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Grantham Centre for Sustainable Futures

Towards Sustainability… but how?

Professor Rachael Rothman
Co-Director Grantham Centre for Sustainable Futures
University of Sheffield

Help Transform Tomorrow.

I-SEE Seminar • 8th February 2022


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Centre
for Sustainable Futures
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Grantham Centre for Sustainable Futures

Initially…

- A doctoral training centre with funded scholarships – all students had two supervisors from different faculties

Now…

- Grantham scholars receive an additional 3 months funding to cover the time they spend doing sustainability related training
- Develop and coordinate multi- and inter-disciplinary projects related to sustainability

Mary, Suma and Reena at COP26

Desert Gardens

Hydroponics in Zaatari Refugee Camp

Prof Tony Ryan & Prof Duncan Cameron

PPE for Refugees

PPE & Refugees: dealing with a crisis by building livelihoods

Participatory Action Research with UNHCR, Al al Byt & Petra

Professor Tony Ryan

GCRF/Newton Fund £800k

H3

Global Food Security

UKRI £15 m

Profs Peter Jackson & Duncan Cameron with a host of Grantham PhD supervisors

Many Happy Returns (for plastic packaging)

Reusable packaging systems with industry, food production and retail stakeholders

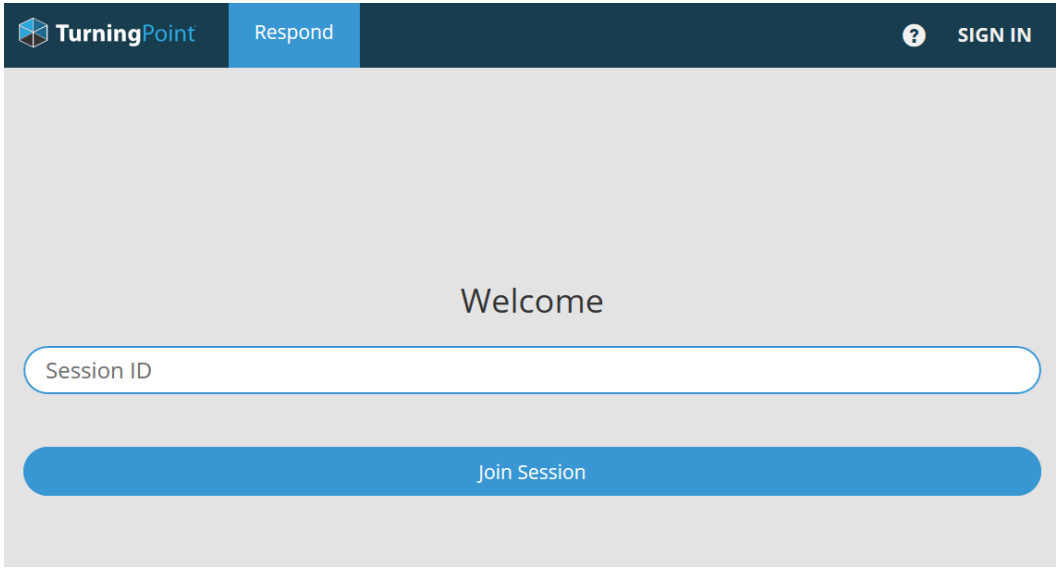
Prof Tom Webb

NERC £1.2 m

Using your laptop/tablet/smart phone, go to the website:

ttpoll.eu

(please note the .eu and NOT .com)



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Yesterday I made salad to go with lunch. Which would be the more sustainable choice: tomatoes from Spain or tomatoes from the UK?

A. Spain

B. UK

Which is more sustainable: fizzy drinks in a PET bottle or fizzy drinks in a Bio-PET bottle?

