



**PIONEERING
DIGITAL
WATERMARKS
FOR SMART
PACKAGING
RECYCLING
IN THE EU**

**Digital Watermarks
Initiative HolyGrail 2.0**



CIRCULAR ECONOMY

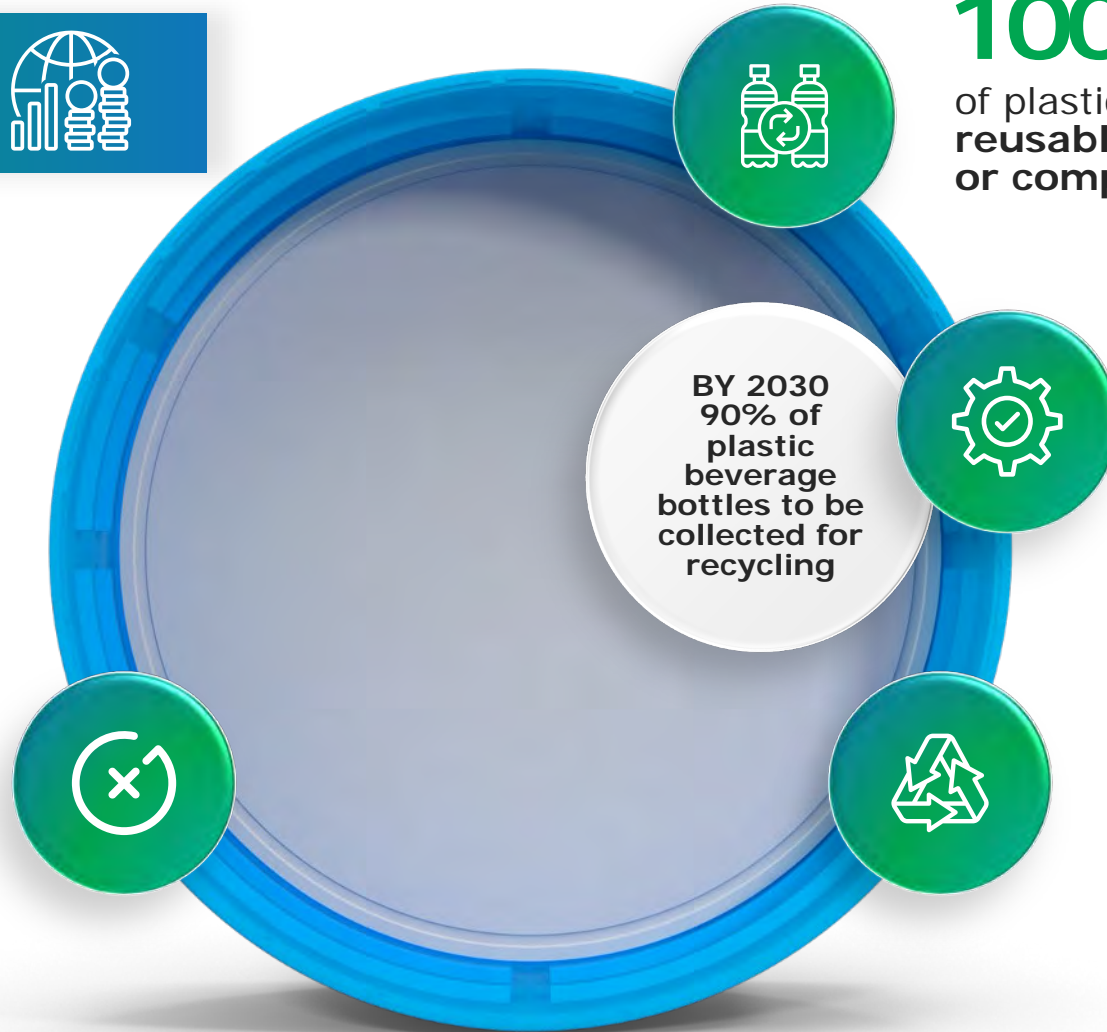
FOR PACKAGING



FACING THE NEW
CIRCULAR REALITY



Eliminate problematic
or unnecessary
**single-use
plastics**



BY 2030

100%

of plastic packaging to be **reusable, easily recyclable, or compostable**

BY 2030

55%

of plastic packaging to be **effectively recycled**

BY 2030

30%

average recycled content across all plastic beverage bottles

CIRCULAR ECONOMY

FOR PACKAGING

How can we achieve a Circular Economy for Packaging in the EU?



