



# D7.1 DEFINED SCENARIOS AND DATA INVENTORIES FOR PRELIMINARY SUSTAINABILITY ASSESSMENT WORK PACKAGE 7

Associated Task(s):

- T7.1 Scenario definition and process flow schemes
- T7.2 Mass and energy balances

**Lead Partner:** UGent  
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## CONTENTS

Publishable executive summary.....	5
1. Introduction .....	9
2. Scenario definition and process flow schemes .....	9
2.3 Scenario definition .....	10
2.3.1 Innovative Cases.....	10
2.3.2 Baseline Scenario.....	11
2.4 Process flow schemes .....	12
2.4.1 Collection and Sorting and Pretreatment.....	16
2.4.2 Purification option A CreaSolv® .....	18
2.4.3 Purification option B Delamination and Deinking .....	18
2.4.4 Posttreatment Recompounding .....	20
2.4.5 Posttreatment Deodorization.....	21
2.4.6 Laminate production.....	22
2.4.7 Tracer production .....	24
2.4.8 Ink and Primer production.....	24
2.4.9 Food packaging production.....	25
3. Mass and energy balances .....	26
3.1 Life Cycle Assessment (LCA) Data collection.....	26
3.2 Life Cycle Costing (LCC) Data collection .....	27
4. Conclusion .....	29
5. Bibliography .....	30
6. Annex.....	31
Loop 1 .....	31
Loop 2 .....	32
Loop 3.....	33
Collection and SoA sorting and Pretreatment-SUEZ .....	31
Purification option A CreaSolv®-IVV.....	34
Purification option B Delamination and Deinking-UGENT .....	35
Recompounding-UM, SUEZ.....	37
Deodorization-KREYEN .....	38
Laminate production-AMCOR .....	39
Tracer production-POLY.....	42
Ink and Primer production-Siegwerk.....	43



Food packaging production-Nestle ..... 44



## PUBLISHABLE EXECUTIVE SUMMARY

In CIRCULAR FoodPack project, the newly developed value chains as part of WP2 and WP3 are assessed by means of a holistic life cycle sustainability assessment (LCSA), taking into account environmental impacts through Life Cycle Assessment (LCA), economic impacts through Life Cycle Costing (LCC) and social impacts through Social LCA (S-LCA).

Within the life cycle thinking approach, four phases are relevant to obtain the assessments:

- a) the goal and scope definition phase,
- b) the inventory analysis phase,
- c) the impact assessment phase and
- d) the interpretation phase (ISO 14044, 2006).

From June 2021 to November 2022, the emphasis was placed on the first two phases. This comprises the definition of the different scenarios which are based on the three use cases that are home packaging (H), personal care packaging (PC) and food packaging (F) including the following six demonstrators/applications: Wet wipes (H1), Detergent tabs (H2), Cosmetics in sachets (PC1), Chocolate powder (F1), Coffee (F2) and Creamer (F3). Regarding the applications, three main loops (loop 1-3) are considered differing for instance in the input of either mixed food-flexibles and non-food flexibles or solely food-flexibles. Another important step was the creation of process flow schemes in close cooperation with the project partners for the following processes:

- (1) Collection, SoA sorting and Tracer-based sorting,
- (2) Pretreatment including Oversorting, Shredding, Washing, Grinding and Float-sink separation,
- (3) Purification with option A-CreaSolv® and option B-Deinking and Delamination,
- (4) Posttreatment consisting of Recompounding and Deodorization,
- (5) Laminate production and also considering Ink production, Primer production and Tracer production and
- (6) Food packaging production.

Based on this work, data collection for LCA and LCC inventories is completed by the respective partners to obtain the data for the preliminary sustainability assessment. The collection of S-LCA data is not considered in this deliverable as the impact indicators relevant for the system will be selected in a next step.



## LIST OF FIGURES

Figure 1 Life Cycle Sustainability assessment (LCSA) definition adapted by (Kloepffer, 2008) ..	9
Figure 2 Loop 1 process flow scheme for NF packaging .....	14
Figure 3 Loop 2 process flow scheme for F packaging .....	15
Figure 4 Loop 3 process flow scheme for NF and F packaging .....	15
Figure 5 Baseline scenario process flow scheme .....	16
Figure 6 Loop 1 Collection and SoA sorting and Pretreatment process flow scheme .....	16
Figure 7 Loop 2 Collection and SoA sorting and Pretreatment process flow scheme .....	17
Figure 8 Loop 3 Collection and SoA sorting and Pretreatment process flow scheme .....	17
Figure 9 Loop 1-3 Purification option A CreaSolv® process flow scheme .....	18
Figure 10 Loop 1-2 Purification option B Delamination and Deinking process flow scheme ...	19
Figure 11 Loop 3 Purification option B Delamination and Deinking process flow scheme .....	20
Figure 12 Loop 1-3 Recompounding process flow scheme .....	21
Figure 13 Loop 1-3 Deodorization process flow scheme .....	21
Figure 14 Loop 1 Wet Wipes Laminate production process flow scheme .....	22
Figure 15 Loop 1 Detergent Tabs Laminate production process flow scheme .....	22
Figure 16 Loop 1 Cosmetics Laminate production process flow scheme .....	23
Figure 17 Loop 3 Tracer production process flow scheme .....	24
Figure 18 Loop 1-3 Ink production process flow scheme .....	25
Figure 19 Loop 3 Primer production process flow scheme .....	25
Figure 20 Loop 2-3 Food packaging production process flow scheme .....	25
Figure 21 Loop 1 process flow scheme for NF packaging (landscape format) .....	31
Figure 22 Loop 2 process flow scheme for F packaging (landscape format) .....	32
Figure 23 Loop 3 process flow scheme for F and NF packaging (landscape format) .....	33
Figure 24 Loop 1 Collection and SoA sorting and Pretreatment data collection sheet .....	31
Figure 25 Loop 2 Collection and SoA sorting and Pretreatment data collection sheet .....	32
Figure 26 Loop 3 Collection and SoA sorting and Pretreatment data collection sheet .....	33
Figure 27 Loop 1-3 Purification option A CreaSolv® data collection sheet (data in green tbd) .....	34
Figure 28 Loop 1-2 Purification option B Delamination and Deinking data collection sheet ...	35
Figure 29 Loop 3 Purification option B Delamination and Deinking data collection sheet .....	36
Figure 30 Loop 1-3 Recompounding data collection sheet .....	37
Figure 31 Loop 1-3 Deodorization data collection sheet .....	38
Figure 32 Loop 1 Wet Wipes Laminate production data collection sheet (data in green tbd) .	39
Figure 33 Loop 1 Detergent Tabs Laminate production data collection sheet (data in green tbd) .....	40
Figure 34 Loop 1 Cosmetics Laminate production data collection sheet .....	41
Figure 35 Loop 3 Tracer production data collection sheet .....	42
Figure 36 Loop 1-3 Ink production data collection sheet .....	43
Figure 37 Loop 3 Primer production data collection sheet .....	43
Figure 38 Loop 2-3 Food packaging production data collection sheet .....	44

## LIST OF TABLES

Table 1 Definition of innovative cases to provide food and non-food packaging .....	11
Table 2 Involved partners per process step .....	12
Table 3 Scenarios per loop, purification pathway and application .....	13
Table 4 Example of Data collection template for Life Cycle Assessment (LCA) .....	27
Table 5 Data collection template for Life Cycle Costing (LCC) .....	28





## ABBREVIATIONS

Abbreviation	
B2B	Business to business
CAPEX	Capital expenditure
EoL	End of life
F	Food
FP	Food packaging
FU	Functional Unit
HP	Home packaging
IVV	Fraunhofer Institute IVV
KREYEN	Kreyenborg
LCA	Life cycle assessment
LCC	Life cycle costing
LCI	Life cycle inventory
LCSA	Life Cycle Sustainability Assessment
NF	Non-Food
OPEX	Operating expenditure
PCP	Personal care packaging
PCR	Post-consumer recyclates
POLY	Polysecure
S-LCA	Social Life Cycle Assessment
SoA	State of the art
Tbd	To be discussed
TBS	Tracer Based Sorting
UM	Maastricht University



## 1. INTRODUCTION

This Deliverable describes the first part of the Work Package 7 (WP7) work: Comprehensive Sustainability Assessment and Decision-support Tool. More specifically, this report comprises the scenario definition and process flow schemes (Task 7.1) and the Mass and energy balances (Task 7.2).

The objective of WP7 is to assess comprehensively the sustainability of the newly developed value chains (with new technology and packaging design), systematically taking into account the entire life cycle, performed in a holistic way by considering environmental, economic and social impacts. Life cycle assessment (LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA) as part of Life Cycle Sustainability assessment (LCSA), shown in Figure 1, serve as the methodological basis for mapping the respective impacts (Kloepffer, 2008).

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{SLCA}$$







*Figure 1 Life Cycle Sustainability assessment (LCSA) definition adapted by (Kloepffer, 2008)*

There are four phases in a LCA study: a) the goal and scope definition phase, b) the inventory analysis phase, c) the impact assessment phase, and d) the interpretation phase (ISO 14044, 2006). These phases also serve as the basis for the LCC modelling structure (Ciroth et al., 2011). The present Deliverable addresses the definition of scenarios in close collaboration with the technology and packaging developers, starting from three defined use cases (loop 1-3), which will be compared to the state of the art (SoA) baseline treatment scenarios. Additionally, the preliminary data collection of LCA and LCC data inventory (for hotspot analysis as a function of intermediate feedback) is also part of the scope, and will be refined in the further course of the project.<sup>1</sup> Therefore, the data collection templates (as shown in chapter 3 and Annex) were provided to the partners.

## 2. SCENARIO DEFINITION AND PROCESS FLOW SCHEMES

The geographical scope of the study is Europe, as the composition of flexible packaging waste was investigated in three sorting facilities in France, Belgium and Germany, which are considered representative for the sorting methods used in many EU countries. The temporal scope of the assessment covers the duration of the project (2021-2024). As functional unit (FU) the comparison of different scenarios through the basket of products approach was chosen. Basket

<sup>1</sup> The collection of S-LCA data is not considered in this deliverable as the impact indicators relevant for the system and the partners will be selected in a workshop during the next General Assembly in Nov. 2022.

of product is defined as a selection of product groups (European Commission, 2012). In this study (1) non-food packaging, (2) food packaging and (3) energy and heat recovery from incineration, are considered as basket of products.

## **2.3 Scenario definition**

### **2.3.1 Innovative Cases**

Innovative scenarios are based on three categories of packaging applications, i.e. home packaging (HP), personal care packaging (PCP) and food packaging (FP) including the following six demonstrators/applications:

- 1.** Wet wipes (HP1)
- 2.** Detergent tabs (HP2)
- 3.** Cosmetics in sachets (PCP1)
- 4.** Chocolate powder (FP1)
- 5.** Coffee (FP2)
- 6.** Creamer (FP3).

Regarding the applications, three main cascade cases here named as loops (Table 1) are considered differing for instance in the input of either mixed end-of-life (EoL)-food (F) flexibles and EoL-non-food (NF) flexibles or solely EoL-F flexibles. EoL-F flexibles are used, for example, for food sub-categories such as dairy products, coffee, tea, cocoa, bakery products, frozen food or fresh products. EoL-NF flexibles are used, for example, for non-food sub-categories such as collection bags, small bags, secondary packaging films or carrier bags. These examples do not include all the identified subcategories that were part of WP2's work. The full list of food and non-food sub-categories can be found in Deliverable 2.1. The result of each loop is a laminate consisting of a combination of virgin polyethylene (PE) and post-consumer-recyclate (PCR) PE. In the case of food applications (FP1-3), functional barriers are added. In loop 3, which comprises two product cycles as sub scenarios, tracers are added to the laminate.



Table 1 Definition of innovative cases to provide food and non-food packaging

Cases	Input	Output	Applications
Loop 1	Mixed = EoL F and NF flexibles	<b>Laminate 1:</b> mono-material with <ul style="list-style-type: none"> <li>• PE virgin</li> <li>• PE PCR from F and NF origin</li> </ul>	HP1: wet wipes HP2: detergent tabs PCP1: cosmetics in sachets
Loop 2	F flexibles	<b>Laminate 2:</b> mono-material with <ul style="list-style-type: none"> <li>• PE virgin</li> <li>• PE PCR from F origin</li> <li>• Functional barriers</li> </ul>	FP1: chocolate powder
Loop 3 cycle 1	Mixed = F and NF flexibles with tracers in F flexibles	<b>Laminate 3:</b> mono-material with <ul style="list-style-type: none"> <li>• PE virgin</li> <li>• PE PCR from F origin</li> <li>• Functional barriers and tracers</li> </ul>	FP2: coffee FP3: creamer PCP1: cosmetics in sachets
Loop 3 cycle 2	Mixed = F and NF flexibles with tracers in F flexibles	<b>Laminate 4:</b> mono-material with <ul style="list-style-type: none"> <li>• PE virgin</li> <li>• PE PCR from F origin</li> <li>• Functional barriers and tracers</li> </ul>	FP2: coffee FP3: creamer PCP1: cosmetics in sachets

### 2.3.2 Baseline Scenario

For the baseline scenario the following end-of-life options and shares for plastic packaging are taken into consideration (Eunomia & Plastic Recyclers Europe, 2020; Plastic Europe, 2020):

- 17% recycling
- 56.5% incineration with energy recovery
- 26.5% landfilling.

