Integrating Life Cycle Costing and LCA: a focus on food waste prevention and valorization

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Background: Food waste impacts

One-third of all edible food produced is wasted (FAO 2011, 2013)

- Carbon footprint of uneaten food: 3.3 Gt CO_{2eq} (third emitter after USA and China)
- Blue water footprint (i.e. surface and groundwater resources): 250 km^3 (3 lakes Geneva)
- Land footprint: 1.4 billion ha = ab. 30% percent of global agricultural land area

Cost for the society (FAO 2014)

- Economic cost: USD 1 trillion
- Cost of environmental externalities: USD 750 billion
- Cost of social externalities: USD 900 billion

Background: a double energy waste (Vittuari et al. 2016)

Food waste implies wastage of

- Energy contained in food
- Energy inputs used to produce it

In Italy:

- 17% of uneaten food until retail
- Equivalent to 22% food energy content
- Waste of 12% of energy used in the supply chain and 1,3% of total

energies MDPI

Article

The Hidden Burden of Food Waste: The Double Energy Waste in Italy

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Table 6. Food Mass Waste (FMW), Food Energy Waste (FEW) and Embodied Energy Waste (EEW) for the different steps of the FSC, year 2011.

Waste Type	Farming	Processing	Distribution	Total
Food Mass Waste (Mt)	12.75	2.47	2.64	17.87
Food Energy Waste (PJ)	37.04	21.35	8.49	66.89
Embodied Energy Waste (PJ)	47.42	28.43	24.21	100.07

Background: the REFRESH project

H2020 - REFRESH: Resource Efficient Food and dRink for the Entire Supply cHain

Aim to contribute towards SDG12.3 of halving per capita food waste at the retail and consumer level and reducing food losses along production and supply chains. To achieve this, the project's main goals are to:

- Develop strategic agreements to reduce food waste in four pilot countries (Spain, Germany, Hungary, and the Netherlands).
- Formulate EU policy recommendations and support of food waste policy frameworks
- Design and develop technological innovations to improve valorization of food waste and ICT-based platforms and tools to support new and existing solutions to reduce food waste
    - 26 Partners from 12 European countries and China
    - Duration: July 2015 – June 2019
    - Funding: ~ EUR 9 million

REFRESH WP5 - Environmental and life cycle costing dimension of food waste

FW prevention and valorization are needed and their environmental and economic sustainability must be properly assessed, but no coherent framework already established and difficult for stakeholders.
Thus WP5 aims to:

- Supply consistent life cycle approaches to environmental and costing dimension of food waste
- Supply comparable and reliable data for selected case studies of prevention and valorisation

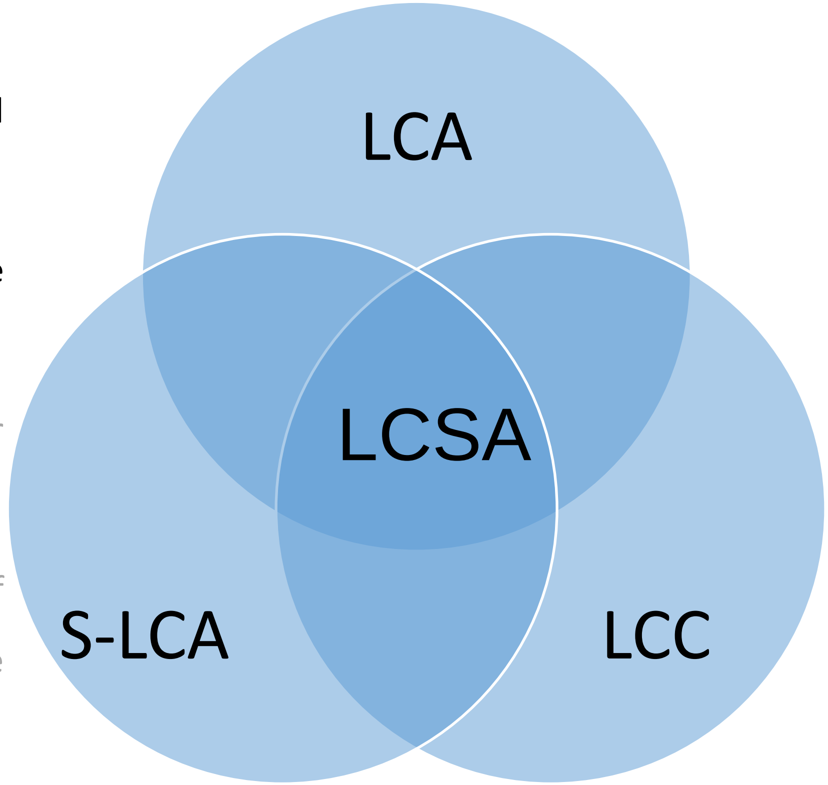
Main WP partners are:

- RISE Agrifood and Bioscience Sweden
- Dept. of Agriculture and Food Science, UNIBO, Italy
- University of Natural Resources and Life Sciences, Vienna, Austria;
- Deloitte Sustainability, France.

Life Cycle Thinking: ok then, how?

Various tools depending on the scope of the analysis

- Life Cycle Assessment: analysis of environmental impacts caused by a product/service/activity
- Life Cycle Costing: analysis of costs associated with the life span/cycle of a product/service/activity
- (Social Life Cycle Assessment: analysis of social impacts per different stakeholders and categories
- Life Cycle Sustainability Assessment: integrated assessment of environmental, costing, and social impacts in a life cycle perspective)



Life Cycle Costing: history and approaches

- Conventional approaches older than LCA

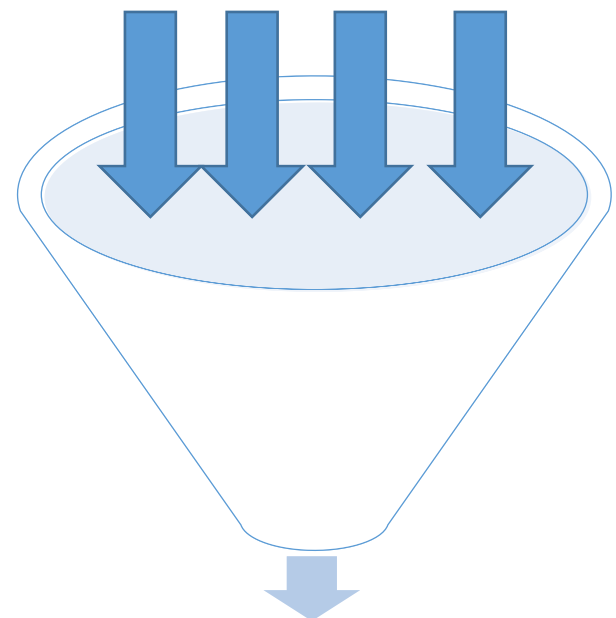
- Conventional LCC calculates the impact of products and services in terms of costs in a life span (e.g. LCC of a dishwasher for a consumer); Basic characteristics:
  - Usually one actor (either supplier or user) and only internal costs
  - Mostly no disposal
  - Very close to conventional economic analysis

- More recently (2008) Environmental Life Cycle Costing (E-LCC); it should…
  - Include costs occurred during the life cycle of a product, directly covered by one or more actors in the product life cycle, potentially from all stages (from feedstock supply to consumption and/or end of life) and eventually including external costs
  - Coherence with LCA: same product system, same functional unit, boundaries,…

WP5: combining different frameworks

Existing standards and literature were reviewed to derive coherent recommendations

- Life Cycle Assessment (ILDC, ISO 14040)
- Life Cycle Costing (Hunkeler, SETAC)
- EU Waste Framework Directive
- FUSIONS Manual /FLW protocol



RECOMMENDATIONS FOR SCOPING E-LCC AND LCA FOR SIDE FLOWS

Recommendation framework was submitted to and reviewed by selected LCA, LCC, and FW experts and practitioners within the REFRESH consortium.