One of the biggest challenges is how to **maximize our resources** through optimal sorting and recycling



We need to **better sort our post-consumer waste in the EU waste management systems** by accurately identifying (plastics) packaging, resulting in more efficient and higher-quality recycling

CIRCULAR ECONOMY

FOR PACKAGING

Digital watermarks for smart packaging to **revolutionise the way packaging is sorted**

Opens **new possibilities** currently not feasible with existing technologies



CIRCULAR ECONOMY

FOR PACKAGING



September 2020: Under the auspices of AIM, European Brands Association, companies and organisations from the complete packaging value chain joined forces under the HolyGrail 2.0 project

Objective: Prove the viability of digital watermarking technologies for accurate sorting and the business case at large scale

Website: www.digitalwatermarks.eu

WHAT ARE Digital Watermarks?

- ▶ Imperceptible codes, the size of a postage stamp, covering the surface of a consumer goods packaging
- ▶ Able to carry a wide range of attributes (e.g. manufacturer, SKU, type of plastics used and composition for multilayer objects, food vs. non-food usage)

LOOKS LIKE THIS ◀



WHAT ARE Digital Watermarks?

BEHAVES
LIKE THIS ◀

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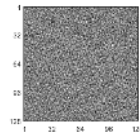
Digital Watermarks @work

