in parallel.

Both upstream and downstream approaches shall work in unison for high effectiveness of waste prevention and management policies. As far as upstream measures are concerned, many instruments and policy options exist and should be implemented together for a better coherence in the product policy.

The focus of this pre-study is on D4R, which is just one of many upstream measures for Ecodesign.

3 Introduction into the concept

3.1 Definition, prerequisites and assumptions

Design-for-recycling is a design principle addressing the recyclability of all sorts of items and therefore including end-of-life considerations at an early life cycle stage (design phase). This concerns products as well as their packaging materials. A broad understanding of recyclability also includes the consideration of the prevailing collection, sorting and recycling system, see chapter 3.2. Before even producing an item, the designer of it should ideally ask the question in which waste stream the material will finally end up and whether it will be collected, sorted and recycled under currently prevailing circumstances. E.g. for a sachet packaging for rice, the material may be recyclable but it will most likely not be separated from the mixed waste stream before incineration or disposal; a rigid bottle packaging could more easily be identified in mixed waste but may have a cap made of different material. In such a case, screw caps should be designed for complete removal for recycling (Figure 3-1, next page).

Design-for-recycling has many advantages: it facilitates the waste handling and sorting process and turns a ‘ material one-way street’ into a stream of high amounts of high-quality recycled material that will be used as secondary raw material for new products. Thus, it creates a win-win situation: The simplification of the end-of-life treatment on the one hand side and insurance of high-quality secondary raw material on the other side. D4R helps reducing plastic waste in recovery plants, landfills or littering by designing products in such a way as to increase likelihood of high-quality recycling.

Prerequisites and assumptions. It is important to clearly differentiate between D4R (as an upstream measure) and downstream measures, even though D4R affects the entire value chain including waste management. Furthermore, D4R emphasizes the need to collaborate closely along the value chain.

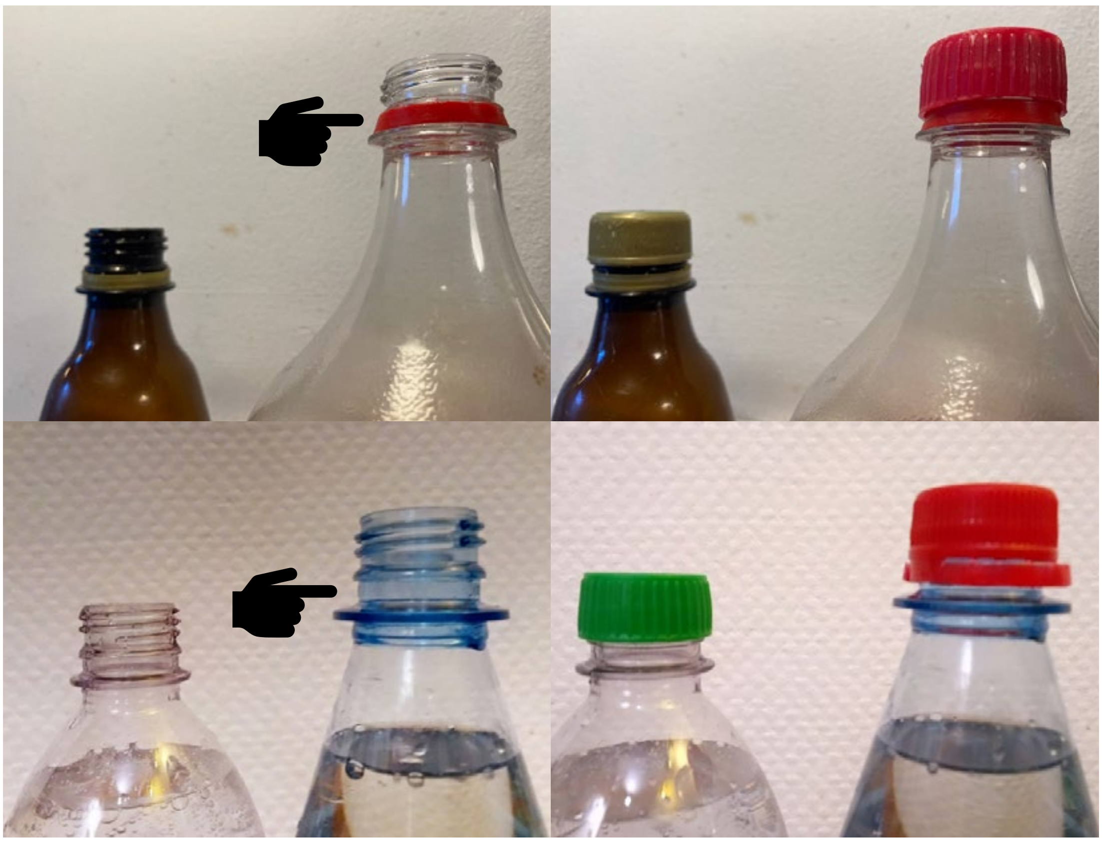
- Firstly, **D4R guidelines should be material- and product-specific**. A label, for example, does not represent a problem if it is easily removable; it is still possible to make sure that the material of the labels is recyclable (e.g. no PVC). However, poorly removable adhesives, for example, show that not only the type of the product’s and label’s material plays a role, but also their interplay, e.g. if they are easily removable or not. For D4R to be implemented successfully, a knowledge of the behavior of the product and material at the end of life under given waste management practices in the countries is crucial.

- An additional important information is the knowledge of the shares of material or polymer in the overall waste volume. **It makes sense to establish design-for-recycling criteria for products that are used in large quantities and that make up a considerable share of the (plastic) waste stream**. The identification of these major fractions is part of the knowledge located in the waste management sector.

- It is assumed that a combination of **design-for-recycling and recycled content targets weakens the argument that there must be better sorting and collection** before any D4R is introduced. Due to a requirement for rPET in new products, for example, the market would need to produce more rPET, thus, sorting and collection of post-consumer PET items would increase. To improve handling efficiency, however, products made from PET should be designed in such a way as to support high quality recycling, which means that additives and other materials such as adhesives, colour and labels are chosen and designed in a manner that supports high-quality recycling.

- It must be noted that **upstream measures only generate benefits if they are adapted to the domestic waste streams and the working mode of the local recycling sector**, e.g. D4R criteria are different for countries with an automatic sorting of waste versus a country where waste is sorted manually. D4R criteria cannot be adopted one-to-one across all countries. Additionally, the D4R criteria must be based on large-scale recycling practices, not laboratory-scale processes promised for the future in order to achieve a large impact.
- Finally, benefits from **D4R and other upstream measures are visible and quantifiable in the downstream stage** as well. If D4R was introduced for a specific type of plastic and implemented by most producers, it would theoretically lead to better collection and recycling rates of that type of products. But as collection and recycling rates are usually a monitoring instrument of the sorting and collection sector, close collaboration is needed to supervise the success of a particular upstream measure.
It should additionally be noted that higher collection and recycling rates can trigger D4R development.