Study purpose definition: focus on food waste flows

- ✓ What product, waste flow, and characteristics?
- ✓ Current situation vs. changes to alternative?
- ✓ Prevention included or foreseen?
- ✓ Value involved in management of the side flow?

Driving product (out of scope)

A flow of the food supply chain can be characterized as a driving product whenever it represents the main reason for the supply chain to exist. This means that in some agro-food processes there can be several driving products

vs.

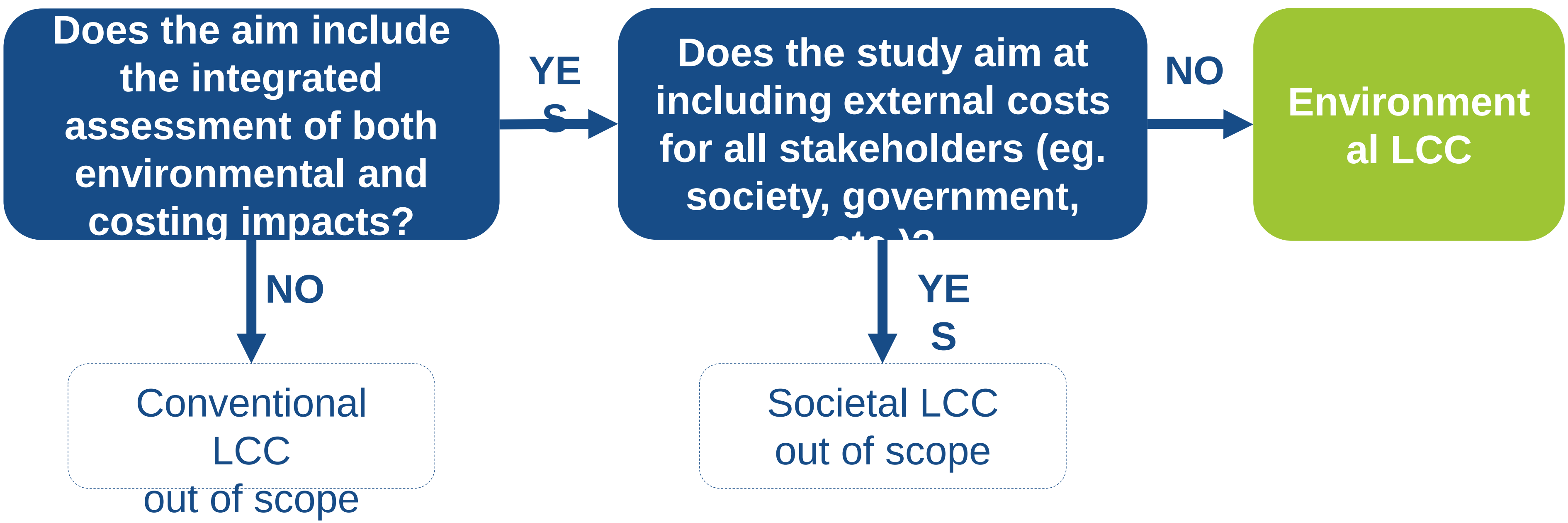
Side flow

Any wasted edible and inedible part of food - including wasted flows of driving product(s) - can be defined as side flow. The main difference with the driving product is that an assessor would like to minimize it, rather than producing more

Life Cycle Costing approach

Distinction based on literature between

- Conventional LCC
- Societal LCC
- Environmental LCC



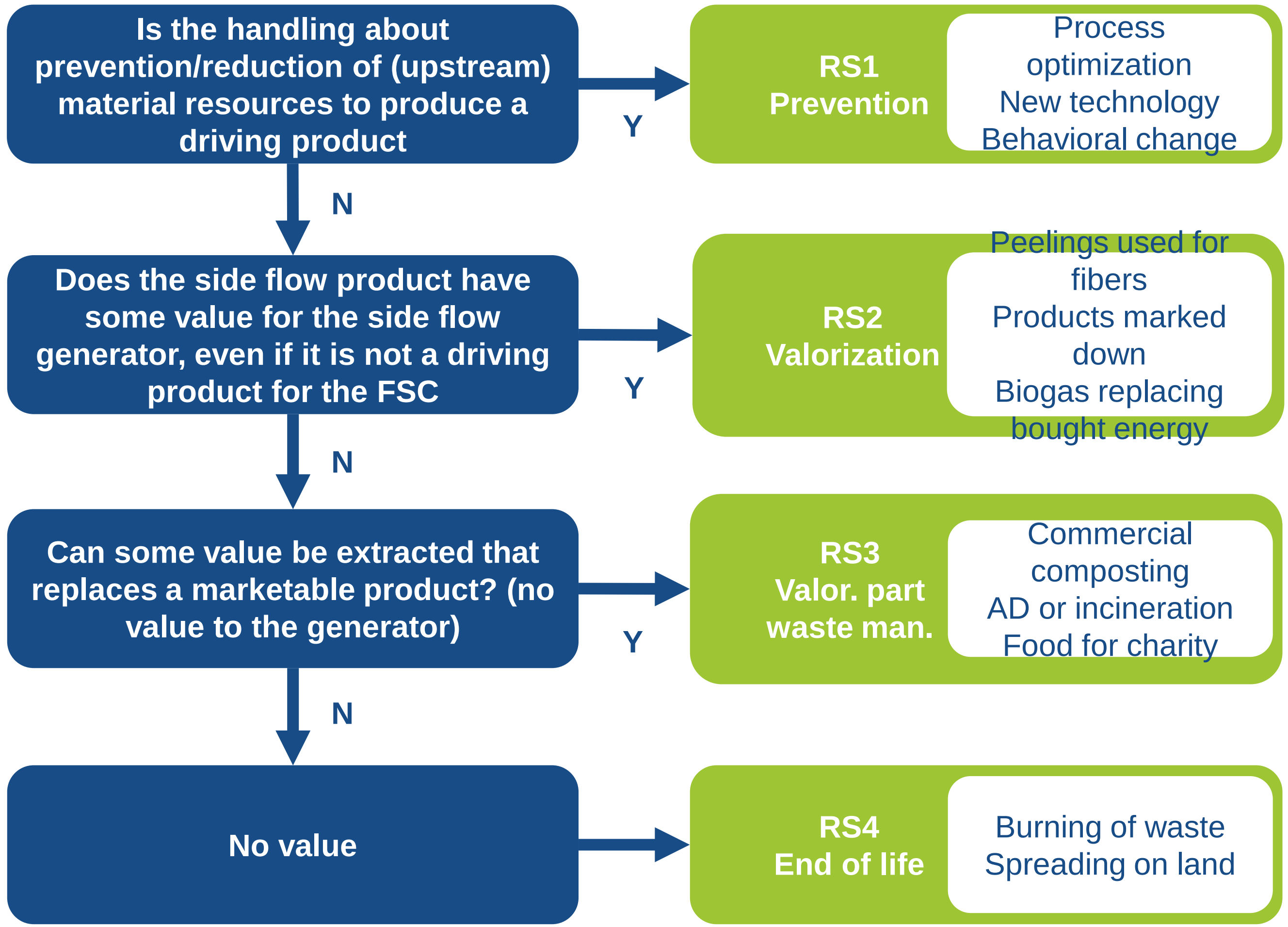
REFRESH Situations and decision tree: scoping LCA and E-LCC of a side flow

