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Case no. 1500217

Critical review of the guide “LCIs for production of plastics (PP, PS, ABS) recycled from WEEE plastics managed in France and regenerated in Europe - Methodological report V1.1-2 October 2020”

*- Final report of Critical Review
ISO 14040 and ISO 14044
ILCD Data-Entry level*

The work providing the foundations of this report was carried out in collaboration
with
Institut Arts et Métiers de Chambéry - Scientific Director: Carole Charbuillet

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1. Introduction

The commissioning eco-organisation **ecosystem** worked with Bleu Safran to build the LCIs of three polymer resins recycled from Waste Electrical and Electronic Equipment (WEEE). The construction of the LCIs required a number of methodological choices and arbitrages in the selection of datasets and their modelling. A methodological guide “LCIs for production of plastics (PP, PS, ABS) recycled from WEEE plastics managed in France and regenerated in Europe V1.1. Date 02 October 2020” was produced. This publication follows on from the creation of LCIs of the end-of-life management of materials contained in WEEE started in 2015 and resulted in the creation of LCIs for WEEE treatment channels in ILCD format, now available to any LCA practitioner desiring to include this end-of-life management in their LCA. These initial LCIs included all the final destinations of the materials but did not contain, for plastic materials, activity data collected directly from WEEE plastics regenerators. The LCIs provided in the aforementioned guide take into account all the stages from the collection of WEEE to the production of ready-to-use recycled plastic.

To ensure compliance with ISO 14040:2006 and ISO 14044:2006 and ensure compatibility with ILCD Data-Entry level requirements, **ecosystem** has requested a critical review of the guide above prior to its publication.

The critical review focused in particular on the modeling of the steps performed by regenerators, the collection of activity data and the methodological choices. Indeed, the end-of-life LCI for WEEE (steps prior to regeneration) were already subjected to critical review in 2018 and the results of the review of the LCI guide for the treatment channel are valid until 2022.

For reasons of confidentiality, the experts providing the critical review did not have access to the detailed quantified data used to model the LCIs. However, they did receive an explanation of the building of the model to calculate the LCIs and the activity data collection questionnaires for regenerators, the collection process and background datasets.

The critical review focused on the methodological choices made in building the LCIs and the exhaustiveness of datasets. This document is the final Critical Review report authored under the direction of Carole Charbuillet and Bertrand Laratte from the Arts et Métiers institute. It is intended for inclusion in the final version of the methodological guide and may also be consulted separately.

2. Critical review experts

The critical review experts are not employed by **ecosystem** and Bleu Safran. They have also not participated in any work conducted to obtain the LCIs. They are presented in the table below.

Expert	Organisation	Title / Speciality	Role in critical review
Carole Charbuillet	Institut Arts et Métiers de Chambéry	Research Fellow PhD Industrial engineering Masters in polymer and composites research, INSA Lyon Engineering degree Materials science and engineering INSA Lyon Areas of expertise: plastic materials, recycling channels, LCA of recycled materials, eco-design	Supervision and drafting critical review report Critical review of report
Bertrand Laratte	Arts et Métiers - Bordeaux campus	Research Fellow PhD in Sciences for engineers Masters Environmental and Sustainable Development Management, UTT Masters Industrial engineering (Operational Reliability), UTT	Critical review of report

		Expertise: LCA, MFA, environmental impact indicators, eco-design	
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The experience of our experts covers LCA methodology, LCI construction and also plastics recycling channels. As the guide subject to critical review does not concern a comparative LCA between materials, the experts were selected primarily to ensure the LCIs are compliant with the ILCD Data-Entry level.

3. Critical review process

The critical review experts applied the recommendations of ISO 14040:2006 and ISO 14044:2006 concerning critical reviews.

The aim of the critical review provided below was to verify that:

- The methods used to build the LCIs for their use in LCA applications are consistent with international standards ISO 14040:2006 and ISO 14044:2006;
- The methods used to build the LCIs for their use in LCA applications are valid in scientific and technical terms;
- The datasets used are suitable and reasonable in relation to the aims of the study.

It will also provide:

- An assessment of the internal consistency of the report, especially the consistency between:
 - o The stated aims
 - o The datasets and methodology
 - o The results obtained and their interpretation
- An evaluation of the transparency of the report.

The critical review took place between October and December 2020, involving the following steps:

- Presentation of the context of the study and its aims at the kick-off meeting by **ecosystem** and Bleu Safran.
- Production of detailed observations by critical review experts on the methodological choices, datasets and the guide.
- Responses to observations by Bleu Safran and **ecosystem**, resulting updates to guide
- Closure of critical review and production of critical review report

For the purposes of confidentiality, the activity data used to model the LCIs could not be verified or tested. However, the construction of the model in the LCA software, the interaction between activity (foreground) data and background data as well as the data collection procedure involving operators have been explained in detail to the critical review experts.

The French version of this critical review report was produced using the French guide referred to in the introduction.

The critical review features 90 observations impacting the following areas: general, methodology, datasets and editing (22 observations). The observations were accepted by Bleu Safran and **ecosystem** for integration in the final version of the guide. However, to continue to ensure data confidentiality concerning regenerators supplying activity data, **ecosystem** opted to redact certain sections of the guide intended for publication. It is important to understand that the critical review process and especially the verification of the report's consistency and transparency were carried out with the non-redacted guide.

This critical review report was forwarded by the critical review experts to **ecosystem**. The conclusions apply to the guide indicated in the introduction and not to any other form of the report, extract or publication thereof. The critical review experts shall not be held liable for use of this work by a third party.

The conclusions of the report were made in consideration of the state of the art at the date of the study and of information received from **ecosystem** and Bleu Safran.

4. General observations of the critical review

The report is well crafted and transmits the serious, quality approach adopted to its preparation. The critical review experts consider that the recommendations of international standards ISO 14040:2006 and ISO 14044:2006 concerning methods have been applied and the work undertaken is compliant with these standards. The guide and datasets used are suitable and reasonable in relation to the aims of the study. The work on the LCIs presented in the guide meets the requirements applicable to methodology, datasets, interpretation and communication, taking into account the limits discussed in the next section.