A. PET

B. Bio-PET

ffPET, fbPET, bfPET and bbPET

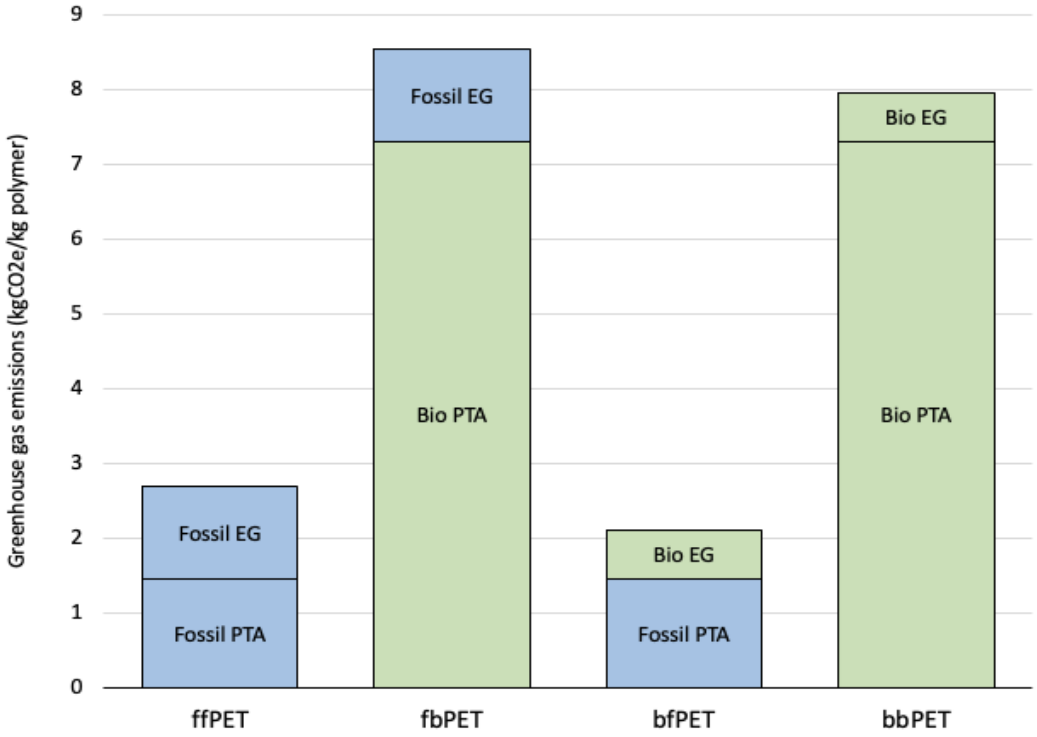
PET

Ethylene Glycol (EG): 30%

Purified Terepthalic Acid (PTA): 70%

ffPET:	fbPET:	bfPET:	bbPET:
Fossil EG	Fossil EG	Bio-based EG	Bio-based EG
Fossil PTA	Bio-based PTA	Fossil PTA	Bio-based PTA

ffPET, fbPET, bfPET and bbPET



- Material and manufacture emissions (no end of life)

Which is more sustainable: a bottle of still water or a can of still water?

A. bottle

B. can

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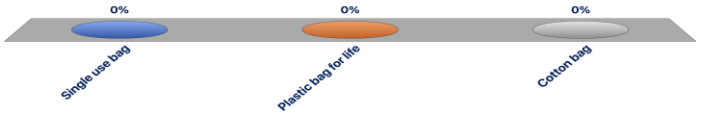
Which is more sustainable: a bottle of Buxton sparkling water or a bottle of Badoit sparkling water?

A. Buxton
B. Badoit

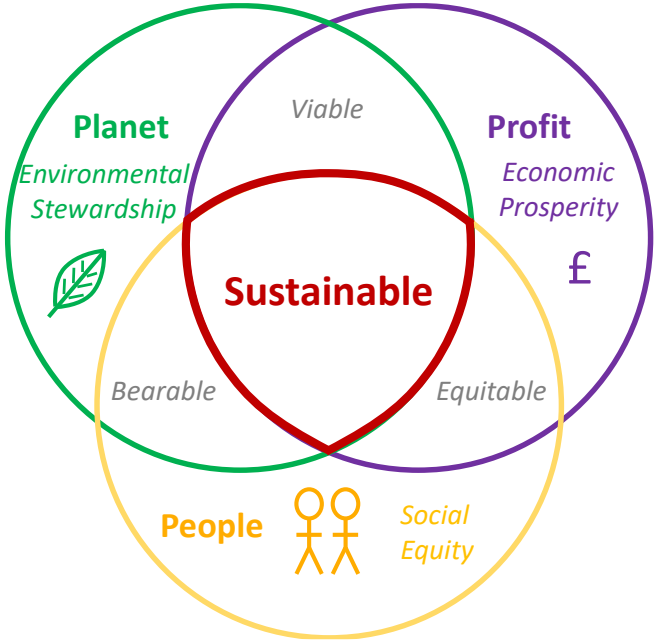
Which is more sustainable: a single use carrier bag, a plastic bag for life or a cotton bag?

