Ranking the environmental benefits and impacts of different biorefining options for food waste – a case study of citrus waste

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Fight Food Waste CRC

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1. Project Overview

Opportunities for managing horticultural food waste using biorefining approaches.

Why is food waste a problem?

Significant **economic**, **social** and **environmental** impacts.

For example:

- 1/3 of food is wasted but more than 820 million people are food insecure. (1)
- Food is resource intensive and carries a lot of imbedded impacts.
- Costs almost $940 billion annually! (2)

(1) FAO. (2019). *The state of food and agriculture 2019*. http://www.fao.org/3/ca6030en/ca6030en.pdf
(2) FAO. (2011). *Global food losses and food waste: extent, causes and prevention*. http://www.fao.org/3/a-i2697e.pdf

The biorefining opportunity…

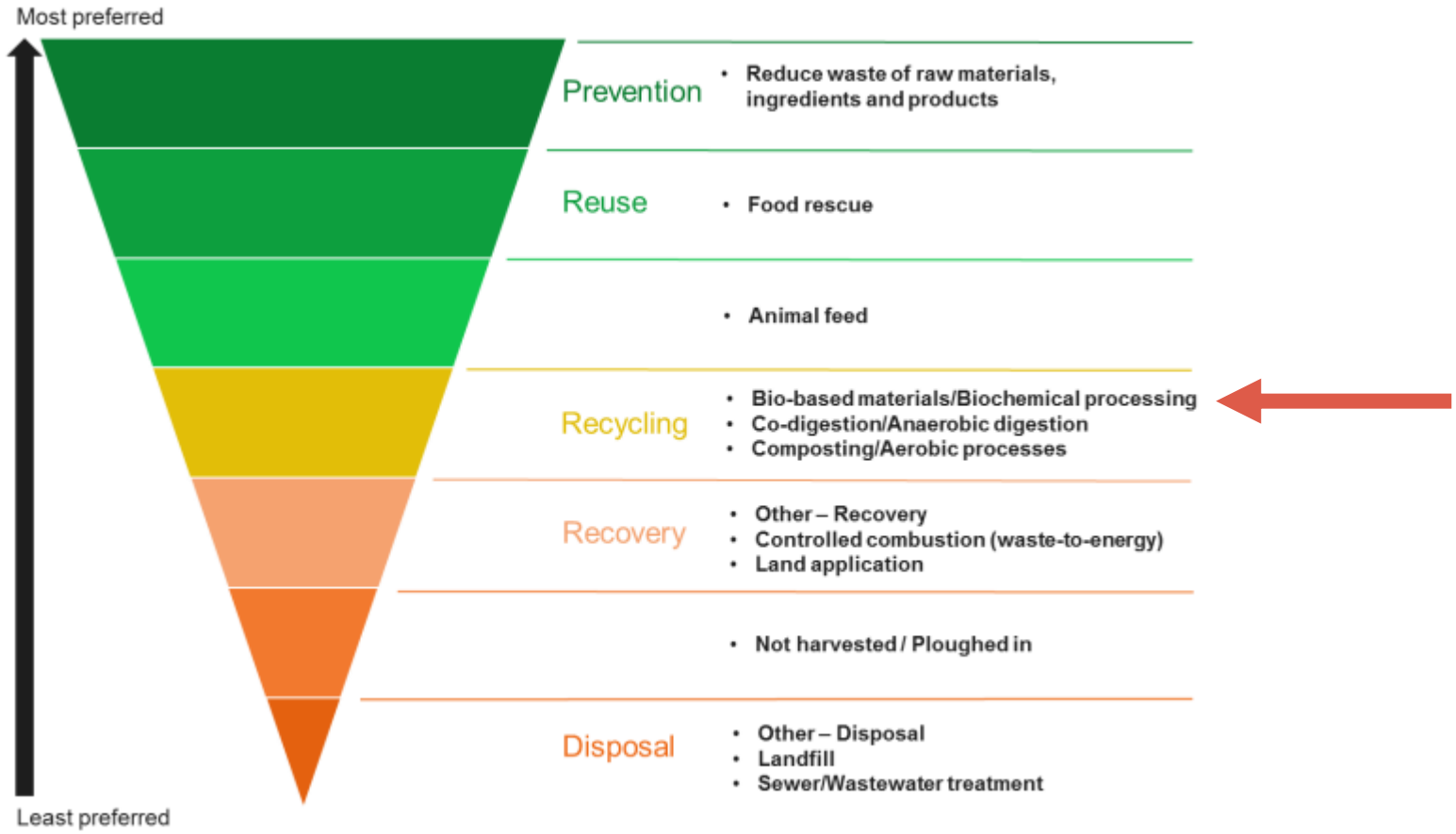
Transformation of renewable organic feedstocks to produce valuable products.

- Energy products (heat, electricity, fuel) [energy-driven biorefining]
- Other products (chemicals, protein, enzymes, materials etc.) [product-driven biorefining]
- Opportunity for
  - Value creation
  - Mitigate environmental impacts.