This study is significant in the understanding of impacts of WEEE plastics regeneration. It is important to note that this study presents points which differ from previous studies and bring genuine value to the current best available knowledge:

- the scope of the study of waste collection to the production of ready-to-use pellets,
- the contribution of representative regenerators with appropriate exhaustiveness,
- the methodology applied to allocate charges to the target plastics treatment processes,
- the non-use of process blocks (details of all production steps from shredded material to ready-to-use pellets).

5. Detailed observations

This part highlights certain observations in the critical review to assist the reader in understanding the guide and the construction of LCIs for the regenerated plastics.

These observations apply either to methodological points that merit highlighting, given their contribution to the state of knowledge or how the choices made differ from those made in currently available recycled material LCIs, or to limits in relation to the expectations of the critical review. All the observations (except editing comments) made in the critical review and their responses are appended to this report.

5.1. The methodology of assessing the impacts of the production of recycled plastics

The methodologies used to build the LCIs are consistent with international standards ISO 14040:2006 and ISO 14044:2006. The guide clearly sets out the steps in building the LCI of the multi-functional activity block of regenerators according to their type. The guide presents three LCIs of regenerated plastic materials. These LCIs are not created to enable a comparative LCA of the three materials, even if future users may make use of the LCIs as part of an eco-design approach and compare the impact of several materials. In this case, a critical review of the LCA study based on the LCIs presented in the guide should take place, especially if the LCA results are published and even if the LCIs have been subjected to a critical review.

The methodology applied to allocate the impacts of flows to each individual step of the processes is robust and brings genuine value in relation to previous studies, based as it is on the principle of independent accounting of materials. For example, in the steps where materials are separated from plastics-rich mixes to obtain shredded flakes, only the impacts relating to the treatment of the target plastic are allocated to this plastic. Therefore, the benefits or impacts of treating other extractable materials such as metals or other non-target plastics are not allocated to the plastics stream studied (e.g. PP). The charges applicable to a step are allocated between the output process flows using a principle of allocation by mass.

An important point to mention regarding this study is the scope considered in the calculation of the LCIs; from the collection of the waste from which plastics are removed to the production of ready-to-use pellets. The methodology applied does not account for benefits to recycling but only the direct impacts of the processes. No recommendation is made in the guide on this point, as the question is not addressed in the aims of the guide. Nonetheless, the allocation choice of a future user of the LCIs must comply with the intended publication format (CFF formula for the PEF).

5.2. Scientific and technical validity

In scientific and technical terms, the guide and the creation of LCIs are highly robust. Indeed, the regenerator models are clearly defined with a high level of detail depending on their nature. Each individual process has been quantified. This provides specific datasets relating to each target regenerated materials stream according to the WEEE source.

The datasets for activities upstream of regeneration are taken from the end-of-life LCIs for WEEE. The same background data were used to ensure consistency between the data used and to ensure homogeneity between the two studies in terms of scientific validity. A question arose concerning the temporal correlation of datasets: the first dates go back to 2014/2015 and the LCIs of recycled materials to 2020. However, the validity period of the end-of-life LCIs is 2014-2022, due to the stability of treatment processes. Certain datasets were updated in 2018. The target LCI datasets have a validity from 2 to 4 years. The link between the datasets of the two studies is therefore appropriate. The datasets should be updated at this time.

The technical validity of the activity data used is ensured by reports on the representative regenerators of the target plastics. When certain regenerators did not produce pellets, the activity block was extrapolated using data from other regenerators surveyed. This choice was also made for the unavailable data. Even if this brings with it a degree of uncertainty, this ensures the exhaustiveness of data.

The resulting level of precision is as high as possible given the state of current knowledge at the time of writing (partial identification of European regenerators, partial knowledge of proportion of plastics sent for regeneration).

The questionnaires used were presented to the critical review experts but without access to the data for reasons of confidentiality. There are no contractual relationships between **ecosystem** and the regenerators. The critical review experts draw your attention to the fact that regenerator data depends on their declarations, which may not always be reliable, as in a certain number of LCAs. Evaluating the quality of this type of data is often difficult as measurements at each step of the process can be complex and time-consuming.

However, if data were unavailable, reasonable extrapolations were made between regenerator facilities (e.g. VOC) and bibliographic research was also done (e.g. compounding of recycled material). The LCI model is exhaustive and robust in the scientific choices made.

It is important to highlight that this study is the most detailed from a modelling standpoint in terms of recycled materials, as it takes into account the collection of the original waste right through to the production of pellets, with details of all intermediate steps.

5.3. Data choices according to aims of the study

The LCI data were not reviewed for reasons of confidentiality but the elements provided in the guide, the description of how the LCIs were built and the presentation of background data are considered to be reasonable in relation to the aims of the study.

In terms of regenerators, the degree of representativeness may be questioned both in terms of their number and the activities represented. For example, the global coverage of the regenerators sample population for recycled PP is 50%. Extrapolations were made both to complete missing activities (conversion from flakes to pellets in certain cases) and to represent regenerators not included in the sample population.

These extrapolations are consistent with the aims of the study and the regenerators used as references are significant players in the WEEE recycled materials sector.

Even if this may bring a certain degree of uncertainty, the use of these datasets is appropriate as it enables the best possible precision to the current state of knowledge. The datasets must be updated in line with developments in plastics recycling.

The datasets used are consistent with the aim of creating LCIs for the production of recycled plastics from WEEE treated in France and regenerated in Europe, for use by any practitioner wishing to include the impact of this production in LCA applications. It is important to mention certain potential limits on the use of LCIs as recycled materials in a new product: compatibility with the compound modelled in the study and lack of user

knowledge of the origin of the recycled material. However, in this study a standard compound was considered and the regenerators often use mixed material sources. The representativeness is therefore consistent with the intended use.

No intentional cut-off criterion was applied in the collection of activity data from regenerators.

5.4. Relevance of production LCIs for recycled materials related to the limits of the study

The relevance of the LCIs calculated is high, given the intended use of the LCIs.

The user of these LCIs must be aware that the benefits of recycling the materials were not taken into account and should envisage using a CFF formula type allocation model.

The principal limits of the project relate to:

- the extrapolations made (on activities and regenerators) but which are reasonable in relation to the aims of the study,
- the allocation keys used by regenerators when they only held aggregate site data,
- the use of certain background data, notably for compounding,
- the exclusion of certain emissions associated with rank 1 processes or regeneration treatments. Some data were replaced by approximations.
- the exclusion of regenerator infrastructures. The same principle is used in the PlasticsEurope inventories of virgin materials available at this time.