The figures for recycling are based on Eunomia & Plastic Recyclers Europe (2020) and refer specifically to PE films from household packaging. As the Eunomia report does not include corresponding figures for incineration with energy recovery and landfilling, the figures for these two waste management pathways are based on Plastic Europe (2020) figures for plastic packaging including household, commercial and industrial packaging. Here, the used ratio (1:2.1) between landfill and incineration is calculated based on the shares for each pathway, which are 39.50% for incineration with energy recovery and 18.50% for landfill (Plastic Europe, 2020). The ratio (1:2.1) is then applied to the delta (83%) of recycling and the remaining pathways.

## 2.4 Process flow schemes

Table 2 shows the partners and one advisory board member involved in relation to the developed processes within this project.

Table 2 Involved partners per process step

Partners	Process
SUEZ	Collection, SoA sorting and Pretreatment
POLY	Tracer-based sorting and tracer production
UGENT	Purification (Delamination and Deinking)
IVV	Purification (CreaSolv®)
UM, SUEZ	Recompounding
KREYEN	Deodorization
AMCOR	Laminate production(including film production and printing)
SIEGWERK	Ink and primer production
NESTLE	B2B collection + F packaging production
UBESOL <sup>2</sup>	NF packaging production

In order to draw the process flow schemes bilateral meetings were held focusing on the inputs and outputs of each individual process step. System boundaries and process flow schemes were drawn for the following processes:

- Collection
- SoA sorting
- Tracer-based sorting
- Pretreatment
  - Oversorting
  - Shredding
  - Washing
  - Grinding
  - Float-sink separation
- Purification option A-CreaSolv®
- Purification option B-Deinking and Delamination
- Posttreatment Recompounding
- Posttreatment Deodorization
- Laminate production (including film production and printing)

<sup>2</sup> UBESOL is part of the advisory board. A first kick-off meeting was organised at the end of November. The creation of process flow schemes and data collection will follow in the next few weeks.

- Ink production
- Primer production
- Tracer production
- F packaging production.

Three different purification pathways are taken into consideration for the preliminary assessment of loop 1-3: (1) Delamination + Deinking, (2) CreaSolv®, (3) Delamination + Deinking + CreaSolv®

CreaSolv® may not be applied in Loop 2 and Loop 3 if the pretreated PE-flakes show a sufficiently high purity and hence do not require additional purification after delamination and deinking. When CreaSolv® is applied as a purification step, the last step within the process is a regranulation/recompounding step, so an additional recompounding step is not required.

Taking into account the number of loops, purification pathways and applications, thirty different scenarios as shown in Table 3 can be distinguished:

*Table 3 Scenarios per loop, purification pathway and application*

Cases	Purification pathway	Applications	Number of scenarios
Loop 1	<ul style="list-style-type: none"> <li>• Purification pathway (1)</li> <li>• Purification pathway (2)</li> <li>• Purification pathway (3)</li> </ul>	HP1: wet wipes HP2: detergent tabs PCP1: cosmetics in sachets	9
Loop 2	<ul style="list-style-type: none"> <li>• Purification pathway (1)</li> <li>• Purification pathway (2)</li> <li>• Purification pathway (3)</li> </ul>	FP1: chocolate powder	3
Loop 3 cycle 1	<ul style="list-style-type: none"> <li>• Purification pathway (1)</li> <li>• Purification pathway (2)</li> <li>• Purification pathway (3)</li> </ul>	FP2: coffee FP3: creamer PCP1: cosmetics in sachets	9
Loop 3 cycle 2	<ul style="list-style-type: none"> <li>• Purification pathway (1)</li> <li>• Purification pathway (2)</li> <li>• Purification pathway (3)</li> </ul>	FP2: coffee FP3: creamer PCP1: cosmetics in sachets	9

### Explanation of terminology:

Since recompounding has been mentioned above, the difference between pelletizing, regranulation and recompounding is explained below.

- Pelletizing: polymer string is molded and cut into pellets (short parts of the string)
- Regranulation: Extrusion (i.e. melting) and pelletizing of post-consumer plastics
- Recompounding: regranulation incl. adding additives

The process flow schemes per loop (Figure 2-Figure 4) and the baseline scenario (Figure 5) are described below, followed by the detailed process flow schemes of each process step i.e. Collection, Sorting and Pretreatment (Figure 6-Figure 8), Purification (Figure 9-Figure 11),

Posttreatment (Figure 12 and Figure 13), Laminate production (Figure 14-Figure 16), Tracer-, Ink- and Primer production (Figure 17-Figure 19) and F packaging production (Figure 20).

The difference between the loops can be seen in the inputs of the process flow charts. In loop 2, the input comes from commercial consumers (Figure 2), while the input of loop 1 (Figure 1) and 3 comes from households. In loop 3, in addition to state of the art (SoA) sorting, tracer-based sorting (TBS) technology has been introduced to ensure that developed packaging with tracers (shown here in Figure 3 as PE-rich flexible food with tracers) is sorted out of the waste stream. In addition, there is a difference in the output of the loops, as loop 1 produces laminate for non-food applications, while loop 2 and loop 3 produce laminates for food applications. Empty boxes and three dots between the arrows [...] serve as a preliminary illustration and represent that either several process steps, e.g. Oversorting, Shredding, Washing, Grinding, Float-sink separation, have to be considered in the case of Pretreatment or that the final order of the cascade, e.g. whether deodorization takes place before or after Recompounding, has to be finally determined. The flow of unpacked NF or F products (in grey) is listed for illustrative purposes only and is not included in the assessments. A representation of the process flow schemes for loop 1-3 in an enlarged view in landscape format can be found in the Annex.

### Loop 1

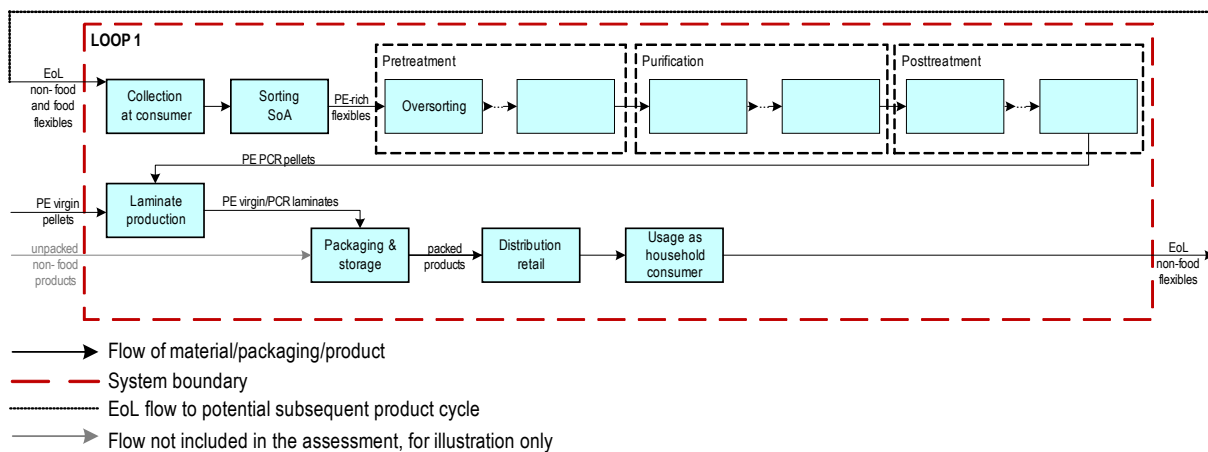


Figure 2 Loop 1 process flow scheme for NF packaging

### Loop 2

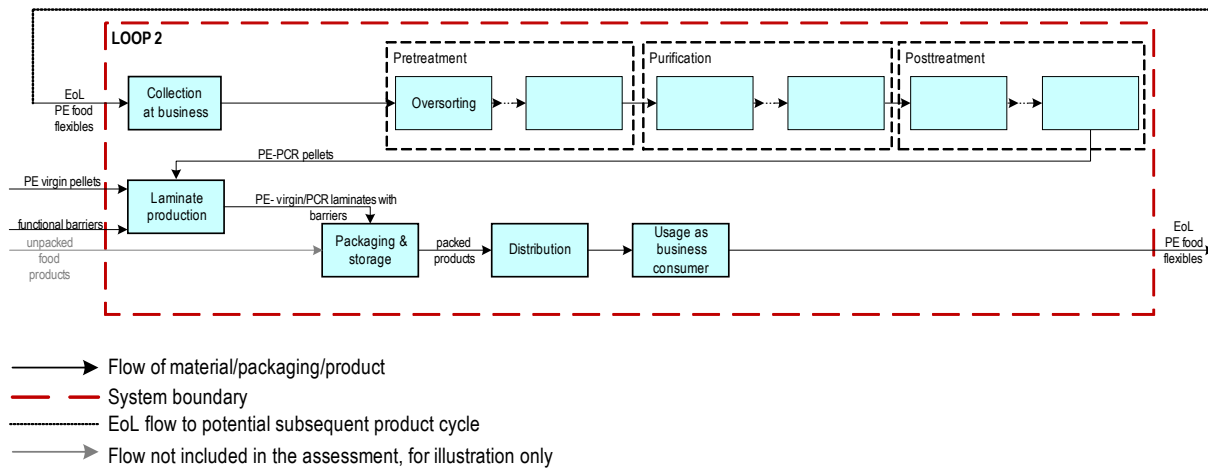


Figure 3 Loop 2 process flow scheme for F packaging

### Loop 3

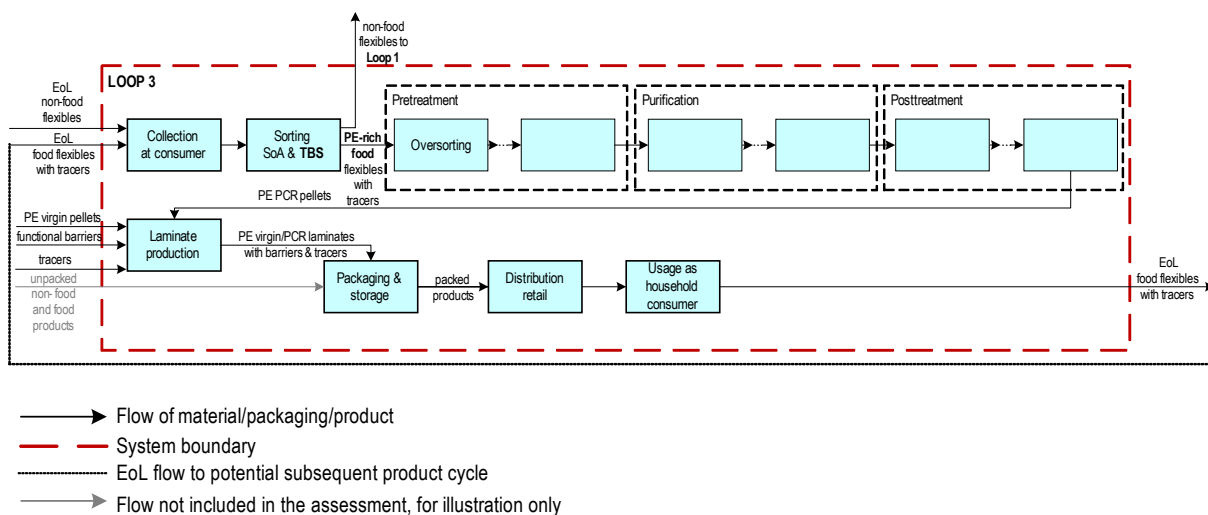


Figure 4 Loop 3 process flow scheme for NF and F packaging

### Baseline scenario

The process flow scheme for the baseline scenario is presented in Figure 5. The current waste treatment (\*) combines incineration with energy recovery, landfilling and open-loop recycling (Plastic Europe, 2020). In open-loop recycling, the properties of the recycled material deviate from those of the virgin material (Huysman et al., 2017). As the waste input, i.e. non-food and food flexible (loop 1), solely food flexibles (loop 2) or non-food and food flexible with tracers (loop 3), differs depending on the respective loop, the baseline scenarios are adapted to the loops accordingly.



