# UNESCO Chair

## in Life Cycle and Climate Change ESCI-UPF

**ARIADNA PROJECT**

*"Sustainability study on the introduction of a mandatory DRS for packaging in Spain: Comparative environmental, social and economic analysis versus current situation"*

***MESSAGE FORMAT***

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UNESCO Chair
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ESCI upf.
School of International Studies

**Study title:**

ARIADNA PROJECT: "Sustainability study on the introduction of a mandatory DRS for packaging in Spain: comparative environmental, social and economic analysis versus current situation"

**Study conducted by:**
ESCI-UPF

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Barcelona, June 2017

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ESCI-UPF is an educational university institution linked to the Universitat Pompeu Fabra (UPF), whose Charter includes, in Article 1 c), the goal of: "Providing training and research services to the company's international department that affects any area of business management, environmental management, sustainability and international relations".

In response to this Charter, the UNESCO Chair on Life Cycle and Climate Change, the Mango Chair on Corporate Social Responsibility and the Research in International Studies and Economics (RISE) Group created a research unit that integrates the three areas of sustainability.

Starting with the Environmental Management Research Group (GiGa, created in 2004), the UNESCO Chair in Life Cycle and Climate Change was created on 17 December 2010 in an agreement between ESCI-UPF at the Universitat Pompeu Fabra (UPF) and the United Nations Organization for Education, Science and Culture (UNESCO). Its mission is to promote research and education, to establish networks of collaboration and to generate knowledge for the sustainable development of products and processes nationally and internationally by enabling cooperation between internationally renowned researchers and professionals from universities and other institutions in Europe, Latin America, the Caribbean, Africa and other parts of the world.

## 1. Legislative background

Directive 94/62/EC on packaging and packaging waste requires member States to take preventive measures against the generation of packaging waste, to promote reuse systems and to develop systems for recycling and recovering packaging, thus fostering a reduction in the amount of this type of waste that is discarded. Directive 2004/12/EC, which expands and amends the previous one, lays out the need to establish return, collection and recovery systems for managing packaging and packaging waste in every member State. It is important to recall that the EU's Court of Justice has notified member States that wish to impose a DRS that they must strictly justify the need to do so, as well as its suitability and proportionality.

Subsequently, and as a result of the transposition of Directive 2008/98/EC, Waste Framework Directive, to national law, Law 22/2011 was created on waste and contaminated soil that, in addition to promoting the implementation of prevention, reuse and recycling measures, aspires to increase the transparency and the environmental and economic efficiency of waste management activities by promoting innovation as the driving force.

In Article 21.2, it states that to promote prevention and reuse in the high-quality recycling of glass, plastic and metal packaging and packaging waste, measures may be adopted that are intended to facilitate the establishment of deposit and return systems. It states that "***the technical and economic viability of these systems, their environmental and social impacts and their impact on human health shall be considered, while respecting the need to ensure the proper operation of the domestic market. The Government shall send to the Parliament the required reports on the technical, environmental and economic viability that are written before any implementation of a deposit and return system".*** In Article 30.3 it also states that "These measures shall be established via a Royal Decree approved by the Cabinet of Ministers, ***taking into account their technical and economic viability and their overall environmental, social and health impacts***".

Said text specifies the requirement to set up the separate collection of waste and details the establishment of a common legal framework for the application of extended producer responsibility (EPR). In keeping with this framework, deposit and return systems shall be voluntary in nature. They may be set up on a mandatory basis for the reuse of products or to ensure the processing of waste that is hard to recover or dispose of, waste whose hazardous characteristics determine the need to establish such a system for its proper handling, or when the management targets specified in the applicable law are not met. In the specific case of packaging and packaging waste, there is also a level of compliance that is specified for the recycling targets laid out in European packaging directives, as well as the viable expectations of exceeding said targets, considering the real possibilities that small and medium enterprises have of implementing them.

## 2. Implementing a DRS for single-use packaging and previous studies

<u>**In Europe**</u>, the origins of the implementation of a DRS for single-use packaging are the four Nordic countries, with Sweden pioneering the system in 1994 (Returpack). It was followed by Finland (Palpa),

Norway (Norsk Resirk/Infinitum) and Denmark (Dansk Retursystem). Two common factors in the implementation of a DRS for single-use packaging in the Nordic countries were:

- the DRS for single-use packaging was implemented on top of a widespread DRS for returnable packaging, and
- when the DRS was implemented, there were no other generalized models for recovering single-use packaging.

Then, after being implemented in Germany in 2003, the DRS spread to Croatia and more recently (March 2016) to Lithuania. The governments of countries like France, the United Kingdom, the Czech Republic, Ireland and Belgium commissioned studies (primarily technical and economic) to analyze the suitability of implementing a DRS for single-use drink packaging, which they all rejected.

In the EU, **14 countries** have considered the introduction of a DRS for single-use packaging. Of these, 8 have implemented it and 6 have not.

The bibliography indicates that a DRS recovers between 80 and 90% of the packaging included in the system, an amount that accounts for 1 to 5% of the used packaging that is generated in the region. None of these systems recovers drink cartons. Glass is also not included in all of them, but they all do recover drink cans and PET containers.

**In Spain**, in 1997 the **Packaging and Packaging Waste Law** was laid out - for household single-use packaging - the principle of Producer Responsibility, allowing producers to choose between two management models: joining an Extended Producer Responsibility Organization (EPR) or setting up a Deposit Refund System (DRS). Ever since, packagers have been complying with their household packaging waste obligations by taking part in an EPR. No packager has voluntarily set up a DRS to manage the waste from single-use household packaging in Spain.

The National Waste Plan (PEMAR) places the achievement of recycling and preparing for reuse 50% of household and commercial packaging as the most important challenge to achieve in waste management in Spain. The most recent figure for the recycling of household and commercial waste published by Eurostat was 33% in 2015, versus a European average of 45%. This gap with the European average is much lower in the case of the recycling of packaging, where Spain is slightly above the European average and above most countries, even some with a great environmental tradition and/or with DRS in place, like Austria, Denmark and Norway.

Some proponents have included among their proposals the idea of requiring a DRS to recycle single-use packaging for certain drinks.

> Many proposals have been debated in Spain so that waste management can successfully face the challenges of this demanding future. Since the time and resources are limited, and since a large-scale implementation has social, environmental and economic consequences, before any decisions are made, a detailed cost-benefit analysis for each option will be required.

A significant number of studies have already been conducted, promoted by different social actors or stakeholders. Those found are described below.

Of the studies promoted by Retorna, the following are worth noting:

- INEDIT environmental study (2011), commissioned by Retorna.
- ISTAS labour study (2011), commissioned by Retorna.
- INCLAM environmental study (2012), commissioned by Retorna.
- EUNOMIA economic study (2012), commissioned by Retorna.

The organizations that run the current EPRs have also done studies:

- Sismega economic, environmental and management study (2011), commissioned by Ecoembes.
- Institut Cerdà economic and environmental study (2012), commissioned by Ecovidrio.

Other organizations have also done studies on behalf of various stakeholders:

- ISR operational study (2009), an initiative of the ISR Board.
- UCE bibliographic study (2011), an initiative of the Spanish Consumer Union.
- Tecnoma logistical, economic and management study, commissioned by the Spanish Federation of Municipalities and Provinces (FEMP).
- The economic studies commissioned by the Packaging and Society Platform (PES) and conducted by the Universidad de Las Palmas de Gran Canaria (for the Canary Islands) and by the Universidad de Alicante (for the region of Valencia), using a methodology developed by the Universidad de Alcalá de Henares and the Universidad Politécnica de Madrid through the Ecoembes chair for the national case. ESCI-UPF started two studies using the same methodology for Catalonia and the Balearic Islands. They were not completed, however, due to the start of the more detailed ARIADNA Project.

Lastly, we know of five new initiatives that are being carried out in 2016-2017:

- ENT technical, environmental and economic viability study (2016), commissioned by the government of Catalonia.
- ESCI-UPF environmental, social and economic study (2016), commissioned by the proponents listed at the start of this document.
- Operational, environmental and economic study by the Institut Cerdà (2016), commissioned by the government of the Balearic Islands.
- NOVOTEC environmental, social and economic study (2016), commissioned by FEMP.
- The government of Valencia has expressed its interest in implementing a DSR, though we do not know if it has commissioned an independent study to evaluate its viability. We were unable to find any public studies.

In May 2015, the Catalan Waste Agency (ARC) published a tender to “contract a study on the technical, environmental and economic viability of implementing a DRS for drink packaging in Catalonia”. The material scope of the DRS that the tender proposes studying is broad and complex, as it includes a significant number of materials and products that have not been considered in other countries with a DRS.

- For materials, it includes: steel, aluminium, drink cartons, HDPE, PET and glass.
- For products, it includes: water, soft drinks, juice, beer, wine, sparkling wine and spirits.
- The size of the container must be between 0.1 and 3 litres.

- The amount of the deposit specified by the ARC is 10 cents per container.

This study, conducted by ENT, is expected to be completed in the first months of 2017.