FOR PRINT



01

Repeated Tile



02

Pieces of multiple tiles can be combined to recover a Barcode

03

The encoder applies the tiles to graphics in a mosaic manner

04

Uses existing pixels
No special inks
No special printing process



Exaggerated view for illustration purposes

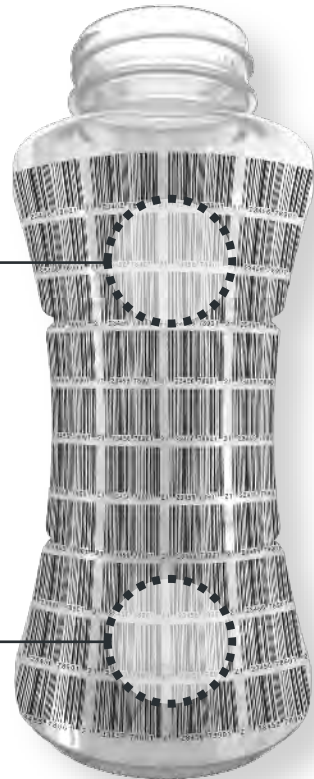
Digital Watermarks @work

FOR MOLDS



Micro-topological variations in substrate create signal tiles

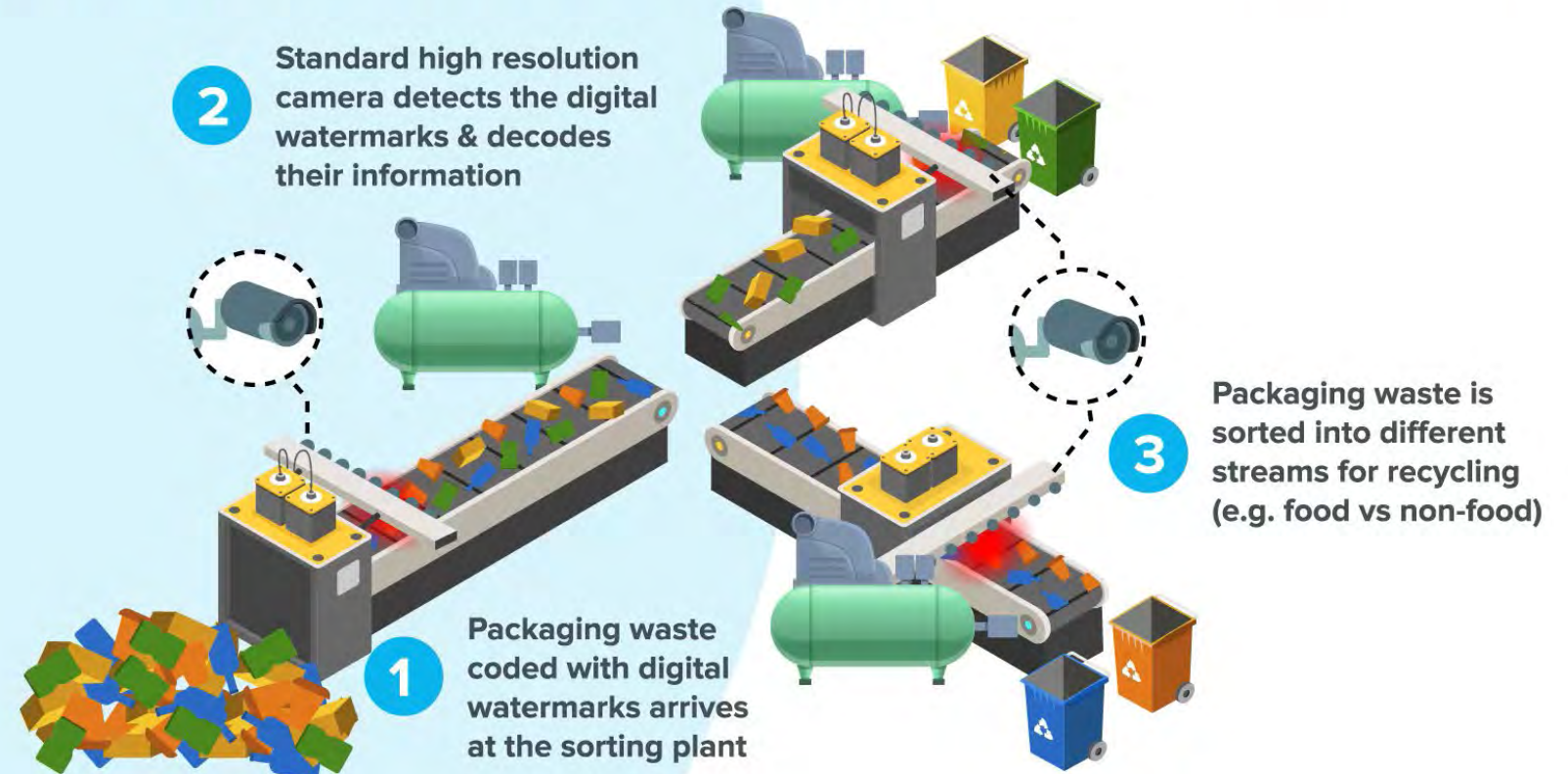
Works in variety of mold types



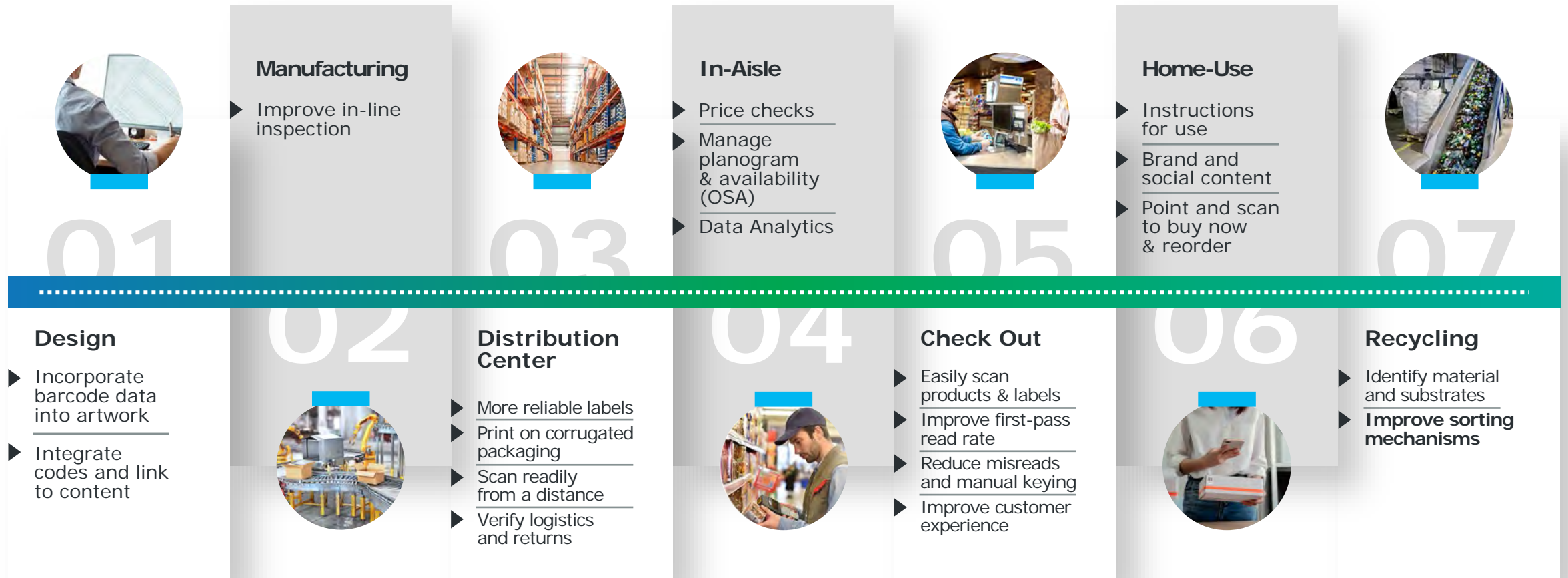
HOW DO DIGITAL WATERMARKS WORK ON A SORTING LINE?