However, many biorefining processes are novel and their environmental impacts are unknown.

Biorefining in the waste hierarchy

Waste hierarchy, taken from the National food waste baseline: final assessment report.



- ARCADIS. (2019). *National food waste baseline: final assessment report*. https://www.environment.gov.au/system/files/pages/25e36a8c-3a9c-487c-a9cb-66ec15ba61d0/files/national-food-waste-baseline-final-assessment.pdf

2. Citrus processing waste case study

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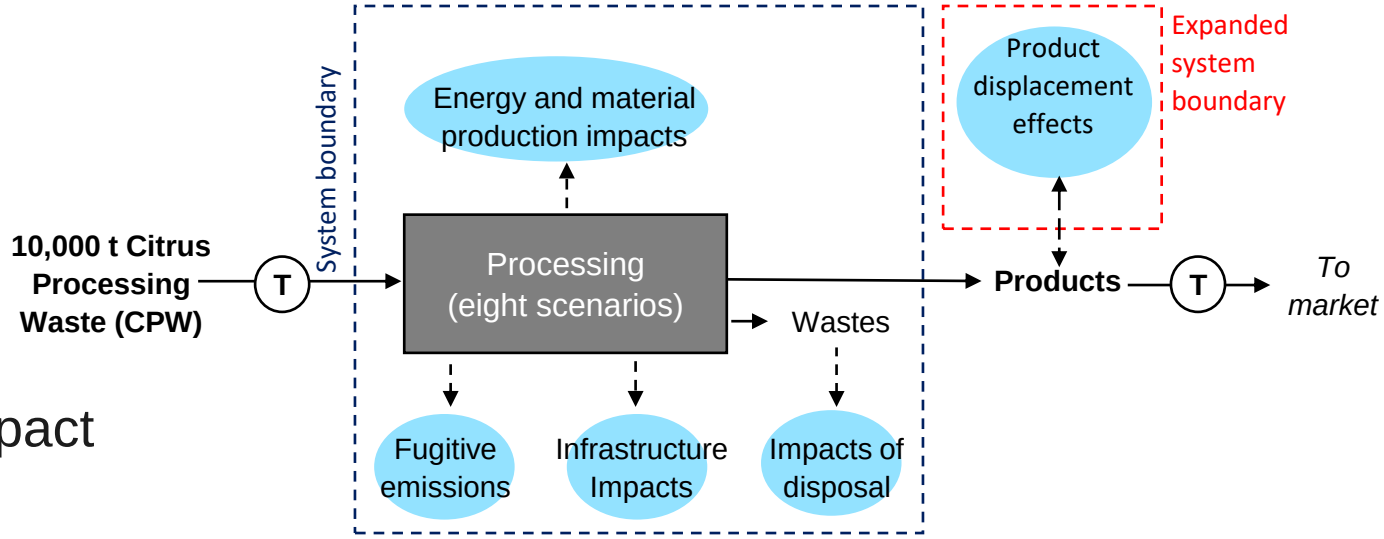
Aim

To compare the relative environmental attributes and ranking of biorefining processes, compared to traditional FLW management options

- Landfilling (disposal/ no recovery)
- Composting
- Feeding to livestock
- Incineration with energy recovery
- Anaerobic digestion
- Solvent extraction of pectin
- Solvent free microwave extraction of essential oil
- Fermentation to produce lactic acid

LCA Key information:

- Consequential LCA
- Partial LCA
- Gate-to-gate system
- Expanded system boundary considered product displacement effects
- Functional unit = 1 tonne of citrus waste
- Initially considered 13 environmental impact categories.