REFRESH situations

Any point/process within the life cycle

Any stakeholder (including consumers)

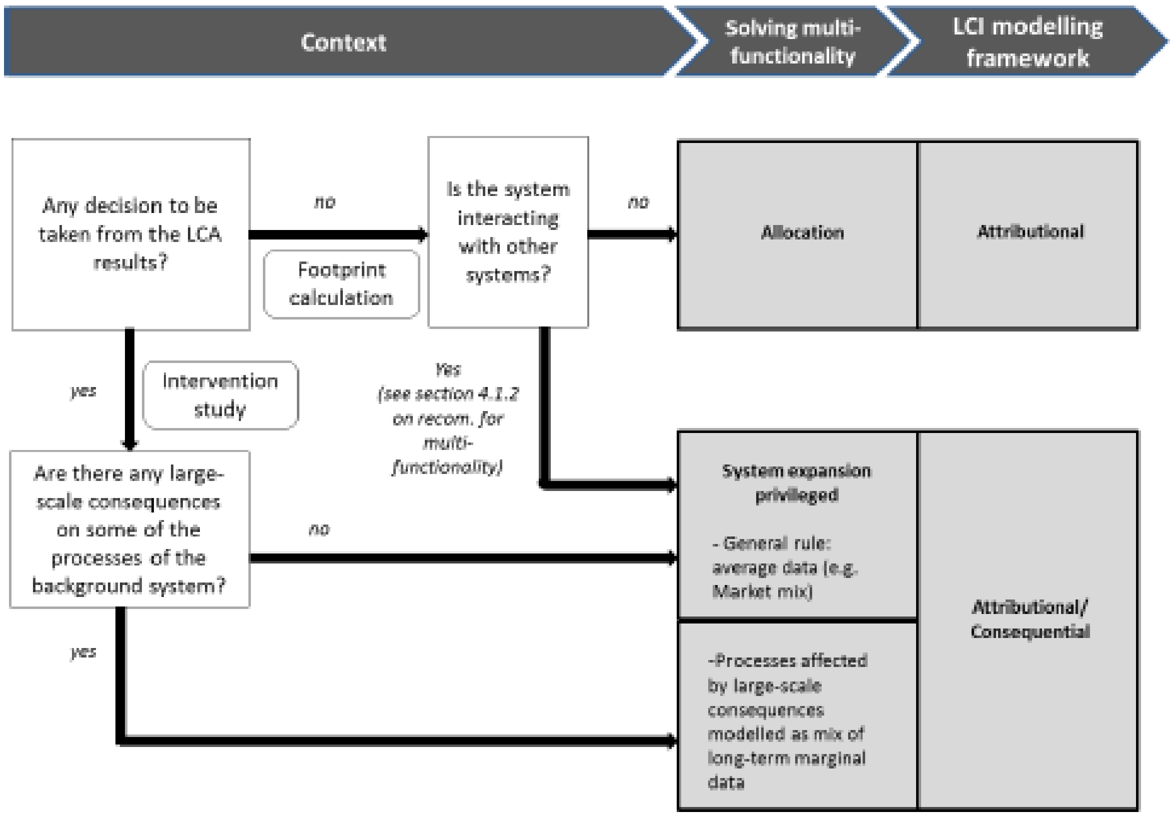
Independent of the perspective taken, i.e. producer of side flow or the receiver



Type of study and modelling framework

Two types of assessment:
Footprint study (RS2-RS4) vs Intervention study

Decision tree to guide practitioneers =>

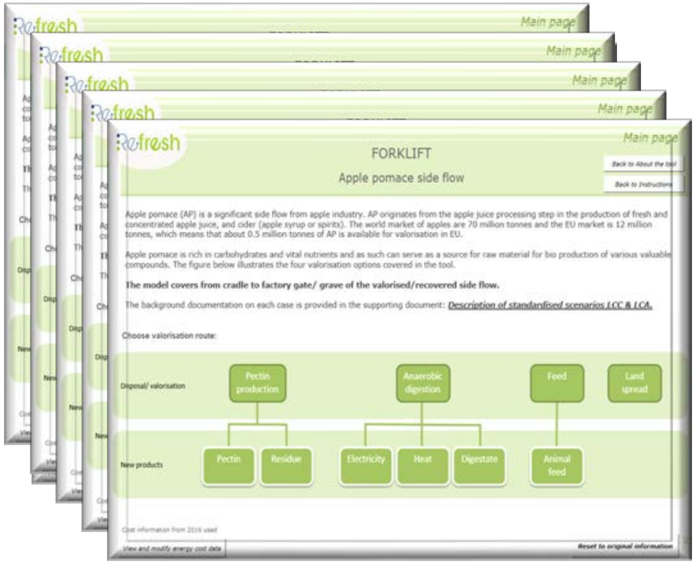


	Footprint studies			Intervention studies
Scope	Evaluation of impact from a product No focus on consequences on the economy			Estimation of the effects of changes in a system Comparison between end/future and current situation
Modelling	Attributional			Consequential
Situations	RS2	RS3	RS4	All RS
Functional unit	Mass-based (or energy) unit of valorized product (or energy source)	Mass-based unit of treated side flow (including treatment service)		All impact referred to the prevented (if RS1 included), valorized, and/or managed side flow
System boundaries	Cradle to gate/grave of valorized product	Gate to gate/grave of valorized product	Gate to grave of side flow management	Cradle of driving product to gate/grave of side flow if RS1 included Gate to gate/grave of valorized/managed side flow if no RS1
Multifunctionality	Allocation from driving product	No allocation from driving product		System expansion and avoided burden of substituted products Revenues from co-products as avoided costs
	Economic allocation for valorized products			
Cut-off	Take into account all processes that contribute significantly to the environmental impact and to the cost impact respectively for LCA and LCC			
Cost categories	Cost can be categorized by typology, stage, and activity			Cost must be categorized at least by typology (e.g. internal, external, avoided, revenue)
Externalities	Externalities can be included in the financial part of the study, but must be highlighted separately from other types of costs			
				Economic external effect may be included
Cost bearers	Multi-actor perspective whenever possible, including: side flow generator, current or perspective managers/users, government/society (in case of transfers and externalities)			
Joint interpretation	Use portfolio presentations to show complete results of both LCA and E-LCC results Plot selected indicators (e.g. GWP and cost or NPV or value added) to show eventual win-win or trade-offs			

FORKLIFT spreadsheet tools

- FORKLIFT (FOod side flow Recovery LIFe cycle Tool) aims at providing stakeholders with a hands-on tool helping to gain a general understanding and highlight the environmental impacts and costs for selected valorisation routes, focusing on selected parameters.

