Fixing the system: why a circular economy for all resources is the only way to solve the plastic problem

Methodology for determining the greenhouse gas impact of packaging consumed in the UK

To understand the greenhouse gas (GHG) impacts of using different materials for packaging within the UK, an impact measurement analysis of the global packaging supply chain for each material was conducted. The results presented in this report are based on extended input-output modelling to assess the GHG impacts of using different packaging materials across the entire global supply chain ('from cradle to gate'). Results have been calculated in traditional metrics (eg kgCO2e). This approach has been chosen over a traditional lifecycle assessment approach as it provides a way of analysing an entire system with a consistent set of assumptions.

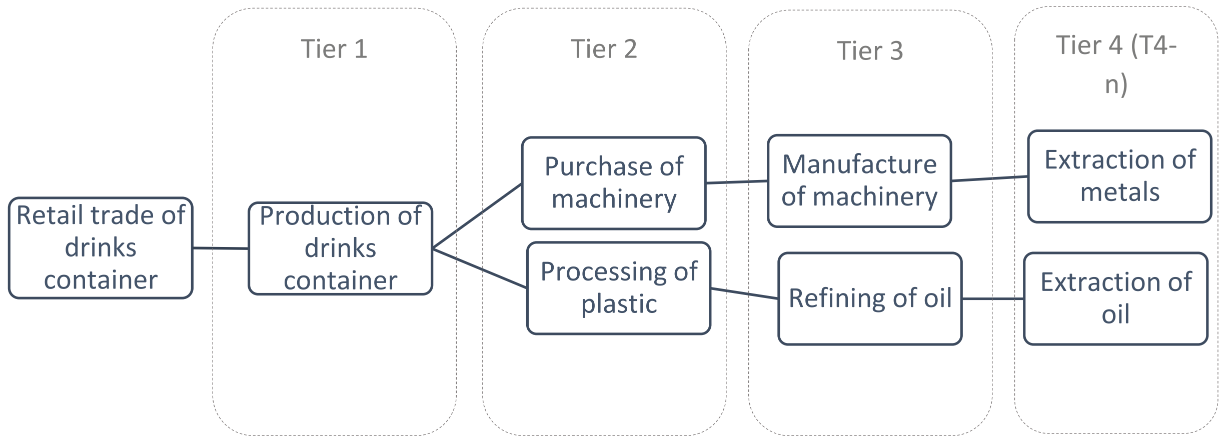
Five packaging materials, aligned with the Department for Environment, Food and Rural Affairs' (Defra) national packaging compliance scheme categorisation of packaging materials, have been analysed:[1]

- Paper
- Plastic
- Aluminium
- Steel
- Glass

Estimating GHG impacts of packaging materials throughout the supply chain

We were interested in UK demand for packaging materials and the consequences of that demand globally, with respect to GHG emissions. To calculate this impact, we first compiled tier 1 spend data on packaging in the UK, analysing how much each sector spent on packaging materials.

Economic input output (IO) modelling was then used to model the flow of money through the supply chain, beyond the direct spend on packaging materials. For each pound spent by the demand sectors on a given material, the IO model estimates where (in terms of sectors and countries) that spending generates economic activity. This represents the packaging supply chain for that sector. IO models are based on average inter-industry economic flow data. The IO model used for this analysis was Exiobase version 3.[2]



IO models are commonly extended to consider environmental or socioeconomic indicators to investigate a wide range of sustainability-related impacts and risks associated with a company's direct operations and its supply chain. This requires a set of 'extensions' which describe the average intensity of environmental or social impact in each country and sector, per unit of economic activity generated (eg kgCO_2e/£ of economic output). For the purpose of this report we have used the GHG extensions, which are part of the Exiobase 3 model.

We then aggregated the supply chain GHG impacts by material type, to show three key outputs:

- Environmental impacts for the total UK spend on packaging in 2018
- Environmental impacts per kg of material used
- Environmental impact per functional unit (500 ml bottle)

GHG impact of total UK spend on packaging

We found that the UK spent an estimated £18 billion on packaging in 2018.[3] We have allocated that spend across each of the materials being analysed according to global market research and Defra compliance scheme data.[4,5] The global percentage allocation of material used for packaging has been taken as a proxy for the UK percentage allocation of materials used for packaging.

	% market share	
Material	**Virgin**	**Recycled**
Paper	7.70%	37.58%
Plastic	31.63%	3.51%
Aluminium	4.89%	3.13%
Steel	1.88%	2.82%
Glass	4.40%	2.48%
Total	50.49%	49.51%

The allocation between virgin and recycled materials for paper, aluminium, steel and glass has been taken from the Valpak PackFlow 2017 report.[6] The breakdown for plastic recycled and virgin materials was not included within the report and was, therefore, taken from WRAP's *The UK Plastics Pact Roadmap* report'.[7]

Material	% recycled	% virgin
Paper	83%	17%
Plastic	10%	90%
Aluminium	39%	61%
Steel	60%	40%
Glass	36%	64%

GHG impact per kilogram of each packaging material used

The environmental impact per kg amount is the extent of the environmental impact caused for the use of one kilogram of each of the packaging materials.