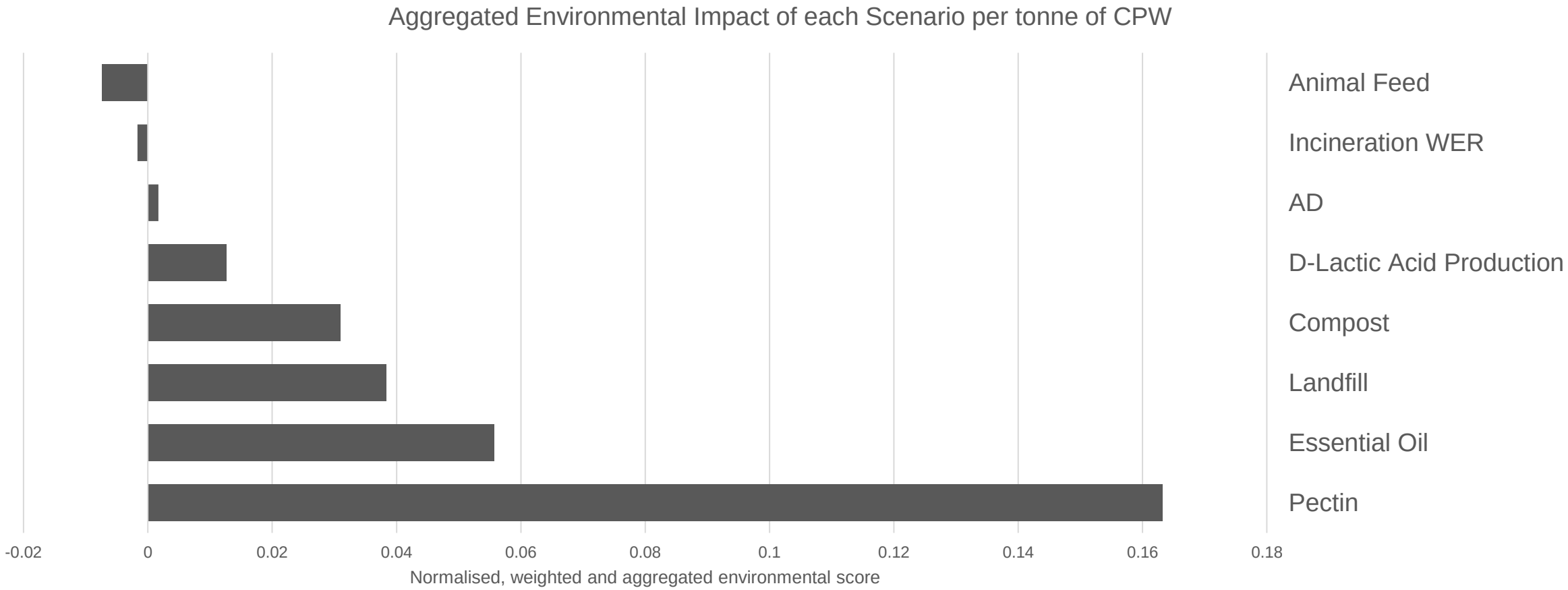


Estimating total impact
(to compare the scenarios)

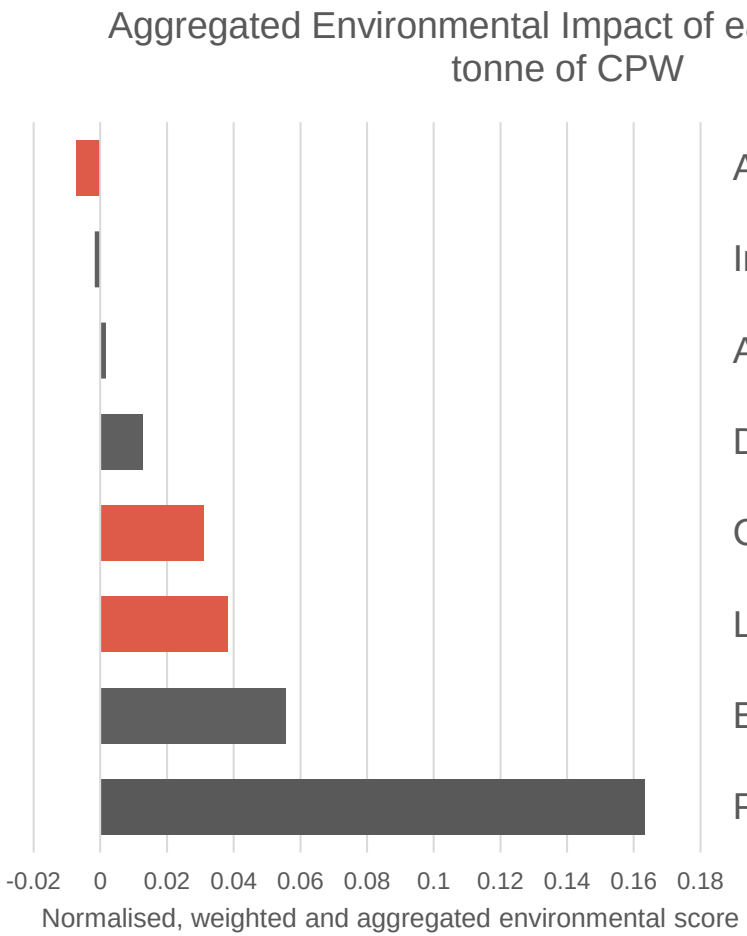
1. Normalised against the annual impacts of a global citizen.
2. Selected significant impact categories.
   - Global warming potential, resource depletion of fossil fuels and elements, eutrophication, acidification.
3. Applied weighting (1)
4. Aggregated

