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This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

*Published Version:*

*Availability:*

This version is available at: <https://hdl.handle.net/11585/602762> since: 2019-07-12

*Published:*

DOI: <http://doi.org/>

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## Food supply chain side flows management through Life Cycle Assessment and Life Cycle Costing: a practitioner's perspective

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### ABSTRACT

Urged by the importance of resource efficiency and circular economy agenda policy makers, many stakeholders are seeking alternatives for current surplus food or side flows within the food supply chain. Any new valorisation or intervention aimed to prevent food waste will however be associated with impacts (monetary and environmental). To allow informed decision making at all levels, from individual stakeholder to policy level, robust, consistent and science based approaches are required. The EU H2020 funded project REFRESH (Resource Efficient Food and dRink for the Entire Supply cHain) aims to contribute to food waste reduction throughout the food supply chain, and evaluate the environmental impacts and life cycle costs. This paper presents a guidance document being developed within REFRESH on how to apply Life Cycle Assessment (LCA) and environmental Life Cycle Costing (E-LCC) and how to combine them in the context of food waste. Recommendations are given on the scoping on footprint studies as well as on change-oriented studies on interventions for side flows from the food supply chain. The overall aim of the current research is contribute to a better scoping practice of LCAs and LCCs of side flows in a food waste context

**Keywords:** *Life cycle costing; Life Cycle Assessment; food waste; food loss; E-LCC; LCA; REFRESH*

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### Introduction

Around 1/3 of edible food produced is wasted (FAO, 2011). Reducing food waste is a triple win activity: as it saves money since less resources are needed, as less waste is equal to the opportunity to feed more people in the future, and as reduced waste decreases the pressure on climate, water, and land resources (e.g. FAO 2013, Kummu *et al.*, 2012). Through the United Nations Sustainable Development Goal (SDG) adapted 2015 a global target has been set to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses (SDG12.3).

Any new valorisation route for side flows or an intervention aiming for reducing a side flow from the food supply chain will generally be associated with impacts (monetary and environmental). To allow informed decision making at all levels, from individual stakeholder to policy level, robust, consistent and science based approaches are required. The EU H2020 funded project REFRESH (Resource Efficient Food and dRink for the Entire Supply cHain) aims to contribute to food waste reduction throughout the food supply chain, and evaluate the environmental impacts and life cycle costs.

Life Cycle Analysis (LCA: ISO, 2016; EC, 2010) and Life Cycle Costing (LCC) (e.g. Hunkeler *et al.*, 2008) are well documented and generic approaches for assessing the environmental and cost dimensions of a system. Both LCA and LCC are characterised by allowing for a large flexibility in problem scoping.

To allow for comparison between different options consistent approaches are required. Furthermore, there is a need to bridge the gap between assessors who might have a deep knowledge of the systems they are assessing, but are not in depth method experts on LCA or LCC, by highlighting challenging methodological aspects and encouraging the practitioner to ask the most relevant questions.

The objective of this study was thus to develop a consistent approach, *combining* LCA and LCA *specifically* to assess impacts of prevention of resource inefficiencies, new/novel valorisation options and waste handling options relating to side-flows in the food supply chain.

## Methodology

A literature review of recent scientific articles and reports was carried out in order to analyse methodological aspects related to LCA (Unger *et al.*, 2016) and LCC (de Menna *et al.*, 2016) exploring existing standards, guidelines and LCA and LCC case studies related to food waste, the focus was on answering the following questions:

- What are the commonly used approaches for key methodological aspects?
- What are areas where there are methodological challenges / gaps / differences?
- Do different types of documents, e.g. standards / protocols, case studies align or not?

The review highlighted that while there are several standards and guidance documents, these may not reach practitioners performing LCA and LCCs. There is a need to bridge this gap for assessors who might have a deep knowledge of the systems they are assessing but are not in depth method experts in LCA or LCC.

Given these insights, concrete recommendations were developed and tested on selected LCA and LCC experts and practitioner within the REFRESH consortium.

## Results

The guidance focuses particularly on the goal and scope stage of an LCA and environmental LCC and on side flows from the food supply chain. The recommendations developed built on findings from the literature reviews (Unger *et al.*, 2016; de Menna *et al.*, 2016) along with existing standards and state-of-the-art LCA- and LCC research (e.g. ISO, 2016; EC, 2010, Hunkeler *et al.*, 2008) and provide guidance on how to overcome specific methodological challenges by specifically responding to:

- Does the question being asked result in an attributional or consequential model?
- What is a suitable functional unit (FU) and system boundary (SB) in relation to the research question(s)?
- How to deal with multi-functionality (allocation/system expansion)?
- What environmental burden/economic costs does a side flow from the food chain have?
- How to identify replaced products, and on what basis?
- Which are the most important environmental indicators to focus on? Climate impact is common, but standards require many aspects to be explored. What is relevant but also feasible?
- Which cost items should be inventoried?