These limits may impact the results of certain indicators. However, the LCIs are relevant to the aims of the study and the exhaustiveness of data was ensured with a method that is scientifically and technically compliant with ISO 14040 requirements.

5.5. Transparency and consistency

The transparency and consistency of the guide subjected to critical review are high and comply with the requirements of ISO 14044:2006. The critical review experts were not able to access data collected from regenerators for reasons of confidentiality. But the presentation of the model and the comparison of the orders of magnitude of the impact results obtained for the LCIs to previous studies enabled us to estimate the consistency of the results.

ecosystem decided to redact certain information in the guide regarding regenerator activities for reasons of confidentiality. This solution was considered optimal to ensure minimal impact on the transparency of the guide. But the report remains consistent. Access to these data would improve the transparency of the publication and highlight this specific value of the study.

6. Data quality rating - ILCD Data-Entry level

The following tables present the critical review actions of the experts and the evaluation of the data quality achieved by the LCIs produced.

	Validation of data sources	Energy data	Mass data (coverage)	Cross-check with other source	Cross-check with other data set	Expert judgement	Compliance with ISO 14040 and ISO 14044	Documentation	Facility visits and questionnaires
Raw data	Yes	Not applicable	Not applicable	No	Not applicable	Yes	Yes	Yes but confidential	Internal to provider
Unit process(es): single operations	Yes	Internal	Internal	Not applicable	Yes but little background data - Extrapolation of activity data	Yes	Yes	Yes	Internal to provider
Unit process(es): black box	No processes are used as black boxes in the construction of the LCIs of regenerated plastics subjected to critical review								
LCI methods	Not applicable					Yes	Yes	Not applicable	Not applicable
LCI results	Not applicable	Internal	Internal	Not applicable	Not applicable	Yes	Yes	Yes	Not applicable
LCA results calculation	Not applicable					Yes	Yes	Yes	Not applicable
Documentation	Not applicable					Yes	Yes	Not applicable	Not applicable

Tableau 1: critical review actions

	LCI regenerated PP	LCI regenerated ABS	LCI regenerated PS
Technological representativeness	Good	Good	Good
Time representativeness	Very good	Very good	Very good
Geographical representativeness	Good	Good	Good
Completeness	Good	Good	Good
Precision	Fair	Fair	Fair
Methodological appropriateness and consistency	Very good	Very good	Very good
Overall quality	Good	Good	Good

Tableau 2: Data quality rating

7. Appendix

The table below presents the detailed observations of the critical review experts and the resulting responses from Bleu Safran and **ecosystem**.

No.	Page	§	Nature of observation	Observation	Proposed modification	Response from Bleu Safran / ecosystem	Follow-up to observation
1	8	A1	Clarification	At this stage it would be interesting to add in the scope of action of ecosystem in relation to recycling operators and not only in relation to members.	Adding a diagram of the scope of action would offer better understanding / anticipate the issue of data collection from regenerators.	<p>The diagram presented at the meeting of 27/10 will be added to the report to indicate:</p> <ul style="list-style-type: none"> - contractual relationships between ecosystem and producers, collection facilities, collection operators, rank 1 operators - a relationship more based on performance monitoring for rank 2 operators responsible for sorting plastics with and without BFRs - the lack of contractual relationships with other players, more specifically regenerators. <p>Before the diagram, we will indicate that it is the “majority” case, with certain operators being rank 1 and rank 2, in which case their contracts may also cover the rank 2 operations.</p> <p>So readers may identify early on in the report that the LCIs are based on data collected from regenerators, a “data owners” paragraph will be added in section A. General aspects (after A.1 “Client”).</p>	OK
2	8	A2	Clarification	Which materials were studied?	Indicate if the plastics were already in the scope of the first study.	The sentence was completed adding: namely the main plastics in household WEEE streams (PP, PS, ABS, ABS-PC, etc.), and separating plastics containing no fillers, those containing BFRs, and plastics containing non-BFR fillers.”	OK
3	8	B1	Scope	It is indicated that the LCIs may be used by ecosystem members to develop the use of recycled plastics. But could it not also be a driver for the development of channels?	To be clarified in the scope of application.	<p>To drive and develop channels, ecosystem primarily uses the environmental assessment calculated using the end-of-life LCIs, to integrate the final destinations of materials into the evaluation. The work done on the recycled plastics LCIs can be used to refine the model of the “recycling” destination of the end-of-life LCIs when they are next updated.</p> <p>In terms of developing channels, the recycled plastics LCIs and the argument concerning the benefits of recycled plastics will serve to encourage projects to integrate recycled plastics in production (and thereby drive the recycled products market).</p> <p>Proposal no modification to the text (item referred to in line 33 of interim report V1.1)</p>	OK

4	8	B1	Term	Within the report, we encounter the term “environmental benefit” and the notion of promoting the environmental, social and economic benefits of using recycled plastic materials. But are we still sure?	Given the results presented with the PEF method, it is indeed the case. But perhaps we should present the ‘potential’ benefits.	We agree with this point. For clarity, the expression was also revised in the report: “ ecosystem has therefore analysed the potential benefits of using recycled plastics, with a view to promoting projects to integrate recycled products” and “Furthermore, ecosystem may use the inventories to study the potential environmental benefits of using recycled plastic.”	OK
5	8	B1	Clarification	What do you mean by ‘argument’? Indicators?	For clarification	A detailed analysis taking into account a panel of environmental indicators and assessing the potential benefits through different scenarios of using recycled material compared to virgin material. We should also point out that for reasons of clarity, the section was revise (see response to observation no. 4)	OK
6	8	B1	Methodology/State of the art	Pre-existing studies are mentioned. But are not referenced. It lacks more precise analysis of the limits of this study, to reinforce and demonstrate its positioning in relation to legacy findings. The limits of the existing databases are also worthy of mention.	The studies should at least be referenced. A comparative table between the limits of these studies and the WEEE LCIs could be inserted.	The following clarifications were made: "Before undertaking this work, we completed an in-depth analysis of a certain number of studies concerning plastics recycling, whether applicable to WEEE or not. This prior assessment was undertaken by Bleu Safran for cooperative research association SCORE LCA, as part of a study on the consideration of plastic recycling in LCA ("SCORE LCA, Recyclage des plastiques et ACV, 2020, n° 2019-02"). This work was completed in late 2020 and can be viewed on the SCORE LCA website (in French) (https://www.scorelca.org/scorelca/etudes-acv.php)." + footnote: "Existing studies examined concerning plastics recycling and LCA: - Eco-profiles produced by SRP, France’s national plastic materials regenerators association - Franklin Associates. Life cycle impacts for post-consumer recycled resins: PET, HDPE, and PP. Submitted to The Association of Plastic Recyclers. December 2018. 49 p. - Haupt M., Kägi T., Hellweg S. Life cycle inventories of waste management processes. Data in Brief. Volume 19, August 2018, Pages 1441-1457. - Patrick A. Wäger, Roland Hischer, Life cycle assessment of post-consumer plastics production from waste electrical and electronic equipment (WEEE) treatment residues in a Central European plastics recycling plant, Science of The Total Environment, Volume 529, 2015, Pages 158-167." This analysis was not carried out as part of this study for ecosystem but for a study carried out by Bleu Safran on behalf of SCORE-LCA, titled "SCORE LCA, Recyclage des plastiques et ACV, 2020, n°2019-02". The report has not yet been published. We propose to cite this work for SCORE-LCA as it provides a detailed analysis of the pre-existing situation. We will contact SCORE LCA for their assent.	OK