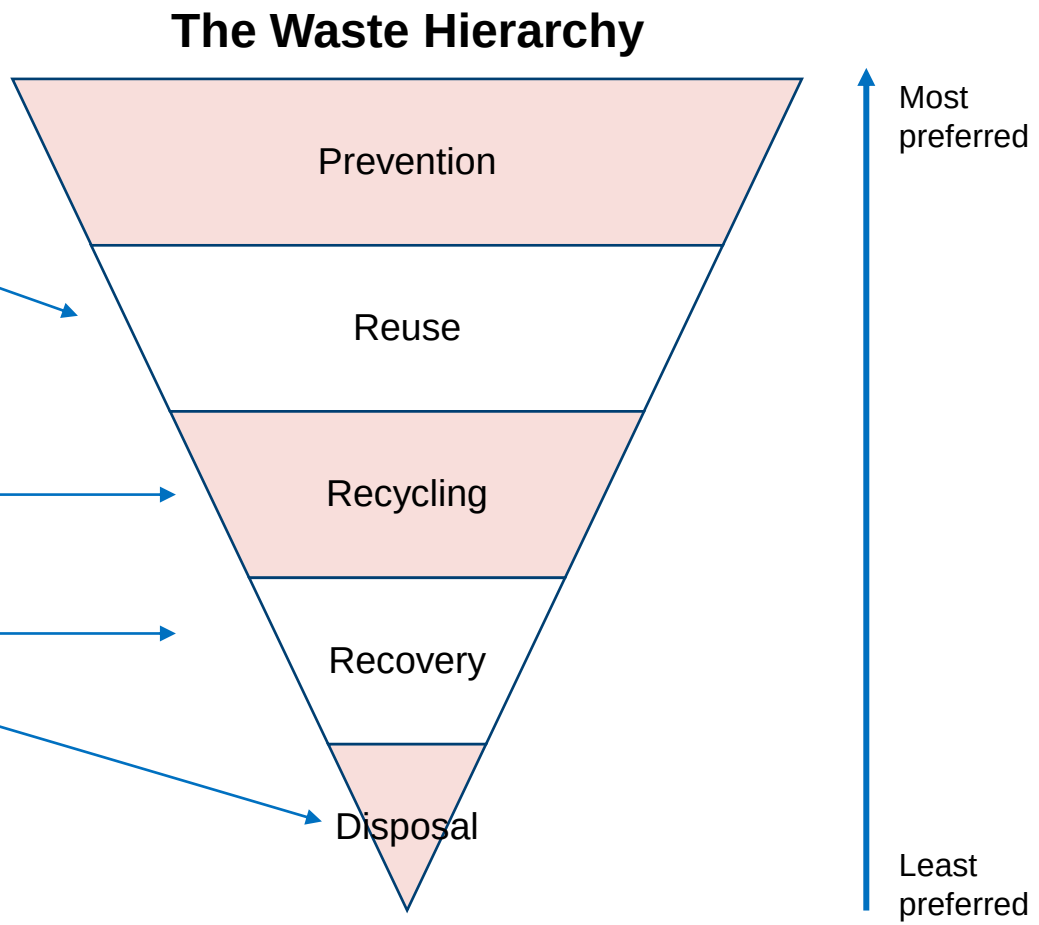
(1) Sala, S., Cerutti, A. K., & Pant, R. (2018). Development of a weighting approach for the Environmental Footprint. European Commission. https://eplca.jrc.ec.europa.eu/permalink/2018_JRC_Weighting_EF.pdf