Figure 3-1: Complete screw cap removal



Source: Own photos.

Arguments why upstream measures are equally important as downstream measures are manifold. Due to its goal of plastic reduction, an upstream measure has the advantage of having a high and future-orientated impact. It is a sort of measure that “attacks the root of the evil”. Projections of material uses in a business-as-usual scenario exceed the planetary boundaries (e.g. PEW und Systemiq 2020); and there is no other possibility than to reduce material consumption and recycle material to fulfil the material needs of the producing industries. Moreover, downstream problems will benefit from upstream measures under the pre-condition that the focus of the activities is set in a way that a domestic material cycle is established[4]. Furthermore, upstream measures are less energy-intense and reduce emissions, e.g. by avoiding primary resource extraction and incineration through a general reduction of material through-put.

Aiming at the low hanging fruits, another argument is put forward: Compared to the number of consumers, the number of manufacturers of products which shall implement e.g. D4R for a certain product and polymer type is small. Introducing measures at the manufacturers’ level reduces the number of entities that are supposed to implement a new system. Since several reporting obligations for manufacturers may already exist, an additional reporting on the recycled content or on the implementation of D4R is easier to accomplish. Monitoring the progress and controlling the production is easier than addressing the consumption level where the target group is a high number of individuals and where material is dissipative.

4 Inputs for plastic recycling should be domestically sourced. The recycler has an economic advantage if he can use well-sorted plastic that lead to a high-quality output. Nationally applied measures shall strengthen the domestic sorting and recycling sector, the mistake of using well-sorted imported plastic for recycling should not be made.

3.2 Interrelation to recyclability

In the concept of D4R, the recyclability of products or packaging is the basis for design and material decisions. In a narrow perspective, recyclability asks whether a technically feasible process at industrial scale can generate a further processable output from an input of scrap. In a wider perspective, recyclability does not only cover the recycling capability of a material, but whether the material is actually effectively recycled at industrial scale. Thus, the broad point of view on recyclability includes the existence of (separate) waste collection schemes that hand over the waste not only to waste incinerators but also to recyclers; and the ability to sort which depends in the first place of the identification of the waste / material or different plastic types, e.g. bottles from caps. Either labels or test procedures can help. Secondly, the components made from different material, e.g. removable labels, should be easy to disassemble. Recyclability in the narrow sense depends on the presence of mono-material streams and the absence of impurities and multi-layer / blend / composite material. Examples of impurities are certain bio-based plastics which may hinder the recyclability of fossil-based materials if they differ in chemical structure.

The preconditions for recyclability in Germany are regulated by the Packaging Act and further specified by the German Federal Environmental Agency. In Germany, a packaging may be described as recyclable according to this definition (Stiftung Zentrale Stelle Verpackungsregister 2020):

- A collection infrastructure must be in place;
- The material must be identified in the commonly applied sorting schemes and match one of the output fractions[5], e.g. the wind sifting is one of the first steps in automated lightweight packaging sorting to separate films (PREVENT Waste Alliance 2020, Factsheet 7), thus, a film must be identified during the wind sifting and sorted to other films;
- A recycling of the material must be possible at industrial scale, not laboratory-scale processes promised for the future, e.g. PET recycling is widely established whereas EPS (extended polystyrene) cannot be recycled at industrial scale.
- The material should have a high content of recyclable material. It is a number (in percent) for which the calculation is defined by law, the report of this number is mandatory. Recyclable materials are the materials of a packaging that are to be recovered via the respective material-specific recycling process, e.g. steel, metallic aluminium, PE, (cellulose) fibers, PET, etc. Adhesive labels on packaging lower this value. The content of recyclable material does not correspond one-to-one to recyclability.
- The material should be easy to recycle, thus there should be no recycling system incompatibilities such as laminates or – depending on the recycling system – biodegradable plastics.

5 Output fractions are: Tetra, non-ferrous metals, mixed rigid plastic, PE, PP, PS, PET, paper an board, ferrous metals, films and residues according to Factsheet 7 published by PREVENT Waste Alliance (2020).

What does these elaborations mean for the design-for-recycling? The D4R guidelines will refer to the actual waste management processes but cannot ensure that the sorting is actually done. For example, a requirement for the separability of certain items of one product or packaging, e.g. cap and bottle, might be formulated differently depending on whether the caps and bottles are manually or automatically sorted apart. Or: whether certain biobased plastics are permitted to be used for manufacturing depends on the chemical structure of the fossil-based analogion and on the question of whether this imposes difficulties in the recycling process. Thus, the guidelines shall ensure compatibility with the waste management systems but are not an implementation measure for downstream measures. This means that e.g. recycling system incompatibilities are not prohibited, the guidelines do not offer any legal certainty and should therefore only be understood as a recommendation as far as they are not taken up in legal acts.

3.3 Material choices

The most important role of design-for-recycling of packaging material is to provide guidance regarding material choices and separability of parts of the product and label. This includes the following details: polymer type, colours and prints, additives, labels, label adhesives, label ink, additional components.

Several reflections guide the development of D4R criteria:

1. Material composition and reduction
   - What type of material should be acknowledged for which type of application?
   - Can we reduce material amount and focus on materials that are separable in the commonly applied sorting processes? Is it possible to reduce the amount of adhesive used for the label? Is the label necessary? This may also lead to lighter packaging materials or to thinner films or wall thicknesses.

2. Collection, sorting and recycling process
   - Has a collection, sorting and recycling process been established for the available material options? If so for example for PET, but not, or not to the same extent, for HDPE, bottles for shampoo should rather be produced from PET than from HDPE.
   - Do certain additives, adhesives or prints hinder high-quality recycling through contamination of the output stream, e.g. adhesives causing black spots in recycled PET?

3. Function of packaging or product
   - Does the material fulfil the function for which it is used? This relates to the debate about what kind of functions need what kind of material. Here, local practices, e.g. using banana leaves rather than plastic-coated cardboard, can play an important role.

Design-for-recycling addresses all three components equally. A preferable option under one aspect, should not be preferred, if it has disadvantages under another aspect, e.g. no weight reduction of packaging material if recyclability is not ensured.

4 The state of play: Existing D4R guidelines

As we can see from the following sub-chapters, there are many guidelines for different product groups and various global initiatives, mainly of multinational industry actors. In the EU, a process has started to tackle the problem of diversity of guidelines from a holistic point of view. This EU initiative is presented in detail in the following.

4.1 EU Circular Plastic Alliance and JRC Study to support D4R of plastic products

The wider EU Plastics Strategy (European Commission 2018) aims at voluntary industry initiatives to make sure that at least 10 million tons of recycled plastics will find their way into products on the EU market by 2025 (in contrast to only 3.9 million t in 2016). In this context, the EU Circular Plastics Alliance (CPA) was established as a multi-stakeholder network to help bridge the gap between the supply and demand for recycled plastics. In 2020, a working group under the Circular Plastic alliance published a workplan on D4R guidelines / standards (European Commission 2020a).