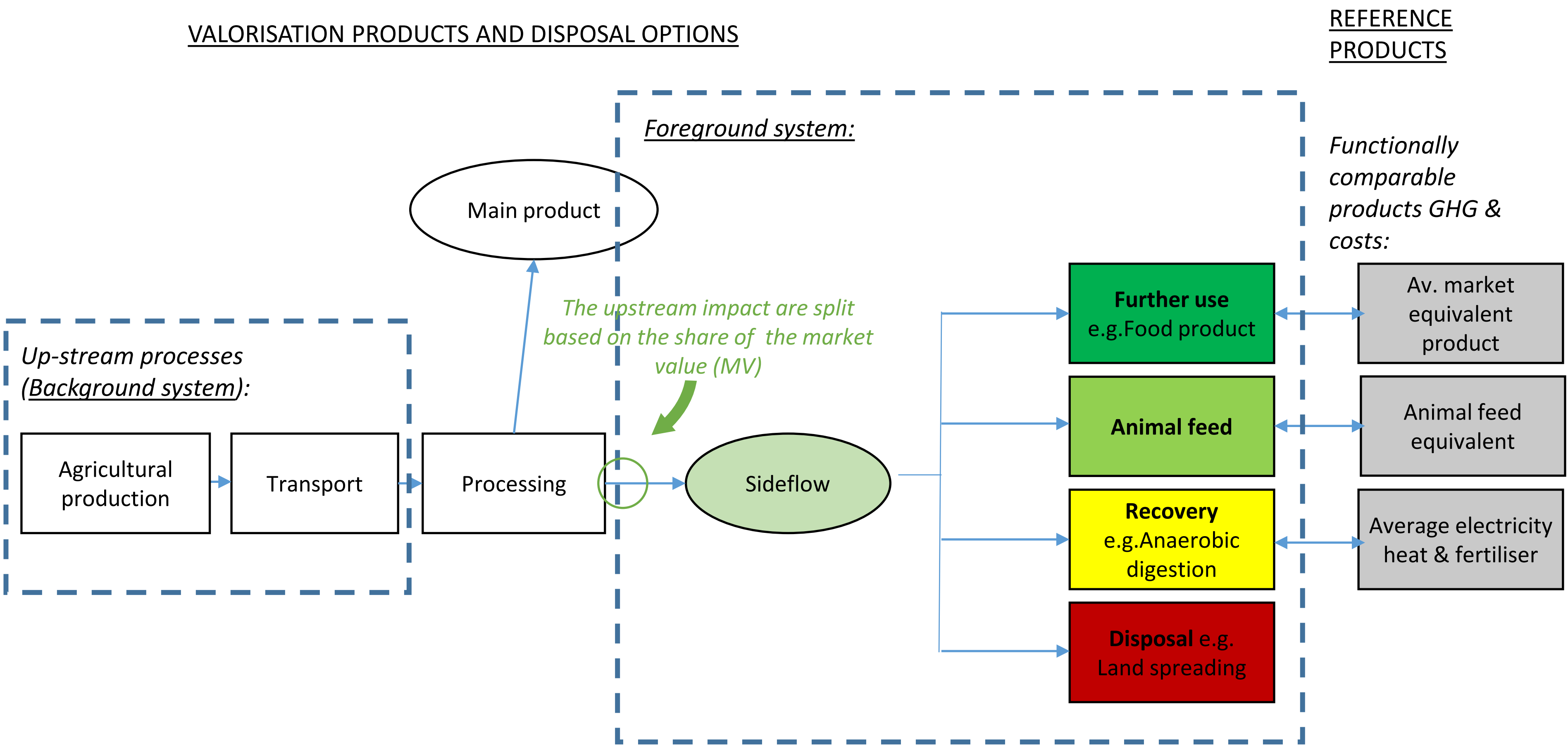
- Food side-flows covered in the tool:
  - Apple pomace
  - Blood from slaughtering
  - Brewers' spent grain
  - Tomato pomace
  - Whey permeate
  - Rapeseed press cake



How does FORKLIFT work?

- Models processing options, GHG and generic costs for one tonne of a side flow.
- Background data, GHG and costs, for energy, transports, processing are included for various countries and can be modified.
- Standard or user-generated costs on labour and equipment can be added
- Impacts are economically allocated between main product and side-flow based upon the value (economic allocation).
- Compares the results from the model (GHG and costs) with similar products on the market

FORKLIFT- the model



Refresh

Main page

FORKLIFT

Apple pomace side flow

Back to About the tool

Back to Instructions

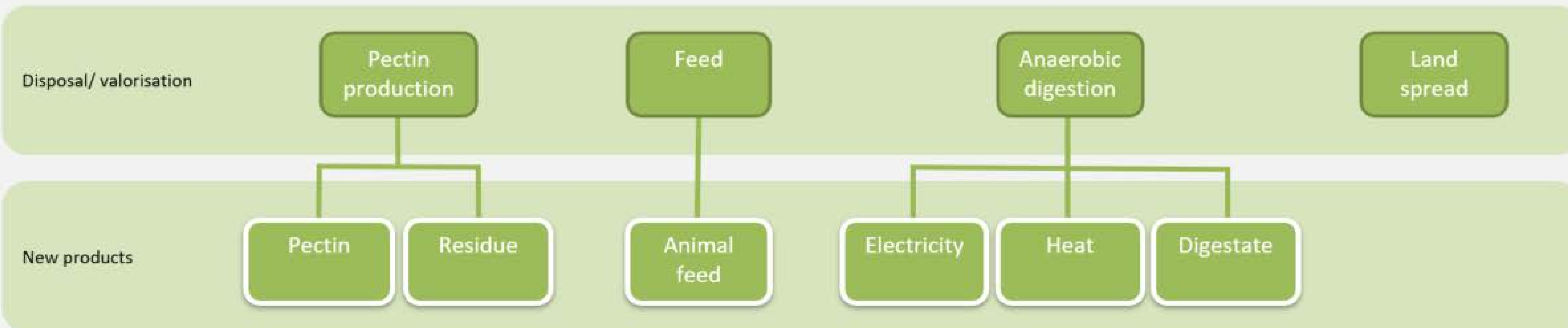
Apple pomace (AP) is a significant side flow from apple industry. AP originates from the apple juice processing step in the production of fresh and concentrated apple juice, and cider (apple syrup or spirits). The world market of apples are 70 million tonnes and the EU market is 12 million tonnes, which means that about 0.5 million tonnes of AP is available for valorisation in EU.