3. Results

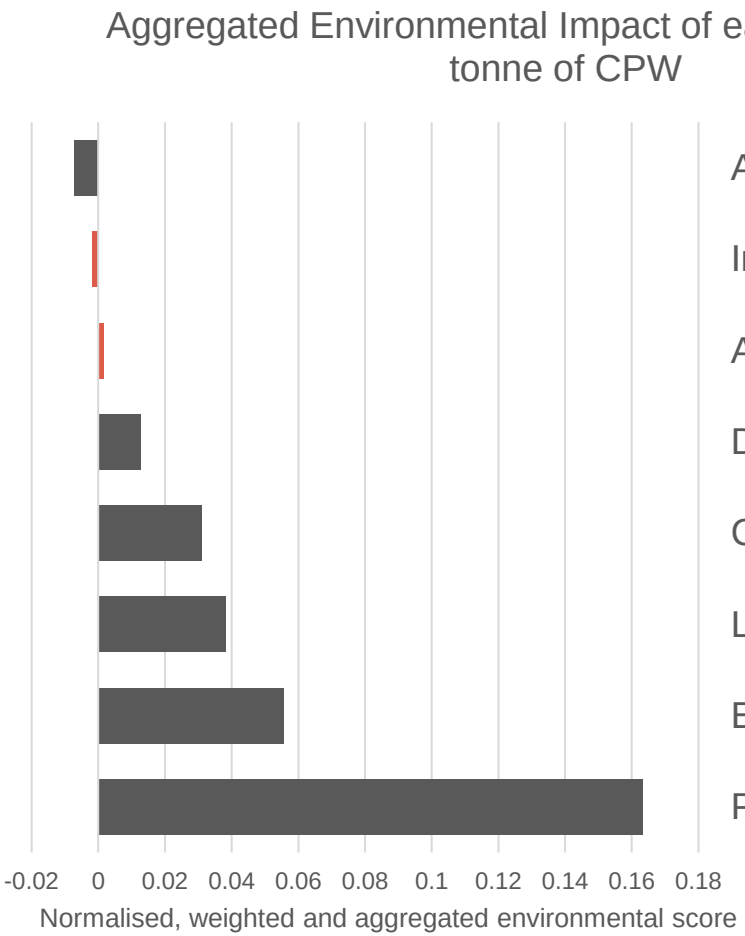


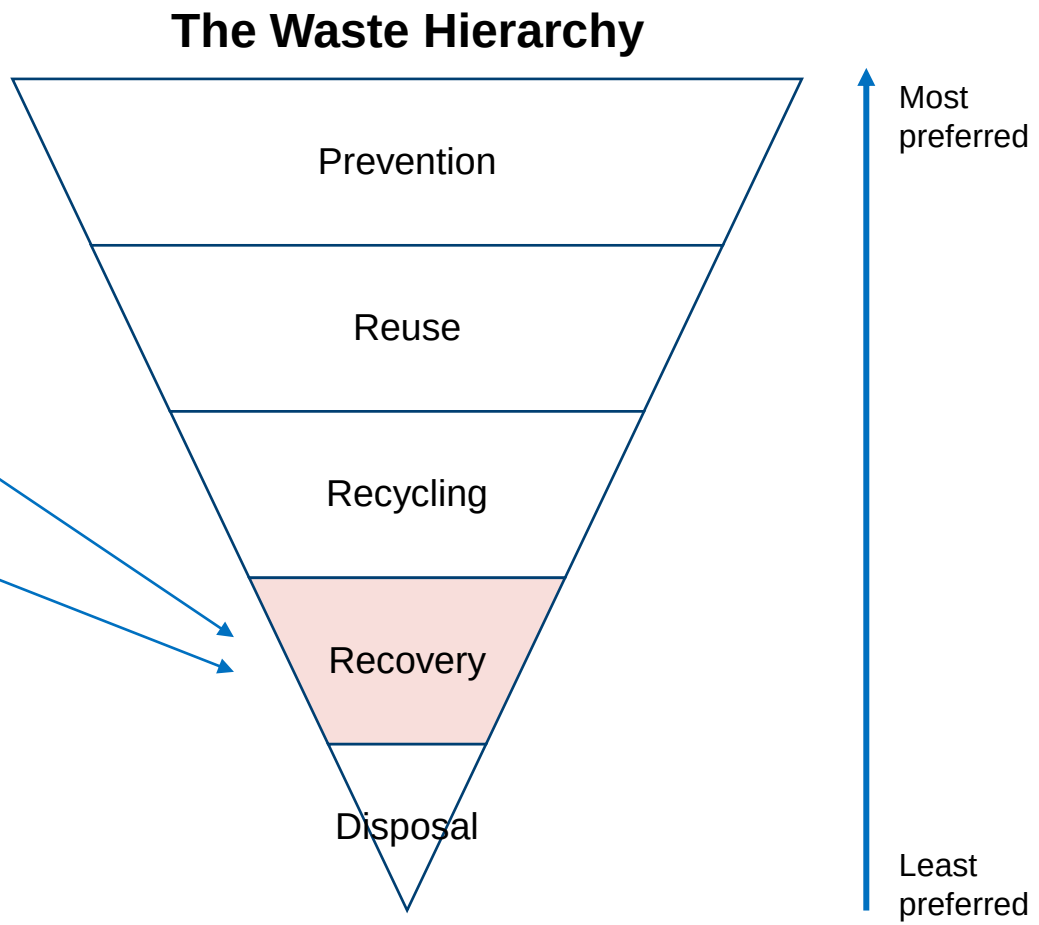
Traditional Management



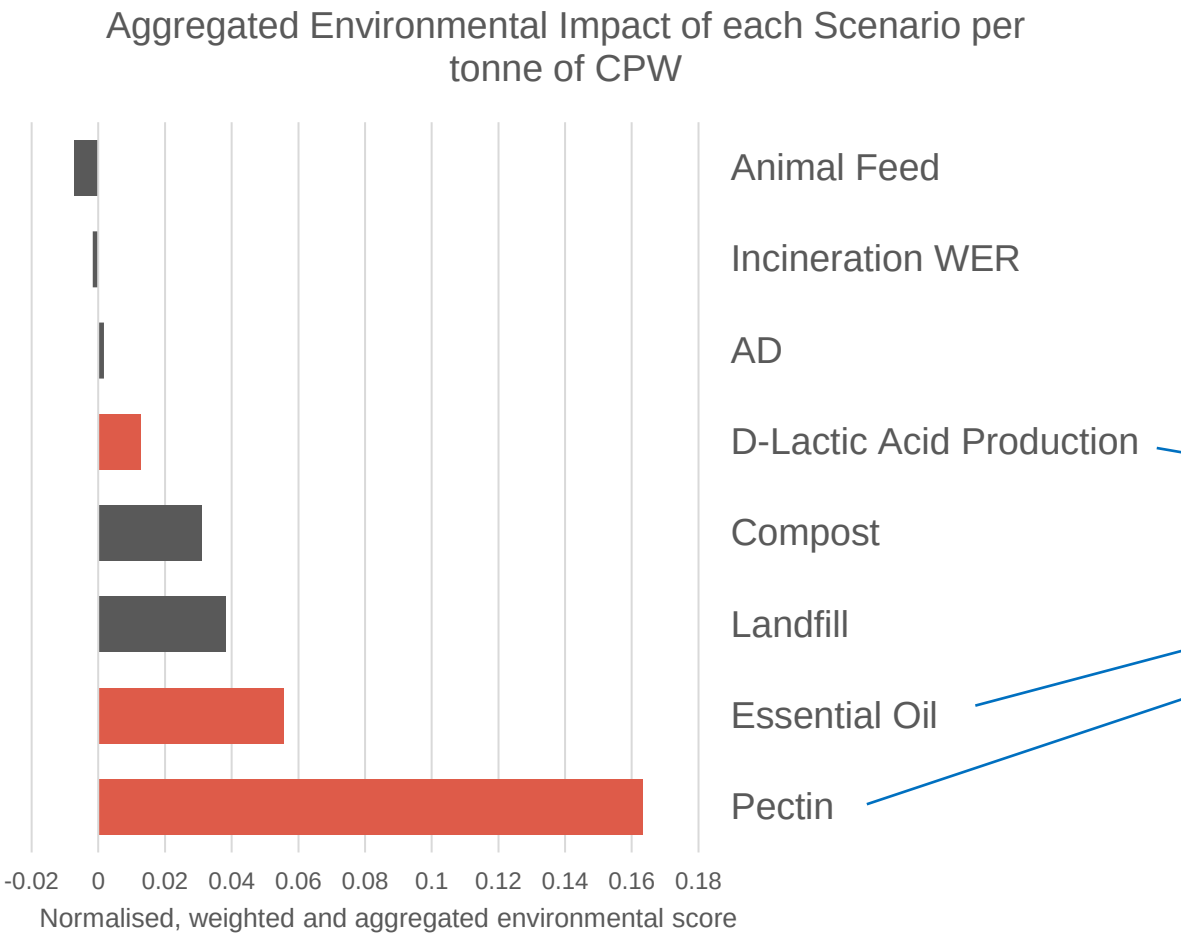


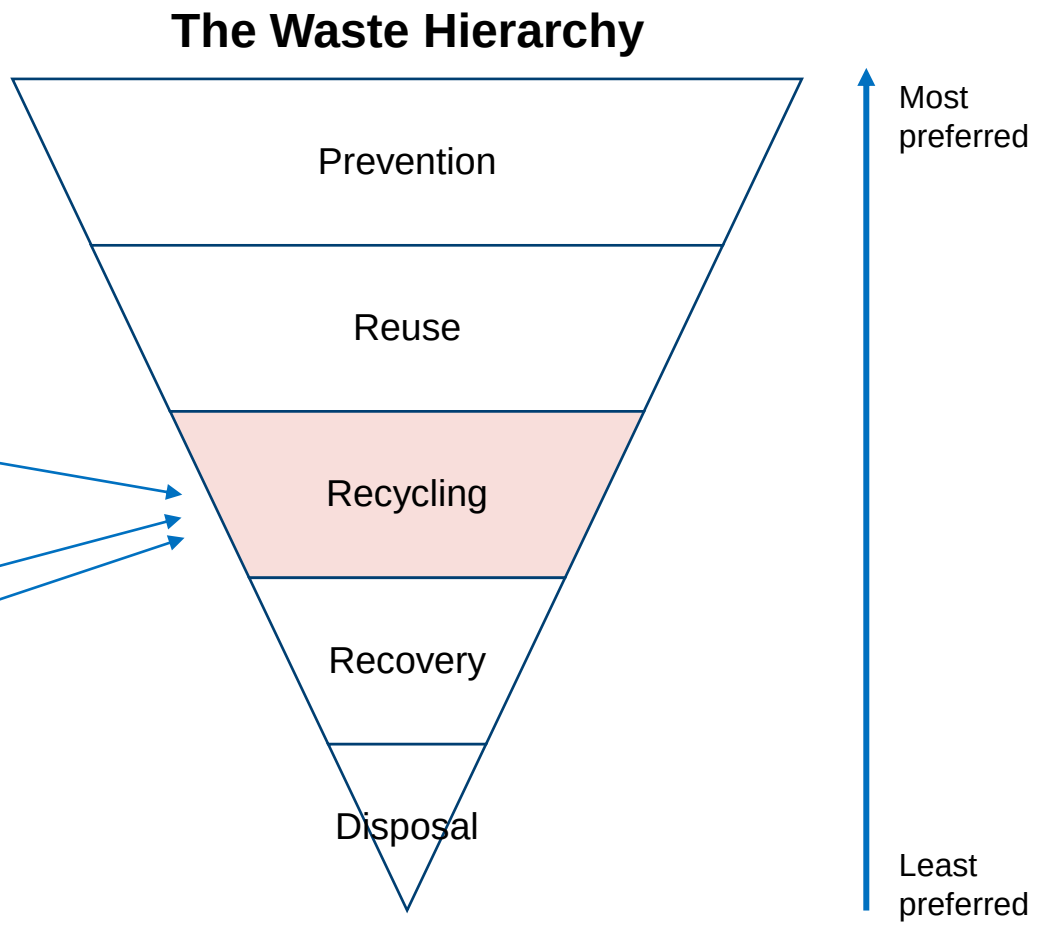
Biorefining energy products





Biorefining non-energy products





4. Key takeaways

