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1 **Requirements for comparative Life Cycle Assessment studies for single-use**
2 **and reusable**
3 **packaging and products comparisons: Recommendation for decision and policy-**
4 **makers**

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23 **Keywords:** Life Cycle Assessment, Environmental Break-Even Point, Packaging Waste,
24 Circular Economy, Reusable Packaging, single-use packaging

25
26
27 Life Cycle Assessments (LCAs) are sensitive snapshots of a products' environmental
28 impact and their findings depend on how they are framed and modelled. Variations in
29 assumptions, functional unit or system boundaries can completely change results and
30 undermine their applicability and final outcome. In the framework of the Circular
31 Economy, particularly important assumptions for reusable and single-use packaging
32 include the number of reuses, weight, sanitising method, transport logistics, and any other
33 aspect which may influence the use phase. In addition, these variables are not fixed over
34 time and may be affected by future changes in product design, consumers' habits or
35 the supply chain management. As a consequence, the impact of different packaging
36 options is not immutable and could change. Therefore, while comparing reusable versus
37 single-use packaging, there is an urgent need to clarify and integrate the
38 methodological requirements necessary to guarantee the reliability of studies and to
39 allow for impartial comparability of results.

40 Indeed, while it is straightforward to compare two single-use products which go from cradle
to grave in one go, it is more complex for products used multiple times, where it is the
business model - not the product - which is evaluated. In such cases, rather than
evaluating

41 only one single scenario (e.g., 20 reuses and 50 km distribution distance for the reuse
42 phase), sensitivity and scenario analyses should be used to determine the break-even point.
43 This represents for example the minimum number of times that a reusable product must be
44 used to be considered environmentally better (if at all) than an equivalent number of single-
45 use products. Only these recursive analyses can provide a systemic and comprehensive
46 view. Studies which compare single-use products with reusable options and do not include
47 sensitivity/scenario analyses or break-even points lack robustness and reliability.
48 Unfortunately, we bumped into four recent LCA studies comparing single-use vs reusable
49 packaging where these methodological requirements are only partially satisfied (Figure 1).

50 Therefore, focusing on the current debate in the European Union (EU) on the Packaging
51 and Packaging Waste Regulation (PPWR), as Members of the European Parliament (MEPs)
52 enter final negotiations on the PPWR, and as the European Council continues to negotiate
53 the text of the Regulation, we are concerned that these and similar studies may influence
54 MEPs' decisions and may set the continent on an unfavourable trajectory for decades and
55 years to come. We urge that, if LCA studies are used to make policy decisions, their
56 methodology must be thoroughly scrutinised before using their results and conclusions. To
57 guarantee its scientific robustness and objective impartiality, it is advised that an LCA study:

- 58 1. is a peer-reviewed and independent study conducted using the ISO 14040 and 14044
59 frameworks. Additionally, prior to public disclosure, the study should be reviewed by
60 an independent third party or by an independently chaired review panel;
- 61 2. respects steps laid out in ISO standards. First, the goal and scope definition stage
62 must precisely describe the product/s studied, the functional unit and corresponding
63 reference flows, the scope of the study, the assumptions made for each life cycle
64 stage, the expected audience and the methodology used to calculate impacts.
65 Second, the inventory stage must describe and quantify the inputs and outputs
66 involved in the life cycle of the system studied, by also declaring the data quality and
67 uncertainty. Third, the LCA results should be presented at least in terms of
68 characterised impact indicators. In fact, the impact assessment stage analyses the
69 potential environmental impacts by converting the inventory data into specific impact
70 indicators. This involves various steps, including the mandatory selection,
71 classification and characterization. Fourth, the results should be evaluated in the
72 interpretation stage with the final aim being the formulation of objective
73 recommendations to improve the environmental performance of the system under
74 study. It is emphasised that access to the goal and scope definition and the inventory
75 data (stages 1 and 2 of an LCA) is a non-negotiable prerequisite to validity. This is
76 because even a small variation in the methodological parameters or the inventory
77 can significantly alter results;
- 78 3. assesses the highest possible number of environmental indicators. This is possible
79 by the use of a multi-impact analysis method. Some examples are the EU
80 Environmental Footprint (EF 3.0), the recognized method for the Commission
81 Recommendation (EU) 2021/2279 that includes 16 midpoint impact categories (i.e.,
82 problem oriented), the ReCiPe 2016 or the IMPACT World+. The latter extends the
83 analysis to 18 impact categories. Among those most used are climate change,
84 resource depletion (water, fossil and mineral), impacts on land compartments (e.g.,
85 use and transformation), human toxicity (cancer and non-cancer), and others. Any
86 exclusion of an impact category must be thoroughly justified;
- 87 4. evaluates the full life-cycle of the product reviewed, from cradle to grave. Both
88 upstream impacts (e.g., material production) and downstream impacts (e.g., recycling
89 or incineration) must be included in the evaluation;

- 90 5. includes clear hypotheses and assumptions on breakage rate, return (trip) rate,
 91 weight and end of life strategies (including e.g. recycling performance and quality of
 92 the recycle) both for single-use and reusable packaging;
 93 6. performs a sensitivity analysis and discloses the source of such data, if lower quality
 94 data on parameters have been used. The conclusion of this sensitivity analysis
 95 should be included in the study, to ensure that the implications of using poor quality
 96 data are transparent;
 97 7. considers different business model configurations for the use and end of life phases,
 98 alongside clear sensitivity and scenario analyses about, among other, sanitizing
 99 types, transport distance, or transport mode;
 100 8. integrates static comparisons with dynamic ones such as the evaluation of the
 101 environmental break-even points.

102 From Figure 1, it immediately emerges that the analysed LCA studies exhibit varying
 103 degrees of criticality i.e. they are lacking the fulfilment of the indicated criteria.

104 We conclude that any report which assesses environmental impacts without respecting the
 105 characteristics listed above lacks robustness, reliability and impartiality, and would
 106 potentially mislead decision-makers. Therefore, caution should be exercised when
 107 considering its results and recommendations emanating from such reports or studies.

Name of the study	McDonald's study (Kearney) [1]	EPPA's study (Ramboll, in-store) [2]	EPPA's study (Ramboll, take-away) [3]	Tomra's study (Eunomia, take-away) [4]
Proposed LCA criteria				
Follows ISO LCA frameworks				
Peer-review (i.e. reviewed by third parties)				
Independent (without conflicts of interest)				
Clear goal and scope definition				
Transparency of inventory data				
Inclusion of sufficient and relevant environmental indicators				
Inclusion of full life-cycle				
Clear assumptions on breakage rate, return rate, weight and end-of-life				
Sensitivity analysis on key parameters and assumptions				
Scenario analysis on model configurations for use & end-of-life				
Integration of static comparisons with dynamic ones (break-even points)				

108

Legend Criteria not fulfilled Criteria partially fulfilled Criteria fulfilled

109 Figure 1. Visual representation of the analysis of four Life Cycle Assessment studies on
 110 single-use and reusable systems for dine-in and food take-away sector. The quality of the
 111 studies was assessed in light of the criteria and requirements for robust and
 112 methodologically sound analyses.

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119 *MULTIPLE-USE DISHES SYSTEMS FOR IN-STORE CONSUMPTION IN QUICK*
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