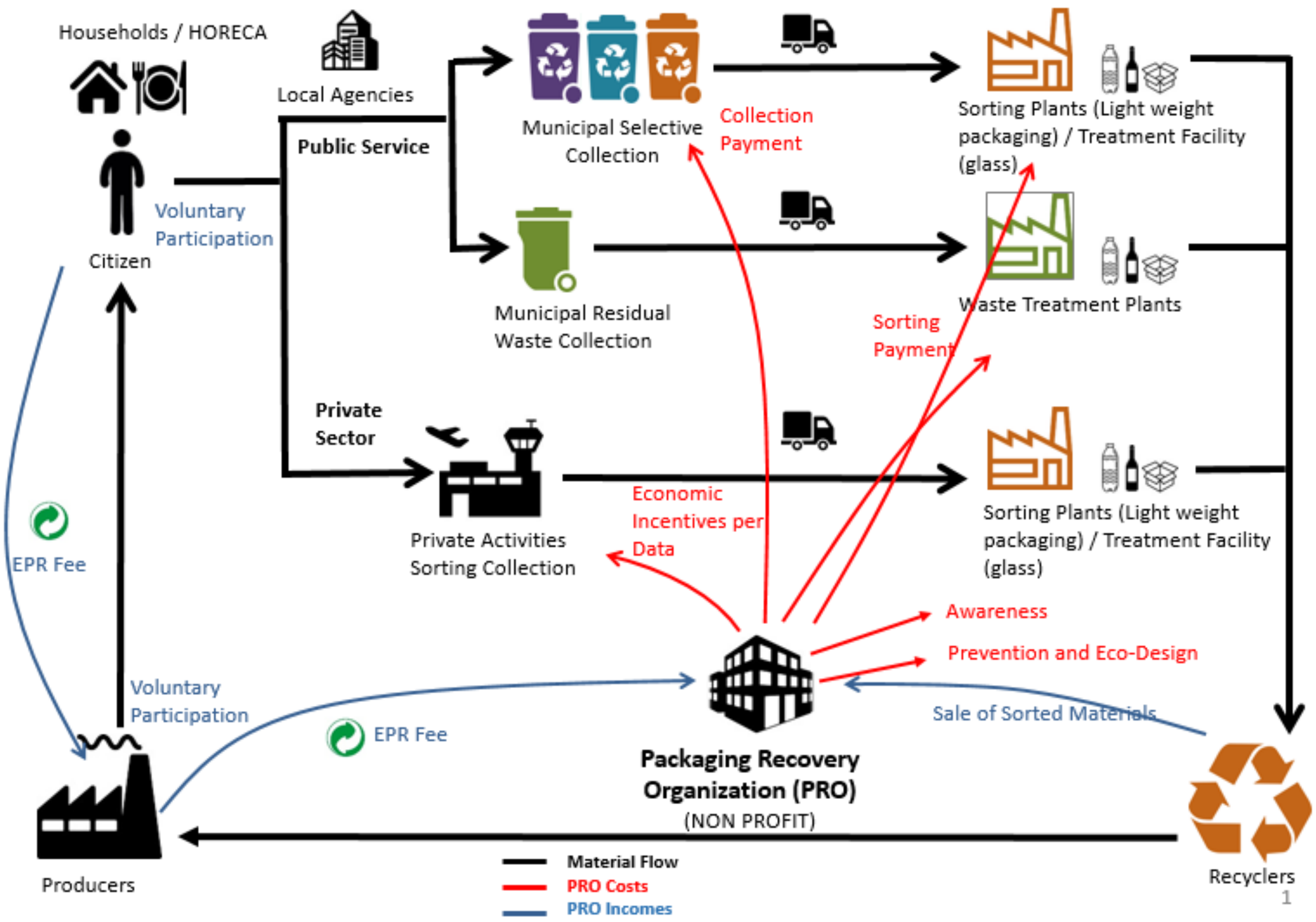
Since the ARC study did not focus on the life cycle or take into account social aspects, the UNESCO Chair on Life Cycle and Climate Change informed, first the ARC and then Ecoembes and Ecovidrio, that it would be important to conduct a study that considers these aspects, and that ESCI-UPF could do such a study. Ecoembes and Ecovidrio decided to promote (along with the organizations shown on page 2) a full sustainability study using whatever methodology the ESCI-UPF deemed suitable and with a proposed timeline similar to that of the ARC. It would be conducted both specifically for Catalonia and for Spain as a whole. Among other factors, it was considered essential to consult with the parties that would be impacted by or involved in its practical execution, including: organizations representing consumers, housewives, neighbours, businesses, hotels, distributors, local agencies, regional governments, packagers, recyclers, environmental organizations, educators, the media, trade unions, political parties and EPRs.

## 3. Extended Producer Responsibility Organization (EPR)

The **Extended Producer Responsibility Organization (EPR)**, better known as an Integrated Management System, or IMS, is a management alternative in which those responsible for marketing packaged products join a non-profit environmental organization in order to coordinate and finance the system for recovering and recycling the waste in question, cooperating technically with local and regional governments. EPRs also encourage eco-design among manufacturers in an effort to reduce the environmental impact of the packaging they market. The allocation of powers in Spain specifies that local agencies are solely responsible for managing municipal waste. It relies, therefore, on a **public-private cooperation model** since it uses private sector funds to finance one task, waste management, that is for the most part carried out by public agencies.

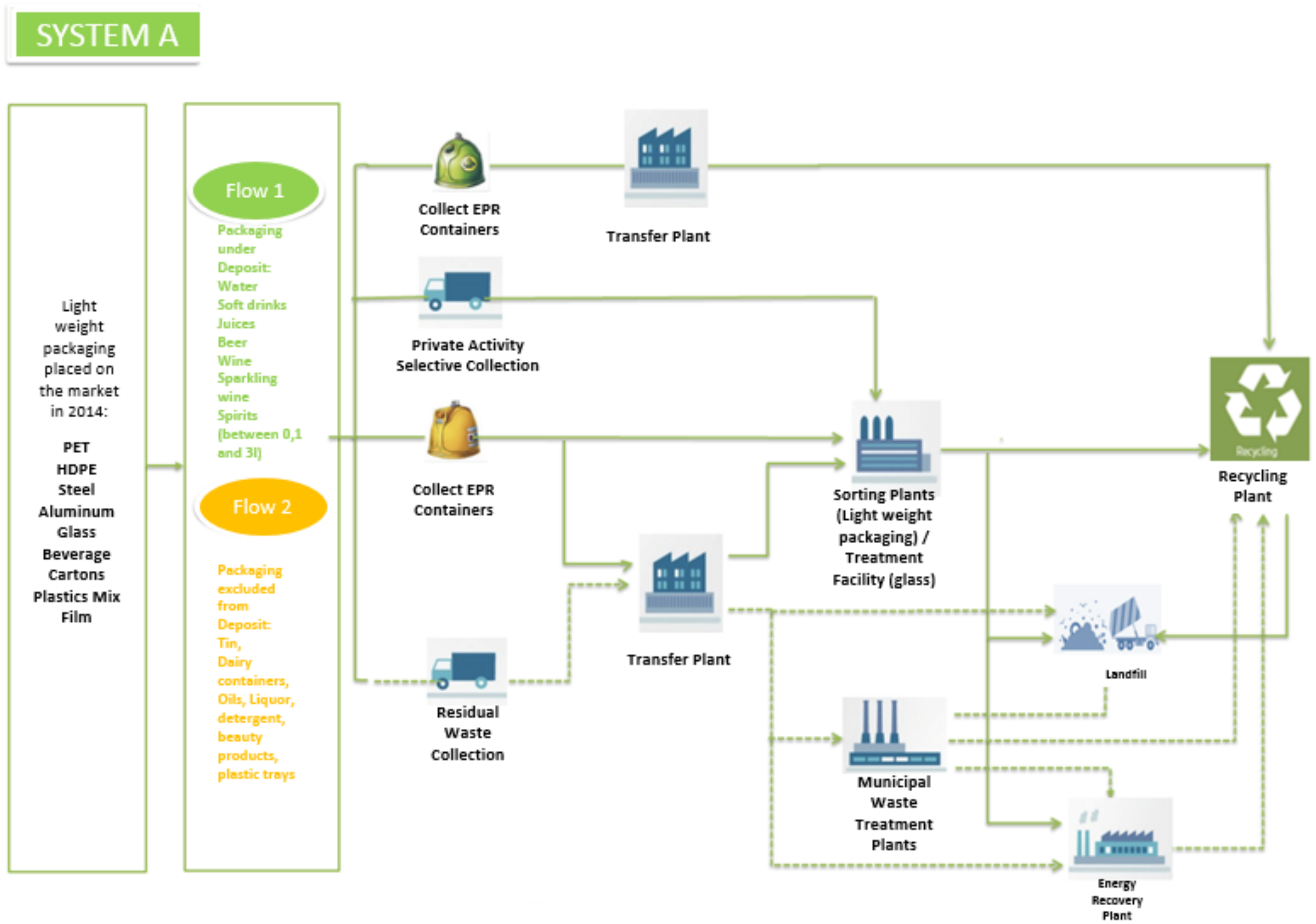
Another defining characteristic of a packaging EPR in Spain is its **universal nature**. It seeks to efficiently manage all types of household packaging and containers throughout Spain. This is why they are also known as *collective systems*. **It includes every region, every material and all types of household packaging, from the most to the least valuable, from the most to the least recyclable, from the largest to the smallest.** It has several areas of action:

- **Encourage eco-design and prevent the generation of packaging** by implementing sectorial plans to prevent packaging waste and providing free tools and services to packaging companies so they can make environmental improvements to their packaging.
- **Finance the added cost** that the separate collection of household packaging represents for local agencies and provide technical advice to improve the efficiency and quality of the service. Optionally, Ecovidrio offers the possibility of replacing this financing by directly managing the separate collection of glass containers, with predefined levels of service.
- **Economic and technical aid** to encourage separate collections of household packaging in places that are privately managed (airports, sports centres, music festivals, prisons, food halls, hospitals, etc.).
- **Economic and technical aid** to local agencies to recover household packaging waste from bulk trash flows through plants to process the residual fraction.
- **Promote, in concert with governments and social groups, awareness and education programs** that engage citizens and the relevant professional sectors, like hotels and shopkeepers.