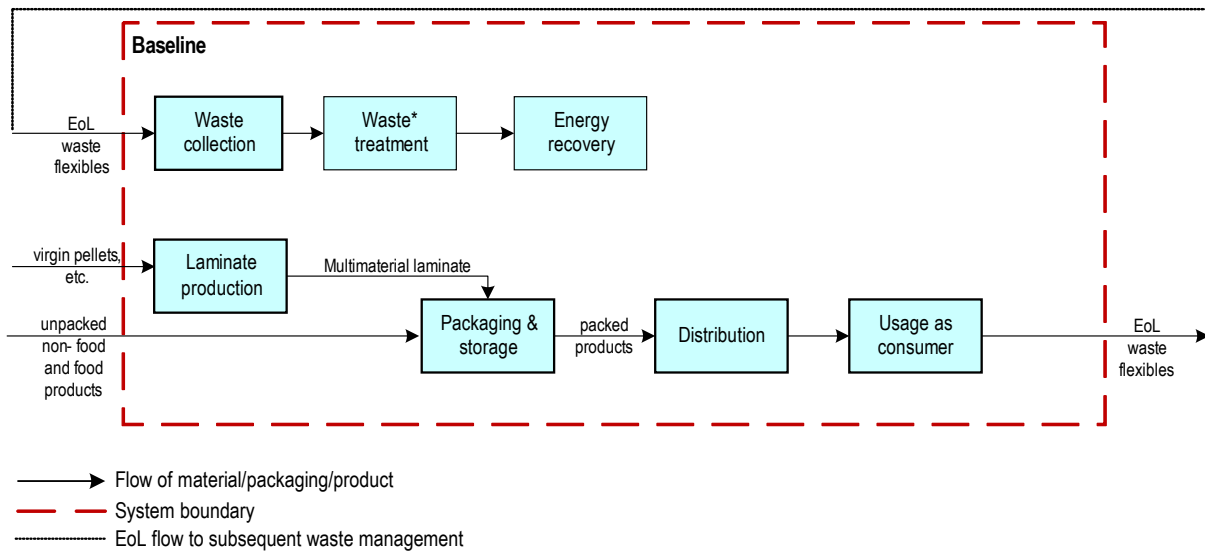


Figure 5 Baseline scenario process flow scheme

In the following the process steps are presented in terms of chronological sequence and loop.

### 2.4.1 Collection and Sorting and Pretreatment

The process flow scheme for Collection and SoA sorting and Pretreatment within loop 1 is shown in Figure 6 based on information provided by SUEZ. The residues from SoA sorting, Oversorting, Waste water treatment and Float-sink separation are sent to incineration with energy recovery. Data marked in green is preliminary and a final decision must be made accordingly i.e. if the following purification process takes place on the recycling site or whether a transport (T) is required.

#### Loop 1

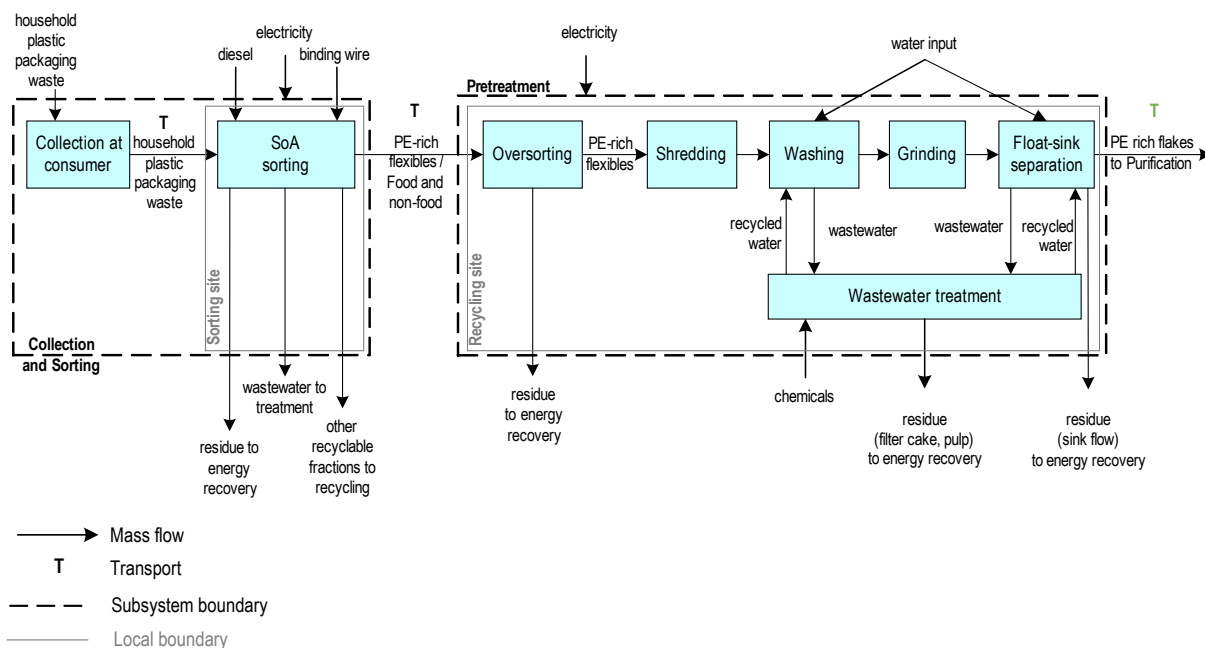


Figure 6 Loop 1 Collection and SoA sorting and Pretreatment process flow scheme

The process flow scheme for Collection and SoA sorting and Pretreatment within loop 2 is shown in Figure 7. The SoA sorting step is omitted because the input material is collected from companies (B2B), resulting in a homogeneous stream that does not require SoA sorting apart from Oversorting.

### Loop 2

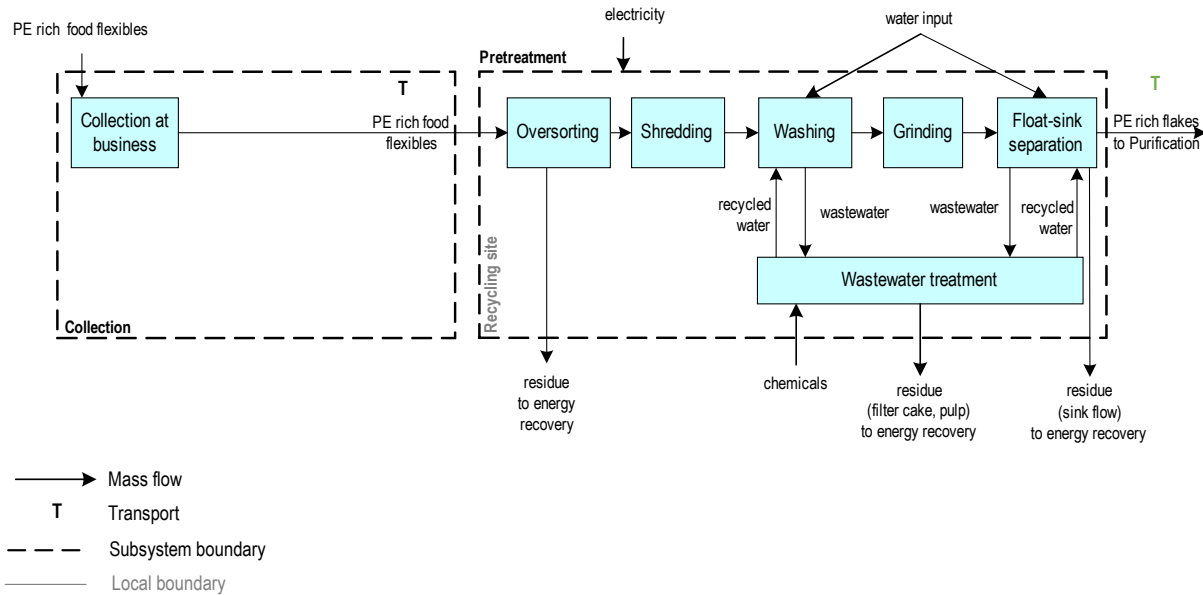


Figure 7 Loop 2 Collection and SoA sorting and Pretreatment process flow scheme

The process flow scheme for Collection and SoA sorting and Pretreatment within loop 3 is shown in Figure 8. An additional TBS sorting step is applied here.

### Loop 3 including Tracer-based sorting (POLY)

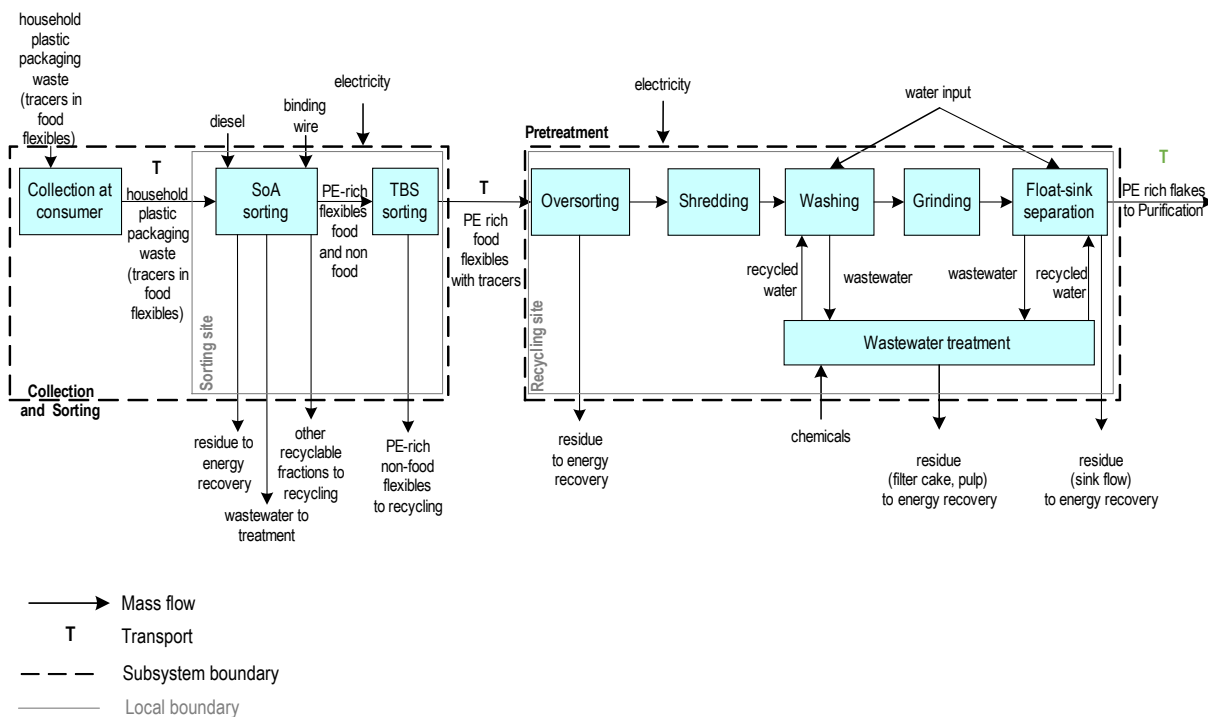


Figure 8 Loop 3 Collection and SoA sorting and Pretreatment process flow scheme



### 2.4.2 Purification option A CreaSolv®

The process flow scheme for Purification option A CreaSolv® within loop 1-3 is presented in Figure 9 based on information provided by IVV. Data marked in green i.e. if additives are added in the regranulation step are preliminary and a final decision must be made accordingly.