Apple pomace is rich in carbohydrates and vital nutrients and as such can serve as a source for raw material for bio production of various valuable compounds. The figure below illustrates the four valorisation options covered in the tool.

The model covers from cradle to factory gate/ grave of the valorised/recovered side flow.

The background documentation on each case is provided in the supporting document: ***Valorisation spreadsheet tools.***

Choose valorisation route:



Default cost information from 2015-2018 period used

View and modify energy cost data

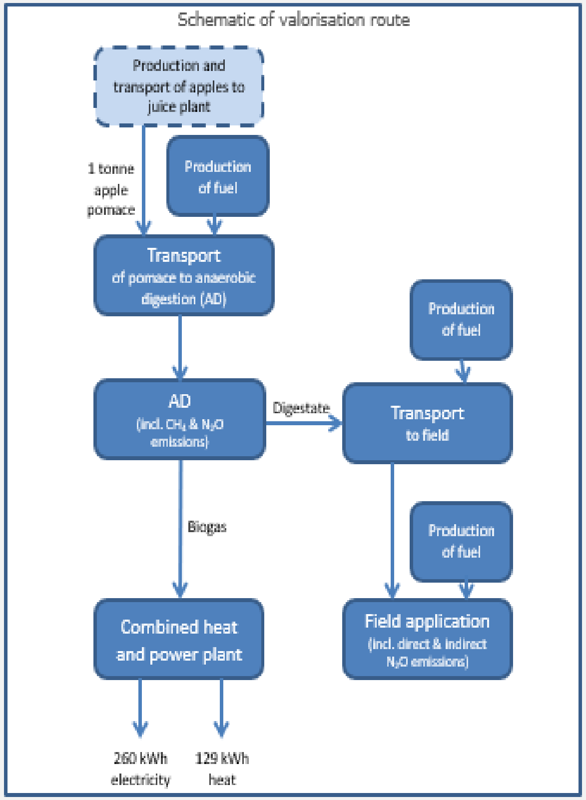
Reset to original information

Refresh

Overview page

Production of heat and electricity with anaerobic digestion

Return to Main Page



The figure above illustrates the processes that are taken into account in the calculation of GHG emissions and costs for using the apple pomace to produce biogas. The environmental impact and cost from the upstream processes are included if the apple pomace carries an economic value (therefore in dotted line). An average value of production and transport of apples to a juice producer has been assumed (0.33 kg CO_2eq./ kg apples).

The pomace is transported to the AD plant by truck.

Inputs

1. Market value of the side flow (/)

What is the revenue for the side flow?

0,0 [/tonne side flow]

What is the relative revenue for the side flow? (/)

0,0 [%]

2. Choose country (/)

EU - European average

3. Energy costs only? (/)

Labour, capital and disposal costs are NOT added

Add additional costs

Change details Here you can view and change the parameters with largest effect on the results.

Check/ amend detailed information

Results

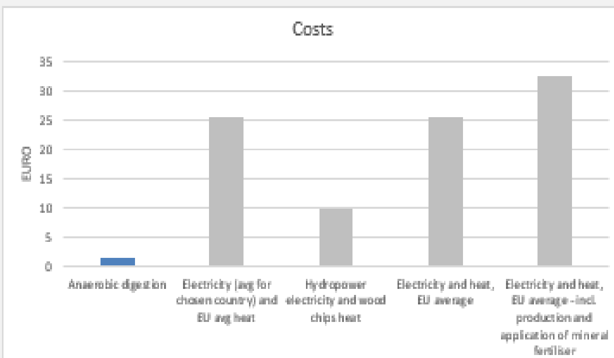
1 tonne of apple pomace results in 260 kWh electricity and 129 kWh heat

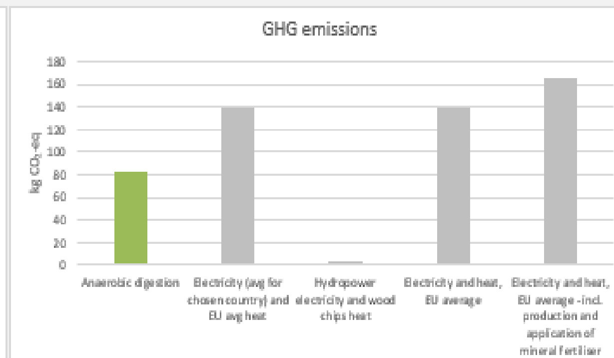
The graphs illustrate:

Production of 260 kWh electricity and 129 kWh heat with anaerobic digestion compared to production of heat and electricity by other means.
The comparison is made for several combinations of heat and electricity production.
Please note that only the bars to the left in each graph represent anaerobic digestion.

Save this scenario

Show saved scenarios





Labour and capital costs have NOT been added

Apple raw material:
0.33 kg CO2 eq/ kg apples

Average EU inhabitant:
24 kg CO2 eq/ day

Detailed results in FORKLIFT

Refresh

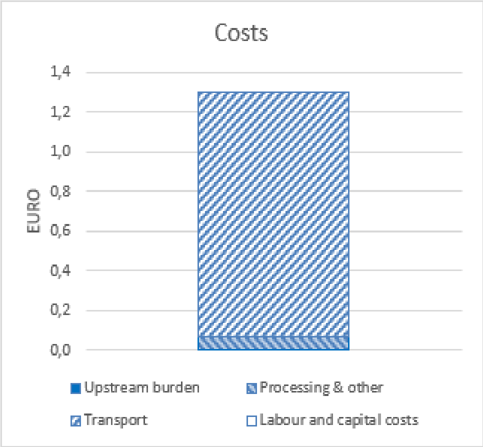
Detailed results

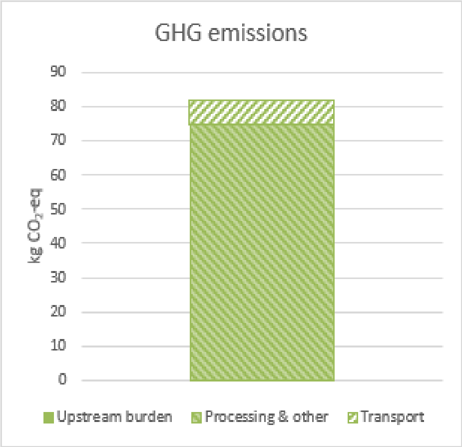
Anaerobic digestion

To Overview Page for Anaerobic digestion

1 tonne of apple pomace results in 260 kWh electricity and 129 kWh heat

The graphs illustrate:
Production of 260 kWh electricity and
129 kWh heat with anaerobic digestion