As a first step, the JRC was commissioned to conduct a study to support the above-mentioned activities of CPA to develop guidelines and standards on design-for-recycling of plastic products (JRC 2020). The work consists of a selection of priority plastic products or product groups, of a mapping and analysis of existing D4R guidelines as well as of recommendations for the further work of the CPA.

With regards to the product groups of priority, among the five sectors agriculture, packaging, EEE, construction and automotive plastic, products were selected for which recyclability can be comparatively easily enhanced to contribute to the EU's 10 million tons of recycled plastic feedstock envisaged for 2025 ("low hanging fruits"). These were determined from intersectoral mass flow modelling. Priority product groups are listed in Table 4-1.

Table 4-1: Priority product groups for enhancing recyclability through design-for-recycling principles

Polymer	Products / product group
Packaging sector	
LDPE	Flexible packaging
PET	Bottles, trays
HDPE	Necked bottles (e.g. for milk and detergents)
PP	Food containers, caps and closures
PS	PS packaging (cups, trays, dairy packaging)
EEE sector	
PP	Dishwashers, dryers, food processing appliancers, hot water appliancers, vacuum cleaners
PS	Fridges
PUR	Cooling appliancers
Agriculture sector	
LDPE	Mulching and silage films
HDPE	Nets (bale wraps and protections)
PP	Twiners
Construction sector	
PVC	Window profiles, roller shutters, doors
HDPE	Pipes
EPS	Insulation
Automotive sector	
PP	Bumpers, body side, dashboards
PUR	Seats padding
PVC	Car interiors, cable covers

Source: (JRC 2020)

The workplan of the working group under the Circular Plastic Alliance on D4R guidelines / standards continues until the end of 2021 (European Commission 2020a). Various activities are included based on dedicated product teams that work on the identified priority products (see Table 4-1). As "standards are identified as a key contributor" to the ambitious goals of the Circular Plastic Alliance, CEN and CENELEC expect an official Standardization Request 'Plastic Recycling and Recycled Plastics' which will be worked out by the CPA working group until the end of 2021 (CEN-CENELEC 2021).

4.2 Selected D4R guidelines

As can be seen from the product prioritization (Table 4-1), design-for-recycling criteria in the plastic sector are specific for a certain product made from a certain polymer, differentiation of the sectors might additionally be important, e.g. due to different collection modalities for example for LDPE foils in packaging and agriculture. Two main methods are used for D4R guidelines: matrices or checklists, see the following examples.

Table 4-2: Examples of D4R guidelines

(a) RecyClass D4R matrix for PE coloured flexible film
(for enhanced readability, please see Figure 8-1 in the Annex)

RecyClass™	PE Colured Flexible Film		
	YES – Full compatibility: Materials that past the testing protocols with no negative impact OR materials that have not been testet (yet), but are known to be acceptable in PE recycling	CONDITIONAL – Limited compatibility: Materials that past the testing protocols if certain conditions are met OR materials that have not been testet (yet), but pose a low risk of interfering with PE recycling	NO – Low compatibility: Materials that failed the testing protocols OR materials that have not been testet (yet), but pose a high risk of interfering with PE recycling
Polymer	PE-LD; PE-LLD; PE-HD	multilayer PP/PE	any other polymer
Colours	light colours; translucent colours	dark colours	
Barrier	barrier in the polymer matrix	≤ 5% EVOH (in polyolefinic combination film); metalized layers; "Ecolam High Plus"; "VO+ LLDPE"	> 5% EVOH (in polyolefinic combination film); barrier layer PVC; PA, PVDC; any other barrier layer foaming agents used as expendant chemical agents; aluminium
Additives			additives concentration ≥ 0.97 g/m³
Labels	PE label	PP label; paper label	metalized labels; any other
Adhesives	water soluble (less than 60°C)		
Inks	no inks	non toxic (follow EUPIA Guidelines)	inks that bleed; toxic or hazardous inks
Direct Printing	laser marked; small production or expiry date		

(b) PETCO D4R criteria for PET trays[6]

LIDS:
DO: Ensure the plastic lid is an integral part of the tray.

ADHESIVES:
DON'T: Use adhesives on body.

MATERIAL IDENTIFICATION:
DO: Show PIC clearly and legibly.

COLOUR:
DO: Transparent, clear.
DON'T: Other/strong colours, opaque colours.

INKS & DIRECT PRINTING:
DON'T: Print directly an the tray.

LABELS:
DON'T: Use materials with densities greater than 1 g/m³ like PVC, PET, PS.
DON'T: Use metals or paper.
DON'T: Use self-adhesive labels that don't detach.

Source: (Recyclass 2019; petco 2019)

6 It should be noted that Petco provides additional, more detailed matrices.

From a list of more than 100 different guidelines[7], the JRC study selected 25 industry-led D4R guidelines (see the criteria for selection in the reference and the 25 examples in the annex of this paper). The authors of JRC (2020) highlight that mostly all of the selected D4R guidelines are applied in the packaging sector, D4R guidelines in other sectors have not yet been developed.

The analysis is summarized as follows:

- 68 % apply to specific product types (e.g. bottles, trays, etc.) and 36 % apply to product groups (e.g. all packaging, flexible packaging, etc.). Looking at this in more depth, 20 % of the guidelines apply to bottles, 16 % to trays, 28 % to films and 28 % to containers. Of the product groups (or packaging types), 28 % apply to all packaging types, whilst 12 % apply specifically to flexible packaging and 4 % to rigid packaging.
- Most of the shortlisted guidelines are specific to either one or several polymers. Only in one case, no polymer type is specified. 64 % of the shortlisted guidelines cover PP, 56 % cover PET, whilst 68 % apply to HDPE, LDPE or PE in general, to name only the most frequently covered polymers.
- The guidelines studied apply across the plastics value chain with a number focusing across different stages e.g. collection (1); sorting (8); or general recycling (2). A number of guidelines focus on closed-loop recycling (12) or on specific end-use applications (5).
- There is some variation in the approach used, with many (66 %) of the guidelines providing a matrix or checklist with which to consider specific product features and / or polymer types which increase recyclability.” (JRC 2020)

7 Download of an Excel with the long list (“Annex 3”) here: https://ec.europa.eu/jrc/en/publication/support-circular-plastics-alliance-establishing-work-plan-develop-guidelines-and-standards-design (last accessed 13.01.21)

4.3 Global initiatives and non-plastic sectors

Signing enterprises of the New Plastics Economic Global Commitments agreed to […] “innovate so all plastics we do need are designed to be safely reused, recycled, or composted”. Every member of this commitment is reporting its activities regarding the “100 % of plastic packaging to be reusable, recyclable, or compostable by 2025”. Examples are PepsiCo, H&M group, Barilla, Nestlé and various others aiming at 100 % recyclable plastic until 2025 (Ellen MacArthur Foundation 2019).