To categorise systems to be assessed, the concept of “REFRESH situations” (RS) has been developed (De Mena *et al.*, 2016; Unger *et al.*; 2016, and Davis *et al.*, 2017). The four REFRESH situations (RS) are: Prevention of side flow (RS 1), side flow valorisation (RS 2), valorisation as part of waste management (RS 3), and end-of-life treatment (RS 4). The REFRESH situations can take place at any point/process in the life cycle, within the remit of any stakeholder (including consumers) and are independent of the perspective taken, i.e. of the producer of side stream or the receiver. For each REFRESH situation, specific recommendations on setting of system

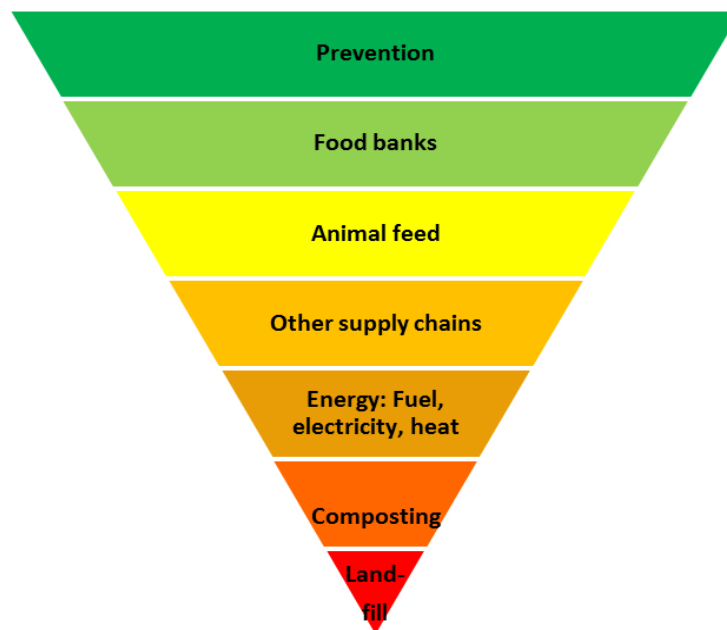
boundary, functional unit(s) and handling of multi-functionality in relation to the stated problem are provided (beside some other aspects).

The importance to distinguish between footprint studies and intervention studies is emphasised. While a footprint study provides general information on the impact associated with a given or future product or service by giving a “snap shot” of the system an intervention study explores effects of interventions to a system by assessing the impact due to a change; thus a comparison of two, or more, well-defined scenarios is performed.

The recommendations focus primarily on change-oriented studies of food waste interventions although some guidance on footprint studies of side flow are given as well. For main products (i.e. not side flows) it is referred to the initiative on product environmental footprints – PEF (EC, 2013). For life cycle costing aspects, the guide focuses on environmental LCC (E-LCC), following the categorization proposed by Hunkeler *et al.* (2008).

## Discussion

The recommendations provided apply to all levels in the food waste hierarchy as shown in Figure 1. The hierarchy states a generic order of preference for handling of side flows. LCA and E-LCC in combination will serve as a complementary tool for better and deeper understanding of the overall impacts of specific interventions as it allows comparison within a hierarchy level or across a hierarchy level. It is worth noting that the EC directive on waste specifically encourages the use of *life-cycle thinking as a complementary tool to the waste hierarchy* (EC, 2008, Directive on waste, paragraph 4) to understand the overall impacts of different interventions. This study provides recommendations for combining LCA with the economic dimension using E-LCC, and thus providing additional value.



**Figure 1:** The scope of this work covers all levels in the food waste hierarchy. Adapted to the FUSIONS framework (FUSIONS, 2014) by Östergren, (2016)

The consistent approach developed (Davis *et al.*, 2017) is believed to contribute towards a more harmonised use of LCA and LCC for informed decision making and in the long run promote sustainable and cost-efficient interventions and a more resource efficient food supply chains. However, it is important to note that LCA and E-LCC provide objective numbers and does only respond to the environmental and cost dimensions for a *given problem*. The food waste hierarchy provide guidance on the most preferred interventions in general and may serve as a first guide on the choice of intervention. Finally, the reduction of food loss and waste also has important social (e.g. availability of food) and political dimensions that need to be considered together with the results obtained from any LCA and E-LCC.

## Acknowledgements

This work was supported by the REFRESH (Resource Efficient Food and dRink for Entire Supply cHain) project, funded by the European Union Horizon 2020 Research and Innovation Programme under Grant Agreement No. 641933. More details on the REFRESH project can be found at <http://eu-refresh.org>.

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