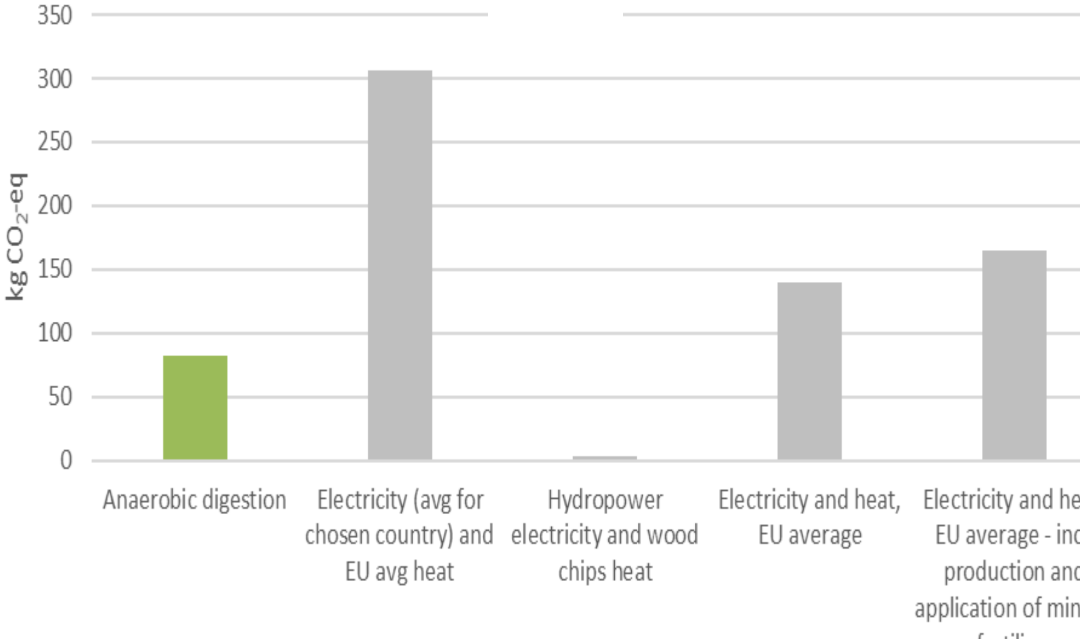


		Preset information:	Change to following information:
Transport of pomace to AD			
Type of transport	(*i*)	Tractor, single trailer, 50% LF	
Distance to AD plant	(*i*)	20	[km]
Transport of digestate to the field			
Type of transport	(*i*)	Tractor, single trailer, 50% LF	
Distance to field	(*i*)	20	[km]