7	9	B.1	Term	“ecosystem node”?	Not web page?	The term node is preferred, even in French. The methodological report will be translated into English	OK
8	9	B1	Clarification	Is the critical review report of the previous study available?	Include the principal conclusions of the CR	Yes, this report is available for download from the ecosystem node indicated in the report. We would like to include a link offering direct access to the document: http://weee-lci.ecosystem.eco/Node/showSource.xhtml?uuid=a8213f5f-bbed-47ae-a875-90f9a593765f&stock=ecosystem_WEEE_LCI	OK
9	9	B2	Methodology	The impact and formulation of a recycled material will depend on its use (material quality, which EEE). Is the destination of regenerator outputs known?	As the study assumes a closed loop, it would be appropriate to indicate the portion of regenerated plastics that depart regenerators to EEE makers.	Our work on supporting member projects to integrate recycled products and dialogue with regenerators provided the major trends; we are however unable to know the specific tonnages for each sector of use, as the search for trade outlets (and therefore the sectors touched) is a major component of the business strategy of each regenerator.	OK
10	9	B3	Insertion	The data format is not indicated.	Ecospold?	ILCD “wml” format	OK
11	9	B4	Clarification	In what way will the LCIs be used as supportive arguments by ecosystem ?		Potential use of recycled plastics LCIs to model the “production of recycled plastics”, put into perspective with several scenarios for comparison with virgin plastics. This use is based on scenarios to achieve models that could be used by producers. For clarity, the reference to this work was reformulated in the final report (see response to observation no. 4)	OK

12	10	B5	Application	For members to use the LCIs, they need to know the portion of recyclable plastic materials in the WEEE they acquire. Yet regenerators mix several sources. What portion is allocated to the ecosystem LCI? What influence do you think this will have on the results?	To be indicated	Effectively, we do not provide an average value for “mixed recycled plastics from various channels”), as we do not have data on the other channels. The information concerning the proportion of resins from different channels (see virgin / recycled proportion) should be identified by the acquirer of the materials. Note that the recently-published standard EN 45 557 stipulates that the difference between post- and pre-consumer plastics must be made, which means that the acquirer must refer back up the value chain for access to the information. As discussed at the meeting on 27/10, a paragraph on the “precautions on using these LCIs” will be inserted, principally to remind users that it is incumbent on them to obtain information on the origin of the recycled plastics they wish to model and therefore check if these LCIs are suitable to their needs or not. Possible differences that you point out concerning the diversity of sources will above all concern the steps upstream of entry into regeneration. It is difficult to pre-judge these differences as minimal data are available for other sources frequently used by regenerators supplied with WEEE plastics, but it still seems possible to say that: - for post-consumer ELV type waste, the environmental impact of upstream steps are probably significant (ELV collection, dismantling and shredding, separation of post-treatment residues and transport between operators); - for industrial waste procured by regenerators, the upstream steps are “simpler” (sorting at source, transport steps, possibly pre-shredding), and probable entail fewer impacts than the upstream steps of the WEEE treatment channel.	OK
13	10	B.5	Clarification	In the end, who will have access and via which medium? ecosystem platform? Agreements with whole supply chain?	To be added	The approach is the same as for the end-of-life LCIs; the data are provided in open access in ILCD format for all practitioners. In parallel, we also contact certain LCA software publishers that we identified to offer to integrate these data directly in their software.	OK
14	11	C1.1	Data	What is the source of the data in table A? ecosystem ?	Indicate source	Table created using ecosystem studies (--> Equipment Material Assessment Programme undertaken annually to analyse the material composition of WEEE input for rank 1 operators). This will be specified.	OK
15	11	C1.1	Data	What portion of plastics is currently sent on for recycling, at first glance low?	Indicate the percentage.	These figures are specific to each “type of plastic / WEEE stream” pairing. As indicated at the meeting on 27/10, these data are confidential. The principle of their production was explained during the meeting.	OK
16	11	C1.1	Clarification	To facilitate understanding, the raw materials retained by the regenerator may be		OK this proposal to reorganised will be implemented.	OK