A. Single use bag
B. Plastic bag for life
C. Cotton bag



Sustainability

- A process or product is only sustainable if it is environmentally, socially and economically sustainable
- Sustainability is a balance between these different tensions



Sustainable Development Goals

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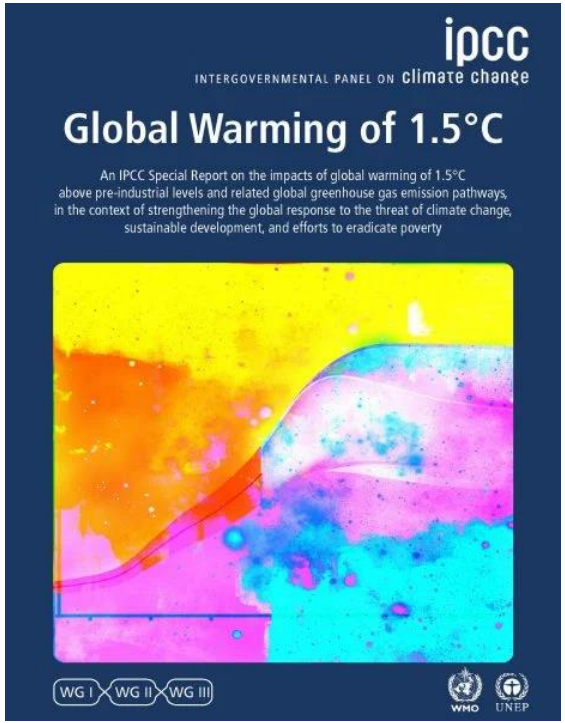
Net Zero



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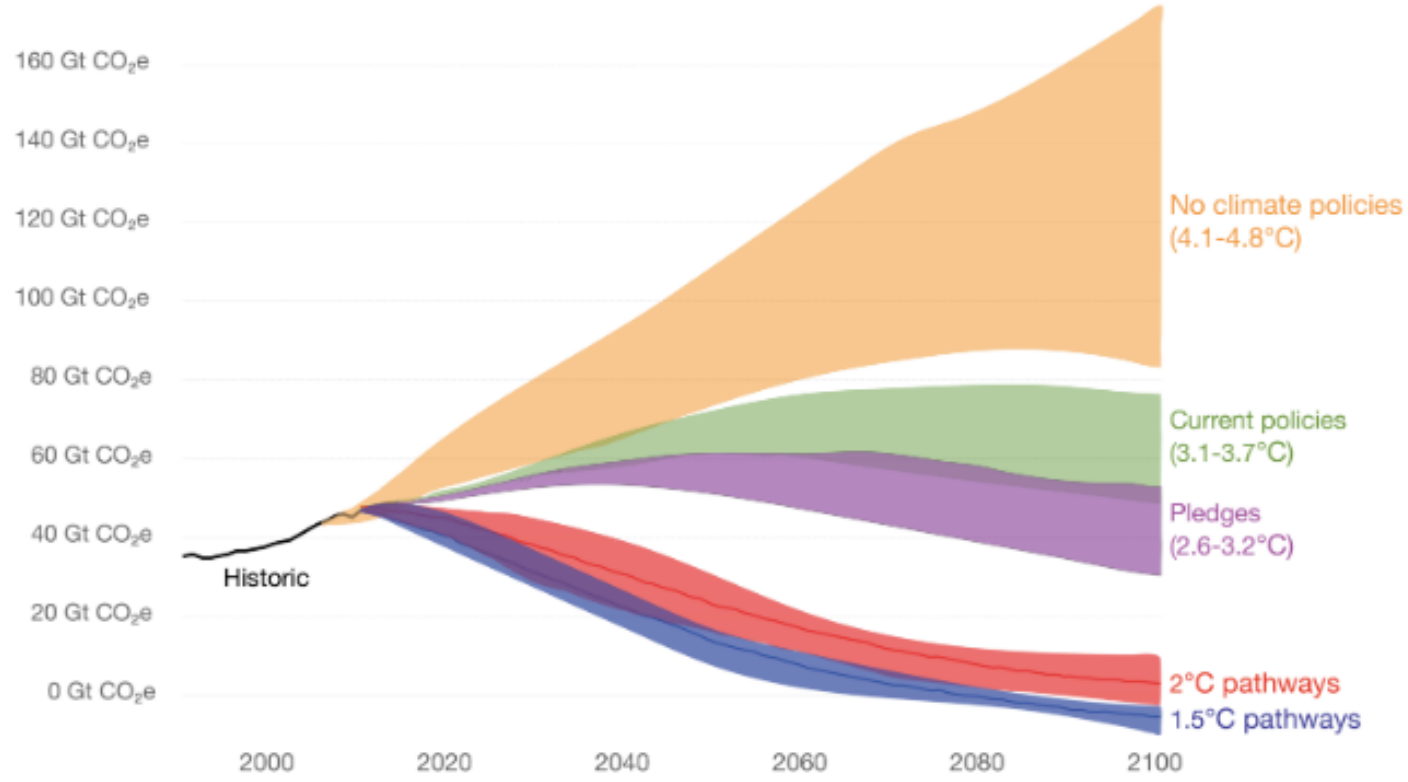
Global greenhouse gas emissions scenarios