Households / HORECA
Local Agencies
Public Service
Municipal Selective Collection
Collection Payment
Sorting Plants (Light weight packaging) / Treatment Facility (glass)
Citizen
Voluntary Participation
Municipal Residual Waste Collection
Waste Treatment Plants
Sorting Payment
Private Sector
Private Activities Sorting Collection
Economic Incentives per Data
Sorting Plants (Light weight packaging) / Treatment Facility (glass)
EPR Fee
Awareness
Prevention and Eco-Design
Voluntary Participation
EPR Fee
Sale of Sorted Materials
Packaging Recovery Organization (PRO)
(NON PROFIT)
Producers
Recyclers
Material Flow
PRO Costs
PRO Incomes

1


SYSTEM A
Light weight packaging placed on the market in 2014:
PET
HDPE
Steel
Aluminum
Glass
Beverage Cartons
Plastics Mix
Film
Flow 1
Packaging under Deposit: Water Soft drinks Juices Beer Wine Sparkling wine Spirits (between 0,1 and 3l)
Flow 2
Packaging excluded from Deposit: Tin, Dairy containers, Oils, Liquor, detergent, beauty products, plastic trays
Collect EPR Containers
Transfer Plant
Private Activity Selective Collection
Collect EPR Containers
Residual Waste Collection
Transfer Plant
Sorting Plants (Light weight packaging) / Treatment Facility (glass)
Recycling Plant
Landfill
Municipal Waste Treatment Plants
Energy Recovery Plant

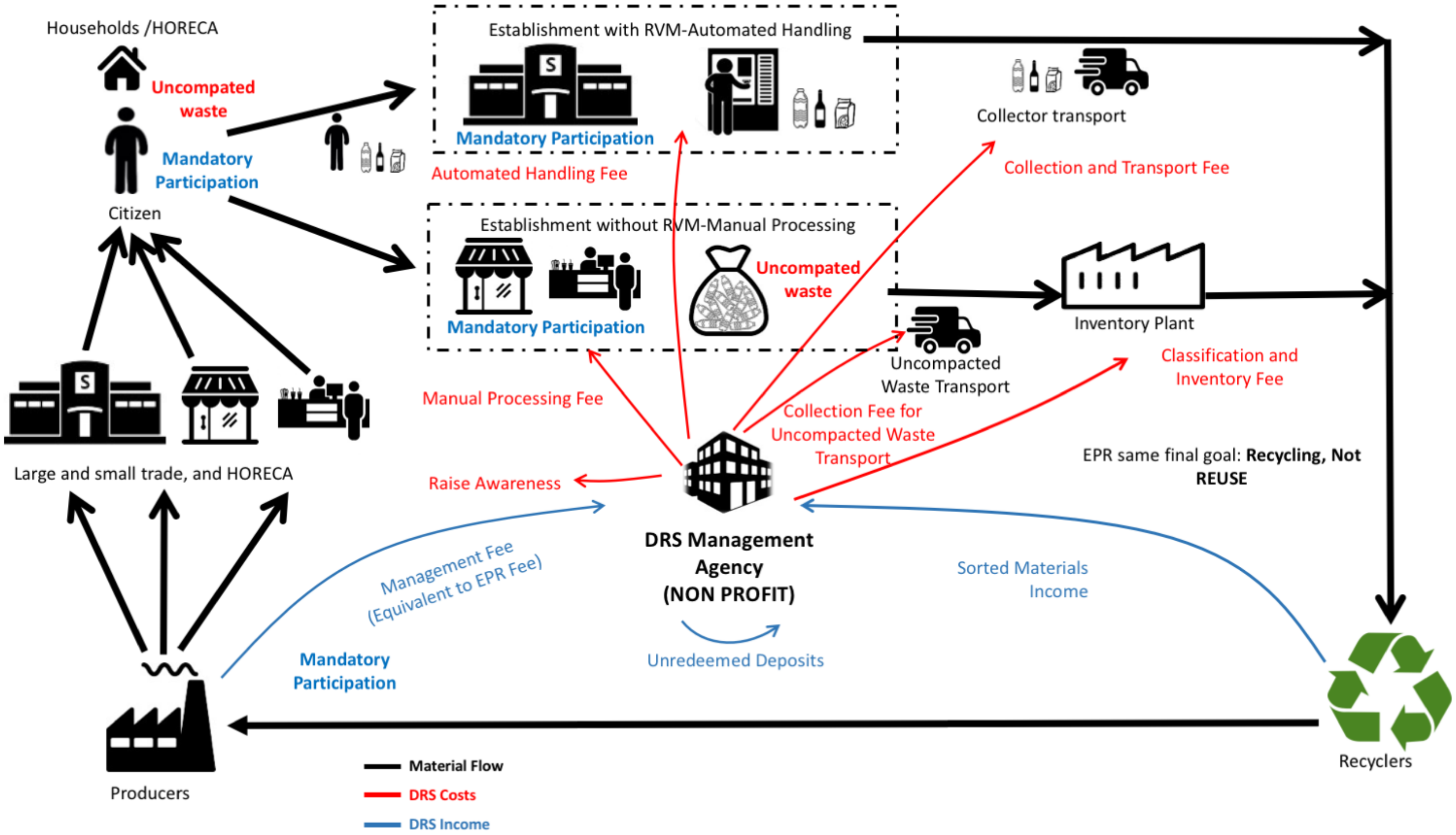
## 4. Deposit Refund System (DRS)

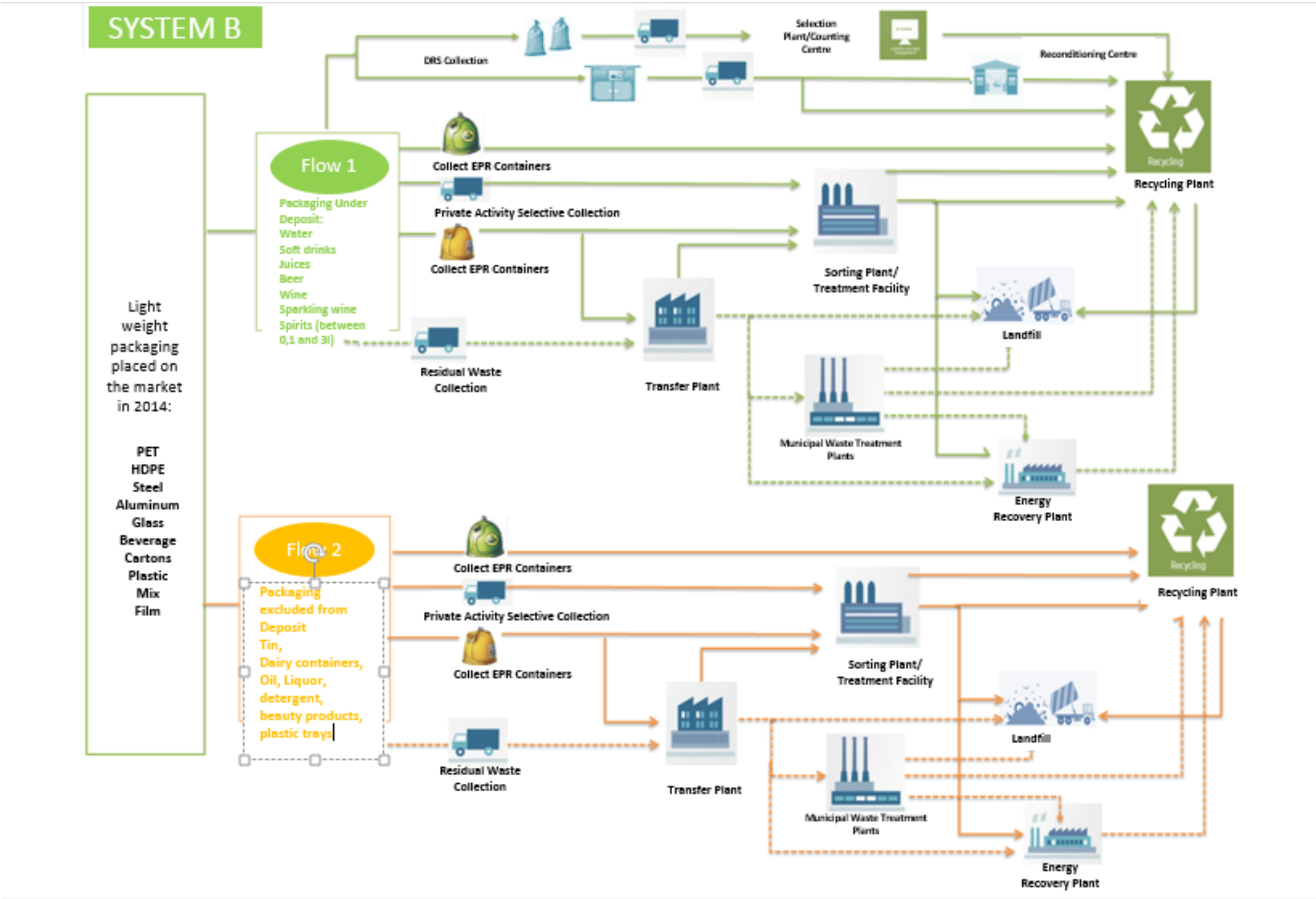
A **Deposit Refund System (DRS)** for single-use (non-reusable) packaging is a management alternative in which those responsible for marketing packaged products charge a deposit to successive customers, up through to the final consumer, an amount for each container in the system. This deposit is refunded in its entirety to the consumer as long as he returns the packaging waste in perfect conditions (not crushed) to commercial establishments, where it is processed for subsequent recycling. The points of sale are responsible for accepting the packaging waste, which they can do manually or by using specific machines. Packaging in a DRS must be labelled with a unique symbol and a bar code that is used to identify and process it.