To calculate this, a price per tonne has been extracted for each packaging material used to calculate how many kg of the material could be purchased in 2018. For most materials, the average price per tonne of each recycled material has been estimated to be the same as the virgin material since the values for both are already hard baked within the split of relationships in Exiobase. For example, the economic interaction being modelling is between the food company and the packaging provider, not between the packaging provider and the material provider. For plastic, these prices have been separated out, given the unique way that plastic is purchased within the market.

Material	Estimated £/tonne
Paper	806
Plastic (virgin)	3,287
Plastic (recycled)	700
Aluminium	2,818
Steel	581
Glass	419

GHG impact per functional unit: 500ml bottle

Although the impact per kg is a useful metric it doesn't give a picture of the greenhouse gas impacts per product used. In many cases for individual products the weight of each material required to produce the product will vary greatly. Therefore, the impact per functional unit provides a practical way to compare impacts between materials.

For the purpose of this analysis, a 500ml bottle has been taken as an example functional unit. The per kg impacts have been multiplied by the weight required to produce each item to give an environmental impact per functional unit. The weight of a 500ml container for each material have been taken from Simon et al (2016).[8]

Material	Weight per 500ml volume of package beverage (kg)
Aluminium	0.020125
Plastic	0.01735
Glass	0.4275

The results presented show the GHG impact using the current mix of recycled materials. The current mix between virgin and recycled materials have been estimated from various sources, specific to the 500ml bottle and, therefore, differs from the industry wide averages presented above.

Material	% recycled	% virgin	Source
Paper	0.00%	100.00%	General
Plastic	16.00%	84.00%	WRAP[9]
Aluminium	67.80%	32.20%	EPA[10]
Steel	32.70%	67.30%	EPA[11]
Glass	35.60%	64.40%	Valpak[12]

The unintended consequences of a switch away from plastic

We have also considered how the GHG impact would change if a tonne of plastic packaging was simply replaced on a like for like basis to the for the other materials currently used for packaging in the UK. We have taken the current market share of packaging use in the UK market, and reallocate the materials according to the weight that would be required to make an equivalent product, using the 500ml bottle as a proxy. Switching all current consumption of plastic packaging on a like for like basis, to the other materials currently used for packaging in the UK could almost triple associated carbon emissions from 1.7 billion tonnes CO_2e to 4.8 billion tonnes CO_2e. This is based on current production methods and levels of recycled content, so the dynamics could change if other materials decarbonised their production methods or increased their use of recycled content.

This research does not suggest we should be continuing to use plastic as we have done, especially given the risk that plastic production will increase and the well documented impacts of plastic pollution. Addressing the root problems of our throwaway culture should be the starting point, not only to prevent plastic pollution but to reduce material use, impacts and waste across the economy.

Endnotes

[1] Defra, 2018, *National packaging waste database*
[2] Exiobase Version 3, www.exiobase.eu/index.php/about-exiobase
[3] PwC, 2020, *analysis on: The future of global packaging to 2022 (Smithers Pira)*
[4] All 4 Pack, 2018, *Worldwide packaging*, available at: www.all4pack.com/Media/All-4-Pack-Medias/Files/FicheMarche_Emballage_Monde
[5] DEFRA, 2018, *National packaging waste database*

[6] Valpak, 2017, *PackFlow 2017*, available at: www.valpak.co.uk/docs/default-source/environmental-consulting/packflow_2017.pdf

[7] WRAP, 2019, *The UK Plastics Pact: a roadmap to 2025*, available at: www.wrap.org.uk/sites/files/wrap/The-UK-Plastics-Pact-Roadmap-v3.pdf

[8] B Simon et al, 2016, *Life cycle impact assessment of beverage packaging systems: focus on the collection of post-consumer bottles*

[9] WRAP, 2019, *The UK Plastics Pact: a roadmap to 2025*, available at: www.wrap.org.uk/sites/files/wrap/The-UK-Plastics-Pact-Roadmap-v3.pdf

[10] US Environmental Protection Agency, 2016, *Documentation for greenhouse gas emission and energy factors used in the waste reduction model*, available at: www.epa.gov/sites/production/files/2016-03/documents/warm_v14_containers_packaging_non-durable_goods_materials.pdf

[11] Ibid

[12] Valpak, 2017, *PackFlow 2017*, available at: www.valpak.co.uk/docs/default-source/environmental-consulting/packflow_2017.pdf