In view of the commitments, the industry is joining plastic reduction and plastic waste management projects, e.g. Nestlé became partner of the Systemiq-lead STOP project in Indonesia. Industry also gathers for joint activity, e.g in the Circular Plastic Alliance or under the Global Consumer Goods Forum, in order to address e.g. packaging design. The Global Consumer Goods Forum published two Golden Design Rules: (1) Increase the value of PET Recycling by using transparent and uncoloured PET or transparent blue or green PET bottles ensuring that material choice, adhesives and sleeves will not be problematic for recycling; (2) Remove problematic elements from packaging, in concrete terms: undetectable carbon black, no PVC or PVDC, no EPS or PS nor PETG in rigid packaging & no oxo-degradable plastic. (The Global Consumer Goods Forum 2021)

Non plastic examples:

- D4R guidelines also exist for **fibre-based packaging** (in addition to plastic packaging). The WRAP design tips for better recyclability of paper and board packaging include considerations on multilayers, coatings, UV-ink, water resistant paper, adhesives, or gift wrap (WRAP 2020). Furthermore, the paper industry has initiated the 4Evergreen[8] campaign for "optimizing fibre-based packaging circularity" (CEPI 2021).

- In the **textiles** and clothing sector, design-for-recycling is implemented through avoidance of fibre and material blends for fabrics and accessories incl. buttons, or / and design for ease of separation of different materials (Nordic Council of Ministers 2017). The Dutch company MUD Jeans apply design-for-recycling by "choosing the right materials, namely the purest materials possible; our buttons and rivets are mono-material, we don't use leather labels, no toxic chemicals, no polyester." (mudjeans.eu 2020)

- Compared to paper, textiles and plastics, the **electronic and electrical equipment** may consist of several components with different recycling needs. An important principle of the design-for-recycling is dismantlability and separability of components, e.g. metal components from plastics such as housings or cable insulation which are highly likely to include non-flammable additives.

8 4evergreen is a cross-industry alliance with the goal of optimizing fibre-based packaging circularity and climate performance

4.4 Analysis of existing experiences with (mandatory) design-for-recycling requirements

Against the background of over 100 existing guidelines (Annex 3 of JRC 2020), no own analysis of existing design-for-recycling guidelines has been performed. Additionally, authors of JRC (2020) indicate difficulties in assessing and comparing the variety of design-for-recycling guidelines in terms of effectiveness, e.g. measured through recycling rates, market uptake or recycling rates achieved (please refer to the JRC study for further details).

However, two experiences provided by JRC (2020) are highlighted:

Yet, there are currently no mandatory D4R guidelines. JRC (2020) was not able to quantify the number of enterprises applying D4R criteria in product design. Often, D4R are developed and published by recyclers for the purpose of influencing product design in their own interest. This means, **broad stakeholder and industry involvement across the value chain** is needed for addressing design and recyclability needs at the same time.

In general, **costs of implementation** are mostly borne by the users of the guidelines (i.e. producers of items) and to some extent by members of the issuing bodies. Not much information was found regarding potential financial benefits of the guidelines for individual companies, but, according to JRC (2020), "in principle benefits could accrue both to society as a whole (from increased recycling), and also, for instance, to recyclers (more high quality feedstock) or producers of items (e.g. through reputational benefits or EPR savings)". Some guidelines charge a membership fee for users (ranging from hundreds to EUR 10,000), others are free to use and effectively paid for by the members of the issuing bodies. Testing costs appear to be the most significant cost factor for users (for those guidelines where testing is applied), while certification costs are generally more modest. The costs of changing products to achieve compliance with guidelines could not be quantified but could potentially be substantial.

5 Implementation

In a wider sense, design-for-recycling can be regarded as a material efficiency perspective on Ecodesign. The implementation of D4R takes place on two playing fields: a technical development of criteria and the embedding of this design principle in a legal framework or policy initiative.

5.1 Implementation through standards and criteria – technical perspective

Ecodesign is implemented on the basis of well-defined product groups through a list of criteria and requirements that may refer to industrial technical standards. In the recycling field, several types of criteria sets are relevant depending on what exactly is the subject of standardisation and for whom it is important. From an environmental perspective, minimum standards for recycling plants serve to minimise pollution. Those who want or need to use recycled material want to be sure that they will receive material of a certain quality on the market. Recyclers are interested in generating the maximum output in their plant, so they want the material to be easy to recycle and not too expensive to sort.

The three types of standards in the context of recycling are compared to each other in the following figure. Under this systematic, a design-for-recycling guideline can be located on the material as well as on the product / packaging level. For example, the criteria could relate to a type of adhesive used to stick labels. Since, however, this adhesive cannot be removed in the recycling process and, in the example, would remain in the recycled material, the D4R guidelines discourage this adhesive with positive impact on the quality of the recycled material (criteria on the material level). If a criterion refers to the separability of different individual parts, e.g. the silicone seals between pipe sections should not be inseparably connected to the pipes made of HDPE, then there is a criterion with concrete product reference, i.e., on the product level (here: pipes).

Table 5-1: Different types of standards in the context of recycling and their goals

Standard	Level	Example
(Recycling) process related standard	Process level	certification of recycling facilities
Quality standard for recycling material	Material level	e.g. eliminate hazardous substances from recycled PET
Recyclability standard / Design for recycling standard	Product level	aiming at mono-material (polymer) stram

Note that such standards cannot ensure that a product will in fact be recycled at its end of life as this also depends on the type of waste collection and the general economic framework conditions for recycling

Source: Own compilation.

5.2 Embedding of guidelines in a legal framework or policy initiative

Technical criteria tend to end up in the drawer and are not accepted or applied if they are developed without connection to larger initiatives. Also, communication about the existence of these criteria works better for a bundle of (upcoming) criteria. Such a bundle of criteria can be introduced through an ecolabelling scheme and / or through an Ecodesign legal framework.

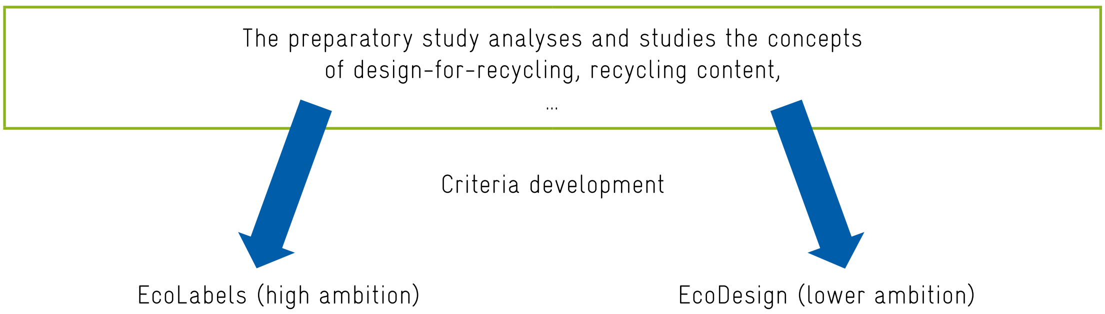
From Table 5-2, the differences between both approaches become clear; it should be noted that they are not alternative but can be additive. In the current project context in the Malaysia component, the technical working group 3 lead by SIRIM, MY, is developing recommendations to build up the political framework which shall bundle the D4R criteria for the products in scope. The preparatory study conducted by technical working group 2 as well as led by SIRIM, MY, will analyse and study the technical requirements for recyclability and options for the introduction of other upstream measures under a potential Ecodesign framework.