As for participation, the system could be voluntary or mandatory. As for its applicability, it could be universal or limited to specific packaging types. It is very important that these terms not be confused.

**The DRS studies in this project would be mandatory and would be intended to recycle - not reuse - certain single-use drink containers.**

In practice, not all packaging waste is ideal for a DRS, and as a result the system's scope is restricted. **This makes it so that its implementation is proposed in parallel with the processing of the remaining packaging types, which would continue to be handled through an EPR.**


Households /HORECA
Uncompated waste
Mandatory Participation
Citizen
Establishment with RVM-Automated Handling
Mandatory Participation
Automated Handling Fee
Establishment without RVM-Manual Processing
Uncompated waste
Mandatory Participation
Collector transport
Collection and Transport Fee
Inventory Plant
Uncompacted Waste Transport
Classification and Inventory Fee
Manual Processing Fee
Collection Fee for Uncompacted Waste Transport
Large and small trade, and HORECA
Raise Awareness
EPR same final goal: Recycling, Not REUSE
DRS Management Agency (NON PROFIT)
Management Fee (Equivalent to EPR Fee)
Sorted Materials Income
Mandatory Participation
Unredeemed Deposits
Producers
Recyclers
Material Flow
DRS Costs
DRS Income


SYSTEM B
Light weight packaging placed on the market in 2014:
PET
HDPE
Steel
Aluminum
Glass
Beverage
Cartons
Plastic
Mix
Film
Flow 1
Packaging Under Deposit:
Water
Soft drinks
Juices
Beer
Wine
Sparkling wine
Spirits (between 0,1 and 3l)
DRS Collection
Selection Plant/Counting Centre
Reconditioning Centre
Collect EPR Containers
Private Activity Selective Collection
Collect EPR Containers
Residual Waste Collection
Transfer Plant
Sorting Plant/ Treatment Facility
Recycling Plant
Landfill
Municipal Waste Treatment Plants
Energy Recovery Plant
Flow 2
Packaging excluded from Deposit
Tin,
Dairy containers,
Oil, Liquor,
detergent,
beauty products,
plastic trays
Collect EPR Containers
Private Activity Selective Collection
Collect EPR Containers
Residual Waste Collection
Transfer Plant
Sorting Plant/ Treatment Facility
Recycling Plant
Landfill
Municipal Waste Treatment Plants
Energy Recovery Plant

## 5. Purpose of the study

There is a proliferation of information and opinions that rely little on the social, environmental and economic impacts of packaging waste management systems in Spain, and a growing interest by some social actors, and specifically by some governments, to propose a change to the system.

The presented legislative background shows that in order to change a model, especially when a consolidated and widespread separate collection system exists for packaging, the technical viability and proper operation of the domestic market must be assured. A study of the three areas of sustainability must also point to a clear benefit from said change. This project does not evaluate the technical viability of the DRS, its technologies, its implementation of the proper adaptation by the various stakeholders, especially SMEs. It also does not evaluate the regional or national influences it could have on the operation of the market.

The goal of the ARIADNA Project is to analyse the economic, environmental and social sustainability of implementing a mandatory DRS in Spain[2] (and in Catalonia, as a pilot region) with the following characteristics:

- The deposit for the packaging types in the DRS is 10 cents per container.
- The types of containers included in the DRS are as follows:
  - Materials: PET, HDPE, steel, aluminium, carton for drinks, glass
  - Products: water, soft drinks, juice, beer, wines, sparkling wine and spirits
- The container size must be smaller than 3 litres

The study compares two situations:

1. **The current situation (System A)** for managing household packaging waste in 2014 in Spain under an EPR.
2. **The hypothetical situation (System B)** for managing household packaging waste in 2014 in Spain **if there had been a fully operational DRS** with no learning curve **(with a hypothetical return rate of 90%) for the drink containers described, alongside an EPR for all other packaging.**

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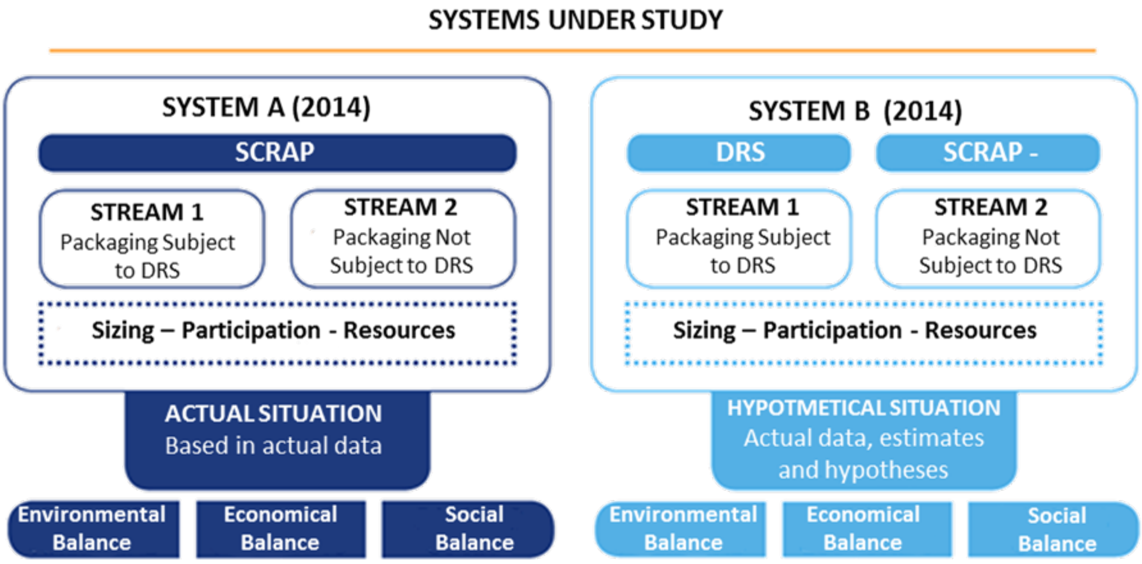
[2] "Sustainability study on the introduction of a mandatory DRS for packaging in Spain: comparative environmental, social and economic analysis against current situation" www.esci.upf.edu/es/ponte-al-dia/noticias/introduccion-del-sddr




The goal was to find and present more rigorous, systematic, transparent and objective information based on scientific methods that would make it easier for the relevant agencies to make decisions and to inform all of the actors involved. In addition, being aware of the sources of uncertainty that this kind of study can entail, its consistency has been enhanced by using various **transparency mechanisms and a triple review**:

- involving a panel of interested/affected parties through periodic meetings for the duration of the project. Their main mission is to contribute to obtaining quality data, to ensure that consistent decisions are made and to contribute to formulating the study's starting assumptions.
- submitting the study to a panel of independent experts at the end of the project so as to ensure that the various methodologies were applied correctly, and
- opening the study to public scrutiny at the conclusion of the critical review in order to allow other stakeholders that did not participate in the project to take part in the review process.

**As a general rule**, when faced with a choice between several options for the initial data or some other working hypothesis, **we opted for a conservative position that would benefit the implementation of a DRS**. When this was not done, it is noted in the document and a basis for the decision is provided. Similarly, in keeping with the recommendation in the ISO 14044 standard, we carried out a series of **sensitivity analyses** for those variables that, a priori, could have a greater influence on the results. Lastly, in order to be rigorous in the methodology and to account for the higher variability that data on waste management has versus other industrial sectors, we will do **uncertainty analyses** and submit the study to a **review**, as commented earlier.