SMART PACKAGING SORTING FOR A CIRCULAR ECONOMY



POTENTIAL BENEFITS OF DIGITAL WATERMARKS across the package life



HOLYGRAIL 2.0 Membership

EASTMAN

Expra
Science
Production
Responsibility
Alliance

wrap

Henkel

DIGIMARC

PÖPPELMANN

PLASTICS RECYCLERS EUROPE

Dr. Oetker

viappiani
member of ci

L'ORÉAL

HALEON

ALPLA

hi-repro
PRESS FORWARD

Johnson & Johnson
CONSUMER HEALTH

ecoembes

METRO

ALDI

The Coca-Cola Company

Hochland

suez

Reclay Systems

Matthews
INTERNATIONAL

Arla

Verstraete
In mould labels

MULTICOLOR
MULTI-COLOR
MULTI-COLOR

Taghleef Industries

SKK

EDEKA
Netto
Marken-Discout

sesotec

Intersnack

Landbell Group

mondi

REYNDERS
label printing

reproflex

PLASTICS EUROPE

REWE
GROUP

P&G

KESTREL
VISION

Constantia
Flexibles

VALORLUX
BE THE CHANGE

essity

(IPL)

Unilever

DANSK
RETUR
SYSTEM

INDORAMA
VENTURES
WELLMAN INTERNATIONAL LTD

Fuji Seal

Logoplaste

amazon

Seeberger

KIEFEL
TECHNOLOGIES
A Member of Brackner Group

DAS STUDIO
Trusted Brand Production

sulayr
GLOBAL SERVICE

PACCOR
PACKAGING SOLUTIONS

Unternehmensgruppe
Theo Müller

müller

ELOPAK

DANONE
LIFEWATER, TOP FRESH

Logoplaste

SUDPACK

SIG

SPIES

Chespa

MARS

Unternehmensgruppe
Theo Müller

müller

SAICAFLEX

Kellogg's

GUILLIN
we protect your food

GIZEH

Mondelēz
International

KALYPSO
A ROCKWELL AUTOMATION BUSINESS

MacDermid
GRAPHICS SOLUTIONS

Linked
janoschka

PELLENC ST
WE CAN SORT IT

CITEO

Graham
Packaging

SLEEVE
INTERNATIONAL

Vandemoortele
shaping a tasty future

SICK
Sensor Intelligence.