A technical D4R guideline may define a high standard which could be used in ecolabels, while less ambitious requirements with regards to recyclability, e.g. through no-go principles, could be referred to in Ecodesign regulations for specific products of the same function. For example, in case of beverage containers, a minimum requirement for recyclability in an Ecodesign regulation could target the easy manual separability of the bottle's cap (Figure 3-1, page 10). At the same time, a broader set of requirements for D4R could apply to Ecolabels, i.e. in the example of bottles, criteria for label material and adhesives in addition to the removability of the lid.

As soon as legal frameworks will be in place for best and worst products on the market, all work can concentrate on technical criteria and guideline development. For this purpose, the framework shall incorporate a process defining how new technical criteria sets can be added to the bundle guidelines under the legal framework.

Table 5-2: Two different policy backbone systems for product criteria

Ecolabels	EcoDesign
voluntary	Mandatory
Promoting the best products on the market	Cutting the worst products in the market



Source: Own compilation.

5.3 Options for action

This chapter seeks to point to the direction where to start with D4R reflections in the operable business as well as for policy makers, as the outlined explanations might portray a complex picture.

Low-hanging fruits for which recyclability could most easily be enhanced were identified by JRC (2020) for Europe. Priority product groups include product & packaging types from five sectors. It is worth evaluating whether – according to some criteria, e.g. the share of the products in the waste stream – these products can also be the starting point for policy and technical standardisation in the considered context, Thailand, Malaysia and Indonesia in this case.

- Packaging sector: flexible packaging (LDPE), bottles and trays (PET), necked bottles for milk and detergents (HDPE), food containers, caps and closures (PP), cups, trays, dairy packaging (PS)
- EEE sector: PP in household appliances (dishwashers, dryers, food processing & hot water appliances, vacuum cleaners, PS and PU from (fridge) insulation)
- Agricultural sector: films (LDPE), nets (HDPE), Twines (PP)
- Construction sector: window profiles, doors etc (PVC), HDPE from pipes, EPS from insulation
- Automotive sector: foam in seats (PU), bumpers, dashboards (PP), interior and cables (PVC)

It is assumed that comparable product groups can be the starting point for the development of D4R guidelines for the CAP SEA countries.

The following easy-to-follow design principles allow thematic focusing:

Figure 5-1: Easy-to-follow design principles

- Mono-materials should be chosen instead of a polymer mixture or composite materials.
- Labels made of the same material as the packaging or, alternatively, water-soluble adhesive for paper labels schould be preferred over labels based on PVC.
- Pigmented polymers, coloured printings and opacifier may hinder automated sorting and not be recyclable to the same degree and quality as transparent polymers.
- Caps and lids of bottles and boxes from plastic should be easily and completely removeable to fully separate the material streams.
- The variety of D4R guidelines for materials, specific products and packaging is high. Some of the above-mentioned examples could be used as a basis for own reflections.

Source: (Sharma 2019)

Based on the learnings from JRC's recommendations for the D4R process in Europe, the following learnings can be transferred to the project context (JRC 2020):

1) Existing knowledge gaps in the transparency of recycling processes could be addressed by starting from guidelines that are effective for certain products and then adapting them to address whole product families. Different guidelines for the same product, packaging type, e.g. PET bottles, and / or polymers should be avoided;
- Example / explanation: Similarities exist in PET bottle and PET tray recycling process. Criteria for labels and adhesives can be similar among those two packaging types, however, collection might be different for the bottles than for trays, at least in the EU, bottles are collected through deposit refund systems (Germany) or separately from other packaging waste (France) whereas trays are collected in the light packaging bin.

2) Ensure regular updating by integrating developments on plastic product design, disruptive recycling technology and trends in consumption;
- Example / explanation: Of cause, technology evolves. And, since it is explicitly proposed here to take into account the large material and waste flows and since these can change, D4R guidelines should be subject to regular revision, e.g. PP could be more an important polymer for packaging than it is today.

3) It was indicated that increased recyclability may lead to a decreased functionality. Guidelines will only be accepted by the market by means of ensuring a level playing field through involving all stakeholders and formulating precise standards, e.g. by recognised standardisation bodies. The coherence with other initiatives and regulatory requirements (e.g. Ecodesign Regulation) is also important;
- Example / explanation: One could imagine that certain inks on the labels would be particularly suitable for advertising purposes. However, if these inks turn out to be recycling incompatibilities, companies following D4R guidelines will have to avoid them. However, because D4R is not mandatory, other manufacturers could continue to use the inks on their labels and have a possible competitive advantage.

4) Testing processes to asses recyclability and to demonstrate compliance with the guidelines through protocols are needed for all sectors and products, while introducing measures to reduce the financial burden imposed by the costs of lab testing and auditing at the same time;
- Example / explanation: D4R guidelines consist of individual requirements which must be verifiable. The fact that printing inks or adhesives must not contain certain substances that have negative influence on the recycling can be determined by chemical analysis. Whether two components of a product are separable, a standardised test procedure must be available to ensure the compatibility of the products with the D4R guidelines.

5) Promoting the guidelines along the value chain, e.g. through awareness raising campaigns, involvement of the industrial stakeholders within the development of the guidelines and creation of a label.
- Example / explanation: It's welcome that product designers and recycling experts together think about the concrete ideas for D4R requirements and how they can be implemented. This dialogue needs to be established, promoted and encouraged.

6 Limitations and improvement of the concept

6.1 Focusing problems

Working on design-for-recycling includes some very broad perspectives on material cycles but a very narrow perspective with regards to specific products, packaging and polymer types. Considerations on both levels need to guide the development of the criteria set:

Broad perspective

- Addressing the difficulties for making a distinction between upstream and downstream measures, it will be challenging to focus discussions around the relevant questions and without losing the focus on the establishment of criteria for the design phase of a product. A D4R guideline will apply for products that enter the market – thus, upstream.

- Introducing D4R principles in product and material-related legal frameworks is closely interwoven with recycled content targets because there will only be an increased interest in enhanced recyclability when the output from recycling streams is used and recyclers have the guaranties that they can sell.

Narrow perspective

- The complexity of the products and the materials from which the products or packaging are made is high. The list of products, packaging types and materials for which D4R guidelines should be developed is long. Where shall you start? This seems to be a major challenge until successes are actually in sight.

- Additionally, against the background of over 100 existing D4R initiatives listed by JRC (2020), best practices are more difficult to identify, certain initiatives have specific benefits and disadvantages. The concept is too new to have a well-devised all-encompassing blueprint to follow.