The UNESCO Chair hopes that the study evolves toward a consensus, integrating the improvements recommended by experts and by the general public and providing scientific reasoning for not considering those proposals that are rejected.

## 6. Methodology

**Environmental analysis**

As detailed in the purpose of the study, we carry out a comparative evaluation between two alternatives for managing packaging waste: System A, the current method based on an EPR, and System B, a combination of DRS and EPR. The study relies on the **Life Cycle Assessment** (LCA), the methodology that stipulations, regulations and standards recommend for a rigorous environmental evaluation, especially when attempting to compare alternatives. European policies (and Waste Directives) place special emphasis on applying the life cycle approach as an essential tool in the area of waste management to establish objective criteria when making decisions toward sustainable development. According to the European Commission: *«Refining decisions within or outside the (waste) hierarchy can lead to better environmental results. The "best" option is often influenced by specific local conditions, and it is important to tread carefully to avoid simply shifting environmental burdens from one area to another. Political officials and decision makers must base their decisions on solid evidence. The LCA provides rigorous scientific information to ensure that the option with the best outcome for the environment is identified and implemented.»*

In order to make the most of the LCA's potential when strategically planning how to manage waste, as suggested by the EU's **Thematic Strategy on the Prevention and Recycling of Waste**, decision makers have to be supplied with objective information and quality scientific data that are easy to use. The most sustainable options complement environmental information with economic data and social indicators, always under a life cycle analysis approach.

The **ISO 14040:2006 international standard** defines LCA as *«a technique for determining the environmental aspects and the potential impacts associated with a product, by compiling an inventory of the system's relevant inputs and outputs, evaluating the potential impacts associated with the inputs and outputs and interpreting the results of the inventory and impact phases in terms of the study's objectives*». Several environmental impact categories are studied, such as: global warming (carbon footprint), acidification, use of natural resources, eutrophication, water usage, etc.

**Economic analysis**

After reviewing the relevant literature, the **economic analysis** does a comparative accounting of the costs of the collection systems that are analysed in the ARIADNA Project: EPR on the one hand and a limited DRS+EPR on the other. The cost accounting methodology has been fully developed for decades and needs no additional introduction. The analysis includes two main blocks, one for each collection system:

- EPR. Analysis of EPR costs, total, per ton and per citizen, first on an aggregate level and then by materials and activities (collection, transport, etc.).
- DRS. Since this system is not currently in use in Spain, it must first be designed and sized (design of waste flows by fraction and calculation of the infrastructure required to collect and sort the waste during the new phases that the DRS entails), so that its net costs can then be inventoried and analysed. In this phase, it is crucially important to have a panel of reviewers made up of representatives from all of the stakeholders involved in its implementation. This will allow us to

have the best sources of information so as to size the potential system and avoid, to the extent possible, the adoption of arbitrary assumptions.

**Social analysis**

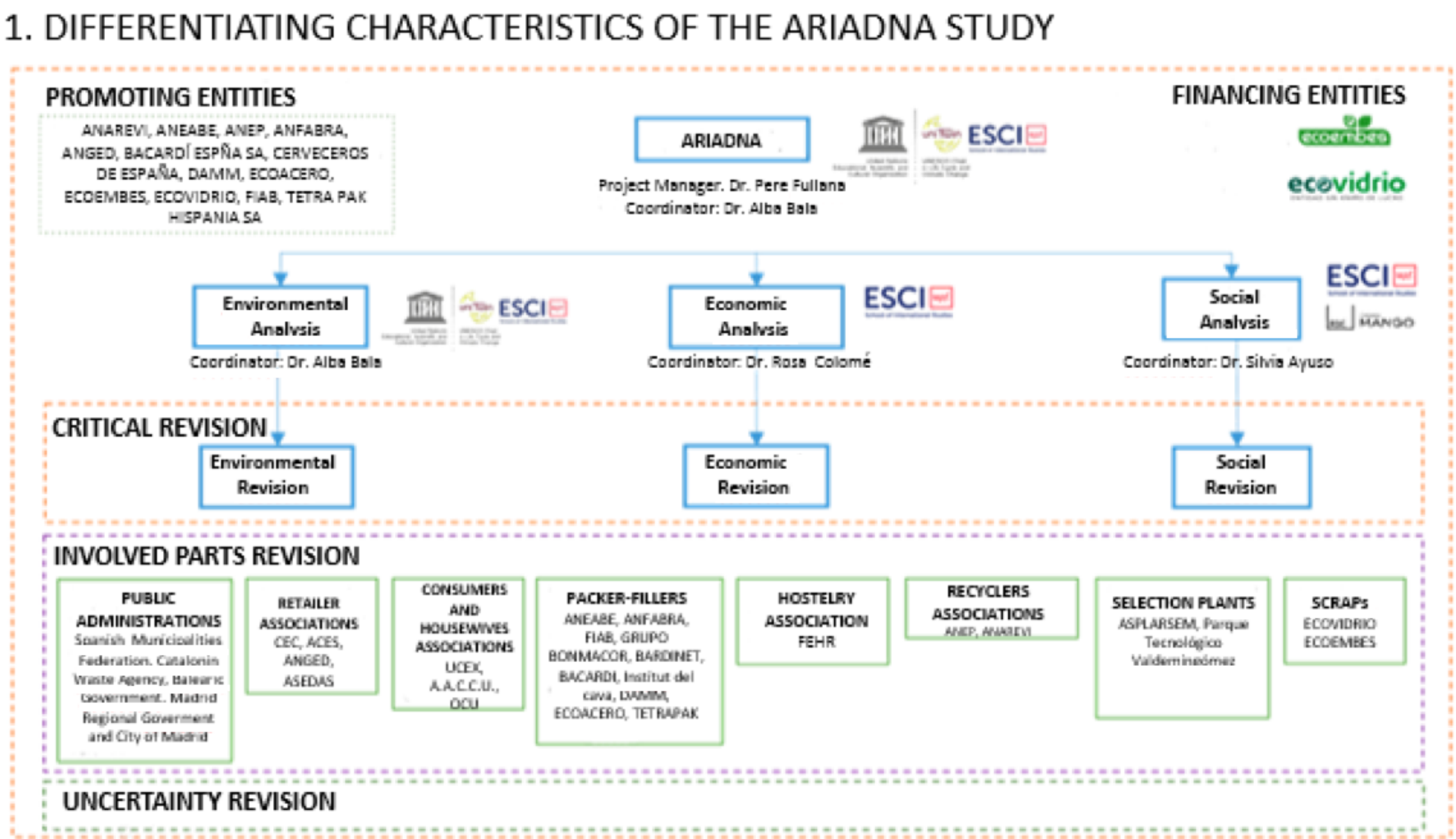
Since there is no standard methodological framework for the **social analysis**, it is carried out from various different and complementary perspectives. First, we conduct a bibliographic review of existing studies on the social impact of packaging collection in an effort to determine the methods and metrics used to date. The social impact of the EPR and DRS packaging collection systems is evaluated using two methods that appeared recently (the authors of said methods are included in the work group):

- The social footprint ( Weidema, B. P., 2016) and
- An adaptation of the methodology for quantifying integrated social value (Retolaza, J.L., 2014).

The former, the social footprint, conducts a socio-economic diagnosis by using a life-cycle approach, while the latter aims to quantify the interests perceived by all of the significant stakeholders. The **social footprint** methodology may be regarded as a simple, but at the same time practical and complete, approach for a social LCA, one that retains the life-cycle perspective while avoiding the onerous demand for data typically associated with a full social LCA. This method employs the same definition of the term "social" as welfare economics, that is, it takes into account social costs that include not only private costs, but also external costs (also called externalities).

The **quantification of integrated social value** methodology is based on the perspective of the theory of stakeholders and on a phenomenological approach to the concept of value. These are used to objectify and visualize the value that an organization creates for all of its stakeholders. The methodology combines qualitative and quantitative analysis. The qualitative analysis seeks to evaluate the impacts that an organization generates for its main stakeholders and is based on conducting interviews with representatives from all of these stakeholders. The quantitative analysis focuses on quantifying the perceived benefits by developing indicators and proxies (value approximations) that allow monetizing the value generated. In this study, we adapt this methodology to take into account the benefits and drawbacks for stakeholders that can affect or that are affected by the packaging collection systems studied. Versus the top-down approach of the social footprint method, this relies on a bottom-up procedure to identify those social (and economic) aspects that the affected groups and/or individuals perceive as relevant.

## 7. Entities involved in the study



## 8. Functional unit and reference flows

The functional unit employed in this study is the collection, management and recycling of single-use packaging waste (light and glass containers) under the EPR in 2014.

**The initial data** for **System A** are based on public information (and occasionally on non-public information but with more detail) made available by government agencies and on data supplied by Ecoembes and Ecovidrio (all of it duly audited). They are based on real information both in terms of size and of the public's involvement in the system and on the resources required for its operation. In contrast, for **System B** we had to establish a series of assumptions to define and scale a non-existent situation. The scale, participation and resources needed for its proper operation were estimated for both Flow 1 (the DRS packaging) and Flow 2 (the rest), since the operation of the EPR would be affected by the coexistence of the two systems. Many of the data on **specific processes** were supplied by those who created the data and who sit on the PIP (Panel of Interested Parties).