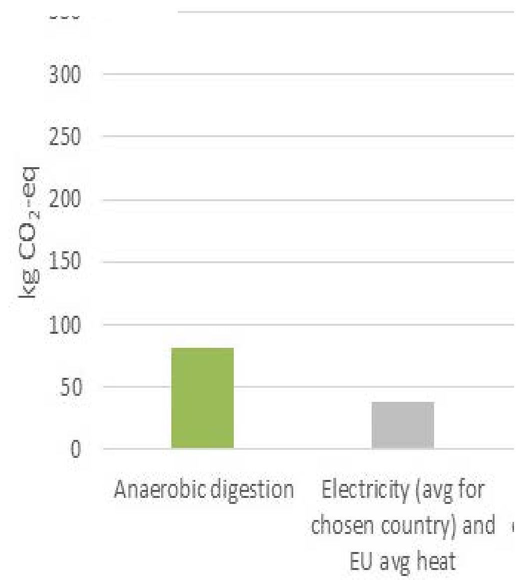
Reset information

GHG emissions from biogas production from 1 tonne of apple pomace

Estonia

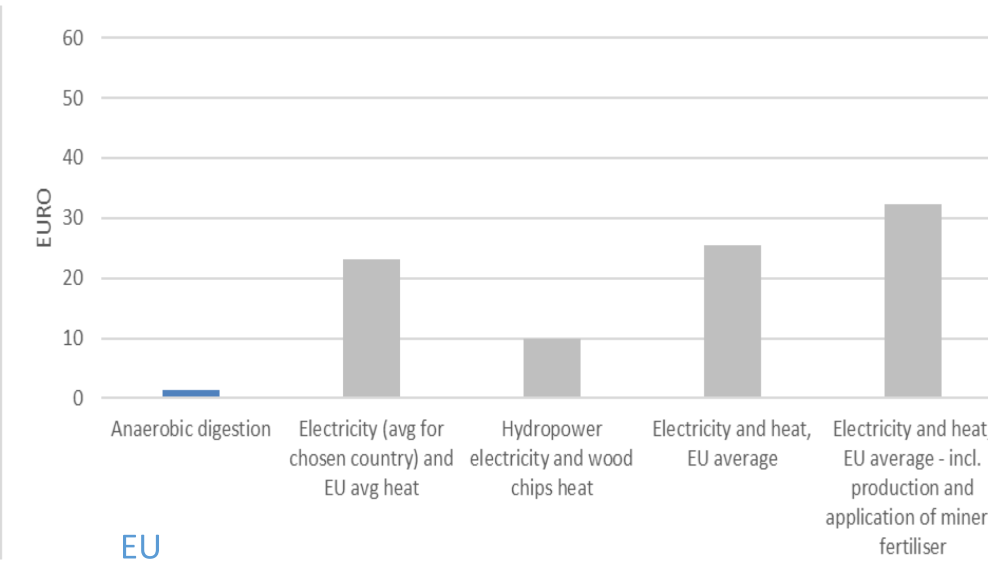


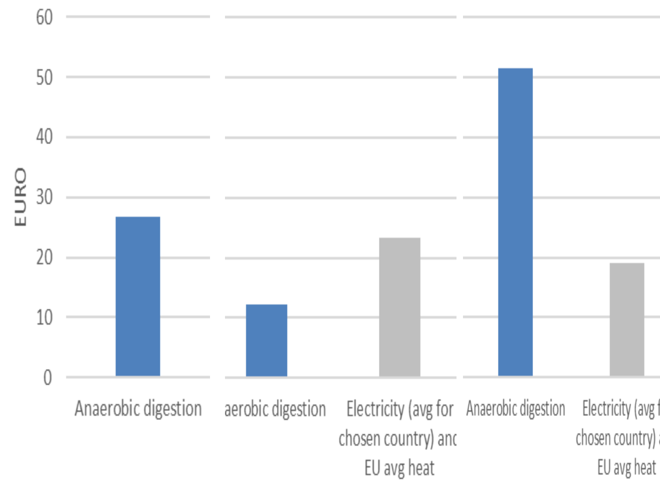
Norway



Costs for biogas production

Added costs: 1 person hour/tonne AP





EU Estonia Norway

EU
Costs for energy, transports, processing

Full LCA & LCC Animal feed case

- **Goal**

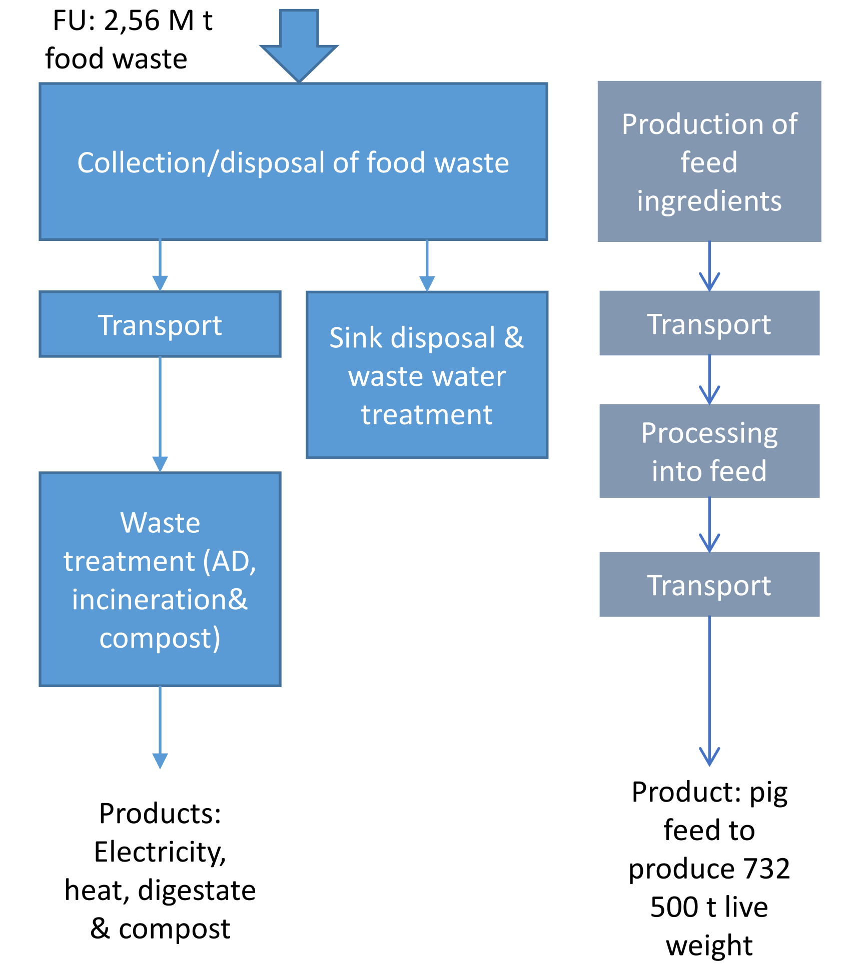
assess the **environmental impacts and cost** of the valorization of yearly food waste from catering, manufacturing and retail in **UK** and **France** as pig feed through the application of the Japanese/South-Korean system (e.g. lifting current ban).

- **Why?**

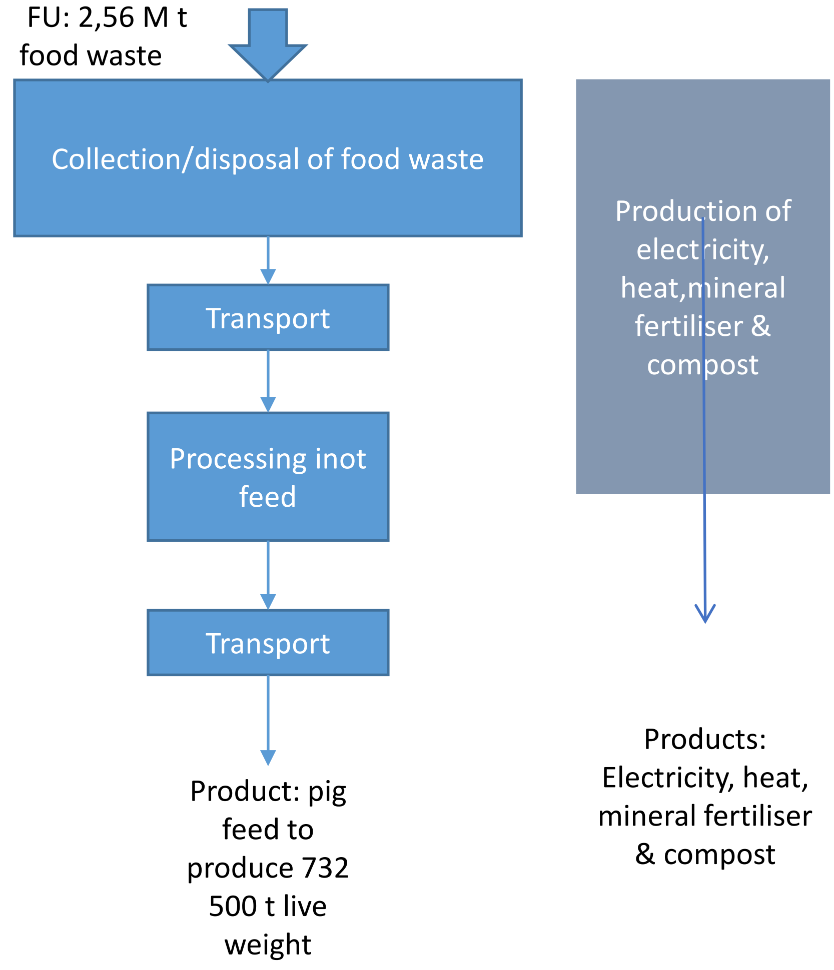
Previous studies focus on UK only, and do not include the economic part, by including two countries we can identify aspects (e.g. environmental and economic hot spots) that determine if there is an environmental and economic gain of lifting the ban or not.

- **For whom**
  - For feed industry, farmers, renderers and other stakeholders, showing business case and environmental benefits
  - For policy makers, showing evidence based assessment of potential policy measures
  - For research community, providing full examples of our methodology and results on specific cases