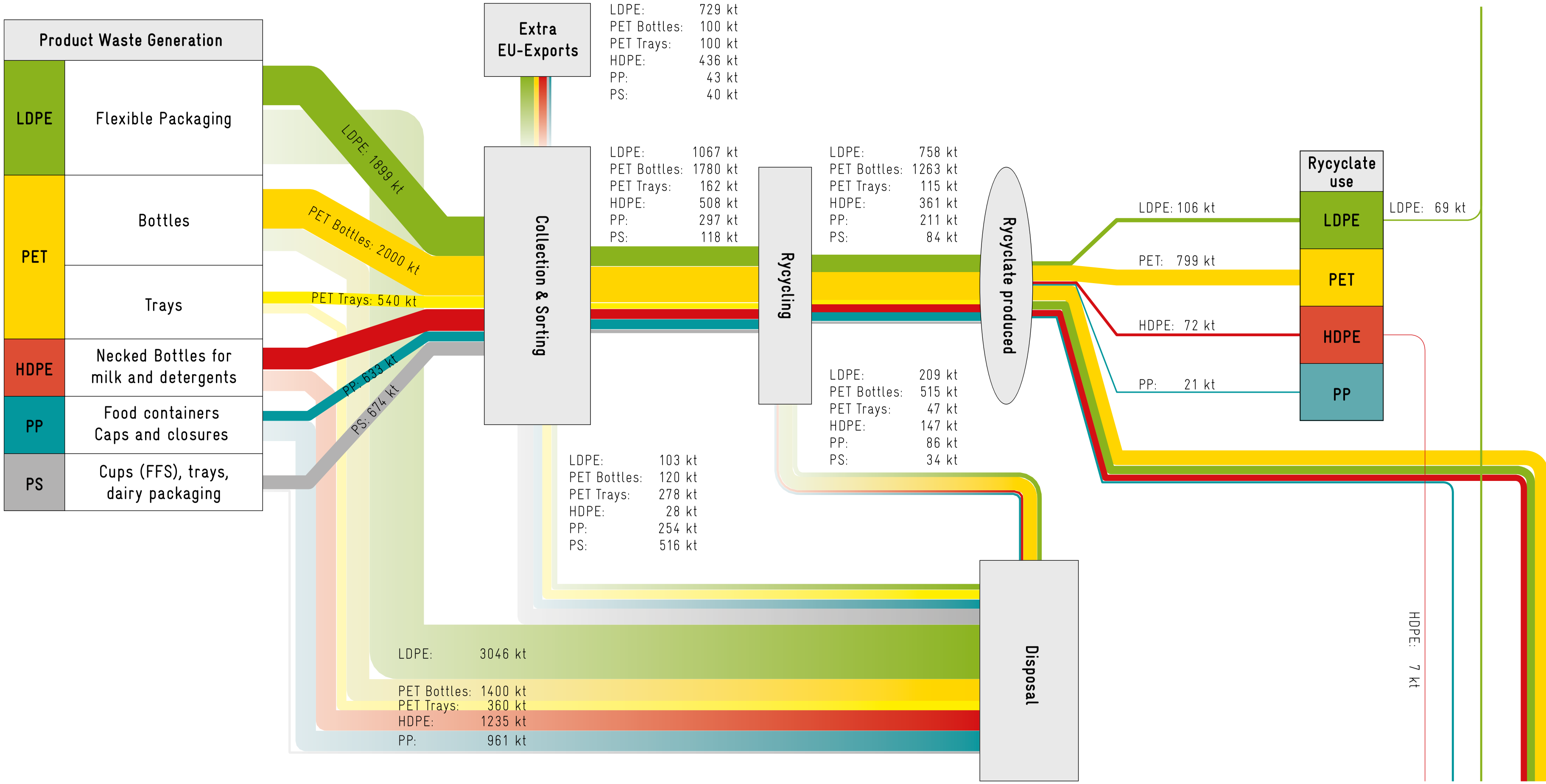
6.2 Knowledge on waste management

As already mentioned as a prerequisite, very detailed knowledge on downstream waste management is needed to define criteria for recyclability in the wider sense (see chapter 3.2). This refers to the waste volumes of certain polymers and to the question in which sectors recycled content is used. Moreover, the domestic collection and sorting system are of relevance here.

To show what level of detail the material flow analysis could have, the following figure (Figure 61, next page) was incorporated, showing an excerpt of the material flow analysis for the packaging sector on which current initiatives under the Circular Plastic Alliance further elaborate the European approach towards D4R.

The EPR Toolbox (PREVENT Waste Alliance 2020) includes general knowledge not only on the establishment of an EPR system (module 1), but in module 2 elaborates on the collection and sorting of packaging waste and focusses on the integration of the informal sector, incentive methods for citizens, and the establishment of a deposit refund system. In module 3 it deals with the question how high-quality recycling can be ensured, how the recyclability of packaging can be improved, and how the market demand for recycled plastics can be increased. Apart from the knowledge aspect, cooperation with the waste management sector for monitoring the fulfilment of the objectives of D4R is crucially important.

Figure 6-1: Material flow analysis of European Packaging Sector



Note: For enhanced readability see the original source. The figure was incorporated to show the level of detail of the analysis; streams of recycled material that leave the graph in the right downer corner are used in other sectors. This kind of graph is also available for other sectors.

Source: (JRC 2020)

6.3 Level of specification

It was found by JRC (2020) that the more precise and closer to the sectors' processes the D4R guidelines are, the better is the acceptance. On the other hand, such guidelines and criteria should be strong and specific enough to be used for regulation and enforcement. Both perspectives indicate that detailed knowledge and close collaboration with waste management as well as manufacturing industry is needed.

In the EU, the CEN-CENELEC is expecting an overarching standardisation request and will start to work on detailed standards by the end of 2021 or beginning of 2022. As can be seen from the global initiatives presented earlier (page 16), not all implementation projects are at the same level of detail compared to the EU process.

7 Trade-offs

One option – in this case increased recyclability – has almost always shortcomings in another area or under specific circumstances. This chapter can only refer to some trade-offs that have been identified but cannot propose perfect solutions yet; it is meant as an impulse to open the reader's eyes for the complexity of conflicting goals.