1. Many biorefining processes are **novel** (particularly product-driven biorefining).
   - There is opportunity for optimisation (e.g. process improvements, improved yield, cascading systems, better utilisation of food waste feedstocks etc.).

2. Large product displacement effects for non-energy products.

3. When considering product-driven biorefining, there are multiple factors that affect the environmental outcome, that aren't captured in a waste hierarchy.

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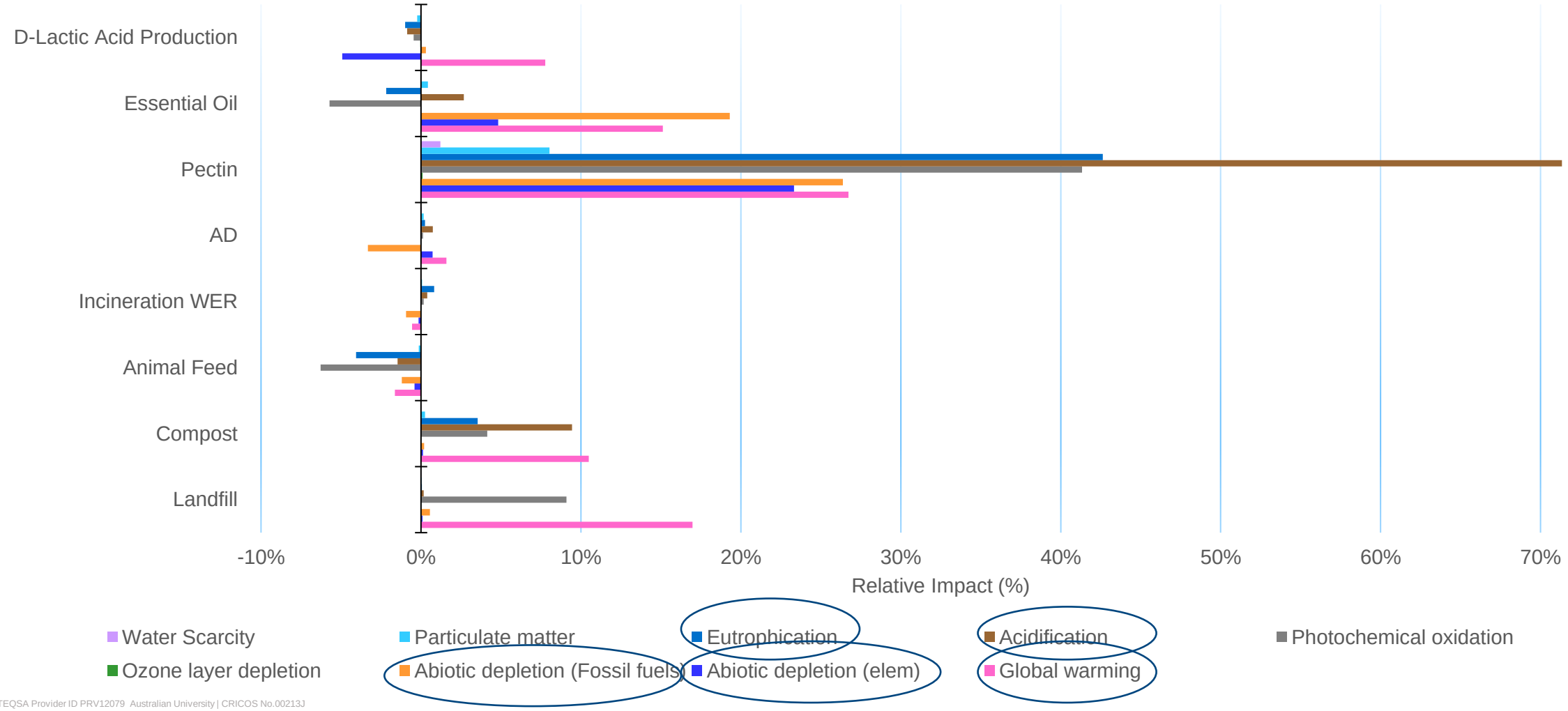
Thank you