				indicated from the outset and then the reasons developed.			
17	12	C1.1	Assumptions	Why these target plastics? Non-filled to make it easier to use them after regeneration? PS has a density similar to PP Talc - how is separation done to prevent contamination?	Provide more information on how regenerators select the plastics used.	<p>This is an established fact which will be explained further in the report. The plastics are current targeted by regenerators, their choices very certainly depending on the tonnages accessible, the production costs involved in producing the recycled plastics, their technology expertise, the markets accessible to or targeted by the regenerators. We do not have further information on the arbitrages of regenerators (which is also confidential).</p> <p>The issue of PS contamination by PP-Talc will depend on the source waste plastics and the technical choices made by regenerators. For regenerators who operate a line specifically for LHA cold plastics, this issue is probably limited (because the stream contains little PP). In case of other sources (other WEEE, ELV) the regenerators may use separation techniques. This is for example the case of regenerator #x who uses triboelectrical techniques to separate PS, ABS and PP-Talc.</p>	OK
18	12	C12	Assumptions/methodology	What is a high purity for you, 95%? 98? This information has a direct impact on the coefficient of transfer from one material to another and on its future use. Has the coefficient of transfer been taken into account? It could be covered by a sensitivity analysis.	For clarification	<p>In table 2, we indicated that the level was “high (> 95% of target polymer)”. In the responses to the questionnaire, some regenerators mentioned purity levels between 95% and 98% (as declared). We will add a clarification to the report that the level indicated is taken from information provided by the regenerators. In all cases, for this work a purity level is required to enable the minimum technical requirements and ensure the recycled plastic pellets can be used by EEE producers especially.</p> <p>Concerning the coefficient of transfer: for these LCIs, we effectively considered that a small part of the extruded shredded plastics would be lost in the form of filtration residues (the management of which was accounted for).</p>	OK
19	12	C1.2	Clarification	What does an average profile mean? In terms of volume?		<p>This clarification follows the explanation of the choice made by certain regenerators to sort by colour. Thereby, the term “average profile” will be replaced with “common profile”, i.e. profile common to white PS, “jazz” PS and PS unsorted by colour.</p>	OK
20	13	C1.2	Clarification	How do you define a sufficient number of regenerators for the LCIs of this study?		<p>Concerning the specific question of non-separation of recycled PS according to colour on page 13, the “sufficient number of regenerators” refers to the commitment made to regenerators to consolidate their data with those of other regenerators, to protect the confidentiality of their profile. A minimum of three therefore.</p>	OK

21	13	C1.2	Data	PS was not separated by colour. But this has a direct impact on the future application.	Justify	Effectively, depending on the colours of the PS pellets, the intended application may differ. Concerning the common LCI created, the report refers to the low usage of optical colour sorting on the LCI: "As the energy requirements for optical colour-based sorting are secondary compared to the energy requirements for other steps (upstream of regeneration, shredding to produce flakes, extrusion-pelletisation), we consider that the choice of an average LCI without colour distinction for PS is suited to the aims of the work". Note that these LCIs are intended to be updated in a few years; perhaps at this time market developments (more regenerators to ensure data confidentiality) will enable us to more finely distinguish separate cases for each polymer, and therefore refine the LCIs.	OK
22	13	C1.2	Data	Are the purity level data provided by regenerators?	Add source	The purity level was requested of regenerators. For pellets, their responses indicated levels between 95% and 98% depending on the case. We therefore used > 95%. The source of this value will be explained in the final report.	OK
23	13	C1.2	Clarification	Why does only PS need to be adapted for closed loop re-use?	Specify source of 2%	To achieve the minimum technical requirements for recycled plastics to be usable by EEE producers especially, the addition of an impact modifier was effectively considered in the case of PS. Only PS is affected by the addition of an impact modifier. The reason for this adaptation is that regenerators can produce PS pellets for different markets, with some being less demanding on the high impact properties of PS.	OK
24	13	C1.3	Clarification	What is the order of magnitude of the tonnages excluded?		Concerning ABS-PC, we do not have this information as the regenerators in the sample population do not produce recycled ABS-PC from waste ABS-PC. For PP-Talc, we have information but it may not be indicated in the report due to its confidentiality.	OK

25	13	C.2	Clarification	Can you clarify the geographical limits? Collection in France then treatment essentially in Europe (what does this mean) for a European market?		<p>In practice, the waste collected in France will be processed by successive operators, who may be based in France or elsewhere in or outside Europe.</p> <p>Concerning the report:</p> <p>1/ for the collection of WEEE (contain plastics), this clarification is made in the report: we focus on waste collected by in France by ecosystem, eco-organisation approved in France (see B.2. Aims of this work and section E “SYSTEM BOUNDARIES: THE STEPS OF THE RECYCLING PROCESS” Therefore, we are only focusing on plastics initially present in WEEE produced in France.</p> <p>2/ for the other steps upstream of transfer to regeneration, section E.1 “STEPS IN RECYCLING CHAIN UPSTREAM OF REGENERATION” clarifies that these steps are mainly carried out in France and sometimes in Europe, as indicated in the diagrams of figure 3 and in the accompanying text.</p> <p>3/ for regenerators, the work focused on regenerators located in France or elsewhere in Europe (c.f. B.2 “Aims of this work”) and who process plastics from WEEE collected in France, as the aim is to create LCIs specific to the recycled plastics produced via the channel organised by ecosystem. Therefore “regenerated in Europe” does not forcibly mean “European market”</p>	OK
26	14	C2	Data	Regulatory obligations (e.g. concerning BFR-filled plastics) are often referred to. To improve the understanding of operator restrictions on raw materials sorting, perhaps they could be mentioned in a footnote. What happens to the BFR-filled streams?	Add regulations	A regulatory reference will be inserted. In France, BFR-filled plastics are sent for incineration as hazardous waste.	OK

27	14	D	Assumptions	A closed loop was selected in relation to the integration of recycled plastic materials by ecosystem members. What would be the impacts on the LCI if an open loop was used, which is certainly the most common case?		The reference to the closed loop in the interim report is effectively overly restrictive. It is preferable to speak of recycled pellets achieving minimum technical requirements so that recycled plastics can be used by EEE producers or by other users. The presentation was therefore revised in this respect.	OK
28	16	E1	Scope	In figure 3, the parts removed from screens are included in the scope. This creates confusion with the information that the parts removed from flat screens are not taken into account. Are these parts associated with CRT screens?	For clarification	The report text will be edited. The original phrase “certain plastics extracted during manual dismantling of flat screens and sent for recycling have not been studied (e.g. flexible filters, transparent rigid panels)” will be edited to clarify that these plastics are not made of PP, PS or ABS, but PMMA or PET for example. The plastic parts dismantled, such as shells and rigid plastic, are indeed taken into account because they may be made of ABS (shells) or PS (rigid plastics).	OK
29	16	E1	Assumptions	How many operators are there per step? How is the technology mix for CRT broken down?		Here we are in the “Scope of the study” section; information on the coverage rate for upstream steps is provided in the “Inventory” section “J. Steps upstream of regeneration”. The coverage rate by mass of the collection & transfer steps by rank 1 operators, see Table 5. The reader is also invited to browse the methodological summary of the work on end-of-life LCI of WEEE, as this document is public and provides more detailed information on the number of operators. With regard to the question on the technology mixes of flat screens (rather than CRT), data taken from the confidential report on flat screens were presented at the meeting.	OK