pre
zero

jokey

WIPAK

BOSCH
Invented for life

SONOCO

greiner
PACKAGING

INNOTECH
COFOPAN emsur

PEPSICO

ITC
Packaging

AEROFLEX

CEFLEX
AEROCORPORATION'S TECHNOLOGICAL

Novacel

PACKAGING
STRATEGY
LAB

Orkla Berry

storaenso

SONOCO

greiner
PACKAGING

INNOTECH
COFOPAN emsur

PEPSICO

Fostplus

Reifenhäuser

ALDI

PROTECTS
WHAT'S GOOD
Tetra Pak

arca

All4Labels
GLOBAL PACKAGING GROUP

FERRERO
SOREMARTEC

FOBOHA
A business of BAKERS

amcor

GREATVIEW

storaenso

Schulstad

AVERY
DENNISON

DNP
Dai Nippon Printing

Nestlé
Good food. Good life

COLGATE-PALMOLIVE

BOREALIS
Keep Discovering

VEOLIA

TOMRA
SORTING SOLUTIONS

KORSINI

ProAmpac

FINAT
Empowering the label industry



Successfully Completed 2021

Phase 1

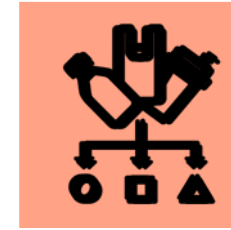
- Develop a functional HG2.0 prototype as an add-on module to detect and separate the DW packaging from packaging waste, allowing category specific sorting.



Successfully Completed 2022

Phase 2

- HG2.0 prototype is tested for speed, accuracy and detection efficiency, and this for a category specific sorting based on DW detection – in combination with NIR and VIS.



We are here Throughout 2022/2023

Phase 3

- HG2.0 prototype will be deployed in a large-scale pilot in a commercial sorting and/or recycling facility, under standard operation conditions.

- **Active progress in Phase 3 (industrial testing)**
 - Completed (Feb 23) : Rigid PET trials (sort non food) successfully completed @ Wellman (Verdun)
 - high detection / sorting efficiencies (92%/ 88% Pass 1 – 96%/95% Pass 2) . Purity ca 80%.
 - Next phases : 1) Flexibles Film sort trial and 2) extended (3 months) testing at MRF (as of Sep 23) @Huendgen (Germany)
 - Final test : Industrial PET non beverage recycling trail @ Wellman (Verdun) (Jan 24)
 - Target Phase 3 completion end 2023 / Jan 24
- To drive impact in the short term, **our hypothesis is that such a multifaceted industry wide transformational program now requires the creation/execution of a pilot/demonstration market (“landing strip”) to test the approach at scale and hence provide all stakeholders with data/ facts to answer value creation questions.**
- **FRANCE selected by the LT – strong engagement by market players, ambitions of French government for a Circular Economy/ funding available, strong PRO, Citeo, engaged & active on HG2.0 LT**
- Smart design to give us data-based answers whilst ensuring benefits/risk ratio is favorable to all.
- 2030 deadlines around the corner. Need to move away from discussions to data/validating hypothesis
 - **End goal: to deliver positive impact and drive circular economy.**

Brand owners/retailers:

- Get early access to additional high-quality PCR volume to “close the loop” with packaging converters, demonstrate technical feasibility and understand pricing/value of new PCR grades.
- Refine costs and process complexity of DW incorporation into artwork process at scale (e.g. 100-500 SKUs range/company).
- Enable commercialisation/exploitation in market to drive consumer engagement and sales.

Technology providers / Machine vendors

- Confirm technical robustness, validate economic value and full potential of the platform including data management.
- Incremental revenues/profits from machine sales/licences.

Waste management companies

- Validate a path to value creation (€ value of sales of new/improved PCRs vs. investments/costs).

PRO

- Data transparency benefits.
- Improving recyclability and recycling rates.
- Establishment of a new-to-the-world, data-based, transparent and granular process to understand what is being effectively recycled (at SKU level) and in turn (if/ when technology is scaled).

Public/Government

- Drive tangible actions towards the public/taxpayers, consistent with declared priorities to drive sustainability benefits via a novel innovative, digital platform.
- Be and be seen as a leader within EU.

Overall Sustainability Positive Impact

- Improvements on purity and quality of materials stream, and creation of new streams (e.g. food/non-food), leading to reduction of waste/material incineration and hence CO2 emissions.