Additional slides

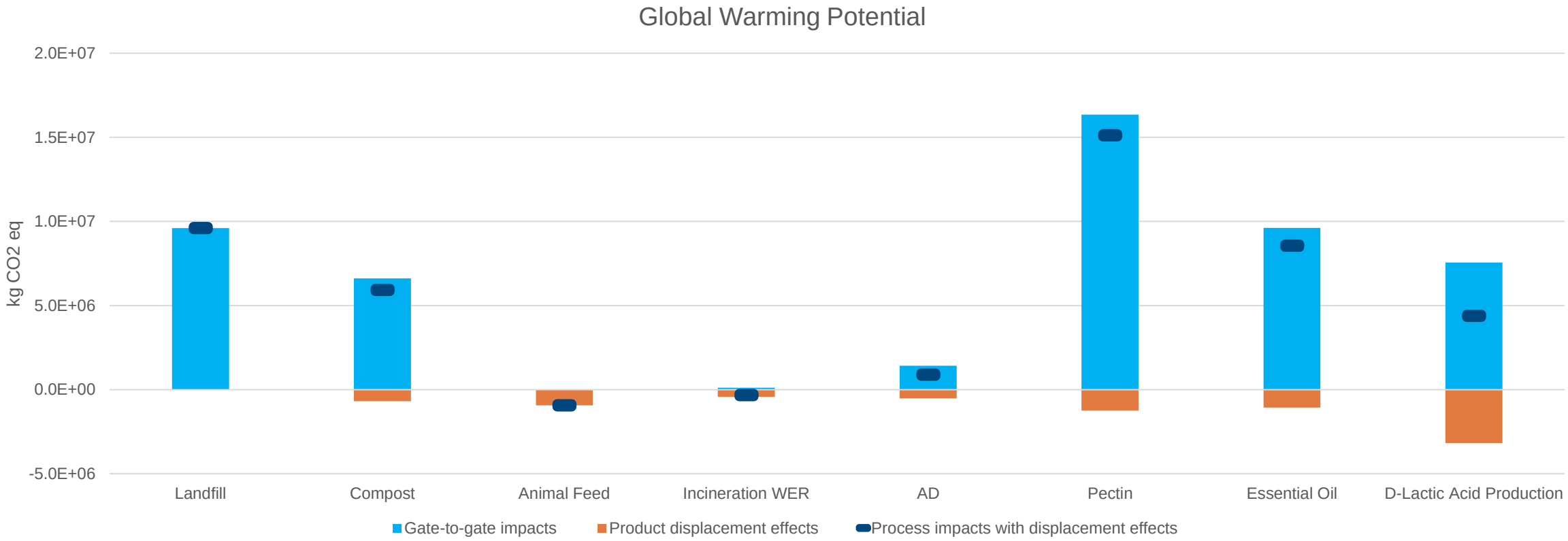
Displaced products

Scenario name		Products	Displaced products (DP)		
			DP1	DP2	DP3
I	Landfilling	None	-		
II	Composting	Compost	Urea	Ammonium nitrate	-
III	Feeding to livestock	CPW animal feed	Soybean meal	Corn gluten meal	-
IV	Incineration with energy recovery	Electricity	Average grid mix	Coal-generated electricity	Solar-generated electricity
		Hot water	Liquid natural gas (LNG)		
V	Anaerobic digestion	Digestate	Urea	Ammonium nitrate	-
		Biogas	Liquid natural gas (LNG)		
VI	Solvent extraction of pectin	Pectin	Modified starch	Gelatine	-
		Hydrosol	Water		
VII	SFME of essential oil	Citrus Oil	Flavours for food and beverage		
		Hydrosol	Water		
		CPW animal feed (after SFME)	Soybean meal	Corn gluten meal	-
VIII	Fermentation to produce lactic acid	Lactic Acid	Lactic acid from traditional production		
		Microbial biomass animal feed	Soybean meal	Corn gluten meal	-

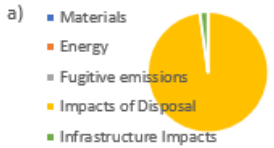
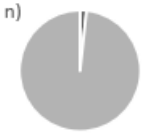
Normalisation and key impact categories



Annual environmental impacts of processing 10,000 tonnes of CPW.



Profile of Impacts

	Landfilling	Composting	Feeding to livestock	Incineration with energy recovery
Processing Impacts	a)  Impact: 3.8%	b)  Impact: 3.7%	Impact: 0%	e)  Impact: 0.1%
Product Displacement Effects	Displacement: 0%	c)  Displacement: 0.6%	d)  Displacement: 0.7%	f)  Displacement: 0.3%
	Anaerobic digestion	**Solvent extraction of pectin**	**SFME of essential oil**	**Fermentation to produce lactic acid**
Processing Impacts	g)  Impact: 1.0%	i)  Impact: 17.5%	k)  Impact: 6.4%	m)  Impact: 4.5%
Product Displacement Effects	h)  Displacement: 0.8%	j)  Displacement: 1.2%	l)  Displacement: 0.8%	n)  Displacement: 3.2%