#### Loop 1-3

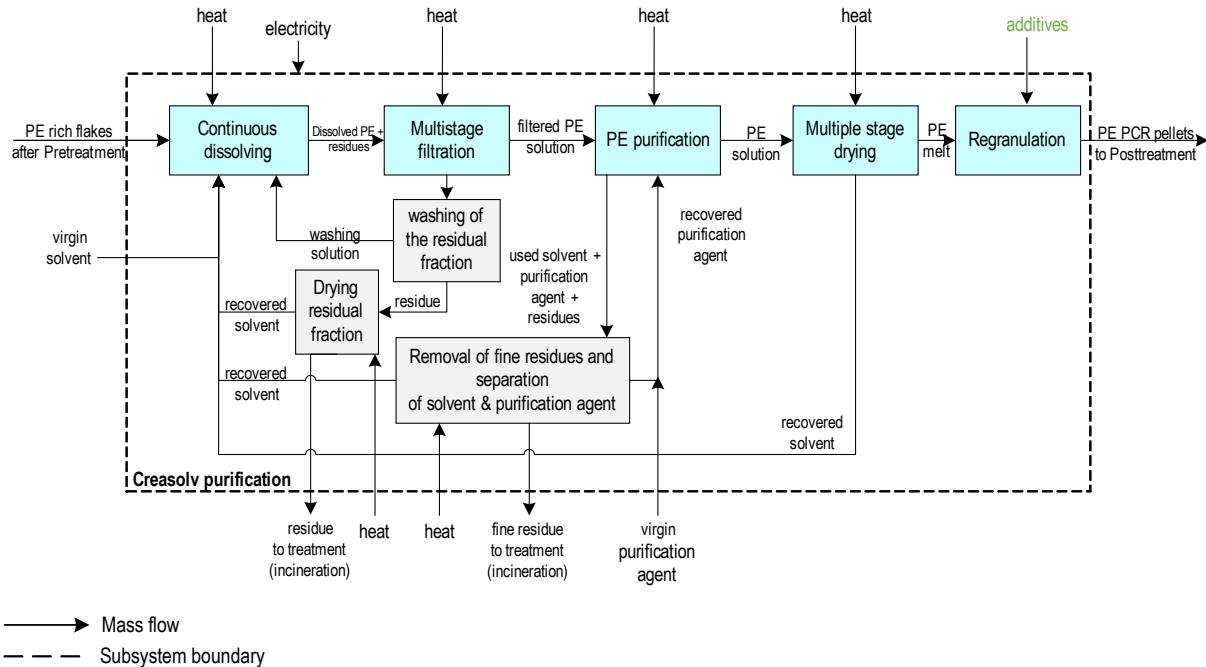


Figure 9 Loop 1-3 Purification option A CreaSolv® process flow scheme

### 2.4.3 Purification option B Delamination and Deinking

The process flow scheme for Purification option B Delamination and Deinking within loop 1 and 2 is shown in Figure 10 based on information provided by UGENT. Data marked in green i.e. if residues are sent to energy recovery are preliminary and a final decision must be made accordingly.

## Loop 1 and 2

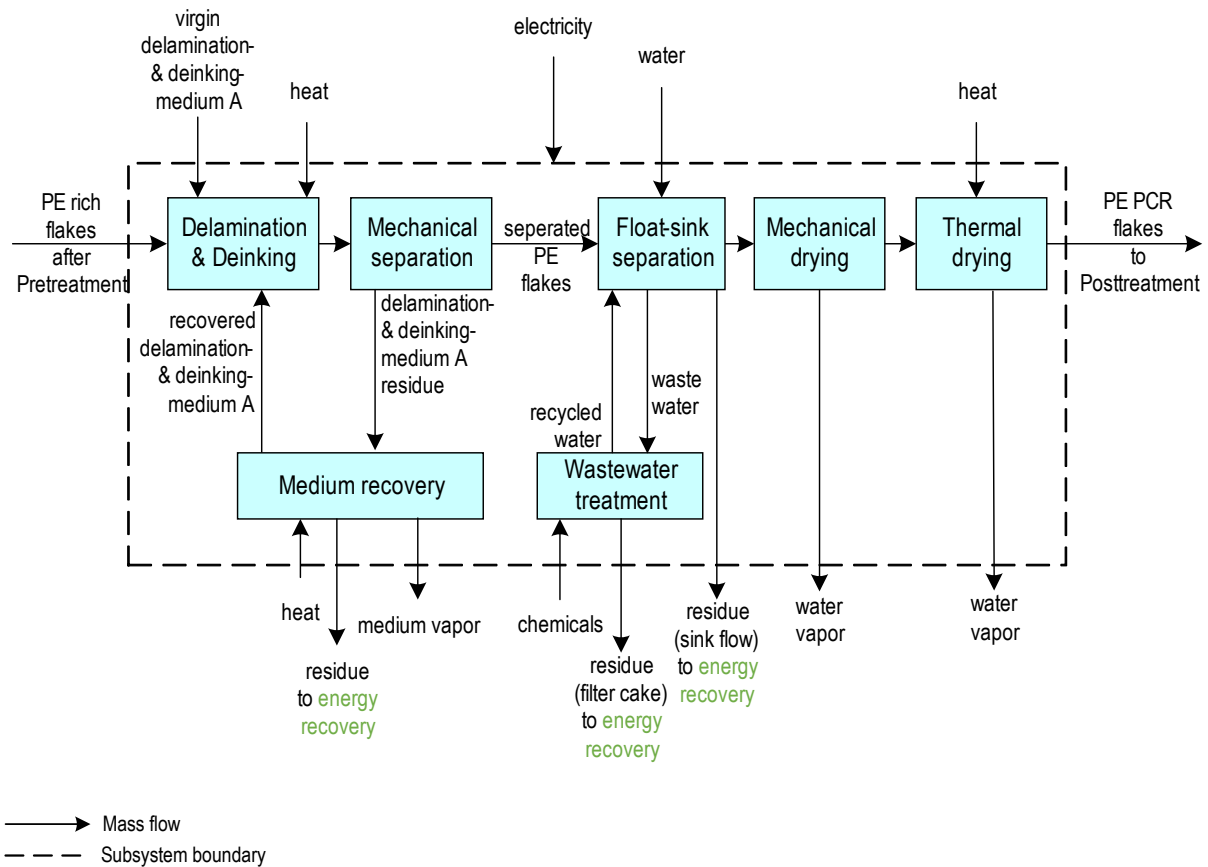


Figure 10 Loop 1-2 Purification option B Delamination and Deinking process flow scheme

The process flow scheme for Purification option B Delamination and Deinking within loop 3 is shown in Figure 11. The delamination and deinking medium B is different from the medium A used in loop 1-2, and medium recovery is not feasible here. Data marked in green i.e. if recycle water can be applied in various steps are preliminary and a final decision must be made accordingly.

### Loop 3

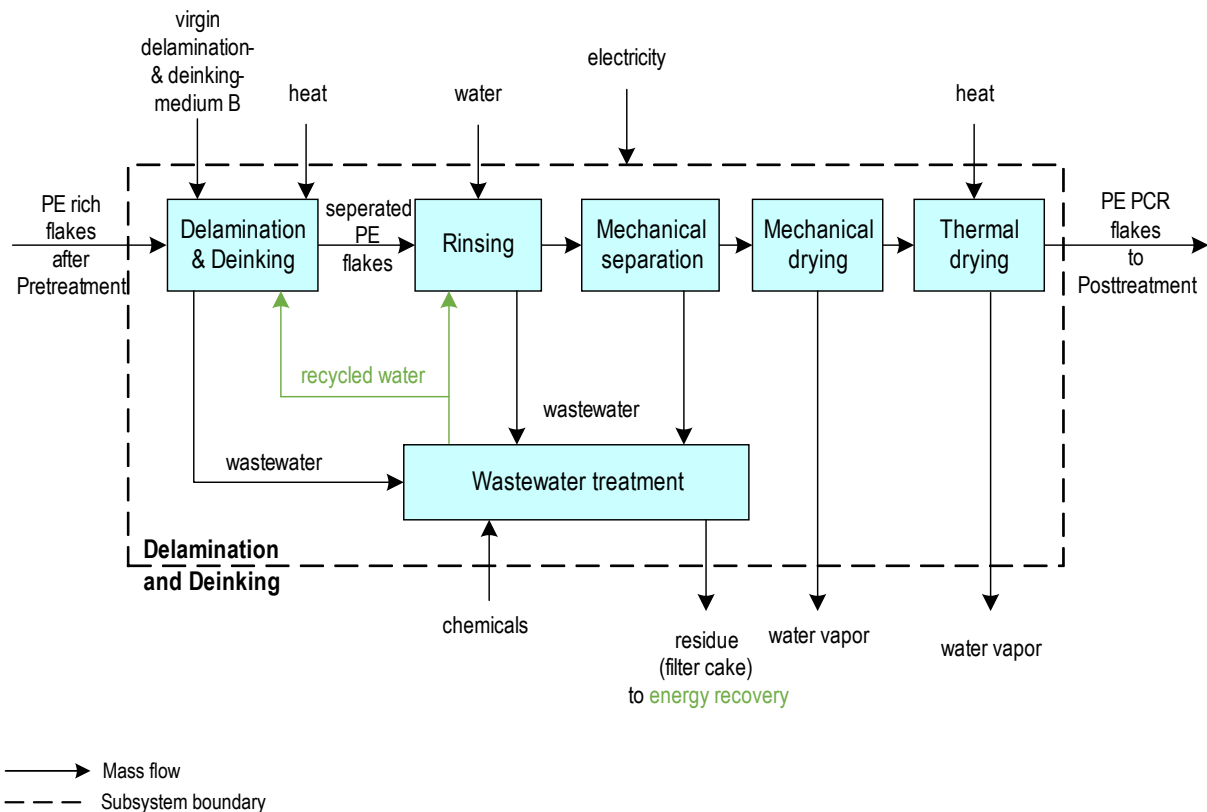


Figure 11 Loop 3 Purification option B Delamination and Deinking process flow scheme

#### 2.4.4 Posttreatment Recompounding

The process flow scheme for Recompounding within loop 1-3 is shown in Figure 12 based on information provided by UM. Data marked in green i.e. if residues are sent to energy recovery and if additives are added are preliminary and a final decision must be made accordingly. Depending on the outcome of the different purification pathways the input (PE PCR flakes) comes either from the Purification option B or from Deodorization, respectively the PE PCR pellets go either to Deodorization or Laminate production.

**Loop 1-3**

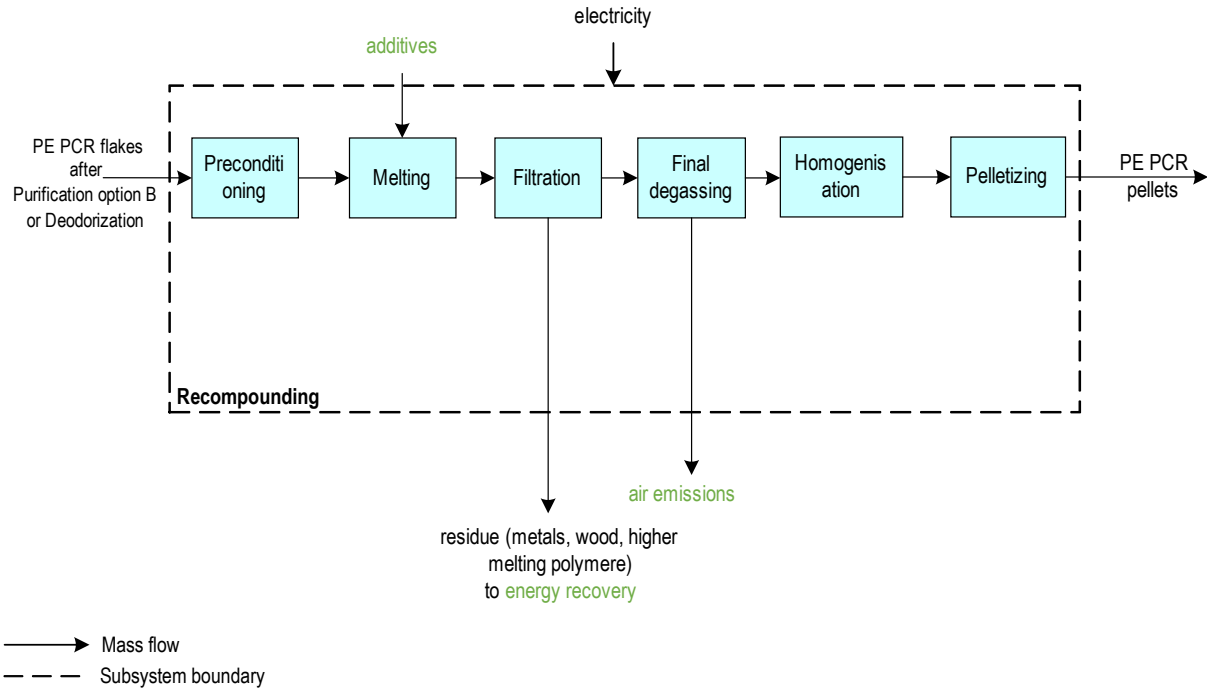


Figure 12 Loop 1-3 Recompounding process flow scheme

**2.4.5 Posttreatment Deodorization**

The process flow scheme for Deodorization within loop 1-3 is presented in Figure 13 based on information provided by KREYEN and consists of infrared and thermal treatment.