<p>Roland Berger (RB) consultancy study</p> <ul style="list-style-type: none"> i. validates the potential for HG2.0 value creation and ii. identify most valuable business cases 	<p>DONE</p>
<p>Digital Watermark (DW) platform is sufficiently advanced and delivers clear benefits vs. other available technologies (including Object Recognition/AI)</p>	<p>DONE</p>
<p>HG2.0 Lead Team and Work Package leaders confirm that we have a ready and executable base plan (including technical readiness, data management base plan in place)</p>	<p>IN PROGRESS</p>
<p>Phase 3 is executed, and tests meet defined criteria</p>	<p>IN PROGRESS</p>
<p>A sufficient critical mass of Brand Owners, Retailers and Waste management operators (sorters and recyclers) ready and willing to participate (across identified key business use cases)</p>	<p>IN PROGRESS</p>

For France, the total net benefit for the system, after deducting sorting costs and brand owners' costs, is at EUR 14 – 44 m/ year in 2030 (two price scenarios)

Net benefit summary, France, 2030 (for adoption rate of 54%)

Disclaimer: DRS is not confirmed yet for France. See example from Belgium



Use Cases	Benefit in 2030 (two price scenarios)	Sorting costs	Brand owners' costs	Net Benefit in 2030 (two price scenarios)
PET bottles ¹⁾	EUR 6-8 m	EUR 5 m	EUR 3 m	EUR -2 - 0
PET trays	EUR 3-5 m	EUR 2 m	EUR 1 m	EUR 1-2 m
HDPE bottles, trays	EUR 14-21 m	EUR 5 m	EUR 3 m	EUR 6-13 m
PP bottles, trays	EUR 9-14 m	EUR 3 m	EUR 2 m	EUR 3-8 m
LDPE films	EUR 11-21 m	EUR 4 m	EUR 3 m	EUR 4-14 m
PP films	EUR 5-9 m	EUR 2 m	EUR 1 m	EUR 2-6 m
	EUR 47-78 m/y	EUR 20 m/ y	EUR 14 m/y	EUR 14-44 m/y

- ### Key take-aways
- All use cases in France are positive (except for PET bottles in downside scenario) – PET volumes exclude beverage bottles assumed to be shifted to DRS (if no DRS, business case is substantially more positive)
 - Overall benefit estimated only for advanced sorting uses case for plastic – upside from other use cases along the value chain and or other materials (e.g. composites)
 - Largest share of costs at station level than on brand owners & retailers in France, given the strongly dispersed landscape of sorting stations in the country (different from EU landscape)

1) Assumes introduction of DRS in France for beverages, i.e. volumes in business case excludes these volumes

Key assumptions for the six advanced sorting use cases consider the adoption rate, benefits and costs (OPEX & depreciated CAPEX, for sorting stations and brand owners)

Key assumptions used in the business case for advanced sorting for plastics in France, per year in 2030



A. Adoption of digital watermarks

- 60% of brand owners & retailers estimated to eventually adopt (in 3 waves: early wave starts in 2024, late adopter wave starts in 2026), 40% will not adopt
- Derived from segmentation of brand owners based on size, packaging portfolio, governance etc.



- Packaging mix/ put on market (polymer volumes¹⁾) of the brand owners, assumed to adopt DW

54% of plastic packaging in scope watermarked in 2030

B. Benefits

B1. Volume effect benefit – additional sorted volumes from improved sorting efficiency at sorter (90% vs. 70%)

Volumes	Prices	EUR 12-19 m
40 k t/ year in addition (5% of put on market ¹⁾)	Ø EUR 340-520/ t bale price ⁶⁾	



B2. Quality effect benefit – better quality of sorted volumes

Volumes	Prices	EUR 35-60 m
250 k t/ year sorted at better quality	Ø EUR 220-370/ t bale premium ⁶⁾	

EUR 47-78 m/ year in 2030 total benefits from DW (at the 54% adoption rate²⁾)

C. Costs (net analysis)⁵⁾

C1. At sorting station level

- CAPEX³⁾: EUR 612 k/ output stream, i.e., EUR 100/ reader+ other CAPEX of EUR 512 k/ stream for belts, installations etc. = Depr. EUR 76 k/ y/ stream (8 years)
- OPEX³⁾: EUR 33 k/ y/ stream for maintenance, power etc.