The general reference flows for the two systems will be the same quantitatively, those defined as a whole for all EPR members (Ecoembes and Ecovidrio) in 2014. The total amount of packaging that comprises the study's functional unit is 2,500,721 t.

| | LIGHT PACKAGING (LP) | | GLASS | | TOTAL IN STUDY (LP+GLASS) | |
|---|---|---|---|---|---|---|
| | **t** | **%** | **t** | **%** | **t** | **%** |
| **Flow 1: DRS-eligible containers** | 330,818 | 29% | 1,092,656 | 80% | 1,423,474 | 57% |
| **Flow 2: Containers excluded from DRS** | 802,618 | 71% | 274,629 | 20% | 1,077,247 | 43% |
| **Total** | **1,133,435** | **100%** | **1,367,285** | **100%** | **2,500,721** | **100%** |

## 9. Summary of material balance results

In order to determine the social, environmental and economic impact of the two systems under consideration, we must define a material balance for all of the collection, processing and selection processes included in the study. This means starting with the amount of packaging placed on the market and determining how it moves through the different collection channels (separate collection, bulk collection, out-of-home collections or collection via DRS) and treatment processes, from the time the container becomes waste until the materials that comprise it are recovered in facilities and processed to be sent to a recycler.

First, we determined the material balance for System A (for which initial data are available), and we then calculated the material balance for System B, which requires making assumptions about potential future scenarios. The results of these balances are shown on the tables that follow.

**SYSTEM A**

| SUMMARY TABLE | Units | BEVERAGE CARDBOARD | METALS | PLASTICS | GLASS |
|---|---|---|---|---|---|
| GROSS AMOUNT RECOVERED | t | 94,589 | 276,459 | 410,845 | 953,100 |
| LANDFILLED | t | 29,152 | 53,561 | 195,736 | 410,043 |
| ENERGY RECOVERY | t | 9,255 | 0 | 60,324 | 0 |
| LITTERING | t | 388 | 541 | 2,586 | 4,142 |
| **TOTAL** | | **133,383** | **330,561** | **669,492** | **1,367,285** |

**SYSTEM B**

| SUMMARY TABLE | Units | BEVERAGE CARDBOARD | METALS | PLASTICS | GLASS |
|---|---|---|---|---|---|
| GROSS AMOUNT RECOVERED | t | 100,649 | 300,126 | 433,398 | 1,214,800 |
| LANDFILLED | t | 24,535 | 30,146 | 179,426 | 151,066 |
| ENERGY RECOVERY | t | 7,880 | 0 | 54,382 | 0 |
| LITTERING | t | 320 | 289 | 2,286 | 1,419 |
| **TOTAL** | | **133,383** | **330,561** | **669,492** | **1,367,285** |

As we can see, if we consider only material flow indicators, System B seems to perform better. It recovered 313,980 additional tons (an increase of almost 12.5% in the packaging recycling rate and of 1.5% with respect to all the Municipal Solid Waste (MSW) in Spain), lowered the amount of waste landfilled by 303,319 tons, 7.317 tons will no longer be incinerated, and it lowered the number of tons littered by 3,343 tons. This improvement in material flows, however, does not directly correlate to its environmental impact, as we will see later. **In other words, the processes needed to achieve these goals have a higher environmental impact.**

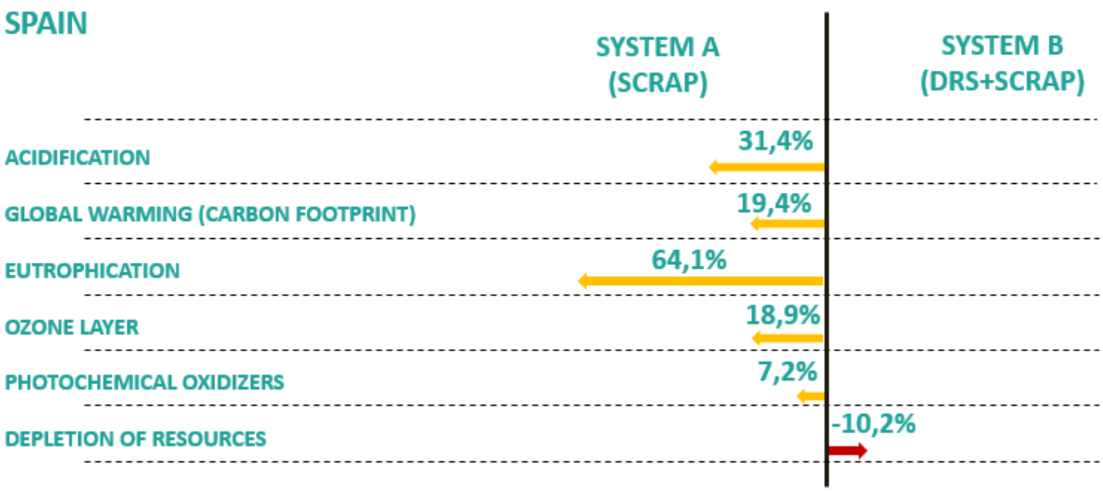
## 10. Summary of the results of the environmental analysis

Six environmental impact categories were analysed though a Life Cycle Assessment, including global impact categories (such as global warming and the use of natural resources), the impact on the quality of ecosystems and water, and the impact on human health. As the table below shows, the overall results are negative. This means that the savings associated with the materials and/or energy recovered by the systems (its credits) are higher than the environmental impacts associated with the waste collection and management operations. Therefore, **it may be said that the implementation of both packaging collection and recovery systems analysed is beneficial to the environment**.

| | SYSTEM A | | | SYSTEM B | | |
|---|---|---|---|---|---|---|
| | IMPACTS | CREDITS | OVERALL | IMPACTS | CREDITS | OVERALL |
| **ACIDIFICATION** (moles of $H^+$ eq.) | 2,772,494 | -5,526,411 | -2,753,917 | 4,875,055 | -6,765,241 | -1,890,186 |
| **GLOBAL WARMING** (kg $CO_2$ eq.) | 1,072,084,939 | -1,750,461,092 | -678,376,152 | 1,582,282,122 | -2,129,021,124 | -546,739,002 |
| **EUTROPHICATION** (moles of N eq.) | 8,145,188 | -13,152,212 | -5,007,023 | 14,375,824 | -16,171,756 | -1,795,932 |
| **OZONE LAYER** (kg CFC-11 eq.) | 49.495 | -57.104 | -7.609 | 67.825 | -73.999 | -6.175 |
| **PHOTOCHEMICAL OXIDIZERS** (kg of $C_2H_4$ eq.) | 169,687 | -566,909 | -397,223 | 291,685 | -660,412 | -368,726 |
| **DEPLETION OF RESOURCES** (kg Sb eq.) | 3,680 | -23,566 | -19,886 | 5,852 | -27,758 | -21,906 |

If we do a more in-depth analysis, we see that the credits associated with System B are always higher than those for System A. This is because the addition of DRS (with the theoretical return rate considered of 90%) would yield an increase in the amount of packaging recovered. This increased recovery rate, however, entails a higher environmental impact due to the required waste collection, processing and recycling processes.

The figure below breaks down the comparative results of the analysis. **For every impact category, except slightly for the depletion of abiotic resources (10.2% lower impact), the results for System A are better than for System B**. Values further away from 0 allow us to state with greater certainty that System A is better than B. For values closer to 0, there is more uncertainty as to which system is better. Similarly, in light of the results, we can state that, as a whole, **the introduction of a DRS system would cause environmental harm in comparison to the current system**.



When we consider which stages have the most impact, we see in both systems that, in general terms, the recycling processes have the greatest impact, followed by the collection and transport processes. The sorting process and the equipment have the lowest impact. The main differences detected in System B with respect to the existing system are: a higher contribution from the collection and transport (e.g., movement of uncompacted containers for 54% of the packaging collected manually) and a higher contribution from equipment (e.g. energy and material use). The contribution of the credits is distributed very similarly, with the credits associated with the recovery of materials for System B increasing slightly (by 0.9%), at the expense of the decrease by the same ratio of the credits associated with the energy recovery.