**Loop 1-3**

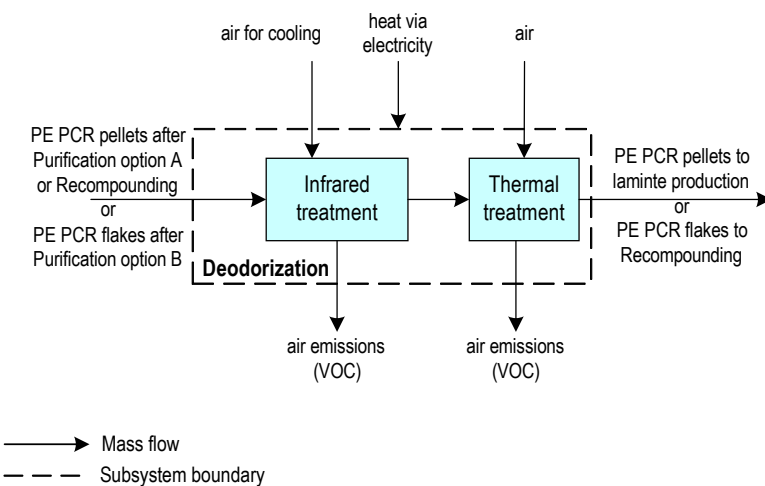


Figure 13 Loop 1-3 Deodorization process flow scheme

### 2.4.6 Laminate production

The process flow scheme for Laminate production within loop 1 is presented in Figure 14-Figure 16 based on information provided by AMCOR and is shown for each application i.e. wet wipes, detergent tabs and cosmetics in sachets. Laminate production involves, in a first step, the production of films, which are then processed into a printed laminate.

#### Loop 1- Wet Wipes (HP1)

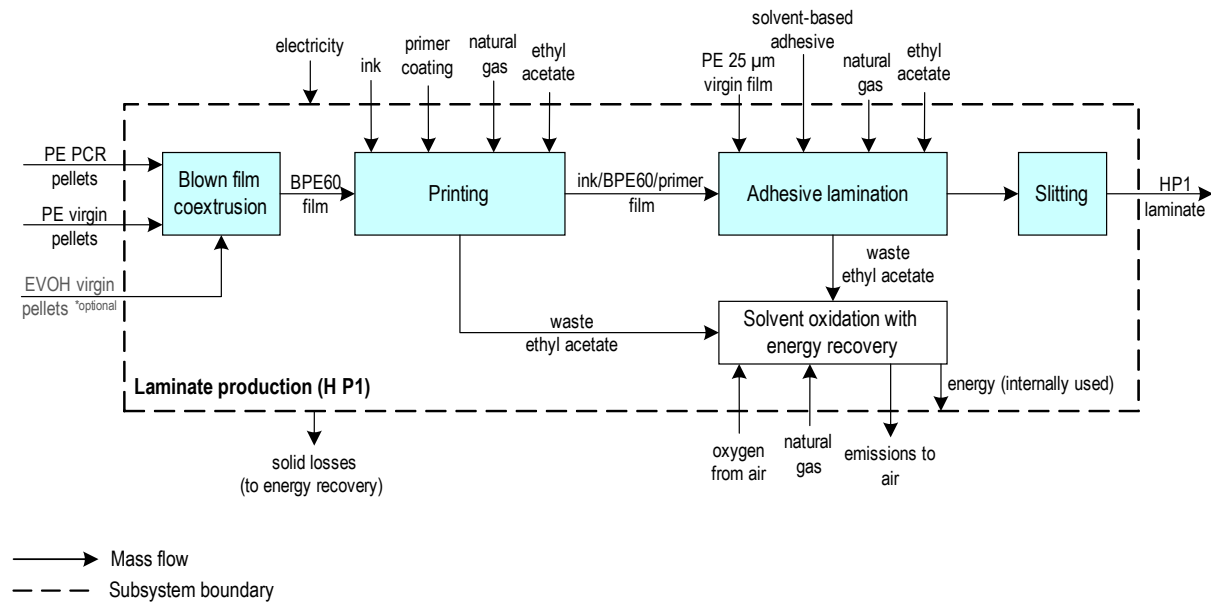


Figure 14 Loop 1 Wet Wipes Laminate production process flow scheme

#### Loop 1- Detergent Tabs (HP2)

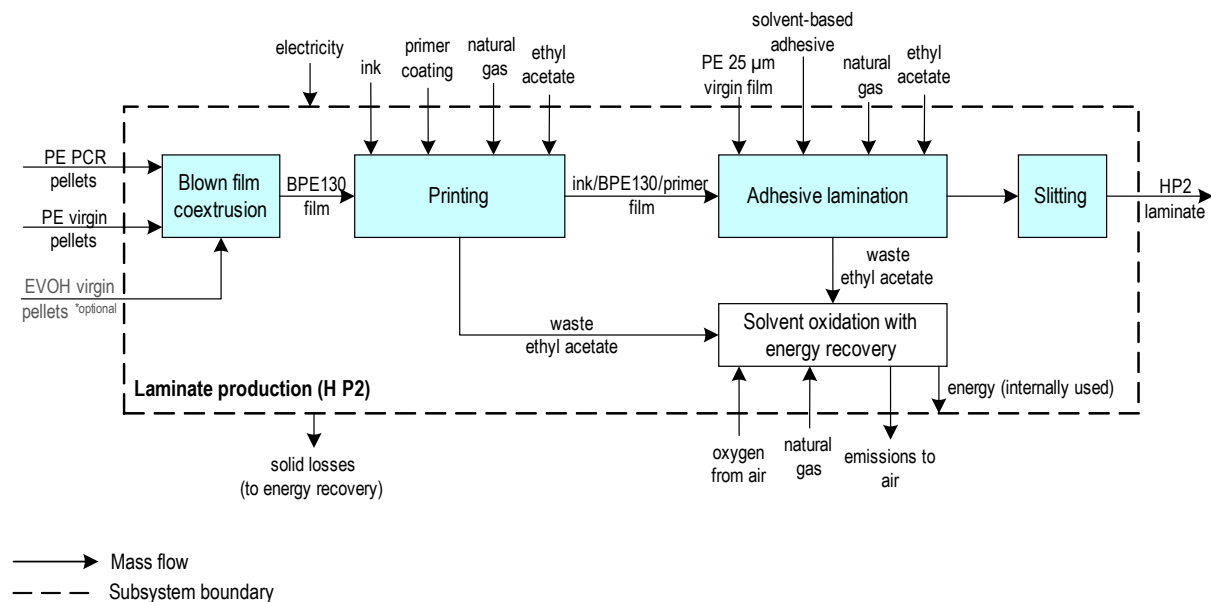


Figure 15 Loop 1 Detergent Tabs Laminate production process flow scheme

## Loop 1- Cosmetics (PCP1)

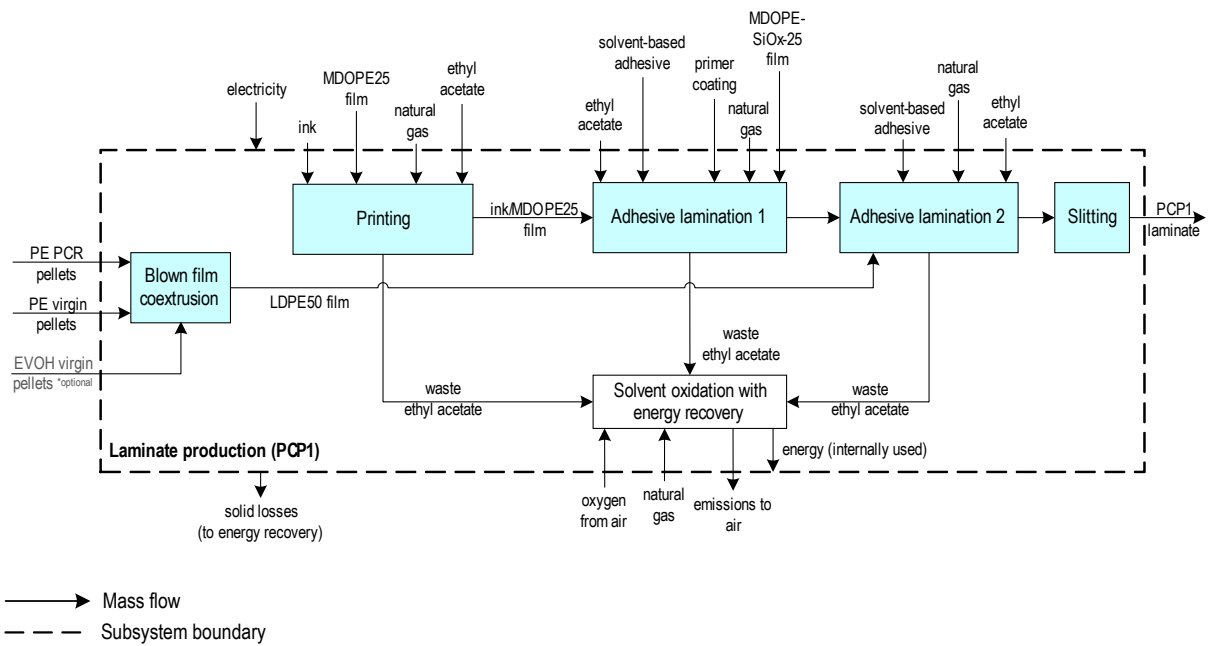


Figure 16 Loop 1 Cosmetics Laminate production process flow scheme

The laminates for food packaging for Loop 2 and 3 are likewise manufactured by AMCOR. The exact structure, including functional barriers, primers and inks, is still under development.



### 2.4.7 Tracer production

The process flow scheme for Tracer production within loop 3 is presented in Figure 17 based on information provided by POLY. Tracers will be implemented in the laminate production of loop 3.

#### Loop 3

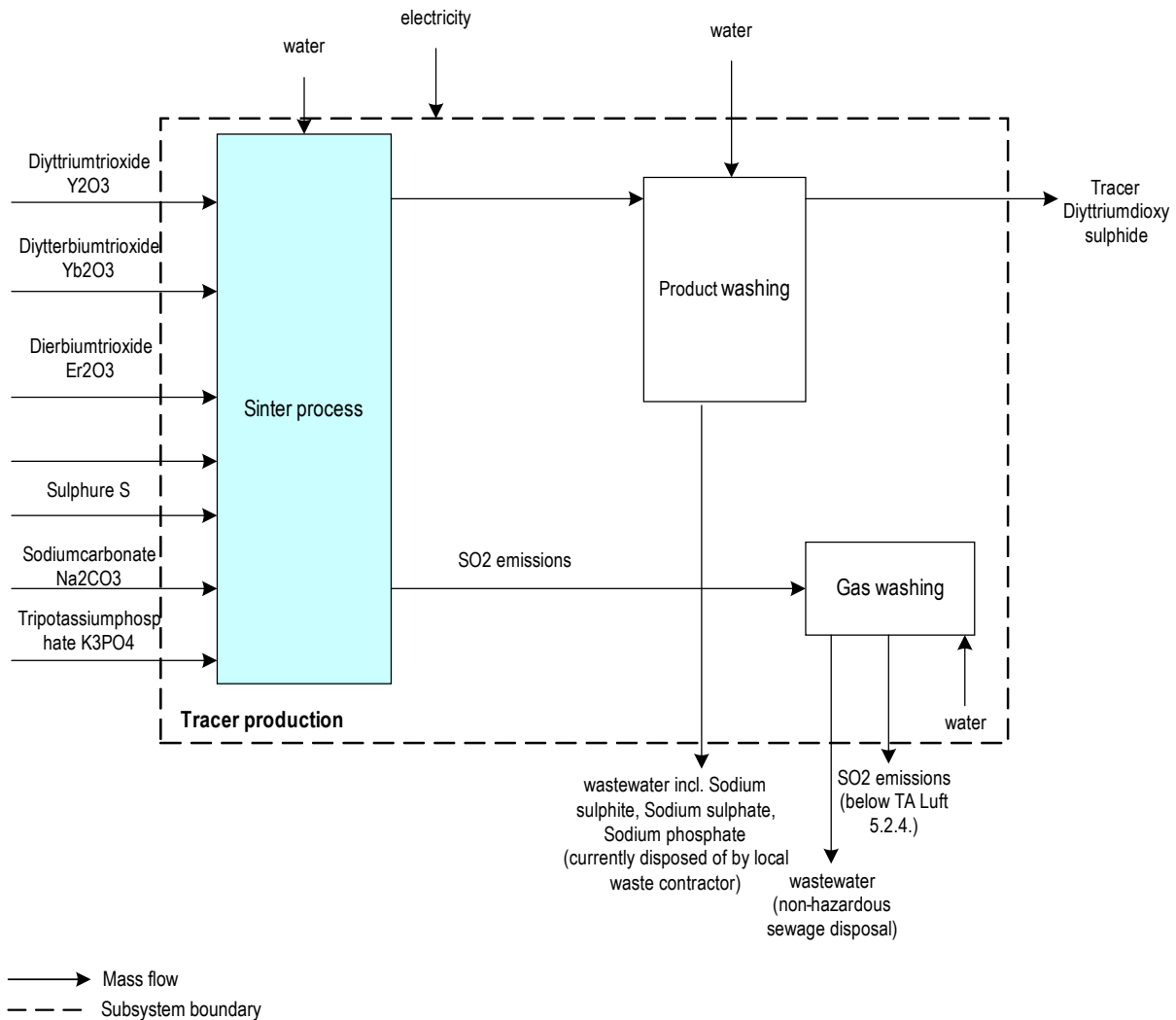


Figure 17 Loop 3 Tracer production process flow scheme

### 2.4.8 Ink and Primer production

The process flow scheme for Ink production within loop 1-3 is presented in Figure 18 based on information provided by Siegwirk. The process flow scheme for Primer production within loop 2 and 3 is shown in Figure 19. The primers will be implemented in the laminate production of loop 2 and 3 to facilitate the purification step.