Environmental performance of non- vs. recyclable packaging in specific contexts

Increased D4R somehow implicitly points into the direction of recyclable mono-material streams, however, it can be questioned whether this is the most efficient way forward when combating environmental problems caused by plastic: It was shown that a multilayer flexible packaging for food packaging which is not recyclable performed better in environmental life cycle assessment (LCA) categories than recyclable thermofilms (Pauer et al. 2020). However, such packaging is less preferable according to the pillars of recyclability defined by the German Packaging Act (chapter 3.2). While increased recyclability contributes to the circular economy, some non-recyclable packaging materials appear to have less of an environmental impact during production, transport and end-of-life. This tradeoff has also been discussed by Pauer et al. (2020). As it is usually the case with conflicting goals, one must look behind the simple comparison and balance the objectives in the context of the problem. Which aspects were considered in the analysis and to what extent, e.g. if the issue were food packaging which has very special hygiene requirements? Does a closer look at the problem with broader system boundaries perhaps allow an assessment of which option would be preferable? Circular Economy for example aims at reducing primary resource extraction. In this sense, recyclability is crucial to substitute primary through secondary raw material, but considering the hygiene requirements for food packaging, this packaging stream requires specific treatment compared to waste streams with less requirements. Furthermore, better environmental results for non-recyclable packaging in the above-mentioned study assume that waste incinerators are equipped with a well-working exhaust gas system which cannot be assumed for all incinerators on a global scale.

Forfeit recyclability while archiving plastic reduction from less recycled material?

In many cases, spec. with mono-material streams rigid plastics perform better in collection and sorting at industrial scale than flexible packaging, mainly because items from rigid plastic, e.g. bottles, containers, trash bins, etc. at the end of life end up in more or less the same form as when entering the market compared to e.g. agricultural foils which may have broken into small pieces during use. It is clear, however, that flexible packaging – which Flexible Packaging Europe defines to be "plastic films, paper and aluminum foil – either separately or in combination" – is lighter than rigid packaging. Aiming at a reduction of plastic, an easy conclusion drawn by Flexible Packaging Europe (Flexible Packaging Europe 2021) was the proposal to substitute rigid through light packaging which reduces the amount of plastic on the market by weight. As outlined in chapter 3.3, the material composition and reduction should be taken under consideration as well as the collection, sorting and recycling processes. At the same time, the substitute packaging must fulfill the needs. The extent to which it makes sense to substitute rigid through light packaging and how far this will influence the total amount of recyclable packaging on the market remains to be seen.

8 Key implementation aspects

This chapter contains the compilation of lessons learned from the incorporated information and from the research behind it.

- A design-for-recycling guideline for a plastic item is developed for a **specific product** made from a **specific polymer** or other materials. It **can additionally be sector-specific**, if needed. Knowledge on the waste management processes and material streams at recycling level is crucial. Furthermore, guidelines should include the recyclability potential for the material but also consider collection and sorting under the commonly applied waste management systems in the country. Due to these specific requirements, it would be better to start with priority products.

- A variety of D4R guidelines for different products is already available and used by industry initiatives in Europe (see TOP 25 in the Annex of this report and over 100 D4R guidelines in Annex 3 of JRC (2020), see download link in footnote 7). These can be used as a **blueprint for own, context-specific developments.**

- The starting point for D4R development was found to be comparable priority product groups as it was proposed for recycled content targets (see the recycled content pre-study), e.g. pipes made from HDPE (construction sector) or agricultural foils (LDPE). Additionally, in view of the bouquet of interrelated upstream measures, it is **advised to implement D4R in combination with recycled content targets**, possibly through the means of Ecodesign.

- The starting point for the implementation of D4R is a parallel way forward with a policy and a technical "track". The former has the aim to bundle guidelines or criteria sets under a **legal umbrella** and propose a method how new guidelines can be added to the framework; the latter focusses on the technical requirements for a certain material or product. As long as no legal umbrella framework exists, the guidelines shall ensure compatibility with the waste management systems but are not an implementation measure for downstream measures, do not offer any legal certainty and should therefore only be understood as a recommendation or industry commitment.

- **Recommendations from current European undertakings** teach us to avoid different guidelines for the same products and / or polymers, to ensure regular updating and to establish a testing process to asses recyclability and to demonstrate compliance with the guidelines. As for some types of products, increased recyclability may lead to a decreased functionality, guidelines will only be accepted by the market by ensuring a level playing field by formulating precise standards, e.g. by recognised standardisation bodies. The coherence with other initiatives and regulatory requirements is also important.

- It is not only the aim of D4R and other upstream measures to **strengthen the domestic sorting and recycling sector.** This rather presents a necessary prerequisite. The aim of design-for-recycling is to subsequently stimulate and improve sorting and recycling. The recycler has an economic advantage if he can use well-sorted plastic. The mistake of using well-sorted imported plastic for recycling should not be made. Inputs for plastic recycling should be domestically sourced.

- Contrary to the general opinion that segregation at source has to be fully established first, that further recycling capacities have to be built up and that no progress is needed in terms of recyclability of products because "as yet, not so much ends up in recycling anyway", **upstream and downstream measures have to be implemented in parallel.**

List of References

CEN-CENELEC (ed.) (2021). CEN-CENELEC Work Programme 2021, 2021. Online available at https://www.cencenelec.eu/news/publications/publications/0953-workprogramme-2021_uk.pdf, last accessed on 1 Feb 2021.

CEPI (2021): Cutting Confusion over Recycling CEPI (ed.). Online available at https://4evergreenforum.eu/cutting-confusion-over-recycling/, last accessed on 17 Feb 2021.

Ellen MacArthur Foundation (ed.) (2019). New Plastics Economy, Global commitment. June 2019 report, 2019. Online available at https://www.ellenmacarthurfoundation.org/assets/downloads/GC-Report-June19.pdf, last accessed on 1 Sep 2020.

European Commission (ed.) (2018). A European Strategy for Plastic in a Circular Economy, 2018. Online available at https://www.europarc.org/wp-content/uploads/2018/01/Eu-plastics-strategy-brochure.pdf, last accessed on 7 Sep 2020.

European Commission (ed.) (2020a). DESIGN FOR RECYCLING WORK PLAN, EU Circular Plastic Alliance, 2020. Online available at https://ec.europa.eu/docsroom/documents/43688, last accessed on 13 Jan 2021.

European Commission (ed.) (2020b): A new Circular Economy Action Plan, For a cleaner and more competitive Europe. COM(2020) 98 final. Online available at https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF, last accessed on 1 Mar 2021.

European Commission; ASEAN (ed.) (2019). Circular Economy and Plastics: A Gap-Analysis in ASEAN Member States. In collaboration with Akenji, L.; Bengtsson, M.; Kato, M.; Hengsbaugh, M.; Hotta, Y. et al., 2019.

Flexible Packaging Europe (2021): Resource Efficiency - Prevention Flexible Packaging Europe (ed.). Online available at https://www.flexpack-europe.org/en/sustainability/resource-efficiency.html, last accessed on 9 Feb 2021.

German Association for Plastic Packagings and Films (ed.) (2019): Jepsen, D.; Zimmermann, T.; Rödig, L. Eco Design of Plastic Packaging, Round Table Management Guidelines, 2019. Online available at https://ecodesign-packaging.org/wp-content/uploads/2020/05/ecodesign_core_guidelines_online_EN.pdf, last accessed on 18 Feb 2021.