PRFs (2nd stage sorting)

EUR 110 k/ y/ stream x 3 streams x ~20⁴⁾ PRFs
= EUR 6.6 m/ year

MRFs (1st stage sorting)

EUR 110 k/ y/ station x 2 streams x ~60⁸⁾ MRFs
= EUR 13.1 m/ year

EUR 20 m/ y at sorting station level

C2. At brand owners & retail level

- Techn. license cost⁷⁾: EUR 250-300/ SKU/ year +
- Artwork: EUR 250-300/ SKU/ year in 2030

Up to 42 k SKUs/ year (watermarked)

EUR 14 m/ year in 2030 for brand owners and retail

1) Polymers in scope: PET bottles outside of DRS, PET trays, HDPE trays and bottles, PP rigid, LDPE and PP films 2) Benefit change proportionally with adoption rate 3) Additional costs are highly dependent on the sorting station type and individual country collection-sorting context 4) Second stage specialized plastic sorters, dividing >600 kt collected (watermarked and not) in 2030 by average capacity of ~38 kt for rigids and flexibles 5) E Comparing with current collection-sorting context in France, thus not considering transportation between stations 6) Down-and upside scenarios considered for bale prices and bale premiums in 2030 7) Including data management cost; price quoted today ranges from EUR 100/ SKU up to EUR 1,000/SKU, dep. on adoption rate and volume; EUR 250-300/ SKU in 2030 assumes an average portfolio and 55% market adoption 8) 50% of MRFs (out of 120 today) assumed to be equipped with 2 streams each, sufficient to fully cover sorting needs in 2030 assuming a concentration of sorting activities by then

- Proceed NOW with the planning towards execution of a Pilot Market in France.
- Timings: start as of 1 Jan 2024, 18-24 months duration.
- Focus is on demonstrating HG2.0 value creation potential for advanced sortation use cases.
- Key business use cases in terms of materials include (based on Roland Berger study)
 - HDPE Bottles and Trays
 - LDPE Films
 - PP Bottles and Trays
 - PP Films
 - PET Bottles and Trays
 - LBC's (not included in RB study but of interest to some)
- Projected Direct Gross Benefit in 2030
 - EU level: in the range of € 450-900 mm/ year
 - FRANCE : in the range of € 50-80 mm/ year (see further slides)
- Projected Direct Net Benefit in 2030
 - EU level : in the range € 250-550 mm EUR
 - FRANCE : in the range € 14-44 mm EUR (see further slides)

Brand owners/Retailers

- We need active and voluntary commitment from a large enough group of brand owners/retailers in France to convert a significant portion (at least 30%) of their French volumes to Digital Watermark across the selected materials of interest. Focus on POWER SKUs (20/80 rule)
- Each company to leverage the data/knowledge AVAILABLE TODAY and make a call on INTENT to participate
- Timing: artwork conversion should start soonest and no later than July 2023 (date may vary by company, to enable significant volume of DW marked product to become part of the waste stream as of Jan 2024).
- Brand owners/retailers need to leverage already planned artwork changes to minimise cost/effort.

Technology providers

- Develop a sufficient number of DW reading modules (estimated 20-40 for the initial state of adoption) to be installed in Sorting Centers/Recyclers.
- Timing: estimated 12 months, to be confirmed
- DW technology provider to provide licensing costs for BO/RE financial assessment and support large-scale artwork implementation as well as implementation of modules in industrial facilities in France.

Waste management companies / Recyclers

- Confirm exact scope (number/location of modules) and readiness to implement in sorting centres/recycling plants.

<input checked="" type="checkbox"/> Roland Berger study conclusions	March 2023
<input checked="" type="checkbox"/> Gain input from “Team France” members on their intention to participate in the scoping of the pilot	Q1 2023
<input type="checkbox"/> “FRANCE Pilot Team” to confirm of the infrastructure plans in France (locations / timings / decision making process)	April 2023
<input type="checkbox"/> Recommendation on holistic data management plan for French pilot market	AMJ 23
<input type="checkbox"/> Confirm support from a sufficiently large set of brand owners, retailers, and waste management operators	April 2023
<input type="checkbox"/> Staff this program as a holistic initiative with a dedicated program manager	April 2023
<input type="checkbox"/> High Level Tentative CPS	
○ Base plan defined (project establishment, who is in, use cases, ..) – Go/No-go decision	May 2023
○ Base plan locked (project commitment)	July 2023
<input type="checkbox"/> Start of execution in market	Jan 2024



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