### Loop 1-3 Ink

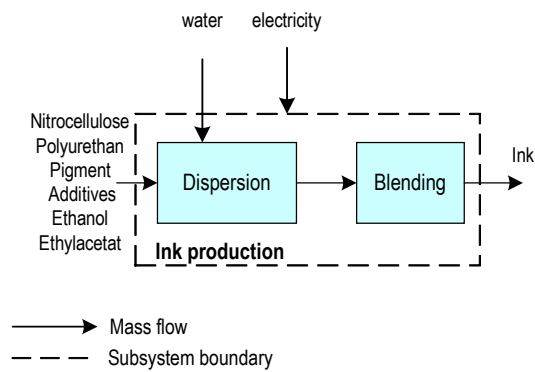


Figure 18 Loop 1-3 Ink production process flow scheme

### Loop 2-3 Primer

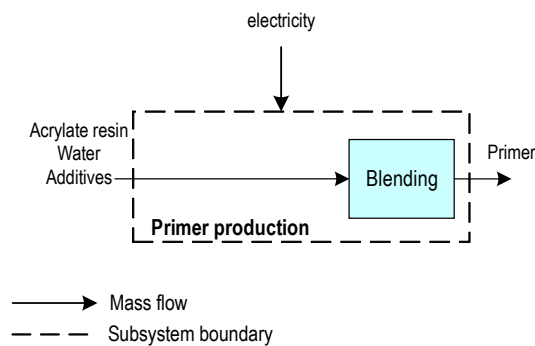


Figure 19 Loop 3 Primer production process flow scheme

## 2.4.9 Food packaging production

The process flow scheme for the Food packaging production within loop 2 and 3 is presented in Figure 20 based on information provided by Nestle.

### Loop 2 and 3

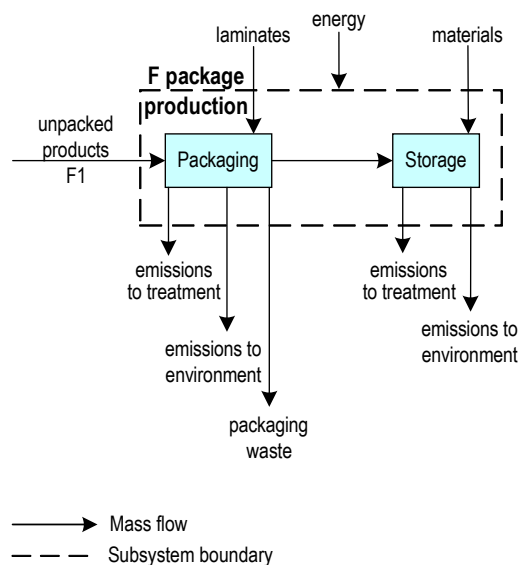


Figure 20 Loop 2-3 Food packaging production process flow scheme

### 3. MASS AND ENERGY BALANCES

“The life cycle inventory analysis phase (LCI phase) is the second phase of LCA. It is an inventory of input/output data with regard to the system being studied. It involves the collection of the data necessary to meet the goals of the defined study” (ISO 14044, 2006). In order to obtain mass and energy balances for the LCA and to collect cost data for the LCC evaluation, templates for data collection were distributed and filled in by the partners.

#### 3.1 Life Cycle Assessment (LCA) Data collection

Table 4 shows an example of a data collection template. The data is collected per process step in order to be able to identify any hotspots within the process flow through the analyses. Data is collected per reference flow, e.g. per year, per tonne of waste processed or per m<sup>2</sup> of laminate produced. The reference flow is the measure of the output of processes in a given product system that is required to fulfil the function expressed by the functional unit (ISO 14044, 2006). The respective unit, e.g. kWh for electricity or kg for input materials, is inserted and the origin of the respective input as well as the destination of the output are given for specification. Any additional information useful for the analysis is provided in the remark section and the source of the information is indicated accordingly.



Table 4 Example of Data collection template for Life Cycle Assessment (LCA)

Process 1							
Inputs	Data per year	per ton	Data per ton	Unit	Origin	Remarks	Source
Input 1							
Input 2							
...							
example: Electricity	10 000			MWh	Grid Belgium		Excel "...xls" or e-mail company x on 02/02
Outputs	Data per year	per ton	Data per ton	Unit	Destination	Remarks	Source
Output 1							
...							
Process 2							
Inputs	Data per year	per ton	Data per ton	Unit	Origin	Remarks	Source
Input 1							
Input 2							
...							
Outputs	Data per year	per ton	Data per ton	Unit	Destination	Remarks	Source
Output 2							
...							
Transport (T)							
T1	Distance	Transport mode	Unit	Truck technology	Remarks	Source	
Input 1		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t		
T2	Distance	Transport mode	Unit	Truck technology	Remarks	Source	
Input 2		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t		

### 3.2 Life Cycle Costing (LCC) Data collection

Life cycle costing (LCC) is based on an economic evaluation that takes into account different phases of the life cycle. It is a method that generally includes the costs of a product that are borne directly by a specific actor (Hunkeler et al., 2008). Costs are divided into capital expenditure (CAPEX), operating expenditure (OPEX) and revenues and clustered by cost type

(Taelman et al., 2020), e.g. investment costs for equipment, costs for personnel, material, utilities, transport, emissions, waste or other operational costs for example taxes and insurance (Table 5).

Table 5 Data collection template for Life Cycle Costing (LCC)

CAPEX, OPEX, Revenues					
Type of cost	Cost points	Quantity	Unit	Remarks	Source
<i>Capital costs</i>					
<b>Investment</b>	Land		€/m <sup>2</sup>		
	Buildings/ property		€/m <sup>2</sup>	e.g. industrial plant	
	Equipment/ software		€/pc. or year	e.g. machinery	<b>e.g. Corporate Carbon Footprint (CCF)</b>
	Vehicles		€/pc. or year		<b>e.g. CCF</b>
<i>Operational costs</i>					
<b>Personnel Services</b>	Salary and wages		€/hour	Please report an average if necessary	
	Fee		€/hour		
<b>Material costs</b>	Raw materials		€/kg or m <sup>3</sup>	e.g. sand, iron, chemicals	
	Industrial intermediate goods		€/kg or m <sup>3</sup>	e.g. steel, plastic, glass, etc.	
<b>Utility costs</b>	Fuel		€/kg; l		
	Freshwater		€/m <sup>3</sup> ; l		
	Electricity		€/kWh		
	Heat		€/MJ		
<b>Transport</b>	Travel and vehicle expenses		€/km	e.g. transport of people and goods	
	<b>Emission discharge &amp; waste related costs</b>	Wastewater		€/m <sup>3</sup>	e.g. cost of waste management i.e. wastewater fee
Emissions			€ per kg of release	e.g. CO <sub>2</sub> emission tax	
<b>Other operational costs</b>	License, legal, ...		€/year		
<b>Other operational costs</b>	Maintenance and repairs		€/year		
<b>Other operational costs</b>	Taxes		€/year		

Other operational costs		Insurance	€/year	
<i>Revenues/ Positive flows</i>	<i>Cash</i>			e.g. Revenues, by sold products, residual value of waste, by-product waste...
Selling products	of	Product	€/product	Market prices for secondary products
		Co-product	€/product	Market prices for secondary products
		Fees	€/year	e.g. inhabitants that pay a fee to collect their waste
		Subsidies	€/year	e.g. for setting up a waste recycling management system

#### 4. CONCLUSION

In order to achieve a holistic life cycle analysis of the technologies and concepts developed within the framework of the CIRCULAR FoodPack project, the definition of scenario and process flow schemes as well as first mass and energy balances were set up. The geographical scope of the study is Europe and the temporal scope of the assessment covers the duration of the project (2021-2024). As functional unit (FU) the comparison of different scenarios through the basket of products approach was chosen: In this study (1) non-food packaging, (2) food packaging and (3) energy and heat recovery from incineration, are considered as basket of products.

Scenarios and respective preliminary process flow schemes (according to the loops 1-3 of the project proposal, baseline) were defined as well as individual process steps have been developed in bilateral meetings with the involved parties. This comprises the definition of the different scenarios, which are based on three use cases such as home packaging (HP), personal care packaging (PCP) and food packaging (FP) including the following six demonstrators/applications: Wet wipes (HP1), Detergent tabs (HP2), Cosmetics in sachets (PCP1), Chocolate powder (FP1), Coffee (FP2), Creamer (FP3). Regarding the applications, three main cascade cases (loop 1-3) are considered differing for instance in the input of either mixed F-flexibles and NF-flexibles or solely F-flexibles. Three different purification pathways are taken into consideration for the preliminary assessment of loop 1-3:

(1) Delamination + Deinking, (2) CreaSolv<sup>®</sup>, (3) Delamination + Deinking + CreaSolv<sup>®</sup>. This results in the number of thirty different scenarios as shown in Table 3 Scenarios per loop, purification pathway and application.

Furthermore, the set-up of a framework for the data collection according to the scenarios was done in close cooperation with the project partners. (1) Collection, SoA sorting and Tracer-based sorting, (2) Pretreatment including Oversorting, Shredding, Washing, Grinding, Float-sink separation, (3) Purification for option A-CreaSolv<sup>®</sup> and option B-Deinking and Delamination, (4) Posttreatment consisting of Recompounding and Deodorization, (5) Laminate production including film production and printing, (6) Ink production and Primer production, (7) Tracer production and (8) F packaging production. The data collection templates for LCA and LCC data were created and distributed by UGENT. These tables are to be completed by the respective partners to obtain the data for the final assessment.



As a next step, the environmental impact assessment (LCA) will be conducted by carefully selecting impact categories for a holistic assessment in order to analyse the hotspots of the systems under study. For the economic assessment of the system, certain data gaps need to be filled. To conduct the social assessment, relevant impact indicators are selected through participatory methods, including a workshop with partners during the second General Assembly, which took place in November 2022.

## 5. BIBLIOGRAPHY

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## 6. ANNEX

### Loop 1

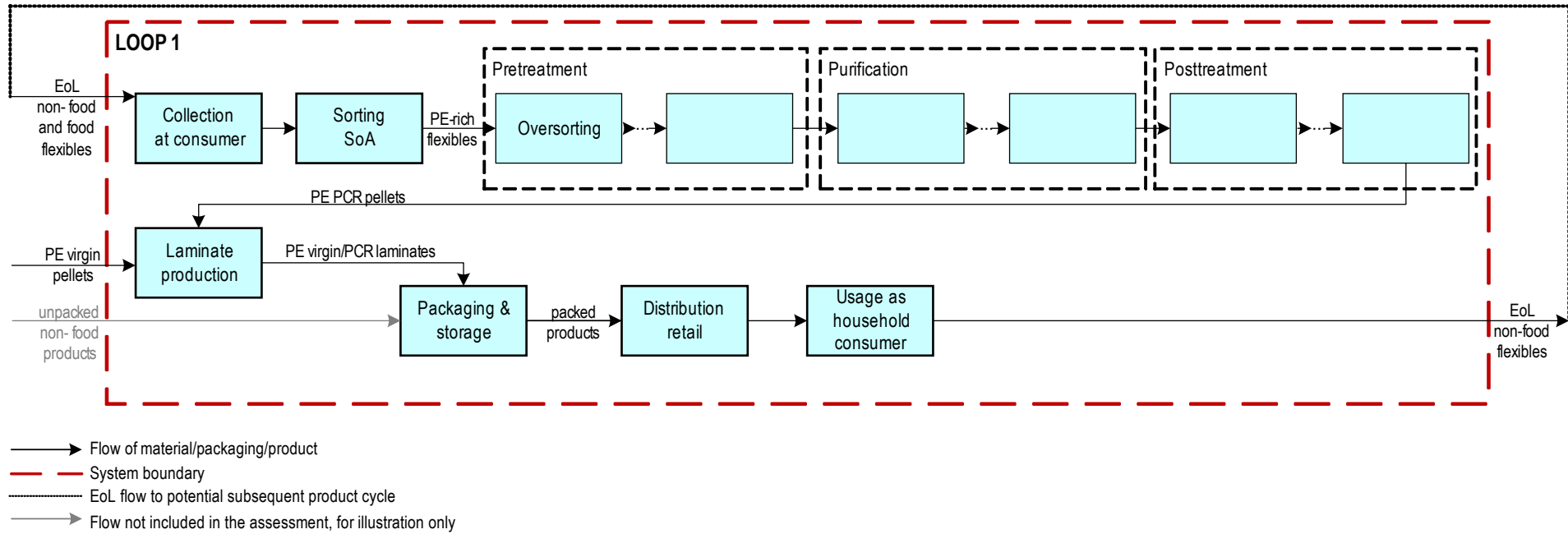


Figure 21 Loop 1 process flow scheme for NF packaging (landscape format)