30	17	E.1	Clarification	Can the proportions be indicated?		This information is provided in table 7, in the “Life Cycle Inventory” chapter. Rank 2 operations: still done in France for SHA and screens due to the regulatory obligation to separate plastics containing BFRs. LHA non cold: rank 2 (separation of metals / plastics mixes and metal fines / plastics), for the majority in France (less than 5% outside France) LHA cold: rank 2 only concerns metals / plastics mixes processed in Germany	OK
31	17	E.1	Clarification	The geographical limits seem vague to me.	Clarify the choice of extending it to Europe for regeneration after starting with just a French scope. Highlight the specific aspect of modelling an end-of-life plastics channel where collection and regeneration are done in different geographical scopes (concept of stream consolidation).	The different geographical scopes for collection (forcibly in France, as this work concerns ecosystem management), and the post-collection steps reflect the in-field management by participants in the end-of-life WEEE treatment chain (market economy). This reflects the effective practices in the field.	OK
32	17	E.1	Clarification	Indicate why plastics materials are not sorted and regenerated in France: lack of operators, technical nature, etc.		The plastic fractions obtained from rank 1 then rank 2 operations belong to the operators (and not to ecosystem), who are free to sell them on to the takers they choose. The market conditions and contractual arrangements between participants therefore apply to the later treatment of these fractions.	OK
33	19	E2	Clarification	What is the level of purity?		We will insert a reference to table 2, page 13 which clarifies this point.	OK
34	19	E2	Clarification	In general the mixes treated by electrostatic sorting feature only two materials. In the study, what mixes is this sorting applied to?	Provide an example	Electrostatic sorting: we will specify that this type of sorting applies to PS/ABS mixes.	OK
35	19	E2	Definition	Provide the definition of a masterbatch in the	Add the definition to the glossary	OK, a definition will be added.	OK

				glossary, for example			
36	19	E2	Clarification	What share of the EEE market is held by regenerators?	Indicate the percentage	<p>The requested information is provided in Table 8 “REGENERATOR SAMPLE POPULATION: ORIGINATING SECTOR OF WASTE INPUTS TO REGENERATION” of the interim report ‘Life Cycle Inventory’ section, chapter K).</p> <p>Note that table 8 will no longer be available in the final version for third parties, but will be provided in a confidential appendix.</p>	Point for attention: providing certain information in the appendix may impact the transparency of the guide.
37	20	G	Data	Were analyses done in relation to the formulation and coefficient of transfer?		<p>Average formulation / purity level: the data provided by regenerators were taken into account (c.f. response to observation 22)</p> <p>Coefficient of transport in extrusion/pelletisation step: the material yield / losses during the extrusion/pelletisation steps were requested from regenerators; these losses (filtration residues) and their handling were integrated in the LCIs and allocated to the recycled plastics.</p> <p>Coefficient of transfer upstream of extrusion/pelletisation step: the efficiencies of transfer in steps upstream of regeneration were analysed during the creation of the end-of-life LCIs (and integrated in their construction); the efficiencies of transfer during regeneration steps upstream of extrusion/pelletisation were discussed with the regenerators.</p> <p>Nonetheless, these efficiencies are not included in the modelling of the production LCIs for recycled plastics; the treatment of material losses occurring in rank 1 or rank 2 during the first step performed by regenerators (block 1) is not allocated to the recycled plastic. For example, the destination of non-filled PS that is not transferred for recycling by rank 1 operators (because it is present as impurities in the metallic fractions or in the “rigid PU foam” fraction for LHA cold) is not allocated to the recycled PS output by regenerators.</p>	OK
38	21	H	Data	What is the time representativeness of the previous LCI?		<p>Concerning the end-of-life LCI for the constituent materials of WEEE: their time representativeness is indicated in the “Life Cycle Inventory” chapter, TABLE 5 - VOLUME COVERAGE RATE OF UPSTREAM LOGISTICS AND RANK 1 OPERATORS CONSIDERED IN RELATION TO TONNAGE HANDLED BY ECOSYSTEM FOR THE YEAR IN QUESTION</p> <p>- the validity period is as follows: “The LCIs produced are considered valid for the period of 2014-2022” (see methodological summary on end-of-life LCIs).</p>	OK

39	21	H	Clarification	Representative at European level? But the mix originates in France, so is it representative for all products in Europe?		It may be representative of the plastics recovered from WEEE collected in France, but only those sent to regenerators located in Europe and not all over the world (via traders). These LCIs do not seek to be representative of all WEEE generated in Europe.	OK
40	21	H	Clarification	What do you mean by better accuracy, but without seeking to high?		For clarity, the text was revised in the report: "best accuracy possible, without it being exceptionally high due to the relative limits on the state of knowledge accessible at the date of this report".	OK
41	21	H	Clarification	What part was identified?	Indicate the percentage	This part is difficult to quantify. This is mainly due to the fact that plastics may be traded and leave Europe, or return or remain in this territory. This point is difficult to quantify at this time and therefore sheds doubt on this precise quantification.	OK
42	24	I1	Methodology	The approach used is appropriate from a methodological standpoint. Did you search for scientific publications to support your choices?		This work was undertaken as part of the SCORE-LCA study referred to earlier. It described the diversity of methodological practices of legacy work, especially the question of multi-functionality, modelling materials other than plastics, etc. We may add that studying the case of WEEE (multiple flake sorting steps) raises the complexity in relation to previous studies.	OK
43	24	I1	Methodology	In the study, benefits were considered for energy recovery. How does this apply to the target recycled plastics? What would your recommendations be?		This question is outside the scope of this work, and will be addressed by ecosystem in the course of another study in progress at this time (see response to observation 69).	OK
44	26	I2	Data	Can you indicate the contribution of the electricity model created using the ecoinvent dataset?		The ecoinvent V3.5 electricity model for the country concerned is based on a single year (2014) which is somewhat atypical given the weather conditions for that year. It was therefore decided to use an average LCI over three years. Note that the majority of section I.2 "Electricity production" will be transferred to the confidential appendix (the geographical location of the regenerators sample population must remain confidential).	OK