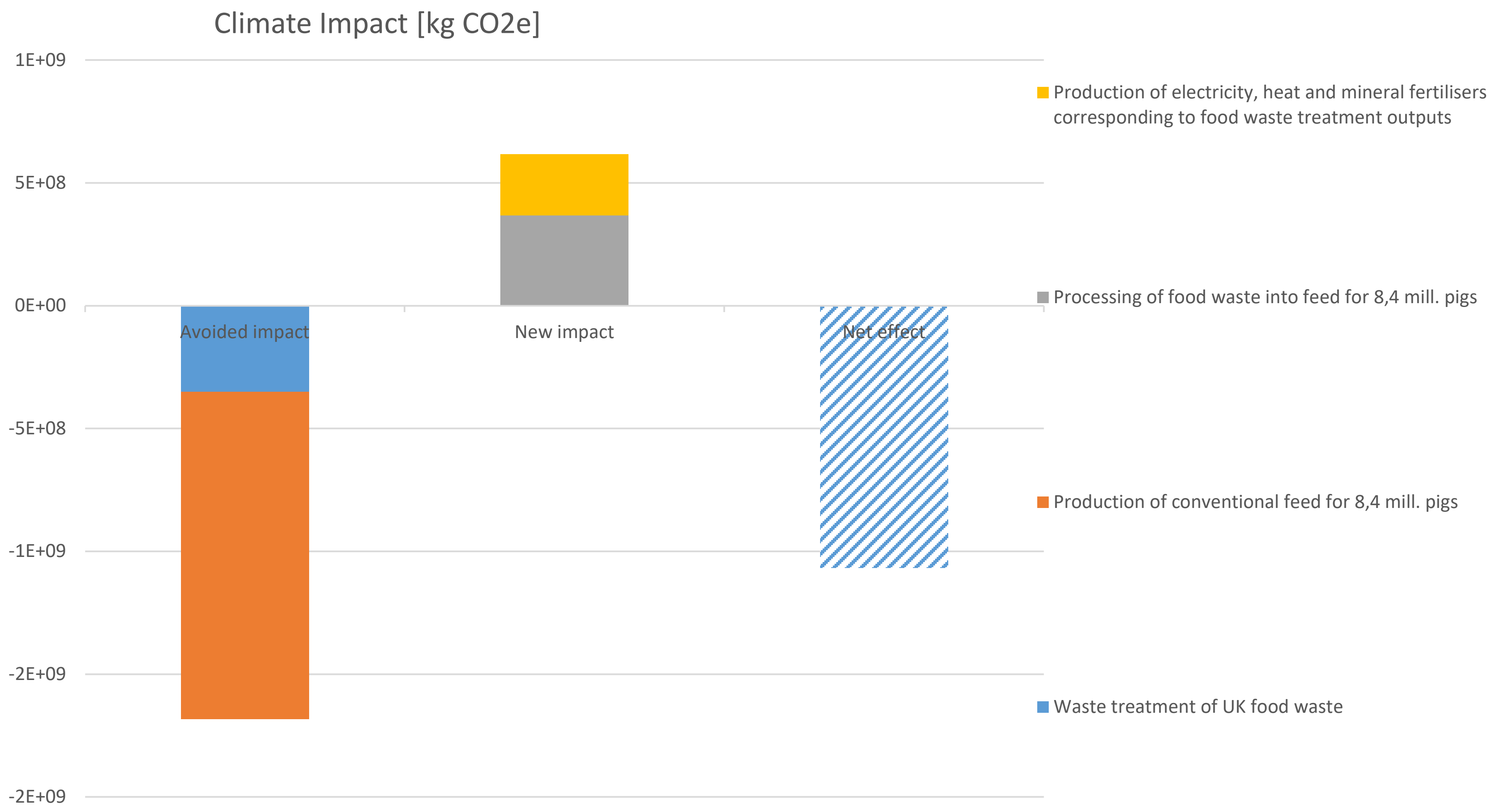
CURRENT PRACTICE



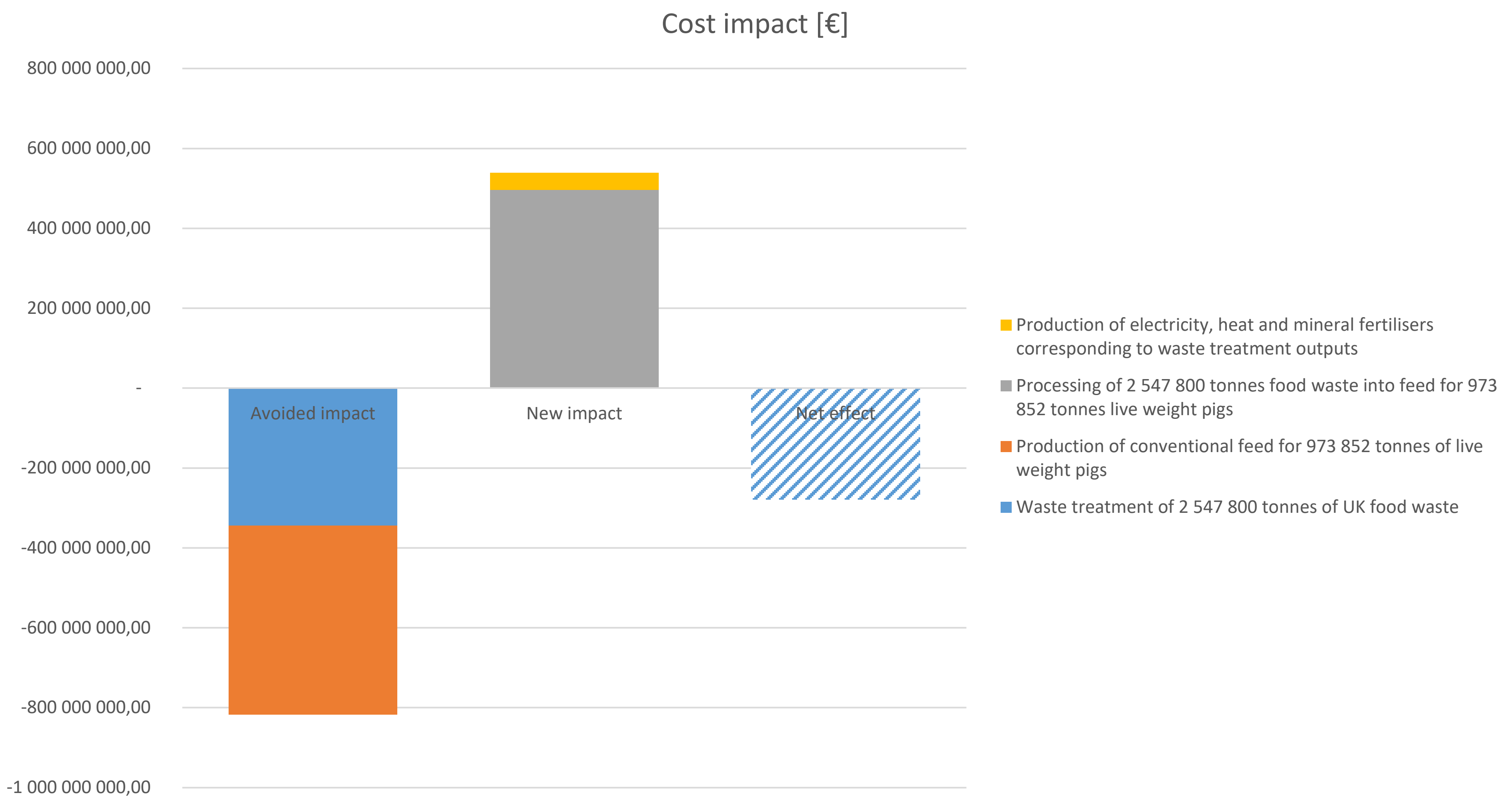
NEW: FOOD WASTE INTO FEED



Results GWP – UK current vs perspective



Results LCC – UK current vs perspective



Thank you! Questions?

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