## Loop 2

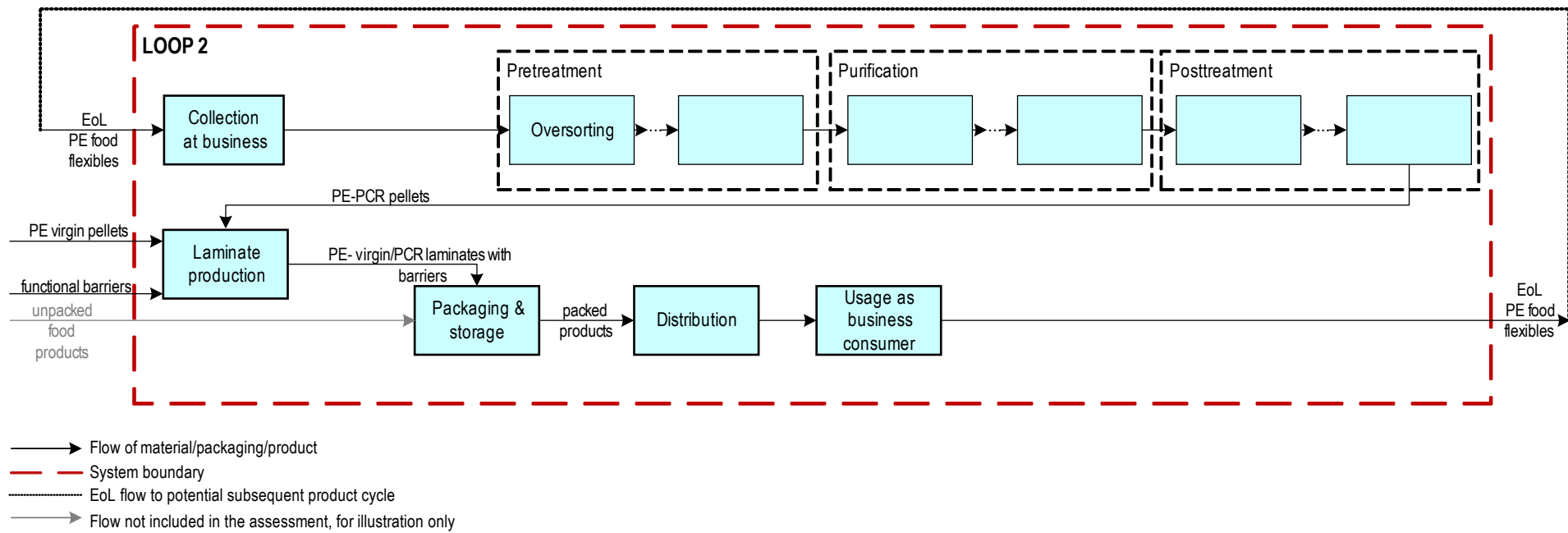


Figure 22 Loop 2 process flow scheme for F packaging (landscape format)

### Loop 3

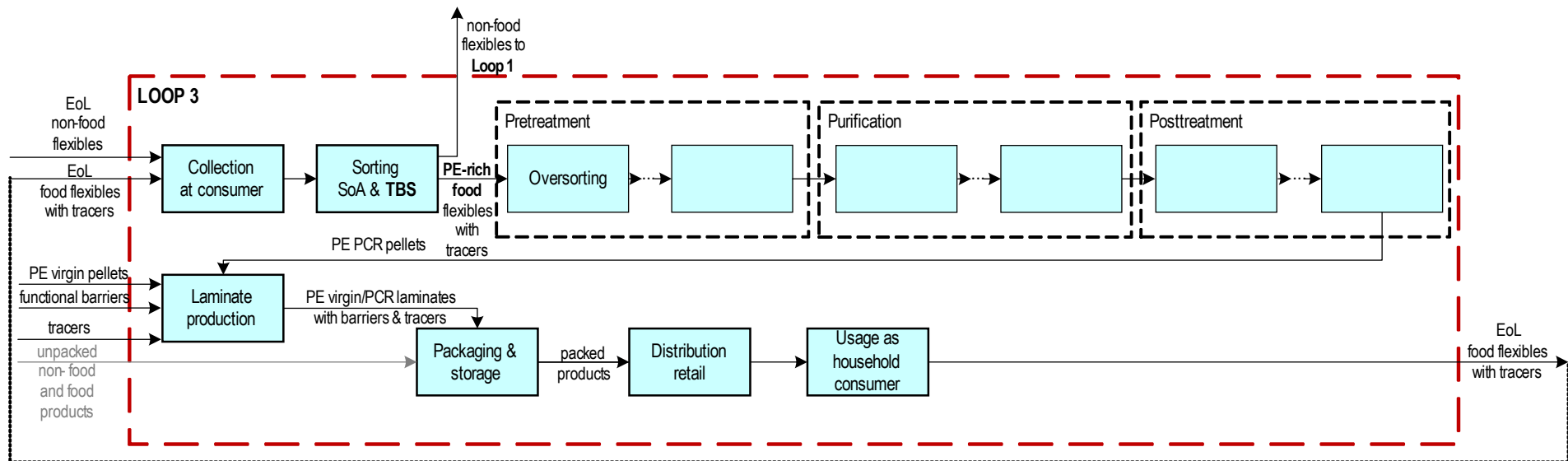


Figure 23 Loop 3 process flow scheme for F and NF packaging (landscape format)

## Collection and SoA sorting and Pretreatment-SUEZ

### Loop 1

Process 1						
Collection at consumer	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Household plastic packaging waste					
Process 2						
SoA Sorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Household plastic packaging waste				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
	Diesel					
	Binding wire					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	Household plastic packaging waste					
	PE-rich flexibles/ Food and non-food Residue				please specify composition of residue e.g. 10% PP, 20% PET	
	Wastewater					
	Recycalbes				please specify composition of recycalbes e.g. 10% PP, 20% PET	
Process 3						
Oversorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles/ Food and non-food				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	PE-rich flexibles					
	Residue				please specify composition of residue e.g. 10% PP, 20% PET	
Process 4						
Shredding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	PE-rich flakes					
Process 5						
Washing	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
	Water					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	PE-rich flakes					
	Wastewater					
Process 6						
Grinding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	PE-rich flakes					
Process 7						
Float-sink separation	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes				please specify e.g. medium voltage, provider, energy mix	
	Electricity					
	Water					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	PE-rich flakes					
	Residue				please specify composition of residue	
	Wastewater					
Process 8						
Waste water treatment	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Wastewater				please specify type of chemical e.g. Chlorine, add product data sheet if applicable	
	Chemicals					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
	Residue				please specify composition of residue e.g. 10% filter cake, 20% pulp	
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	Household plastic packaging waste	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE-rich flakes/ Food and non-food	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 24 Loop 1 Collection and SoA sorting and Pretreatment data collection sheet

## Loop 2

Process 1						
Collection at consumer	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE food flexibles					
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE food flexibles					
Process 2						
Oversorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE food flexibles					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE-rich flexibles					
	Residue				please specify composition of residue e.g. 10% PP, 20% PET	
Process 3						
Shredding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE-rich flakes					
Process 4						
Washing	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE-rich flakes					
	Wastewater					
Process 5						
Grinding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE-rich flakes					
Process 6						
Float-sink separation	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE-rich flakes					
	Residue				please specify composition of residue	
	Wastewater					
Process 7						
Waste water treatment	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Wastewater					
	Chemicals				please specify type of chemical e.g. Chlorine, add product data sheet if applicable	
	<b>Outputs</b>	<b>Quantity per hour</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Residue				please specify composition of residue e.g. 10% filter cake, 20% pulp	
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE-rich flexibles	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE-rich flakes	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 25 Loop 2 Collection and SoA sorting and Pretreatment data collection sheet



### Loop 3 including Tracer-based sorting

Process 1						
Collection at consumer	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Household plastic packaging waste					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
Household plastic packaging waste						
Process 2						
SoA Sorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Household plastic packaging waste					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Diesel					
	Binding wire					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flexibles/ Food and non-food						
Residue					please specify composition of residue e.g. 10% PP, 20% PET	
Wastewater						
Recycalbes					please specify composition of recycalbes e.g. 10% PP, 20% PET	
Process 3						
TBS Sorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles/ Food and non-food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flexibles incl. Tracers/ f. Food						
PE-rich non-f. Food flexibles					please specify composition of residue e.g. 10% PP, 20% PET	
Process 4						
Oversorting	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles incl. Tracers/ f. Food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flexibles incl. Tracers/ f. Food						
Residue					please specify composition of residue e.g. 10% PP, 20% PET	
Process 5						
Shredding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flexibles incl. Tracers/ f. Food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flakes incl. Tracers/ f. Food						
Process 6						
Washing	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes incl. Tracers/ f. Food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flakes incl. Tracers/ f. Food						
Wastewater						
Process 7						
Grinding	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes incl. Tracers/ f. Food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flakes incl. Tracers/ f. Food						
Process 8						
Float-sink separation	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	PE-rich flakes incl. Tracers/ f. Food					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
PE-rich flakes incl. Tracers/ f. Food						
Residue					please specify composition of residue	
Wastewater						
Process 9						
Waste water treatment	Inputs	Quantity per hour	Unit	Origin	Remarks	Source
	Wastewater					
	Chemicals				please specify type of chemical e.g. Chlorine, add product data sheet if applicable	
Outputs	Quantity per hour	Unit	Destination	Remarks	Source	
Residue					please specify composition of residue e.g. 10% filter cake, 20% pulp	
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	Household plastic packaging waste	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE-rich flakes incl. Tracers/ f. Food	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	

Figure 26 Loop 3 Collection and SoA sorting and Pretreatment data collection sheet



## Purification option A CreaSolv®-IVV

### Loop 1-3

Process 1						
Continuous dissolving	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	PE-rich flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	Recovered solvent				please specify type of solvent, add product data sheet if applicable	
	Virgin solvent				please specify type of solvent, add product data sheet if applicable	
	Washing solution				please specify type of washing solution, add product data sheet if applicable	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Dissolved PE (incl. Residues)					
Process 2						
Multistage filtration	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Dissolved PE (incl. Residues)					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Filtered PE solution					
Process 3.1						
Washing of the residual fraction	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Residues				please specify composition of residue e.g. 10% PP, 20% PET	
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Filtered PE solution					
	Washing solution					
Process 3.1.1						
Drying residual fraction	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Residues				please specify composition of residue e.g. 10% PP, 20% PET	
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Filtered PE solution					
	Recovered solvent					
Process 3.2						
PE purification	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Filtered PE solution					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	Recovered purification agent				please specify type of purification agent, add product data sheet if applicable	
	Virgin purification agent				please specify type of purification agent, add product data sheet if applicable	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE solution					
Process 3.2.1						
Removal of fine residues and separation of solvent & purification agent	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Used solvent/purification agent/residues mixture					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Recovered solvent					
	Residues fine				please specify composition of residue e.g. 10% PP, 20% PET	
Process 4						
Multiple stage drying	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	PE solution					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE melt					
	Recovered solvent					
Process 5						
Regranulation/-compounding	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	PE melt					
	Electricity				please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	Additives					
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	PE PCR pellets					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 27 Loop 1-3 Purification option A CreaSolv® data collection sheet (data in green tbd)



## Purification option B Delamination and Deinking-UGENT

### Loop 1 and 2

Process 1						
Delamination & Deinking	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	pretreated PE flakes					
	virgin Delamination-Deinking medium A					
	recovered Delamination-Deinking medium A					
	Heat				please specify source of heat e.g. natural gas	
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	seperated/deinked PE flakes					
Process 2						
Mechanical separation	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	seperated/deinked PE flakes					
	Delamination-Deinking medium A Residue				to recovery	
Process 2.1						
Medium recovery	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	Delamination-Deinking medium A Residue					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Heat				please specify source of heat e.g. natural gas	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	recovered Delamination-Deinking medium A					
	Residue				to energy recovery	
Process 3						
Washing	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	virgin Water					
	recycled Water					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	seperated/deinked PE flakes					
Process 4						
Mechanical drying	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	seperated/deinked PE flakes					
	Wastewater				to wastewater treatment	
Process 5						
Thermal treatment	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Heat				please specify source of heat e.g. natural gas	
	Electricity		kWh		please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	seperated/deinked PE flakes					
	Water vapor					
Process 6						
Waste water treatment	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	Wastewater					
	Chemicals				please specify type of chemical e.g. Chlorine, add product data sheet	
	<b>Outputs</b>	<b>Quantity per ton</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Residue (sinkflow, filter cake)				to energy recovery; please specify composition of residue	
	recyled Water					
Transport (T)						
T1 (upstream)	Inputs	Distance	Unit	Truck technology	Remarks	Source
	pretreated PE flakes		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2 (downstream)	Inputs	Distance	Unit	Truck technology	Remarks	Source
	delaminated/deinked PE flakes		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 28 Loop 1-2 Purification option B Delamination and Deinking data collection sheet