45	26	J1	Data	There is a time lag between the regenerators data and the upstream datasets. What impact does this have on the consistency of data?		The validity period of the end-of-life LCIs is 2014-2022, due to the stability of treatment processes. Moreover, updates were made in 2018 to integrate the latest developments in fraction management, especially concerning plastics. The system is globally stable since 2018. Note that future calls for tenders to select logistics and treatment providers are planned for 2021, to commence operations in 2022. Effectively, this could alter the landscape of market participants with whom ecosystem can work. The end-of-life LCIs will then be updated and the recycled plastics LCIs will be aligned with the latest datasets available. We recall that we paid substantial attention to the consistency of background datasets by using the same LCI database (this is indicated in the report).	OK
46	27	J2	Data	Flat screen technologies are vastly different from CRT screens. How do you justify using the same upstream steps?	Provide details of the process	As a reminder, the upstream steps apply to the collection and transfer to rank 1 facilities, rank 1 operators, rank 2 operations applicable to plastics fractions (separation of BFR and non-BFR plastics). Contrary to SHA, LHA cold and LHA non cold (e.g. mechanised treatment by breaking, shredding), a large proportion of flat screens are dismantled manually or with the assistance of a robot to remove the screws. This therefore applies to the household WEEE stream with the rank 1 treatment method most similar to that of CRT screens. From our standpoint, it is therefore the least weak proxy.	OK
47	28	J2	Data	Recall the major lines of acquisition strategies		The datasets considered come from the following sources: - analogy with certain aspects of rank 1 treatment operations (SHA) such as electricity consumption, fuel for motorised equipment and dust emissions - validation of consistency with single value collected from a rank 2 operator applying a plastics separation process.	OK
48	28	J2	Data	Why is the LHA cold located in Germany?		Table 7 provides the geographical location of rank 2 operators (rank 1 operators in LHA cold are located in France, as indicated in the report). In the case of LHA cold, the plastics / metals mixes obtained by some rank 1 operators are indeed sent to an operator located in Germany. This is a result of the choices made by the rank 1 operators, being free to trade the metals/plastics fractions they produce with the takers they select.	OK
49	28	J2	Data	How were the balances defined?		They were defined based on our feedback, separating national transport in France and transport between France and neighbouring countries. We consider that the distances proposed are plausible.	OK
50	29	J3	Data	Are these ecosystem datasets?		Indeed this information is owned by ecosystem . This information is based on an ecosystem study that will remain confidential. The paragraph referred to will be withdrawn from the final report for publication and provided in the confidential appendix.	OK
51	29	J3	Data	Does the content level correspond to fillers such as talc and not additives?		The answer to your question is yes. Same response as to previous observation: the paragraph referred to will be withdrawn from the final report for publication and provided in the confidential appendix.	Point for attention: providing certain information in

							the appendix may impact the transparency of the guide.
52	29	J3	Data	For percentages transferred to regenerators, how were the approximations made?		These values were calculated using our knowledge of the fractions output by rank 1 operators, of their composition, of the takers of these fractions. These aspects are explained in greater detail in the methodological summary on the end-of-life LCI of WEEE.	OK
53	33	K1.3	Methodology	What is the degree of uncertainty brought about by the extrapolations?		This degree may be significant, yet impossible to calculate (otherwise we would have modelled the data collected). However, this aspect has an incidence on the validity period of the LCIs. Indeed, we intend to consider the validity period as 2020-2024.	OK
54	34	K1.4	Assumptions	On output from shredding, are there no intermediate steps prior to extrusion?	Indicate if the flakes stream is ready to use.	Concerning flakes that are transferred directly for extrusion by regenerators, a flake sorting step is applied when available to the regenerator, and when the data collected allow us to consider this. For flakes where extrapolations are needed for the extrusion/pelletisation step, flake sorting was taken into account if performed by the regenerator in the sample population. However, no flake sorting performed by regenerators afterwards prior to extrusion was considered, as the existence of this type of intermediate step was unknown.	OK
55	36	K2.2.1	Data	Has the maintenance of shredder blades been taken into account?		Wear on the blades has been accounted for (materials consumption, including shaping processes)	OK
56	36	K2.2.1	Data	If the recycled plastic materials return to the EEE, has not the use of FR been considered? In general, this is generally added by plastics manufacturers.		No, it applies to recycled plastics not containing FR, as to our knowledge regenerators do not use such additives. Modelling the addition of FR will remain the responsibility of future users of these LCIs, like the injection of specific additives for very specific needs (fibres).	OK

57	36	K2.2.1	Data	Is all filtration waste recycled on site?		The report text will be improved. Indeed, if "Compounding - extrusion - pelletisation steps" is indicated in table 10 for filtration residues, it is to clarify that this waste only applies to these steps and not to preceding steps (blocks 1 and 2). The quantities of filtration waste collected from regenerators concern waste that is not recycled internally but sent for elimination/incineration.	OK
58	37	K2.2.2	Data	What portion of the data is unavailable?		The number of operators concerned by unavailable data is already given in TABLE 11 - REGENERATION: PRESENTATION OF TYPE OF UNAVAILABLE DATA AND APPROXIMATIONS USED", column "Nbr concerned".	OK
59	37	K2.2.2	Data	These items are indicated as recycled in Table 10.		No, your interpretation of Table 10 is incorrect. It will therefore be revised as the remarks in the table seem to generate confusion in terms of their meaning.	OK
60	37	K2.2.2	Scope	Also indicate this exclusion in the scope.		This point concerning confidential consumables is already covered under cut-off criteria in the "Scope of this study" chapter. C.f. Text "Nonetheless, some information requested during the data collection phase has produced little or no results. This concerns especially: - Certain consumables with annual consumption levels below those of main consumables (e.g. consumables used in pre-treating ²¹ industrial wastewater, oils used in equipment operation) or which are confidential (e.g. certain consumables used in density separation)." From our standpoint, it is more suitable to indicate them in the cut-off criteria rather than in the exclusions, because their non-inclusion is not the result of a choice to exclude them but an issue of access to data, which may vary from one regenerator to another.	OK
61	38	K3.2	Data	Indicate the sources used to quantify the masterbatches. What blend ratio is used (data on p.41)? In general, an anti-oxidant is added to the PP formulation. Additives used will depend on the intended application but certain are added by the plastics manufacturer.		For the formulation of a masterbatch, only partial qualitative information was provided by the regenerators (namely the presence of carbon black or titanium dioxide for white). We ran patent searches on the preparation of masterbatches containing either carbon black or titanium dioxide, which indicate that content ranges could be fairly wide: 10-65%, 30-85%, 20-50%. Failing more precise information, we used an arbitrary value of 25% and made this fact clear in the report to inform the reader. In terms of the addition of anti-oxidants, this type of additive was not reported by regenerators in their responses to the questionnaires.	OK