| | SYSTEM A | | | | | | |
|---|---|---|---|---|---|---|---|
| | Equipment | Collection and transport | Sorting | Recycling | Landfilling/ incineration | Energy credits | Material credits |
| ACIDIFICATION | 2.8% | 20.1% | 2.4% | 68.8% | 5.8% | -3.3% | -96.7% |
| GLOBAL WARMING | 1.8% | 9.6% | 1.0% | 69.0% | 18.6% | -3.2% | -96.8% |
| EUTROPHICATION | 1.7% | 34.3% | 2.9% | 51.9% | 9.2% | -3.3% | -96.7% |
| OZONE LAYER | 0.0% | 0.0% | 1.3% | 97.6% | 1.1% | 0.0% | -100.0% |
| PHOTOCHEMICAL OXIDIZERS | 3.0% | 27.8% | 1.4% | 58.9% | 8.8% | -1.2% | -98.8% |
| DEPLETION OF RESOURCES | 13.4% | 1.1% | 0.6% | 84.6% | 0.4% | -0.8% | -99.2% |

| | SYSTEM B | | | | | | |
|---|---|---|---|---|---|---|---|
| | Equipment | Collection and transport | Sorting | Recycling | Landfilling/ incineration | Energy credits | Material credits |
| ACIDIFICATION | 6.8% | 39.3% | 1.4% | 50.5% | 2.0% | -2.4% | -97.6% |
| GLOBAL WARMING | 6.8% | 21.5% | 1.0% | 59.5% | 11.1% | -2.3% | -97.7% |
| EUTROPHICATION | 5.2% | 52.9% | 1.5% | 37.3% | 3.1% | -2.4% | -97.6% |
| OZONE LAYER | 2.5% | 0.0% | 0.2% | 96.9% | 0.4% | 0.0% | -100.0% |
| PHOTOCHEMICAL OXIDIZERS | 26.4% | 25.5% | 0.9% | 42.9% | 4.3% | -0.9% | -99.1% |
| DEPLETION OF RESOURCES | 17.1% | 2.2% | 0.9% | 79.7% | 0.1% | -0.6% | -99.4% |

## 11. Summary of the results of the economic analysis

The economic analysis was disaggregated for System A and System B, separating the results of Flow 1 and Flow 2 in each of them before presenting the aggregated results of the two flows and a comparison between System A and System B. The table below shows the results, as well as the additional cost for System B with respect to System A:

| ITEM (ALL MATERIALS) | SYSTEM A | | | SYSTEM B | | |
|---|---|---|---|---|---|---|
| | FLOW 1 | FLOW 2 | TOTAL | FLOW 1 | FLOW 2 | TOTAL |
| Tons | 1,423,474 | 1,077,247 | 2,500,720 | 1,423,474 | 1,077,247 | 2,500,720 |
| Packaging units | 17,802,793,360 | N/A | N/A | 17,802,793,360 | N/A | N/A |
| **TOTAL NET COST (€/yr.)** | **164,422,302** | **327,199,800** | **491,622,102** | **1,810,321,089** | **465,473,766** | **2,275,794,855** |
| NET COST PER INHABITANT (€/inh/ yr.) | 3.5 | 7.0 | 10.5 | 38.7 | 10.0 | 48.7 |

** This net cost corresponds to 90% of the packaging in Flow 1 managed by the DRS and 10% managed by the EPR.*

| ITEM (ALL MATERIALS) | ADDITIONAL | | |
|---|---|---|---|
| | FLOW 1 | FLOW 2 | TOTAL |
| Tons | 1,423,474 | 1,077,247 | 2,500,720 |
| Packaging units | 17,802,793,360 | N/A | N/A |
| **TOTAL NET COST (€/yr.)** | **1,645,898,787** | **138,273,966** | **1,784,172,753** |
| NET COST PER INHABITANT (€/inh/yr.) | 35.2 | 3.0 | 38.1 |

**For Spanish society, the net cost of managing all of the light packaging and glass waste with System B would go up by €1.784B** (going from €491.6M to €2,275.8M). This is because:

- The way that the DRS manages the packaging waste would cost €1.645B more than with the current system (going from €164.4M to €1,810.3M).

- The DRS would also increase the cost of processing the remaining packaging waste (that not in the DRS), raising the net cost for Spanish municipalities by €138.2M (going from €327.1M to €465.4M).

In order to analyse the introduction of a DRS alongside the EPR, a DRS was evaluated that is adapted to Spain's commercial structure. The total cost of the DRS in System B (€1.794B) has the structure shown in the table below. **The increased economic impact would affect the points of sale**, which would be required to take part in handling the DRS containers at an **annual cost of €1.508B**. This results from the necessary processing of the containers at the points of sale. 21% of this cost corresponds to the automated handling of containers and 79% to points of sale with manual processing. **The annual cost of the transport phase from the point of sale to the counting/pre-treatment plants would be €323M.** 79% corresponds to the handling of containers from manual points of sale and 21% to those from automated points of sale.

| ANNUAL AMOUNT (M€) | COSTS | | | | | |
|---|---|---|---|---|---|---|
| | Labeling | Handling at point of sale | Transport | Counting/pre-treatment | Indirect costs | Total costs |
| | 131 | 1,508 | 323 | 79 | 68 | 2,109 |
| | REVENUE | | | | | |
| | Sale of materials | Unreturned deposits | Total revenue | | | NET COST |
| | 137 | 178 | 315 | | | 1,794 |

Based on the estimates made in this study, 54% of the tons (51% of the units) would be handled through a manual system and 46% of the tons (49% of the units) would be handled using automatic systems. This is a large difference with respect to countries in the north of Europe that has significant repercussions of all kinds, since most of the waste managed by the DRS would have to be sent uncompacted to the 45 counting plants that would have to be opened. Handling at the point of sale and transporting a material with such a low density requires a large allocation of resources and a high environmental impact. It is estimated that 10,895 points of sale would handle the packaging waste using reverse vending machines (RVM), which would require purchasing 38,752 such RVMs (at a cost of €819.71M).

The **cost per container processed** for each type of point of sale is shown in the table below. Note that the cost for each type of establishment would be different depending on how the packaging waste is handled. The points of sale with manual processing would bear a higher cost.

| HANDLING METHOD | Superstore | Large supermarket | Medium supermarket | Small supermarket | Mini market | Traditional store | Gas station | Bar | Hotel - Restaurant | Nighttime Consumption |
|---|---|---|---|---|---|---|---|---|---|---|
| **Automatic (Large-capacity machine)** | €0.0238 | | | | | | | | | |
| **Automatic (Large-capacity machine + Inverse logistics)** | €0.0238 | €0.0359 | | | | | | | | |
| **Automatic (Medium-capacity machine + storage in store)** | €0.0224 | €0.0281 | €0.0537 | | | | | | | |
| **Automatic (Medium-capacity machine with no storage in store)** | €0.0296 | €0.0341 | €0.0498 | €0.1167 | | | | | | |
| **Manual** | | | €0.0602 | €0.0654 | €0.0824 | €0.0908 | €0.0862 | €0.2425 | €0.1137 | €0.1499 |

The channel that would handle the most tons of waste would be large supermarkets, followed by bars, above the superstores. In cost terms, the most significant economic impact would be to bars (€732.5M), followed by large, medium and small supermarkets (€384.1M). In all, the food service sector would incur costs in excess of €941.6M, and the commerce sector in excess of €566.5M.

## 12.Summary of the results of the social analysis

An **analysis of social benefits and harms** of the packaging collection systems studies reveals a series of positive and negative effects associated with a hypothetical implementation of a DRS. These effects primarily involve the economic costs and benefits that would result from the introduction of the new system. Those aspects that were not considered in the environmental and economic study of the ARIADNA Project are discussed qualitatively from the standpoint of the different stakeholders involved. In addition, the analysis quantifies and monetizes the **benefits and harms** that may be deemed relevant for society as a whole; specifically, those resulting from the space and time requirements, the need to learn and the repercussions of littering. The social costs and benefits of Systems A and B are summarized in the following table.

| | System A (EPR) | System B (EPR+DRS) |
|---|---|---|
| **Cost per household** | | |
| Space required | 1.00 EUR | 1.49 EUR |
| Time required | 21.26 EUR | 136.54 EUR |
| Learning needs* | - | - |
| **Benefits** | | |
| Reduction in littering | 0 EUR | 20.41 EUR |
| **Net cost per household** | **22.26 EUR** | **117.62 EUR** |
| **Net cost per inhabitant** | **8.83 EUR** | **46.67 EUR** |

*not considered, since they are included in the economic evaluation

- On the one hand, System B involves greater harms or costs for society as a whole both in terms of the space required (1.5 times more than System A) and time required (6 times more than System A).
- On the other hand, System B offers the social benefit associated with reduced littering of the packaging types included in this study. This would result in greater enjoyment of public spaces.

The **social footprint** results for Systems A and B are shown in the table below. The results are shown on three levels for both systems: the impact on productivity (IP), the redistribution of revenue (RR) and the social footprint (SF), resulting from adding IP and RR. The units of measurement are millions of euros (in 2014), adjusted by purchasing power parity and weighted by utility. This adjustment and weighing means that the amounts shown in the table cannot be directly compared to those resulting from the economic study.

| System | Indicator | Total | Labeling of packaging | Collected in stores | Collected in containers | Transport | Sorting, pre-treatment, counting, classification | Recycling | Final disposal | Other activities | Consumer |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Impact on productivity ($IP_A$) | -5,247 | 0 | 0 | 321 | 639 | 468 | -6,886 | 93 | 118 | |
| | Redistribution of revenue ($RR_A$) | 181 | 0 | 0 | -17 | -40 | -28 | 239 | -6 | -11 | 44 |
| | **Social Footprint ($SF_A = IP_A + RR_A$)** | **-5,067** | **0** | **0** | **304** | **599** | **440** | **-6,647** | **87** | **107** | **44** |
| B | Impact on productivity ($IP_B$) | -2,413 | 28 | 3,019 | 321 | 1,364 | 612 | -8,081 | 62 | 263 | |
| | Redistribution of revenue ($RR_B$) | -100 | -22 | -450 | -17 | -85 | -37 | 281 | -4 | -25 | 259 |
| | **Social Footprint ($SF_B = IP_B + RR_B$)** | **-2,513** | **6** | **2,568** | **304** | **1,279** | **575** | **-7,800** | **58** | **238** | **259** |

- The results show that the social footprint for both systems is negative overall, meaning that both systems have a net benefit for society. The result in both cases is dominated by the value of the impact on productivity, since the value of the redistribution of revenue is one order of magnitude lower.