### Loop 3

Process 1						
Delamination & Deinking	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	pretreated PE flakes					
	virgin Delamination-Deinking medium B					
	Heat				please specify source of heat e.g. natural gas	
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	seperated/deinked PE flakes					
Process 2						
Mechanical separation	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	seperated/deinked PE flakes					
	Residue				to energy recovery	
Process 3						
Neutralisation	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Solution					
	recycled Water					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	seperated/deinked PE flakes					
Process 4						
Mechanical drying	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	seperated/deinked PE flakes					
	Salt					
	Wastewater				to wastewater treatment	
Process 5						
Thermal treatment	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	seperated/deinked PE flakes					
	Heat				please specify source of heat e.g. natural gas	
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	seperated/deinked PE flakes					
	Water vapor					
Process 6						
Waste water treatment	Inputs	Quantity per ton	Unit	Origin	Remarks	Source
	Wastewater					
	Chemicals				please specify type of chemical e.g. Chlorine, add product data sheet	
	Outputs	Quantity per ton	Unit	Destination	Remarks	Source
	Residue (sinkflow, filter cake)				to energy recovery; please specify composition of residue	
	recyled Water					
Transport (T)						
T1 (upstream)	Inputs	Distance	Unit	Truck technology	Remarks	Source
	pretreated PE flakes		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2 (downstream)	Inputs	Distance	Unit	Truck technology	Remarks	Source
	delaminated/deinked PE flakes		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 29 Loop 3 Purification option B Delamination and Deinking data collection sheet



## Recompounding-UM, SUEZ

### Loop 1-3

Process 1						
Preconditioning	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	Pretreated PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE flakes					
Process 2						
Melting	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
Process 3						
Filtration	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE flakes Residue				please specify composition of residue e.g. 10% metals, 20% wood, 50% higher melting polymere (i.e. PP, PE,...)	
Process 4						
Final degassing	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE flakes Air emission				please specify	
Process 5						
Homogenisation	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE flakes					
Process 6						
Pelletizing	Inputs	Quantity per x kg output	Unit	Origin	Remarks	Source
	PE flakes Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per x kg output	Unit	Destination	Remarks	Source
	PE PCR pellets					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE flakes	Lorry	km	EURO 5	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE PCR pellets	Lorry	km	EURO 5	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 30 Loop 1-3 Recompounding data collection sheet



## Deodorization-KREYEN

### Loop 1-3

Process 1						
Infrared treatment	Inputs	Quantity per year	Unit	Origin	Remarks	Source
	PE PCR pellets					
	Air for cooling					
	Heat via electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per year	Unit	Destination	Remarks	Source
	PE PCR pellets					
	Air emissions (VOC)				please specify	
Process 2						
Thermal treatment	Inputs	Quantity per year	Unit	Origin	Remarks	Source
	PE PCR pellets					
	Air					
	Heat via electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per year	Unit	Destination	Remarks	Source
	PE PCR pellets deodorized					
	Air emissions (VOC)				please specify	
Transport (T)						
T1 (upstream)	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE PCR pellets	Lorry	km	EURO 5	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2 (downstream)	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE PCR pellets deodorized	Lorry	km	EURO 5	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 31 Loop 1-3 Deodorization data collection sheet



## Laminate production-AMCOR

### Loop 1- Wet Wipes (HP1)

Process 1						
Blown film coextrusion	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	PE PCR pellets					
	PE virgin pellets					
	EVOH virgin pellets *optional					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	BPE60 film					
	Solid losses					
Process 2						
Printing	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	BPE60 film					
	Ink				please specify	
	Primer coating				please specify	
	Natural gas					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Ethyl acetate					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	Ink/BPE60/primer film					
	Waste Ethyl acetate					
	Solid losses					
Process 3						
Adhesive lamination	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	Ink/BPE60/primer film					
	Solvent-based adhesive				please specify, add product data sheet if possible	
	PE 25 µm virgin film				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Electricity					
	Ethyl acetate					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	Laminate					
	Waste Ethyl acetate				please specify composition of residue e.g. 10% PP, 20% PET	
	Solid losses					
Process 2./3.1						
Solvent oxidation with energy recovery	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	Waste Ethyl acetate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Oxygen from air					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	Energy (internally used)					
	Emissions to air					
Process 4						
Slitting	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	Laminate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	H1 laminate					
	Solid losses					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE PCR pellets	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	
	PE virgin pellets					
	EVOH virgin pellets *optional					
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	H1 laminate	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	

Figure 32 Loop 1 Wet Wipes Laminate production data collection sheet (data in green tbd)



## Loop 1- Detergent Tabs (HP2)

Process 1						
<b>Blown film coextrusion</b>	<b>Inputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Origin</b>	<b>Remarks</b>	<b>Source</b>
	PE PCR pellets					
	PE virgin pellets					
	EVOH virgin pellets *optional					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	BPE130 film					
	Solid losses					
Process 2						
<b>Printing</b>	<b>Inputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Origin</b>	<b>Remarks</b>	<b>Source</b>
	BPE130 film					
	Ink				please specify	
	Primer coating				please specify	
	Natural gas					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Ethyl acetate					
	<b>Outputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Ink/BPE130/primer film					
	Waste Ethyl acetate					
	Solid losses					
Process 3						
<b>Adhesive lamination</b>	<b>Inputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Origin</b>	<b>Remarks</b>	<b>Source</b>
	Ink/BPE60/primer film					
	Solvent-based adhesive				please specify, add product data sheet if possible	
	PE 25 µm virgin film				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Electricity					
	Ethyl acetate					
	<b>Outputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Laminate					
	Waste Ethyl acetate				please specify composition of residue e.g. 10% PP, 20% PET	
	Solid losses					
Process 2./3.1						
<b>Solvent oxidation with energy recovery</b>	<b>Inputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Origin</b>	<b>Remarks</b>	<b>Source</b>
	Waste Ethyl acetate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Oxygen from air					
	<b>Outputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Energy (Internally used)					
	Emissions to air					
Process 4						
<b>Slitting</b>	<b>Inputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Origin</b>	<b>Remarks</b>	<b>Source</b>
	Laminate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per m2 of packaging product</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	H2 laminate					
	Solid losses					
Transport (T)						
<b>T1</b>	<b>Inputs</b>	<b>Transport mode</b>	<b>Unit</b>	<b>Truck technology</b>	<b>Remarks</b>	<b>Source</b>
	PE PCR pellets	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	
	PE virgin pellets					
	EVOH virgin pellets *optional					
<b>T2</b>	<b>Inputs</b>	<b>Transport mode</b>	<b>Unit</b>	<b>Truck technology</b>	<b>Remarks</b>	<b>Source</b>
	H2 laminate	Lorry	km	EURO 6	please specify truck payload e.g. 3.5t-7.5t; 7.5t-16t, 16t-32t, >32t	

Figure 33 Loop 1 Detergent Tabs Laminate production data collection sheet (data in green tbd)

### Loop 1- Cosmetics (PCP1)

Process 1						
Blown film coextrusion	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	PE PCR pellets					
	PE virgin pellets					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	LDPE50 film					
	Solid losses					
Process 2						
Printing	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	MDOPE25 film					
	Ink				please specify	
	Natural gas				please specify	
	Electricity					
	Ethyl acetate				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	ink/MDOPE40					
	Waste Ethyl acetate					
	Solid losses					
Process 3						
Adhesive lamination 1	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	ink/MDOPE40					
	MDOPE25 film					
	Solvent-based adhesive				please specify, add product data sheet if possible	
	Natural gas					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Ethyl acetate					
	Primer coating					
	SiOx					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	ink/MDOPE40 SiOx/primer laminate					
	Waste Ethyl acetate				please specify composition of residue e.g. 10% PP, 20% PET	
	Solid losses					
Process 4						
Adhesive lamination 2	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	ink/MDOPE40 SiOx/primer laminate					
	LDPE50 film				please specify, add product data sheet if possible	
	Solvent-based adhesive				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Electricity					
	Ethyl acetate					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	Laminate					
	Waste Ethyl acetate				please specify composition of residue e.g. 10% PP, 20% PET	
	Solid losses					
Process 2.-4.1						
Solvent oxidation with energy recovery	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	Waste Ethyl acetate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Natural gas					
	Oxygen from air					
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	Energy (internally used)					
	Emissions to air					
Process 4						
Slitting	Inputs	Quantity per m2 of packaging product	Unit	Origin	Remarks	Source
	Laminate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per m2 of packaging product	Unit	Destination	Remarks	Source
	PC1 laminate					
	Solid losses					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PE PCR pellets	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
	PE virgin pellets					
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	PC1 laminate	Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 34 Loop 1 Cosmetics Laminate production data collection sheet



## Tracer production-POLY

### Loop 3

Process 1						
Sinter process	Inputs	Quantity per	Unit	Origin	Remarks	Source
	Diyttriumtrioxide Y2O3					
	Diyttriumtrioxide Yb2O3					
	Dierbiumtrioxide Er2O3					
	Diholmiumtrioxide Ho2O3					
	Sulphure S					
	Sodiumcarbonate Na2CO3					
	Tripotassiumphosphate K3PO4					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per	Unit	Destination	Remarks	Source
	Diyttriumdioxysulphide					
	Sodium sulphite					
	Sodium sulphate					
	Sodium phosphate					
	SO2 emissions					
Process 2						
Product washing	Inputs	Quantity per	Unit	Origin	Remarks	Source
	Diyttriumdioxysulphide					
	Sodium sulphite				please specify e.g. medium voltage, provider, energy mix	
	Sodium sulphate					
	Sodium phosphate					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Outputs	Quantity per	Unit	Destination	Remarks	Source
	Diyttriumdioxysulphide					
	Wastewater				please specify composition of residue e.g. 10% PP, 20% PET	
Process 3						
Gas washing	Inputs	Quantity per	Unit	Origin	Remarks	Source
	SO2 emissions					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
	Outputs	Quantity per	Unit	Destination	Remarks	Source
	Wastewater					
	SO2 emissions (below TA Luft 5.2.4.)					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	Diyttriumtrioxide Y2O3	Lorry	km	EURO 5	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
	Diyttriumtrioxide Yb2O3					
	Dierbiumtrioxide Er2O3					
	Diholmiumtrioxide Ho2O3					
	Sulphure S					
	Sodiumcarbonate Na2CO3					
	Tripotassiumphosphate K3PO4					
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
	Diyttriumdioxysulphide	Lorry	km	EURO 5		

Figure 35 Loop 3 Tracer production data collection sheet

## Ink and Primer production-Siegwerk

### Loop 1-3 Ink

Process 1						
Dispersion	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Nitrocellulose					
	Polyurethan					
	Pigment C or M or Y or K					
	Additives					
	Ethanol					
	Ethylacetat					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	Water					
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
Process 2						
Blending	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Dispersion					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Ink					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 36 Loop 1-3 Ink production data collection sheet

### Loop 3 Primer

Process 1						
Blending	Inputs	Quantity per kg	Unit	Origin	Remarks	Source
	Acrylate resin					
	Water					
	Electricity				please specify e.g. medium voltage, provider, energy mix	
	<b>Outputs</b>	<b>Quantity per kg</b>	<b>Unit</b>	<b>Destination</b>	<b>Remarks</b>	<b>Source</b>
	Primer					
Transport (T)						
T1	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Unit	Truck technology	Remarks	Source
		Lorry	km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 37 Loop 3 Primer production data collection sheet

## Food packaging production-Nestle

### Loop 2 and 3

Process 1							
	Inputs	Quantity per year	Quantity per ton	Unit	Origin	Remarks	Source
						please specify e.g. medium voltage, provider, energy mix, provider, energy mix	
	Outputs	Quantity per year	Quantity per ton	Unit	Destination	Remarks	Source
Transport (T)							
T1	Inputs	Transport mode	Distance	Unit	Truck technology	Remarks	Source
		Lorry		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	
T2	Inputs	Transport mode	Distance	Unit	Truck technology	Remarks	Source
		Lorry		km	EURO 6	please specify truck payload e.g. 3,5t-7,5t; 7,5t-16t, 16t-32t, >32t	

Figure 38 Loop 2-3 Food packaging production data collection sheet