62	38	K3.3	Data	What are your justifications for choosing the proxies? For example for the flocculant	Justify	We requested the MSDS for the flocculant used by one of the regenerators. It was not possible to obtain it, as it was a special confidential formulation. The regenerator did however indicate that this flocculant belonged to a family of cationic polymer flocculants marketed by R&R Watertechnology, This information will be inserted into the final report.	OK
63	39	K3.3	Data	Is the sludge composition provided by regenerator data? Waste glass? What is the NCV value? And its calculation method?	Specify source	<p>Composition of sludges supplied in approximate form by regenerators. It comprises initially:</p> <ul style="list-style-type: none"> - plastics - cationic polymers used in treatment (flocculant) - rigid PU - wood - inert substances such as sand - water (humidity) <p>In this composition, the rigid PU, wood and plastics are considered to be output streams and not "charges to apply". The impacts of their treatment are not taken into account.</p> <p>In the case of the regenerator sending sludge to incineration, the NCV is calculated as follows:</p> <ol style="list-style-type: none"> 1) anhydrous GCV = combination of anhydrous GCV of each material in proportion to their content in the mix 2) anhydrous NCV = anhydrous GCV / 1.1 3) gross NCV = anhydrous NCV x (100 - % hu) / 100 - 2.443 x %hu /100, this second term being the energy consumption necessary to vaporise water (enthalpy of water vaporisation) <p>Example: Sludge = 0.4 polymer + 0.3 inerts + 0.3 water (by mass) GCV polymer = 36 MJ/kg dry GCV inerts = 0 MJ/dry GCV anhydrous sludge = (0.4 x 36 + 0.3 x 0)/0.7 = 20.1 MJ /kg dry sludge NCV anhydrous sludge = 20.1/ 1.1 = 18.7 MJ/ kg dry sludge NCV sludge = 18.7 x 0.7 - 2.443 x 0.3 = 18 MJ/kg dry sludge</p>	OK

64	39	K3.3	Data	What is the source of the 33 MJ/kg information?	Specify source	<p>The source datum is the GCV of 36.29 MJ/kg associated to the inventory Waste plastic, consumer electronics {RoW} treatment of, municipal incineration Cut-off, U.</p> <p>We made the assumption of a GCV/NCV ratio of 1.1; for conventional fuels this ratio lies between 1.05 (coal) and 1.1 (natural gas). Its actual value depends on the composition of fuels (hydrogen content) and the quantity of water they will form during combustion.</p> <p>We opted for the high bound of conventional fuels, giving us rather a minimal NCV value.</p>	OK
65	39	K3.4	Data	Explain your choices for VOC.		<p>At the temperatures applied to the plastics, especially polyolefins and polystyrenes, aldehydes may form, especially acetaldehyde, formaldehyde. C.f. INPRS publication on plastics degradation.</p> <p>As we do not know the possible proportions of the VOC, we opted to simplify, namely considering similar to acetaldehyde in the interim report.</p> <p>We propose to alter this simplification in the case of PS and ABS as aromatic hydrocarbon emissions (e.g. styrene) are also possible, yet the breakdown of aldehydes and aromatic hydrocarbons will remain arbitrary.</p>	OK
66	41	K.4	Assumptions	No losses were considered on the line. This assumption seems very favourable. Are they regenerator data? Was a sensitivity analysis done on these data?		<p>The losses in the form of “filtration residues” during extrusion are correctly integrated (consideration of steps upstream of extrusion and consideration of their end of life management, namely transfer for incineration with energy recovery). As indicated on page 41, this represents around 2% of flakes sent to the “compounding - extrusion - pelletisation” block.</p>	OK

67	42	K.5	Clarification	<p>Why not complete this with the Pedigree matrix + basic uncertainty or from the PEF method? What about exhaustiveness? What part does AD have in the LCI datasets? What is the data quality level in relation to the aims of the study?</p>	Justify	<p>Scoring criteria for pedigree matrix rating or its PEF equivalent do not always seem appropriate to us. ISO 14040 / 14044 do not impose the use of the pedigree matrix and we prefer to use the same principle of rating scale and same list of criteria as PEF, but with an “expert opinion” rating, explaining the reasons leading use to use low scores.</p> <p>We evaluated the four criteria of the PEF DQR (Data Quality Rating) form and exhaustiveness is not explicitly part of them. We intend to complete the report, clarifying that we have sought to ensure full exhaustiveness:</p> <ul style="list-style-type: none"> - by identifying and modelling all the successive steps of the regeneration chain for the recycled plastics studied - by limiting exclusions and intentional cut-off criteria - by making extrapolations to improve the coverage rate of our work beyond just the regenerators participating in our data collection - by identifying unavailable data (inputs/outputs) requested from regenerators and by adopting an organised approach to addressing unavailable data whenever possible. <p>The quality of the LCIs meets the aims of the study, namely have a first set of LCIs dedicated to plastics recycled from WEEE as desired by ecosystem, notably in terms of geographical representativeness and precision.</p> <p>But beyond this overall appraisal, information that from our point of view is important for the users of these LCIs is to have an idea of the capacity of these LCIs to evaluate the impacts commonly analysed in LCA. To enable this, we created TABLE 23 - OVERALL QUALITY OF LCIS PRODUCED IN TERMS OF IMPACT CATEGORIES.</p>	OK
68			Clarification	How will these data be updated?		<p>It is intended that updating these LCIs will be combined with updating the end-of-life LCIs (planned starting in 2022). Over time, several ecosystem studies that are currently in progress should provide greater robustness of data collection and representativeness of the recycled plastics LCIs.</p>	OK
69			Methodology	What recommendations do you have on using the LCIs in terms of the benefits considered?		<p>In effect, these LCIs will be made available to ecosystem members and LCA practitioners. They will also be re-used by ecosystem as part of a current study to estimate the environmental benefits of recycled plastics. The report from this study will determine the scenarios used for comparison with virgin material.</p>	OK