- From a comparative standpoint, the results show that this benefit to society is higher for System A than for System B.

- System B is more beneficial than System A in terms of the redistribution of revenue, since the former yields a negative result while the result for the latter is positive. This benefit from System B, however, is not enough to offset the general benefits exhibited by System A, which yields a relatively high social benefit through its impact on productivity.

## 13. Conclusions and recommendations

**GENERAL**

1. **In order to comply with the law on waste and with the European Commission's recommendations, before deciding whether to require the implementation of a DRS, its technical viability and sustainability must be studied throughout its life cycle in three areas: social, environmental and economic. A study that does not consider these aspects is not adequate for making decisions involving waste policy.**
2. Existing data on waste management are more variable than those that are available for other industrial sectors, such as chemical, automotive, construction and others. This variability applies to both geographic and time-related aspects. In addition, the various sources available (including official ones) are sometimes conflicting. It is important to note this fact and correctly argue for the option selected. It is essential that the sources of data lead to the necessary consensus. The ARIADNA Project featured a Panel of Interested Parties, with representatives from the entire value chain, who provided, compared and validated the data and assumptions taken into consideration.
3. Obtaining a sufficiently accurate material balance (quantification of the various material flows) is the first, and most difficult, step in evaluating the sustainability. Given the inherent uncertainty in the waste management figures, first the flows that have the greatest influence on the result are tallied, and then the total is closed out with the least influential flows to balance the inputs and outputs.
4. **A full and rigorous analysis indicates that the suggested change to the management of packaging waste caused by the addition of a DRS under the conditions of this study would be less sustainable than continuing with the current system, since: its social impact would not be beneficial to Spanish citizens or to the parameters evaluated for the general economy; its cost would be much higher for society; and the environmental impact would be higher in most of the impact categories.**
5. In Spain, most of the DRS packaging waste would be handled manually by stores and consumers and involve a vast network of small establishments. This is hugely different from countries in the north of Europe, with significant repercussions of all kinds, since most of the waste managed by the DRS would have to be sent uncompacted to the counting plants.
6. **The vast majority of the economic and human resources the change would require would be better devoted to improving the existing system and the processing of other types of waste that are more abundant and environmentally problematic.** Packaging waste is a small and relatively problem-free fraction of all municipal waste, and the packaging proposed for the DRS is the kind that is handled well by the current system.
7. The set of methodologies, researchers and calculation tools, along with the help provided by a panel of interested parties, mean that the **ARIADNA project is reproducible on different scales** for both EPR and for other possible implementations of the DRS.

8. If the ARIADNA methodology were agreed upon as being the most suitable, it would be interesting to be able to share and complement the information and teams from several studies and create an ad hoc team to resolve this and new challenges involving packaging waste.

**ENVIRONMENTAL**

The main findings of the environmental study are as follows:

1. **The environmental savings of both systems exceed their impacts, meaning both offer a positive environmental service.** However, even if the DRS were fully developed and attained a return rate of 90% for containers, **the current system obtains significantly better results in every impact category analysed, with the exception of the resource depletion potential**, which is closely related to the potential higher recycling rate of System B (12.5% for packaging and 1.5% for all MSW in Spain).

2. **The increased recycling rate of the DRS relies on processes that entail more pollution**, primarily associated with the need for more equipment (machinery, bags and boxes) and with the less efficient transport of the packaging waste that is collected manually (approximately 54% of the weight of DRS containers). These results are due to the commercial structure and to the characteristics of the stores that sell packaged drinks in Spain, which may differ from that of other countries that have implemented a DRS.

3. As for the impact on human health, which the Law on Waste also considers, it is represented by the impact categories on ozone layer depletion and smog. For these categories, System A performs better than B in every scenario analysed.

4. **The impact of collecting packaging subject to a DRS (Flow 1) in System B is much higher than that for Flow 2, and even higher in every impact category analysed than the total in System A for collecting the two flows.**

5. In keeping with the recommendation in the ISO 14044 standard, we carried out a series of sensitivity analyses for those variables that, a priori, could have a greater influence on the results. Overall, we conclude that **none of the alternatives analysed (in both the base and alternate scenarios) suggest changing systems**, not even for the resource depletion impact category. The difference in this impact category for the two systems analysed is very small and assumes a DRS packaging return rate of 90%. A smaller return rate would reduce the difference in this impact category between the two systems and increase the difference in the remaining impact categories in favour of System A.

**ECONOMIC**

The main findings of the economic study are as follows:

1. For Spanish society, the total net collection cost would go from €491,622,102 in System A to €2,275,794,855 in System B, a 4.6-fold increase in the total cost of collecting packaging in Spain. The additional cost would be €1,784,172,753. This increased cost would be due primarily to:

- Handling the packaging in Flow 1 would cost €1,645,898,787 more than under the current system (going from €164,422,302 to €1,810,321,089). 99% of this additional cost is associated with collection under a DRS.
- Furthermore, adding a DRS would also make it more expensive to handle the packaging waste for packaging not under the DRS, raising the net cost for Spanish municipalities by €138,273,966 (going from €327,199,800 to €465,473,766).

2. In per capita terms, the net cost per inhabitant would go from 10.5 to 48.3 euros, a 4.6-fold increase in cost and an additional expense of €38.1 per person. This increase in cost can be disaggregated between Flow 1 and Flow 2:
   - In per capita terms, the net cost of Flow 1 would go from €3.5/inhabitant to €38.7/inhabitant, an increase of 1,001.02% or an 11.01-fold increase in the cost.
   - The net cost of managing the packaging in Flow 2 would increase, both in total terms and in per capita terms, by 42.26%. In euros per inhabitant, this means going from €7/inhabitant with System A to €10/inhabitant with System B.
3. If we focus on Flow 1 packaging, which would be subject to the DRS, the additional increase in the net cost would be €1,645,898,787, equivalent to multiplying the net cost by 11.01.
4. The scale of the DRS used revealed that 54% of the tons of packaging subject to the DRS would be managed manually (which entails high costs for labour and for storing and transporting uncompacted packaging), and the remaining 46% would be processed using automated systems (which entails high machinery costs). This is hugely different with respect to countries in the north of Europe, with significant repercussions of all kinds, since most of the waste managed by the DRS would have to be sent uncompacted to 45 counting plants. The handling at the store and the transport of such low-density material require a large allocation of resources.
5. The most significant economic impact involves the points of sale, the cost for which would go up to €1.508B annually.

   This is because these establishments would have to process this waste at the store, and as we saw in the cost estimate, 21% of this cost would correspond to the automatic handling of the packaging and 79% to the manual handling.

   The channel that would process the most tons of waste would be large supermarkets, followed by bars, above the superstore channel. In cost terms, the most significant economic impact would be to bars (€732.5M annually), followed by large, medium and small supermarkets (€384.1M annually). In all, the food service sector would incur annual costs in excess of €941.6M, and the commerce sector in excess of €566.5M.

6. The annual cost of the transport phase from the point of sale to the counting/pre-treatment plants would be €323M. 78% would correspond to the handling of containers from points of sale that process the collection manually and 21% to those from those that would resort to automated processes.
7. It is calculated that 10,895 points of sale would process the packaging waste using RVM, which would require the purchase of 38,752 machines (at a cost of €819.71M).

**SOCIAL**

An **analysis of the benefits and harms** reaches the following conclusions:

1. If the social costs and benefits are translated into monetary terms, the benefits do not offset the costs, and System B has 5 times more net costs than System A. The largest social costs come primarily from the increased time required for consumers to process containers subject to the DRS.
2. If the social costs per inhabitant were integrated into the costs resulting from the economic study, the latter would increase by 83% for System A and 96% for System B; that is, the costs of both systems would approximately double.

The main findings of the **social footprint** study are as follows:

1. The social footprint for both systems is negative overall, meaning that both systems have a net benefit for society.
2. The benefit for society is higher for System A than for System B; specifically, the introduction of a DRS alongside EPR would worsen the social footprint of managing packaging waste in Spain, reducing its beneficial impact by 50% compared to the current situation, despite the higher recycling rate that a DRS would achieve based on the study's assumptions.
3. These findings match those of the economic and environmental analyses: the benefits to society of System B are reduced by the cost of the other activities in this system, especially those associated with the collection and transport of containers.
4. It should be noted that in two specific aspects, System B involves a smaller social footprint than System A: recycling (lower production of raw materials in Spain and in other countries) and final disposal of waste (lower waste landfilling/incineration rates in Spain). This smaller social footprint, however, is not balanced out by this system's higher social footprint in other activities, especially in the collection of containers from stores (production of materials and machinery for collection, use of commercial space, etc.) and the transport of packaging and packaging waste.

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