JRC (ed.) (2020). Support to the circular plastics alliance in establishing a work plan to develop guidelines and standards on design-for-recycling of plastic products. European Commission Joint Research Center, 2020.

mudjeans.eu (2020): Factivism Circular Economy mudjeans.eu (ed.). Online available at https://mudjeans.eu/blogs/geen-categorie/blog-factivism-circular-economy, last updated on 11 Sep 2020, last accessed on 13 Jan 2021.

Nordic Council of Ministers (ed.) (2017): Watson, David: Elander, Maria; Gylling, A.; Andersson, T.; Heikkaillä, P. Stimulating Textile-to-Textile Recycling, 2017. Online available at https://norden.diva-portal.org/smash/get/diva2:1161916/FULLTEXT01.pdf, last accessed on 13 Jan 2021.

Pauer, E.; Tacker, M.; Gabriel, V.; Krauter, V. (2020): Sustainability of flexible multilayer packaging: Environmental impacts and recyclability of packaging for bacon in block. In: Cleaner Environmental Systems 1, p. 100001. DOI: 10.1016/j.cesys.2020.100001.

petco (ed.) (2019). DESIGNING FOR THE ENVIRONMENT, 2019. Online available at https://petco.co.za/wp-content/uploads/2019/08/PETCO_Design-for-Recyclability_Guideline-Document_2019_FINAL.pdf, last accessed on 1 Feb 2021.

PEW; Systemiq (2020): Breaking the plastic wave, A comprehensive Assessment of Pathways towards stopping Ocean Plastic Pollution, 2020. Online available at https://www.systemiq.earth/breakingtheplasticwave/, last accessed on 26 Aug 2020.

PREVENT Waste Alliance (2020): EPR Toolbox, Know-how to enable Extended Producer Responsibility for packaging. In collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH PREVENT Waste Alliance (ed.). Online available at https://prevent-waste.net/en/epr-toolbox/, last updated on June 2020, last accessed on 25 Jan 2021.

Recyclass (ed.) (2019). PE Coloured Flexible film, 2019. Online available at https://recyclass.eu/wp-content/uploads/2019/11/PE-Coloured-Flexible-films-guidelines-11-2019-2.pdf, last accessed on 1 Feb 2021.

Sharma, S. (2019): Plastic Packaging: Principles of design for Recycling, supervised by Holmberg, Mariann, Acarda University of Applied Sciences. Helsinki, Finland, 2019. Online available at https://www.theseus.fi/bitstream/handle/10024/167495/Thesis_SujalSharma2019.pdf, last accessed on 19 Jan 2021.

The Global Consumer Goods Forum (2021): Packaging Design, Reducing the Complexity of the Recycling Process & Increasing Recycling Rates The Global Consumer Goods Forum (ed.). Online available at https://www.theconsumergoodsforum.com/environmental-sustainability/plastic-waste/key-projects/packaging-design/, last accessed on 17 Feb 2021.

WRAP (2020): Fibre packaging design guide WRAP (ed.). Online available at https://wrap.org.uk/sites/default/files/2020-08/WRAP-Fibre-packaging-design-guide-v3.pdf, last accessed on 17 Feb 2021.

Annex

Table 8-1: Shortlist of 25 industry led D4R guidelines selected by JRC 2020

Name of guideline	Issuing body
Borealis 10 codes of conduct for Design for Recyclability for Polyolefin Packaging Design	Borealis
https://circularanalytics.com	Circular Analytics
Circular Packaging Design Guideline	FH Campus Management Wien; Section of Packaging and Re-source
Citeo 2020 rate list for recycling household packaging	Citeo (France)
cyclos-HTP	Institute cyclos-HTTP
Design 4recycling. Design plastic packaging so it can be recycled	Der Grüne Punkt
Design-for-recycling Guidelines	SUEZ.circpack®
Design Guide for PET Bottle Recyclability	EFBW (European Federation of Bottled Waters) and UNESDA (Union of European Beverages Associations)
Designing for a Circular Economy Guidelines (draft)	CEFLEX
European (EPBP) PET Bottle Platform initiative	European Association of Plastics Recycling and Recovery Organisations (EPRO), European Plastics Recyclers (EuPR), PET Containers Recycling Europe (Petcore), Union of European Beverages Association (UNESDA), European Federation of Bottled Water (EFBW)
Packaging 4 Recycling	EXPRA's Sustainability and Packaging Working Group
PETCORE Europe Design-for-recycling guidelines for PET thermoformed trays: Clear transparent to be recycled even in food applications	PETCORE (PET COntainers REcycling) Europe
RECOUP	Recycling of Used Plastics Limited (RECOUP)
Recyclability of plastic packaging: Eco-design for improved recycling	COTREP (Comite Technique pour le Recyclage des Emballages Plastiques), France
RecyClass design-for-recycling guideline for HDPE Coloured Containers	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for HDPE Natural Containers	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PE Coloured Flexible film	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PE Transparent Flexible film	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PO Pots, Tubs, Blisters & Tray	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PP Coloured Containers	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PP Natural Containers	RecyClass / Plastics Recyclers Europe (PRE)
RecyClass design-for-recycling guideline for PP Transparent Natural Flexible film	RecyClass / Plastics Recyclers Europe (PRE)
Recycled plastics - Practical guide for integrating recycled plastics into the electrical and electronic equipment	Eco-systemes (France)
Reuse and recycling of plastic packaging for private consumers	Network for Circular Plastic Packaging (on behalf of the Danish Plastics Federation)
Round Table Packaging Eco Design of Plastics	IK Industrievereinigung Kunststoffverpackungen e.V. (German Association for Plastic Packaging and Films)

Source: (JRC 2020)

Figure 8-1: RecyClass D4R matrix for PE coloured flexible film

RecyClass™	PE Colured Flexible Film		
	YES Full compatibility Materials that past the testing protocols with no negative impact OR materials that have not been testet (yet), but are known to be acceptable in PE recycling	**CONDITIONAL** Limited compatibility Materials that past the testing protocols if certain conditions are met OR materials that have not been testet (yet), but pose a low risk of interfering with PE recycling	**NO** Low compatibility Materials that failed the testing protocols OR materials that have not been testet (yet), but pose a high risk of interfering with PE recycling
Polymer	PE-LD; PE-LLD; PE-HD	multilayer PP/PE	any other polymer
Colours	light colours; translucent colours	dark colours	
Barrier	barrier in the polymer matrix	≤ 5% EVOH (in polyolefinic combination film); metalized layers; "Ecolam High Plus"; "VO+ LLDPE"	› 5% EVOH (in polyolefinic combination film); barrier layer PVC; PA, PVDC; any other barrier layer foaming agents used as expendant chemical agents; aluminium
Additives			additives concentration ≥ 0.97 g/m^3
Labels	PE label	PP label; paper label	metalized labels; any other
Adhesives	water soluble (less than 60°C)		
Inks	no inks	non toxic (follow EUPIA Guidelines)	inks that bleed; toxic or hazardous inks
Direct Printing	laser marked; small production or expiry date		

Source: (Recyclass 2019)

Last updateed November 2019

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 – 5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

I www.giz.de