Our World in Data

Potential future emissions pathways of global greenhouse gas emissions (measured in gigatonnes of carbon dioxide equivalents) in the case of no climate policies, current implemented policies, national pledges within the Paris Agreement, and 2°C and 1.5°C consistent pathways. High, median and low pathways represent ranges for a given scenario. Temperature figures represent the estimated average global temperature increase from pre-industrial, by 2100.



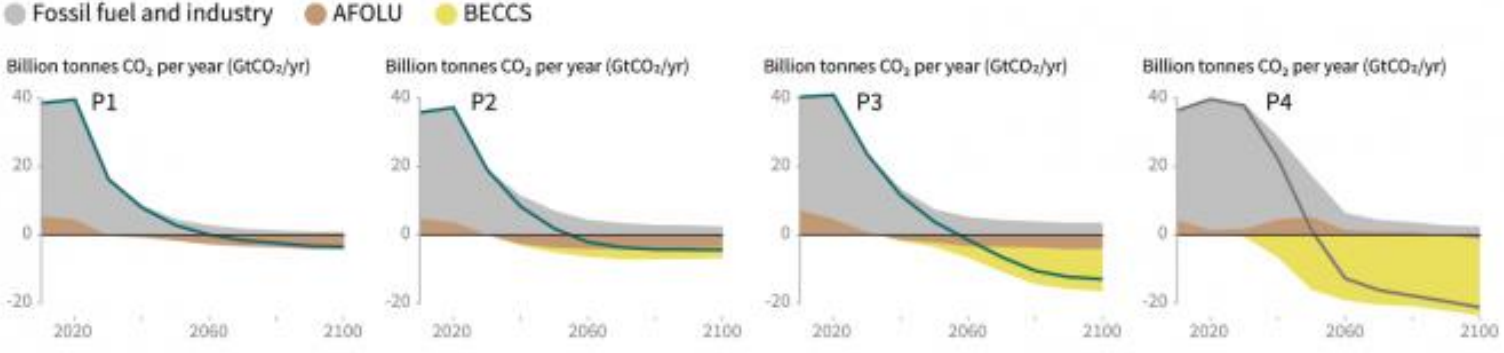
Based on data from the Climate Action Tracker (CAT).
The data visualization is available at OurWorldinData.org. There you find research and more visualizations on this topic.

https://www.ipcc.ch/sr15/

Characteristics of four illustrative model pathways

Different mitigation strategies can achieve the net emissions reductions that would be required to follow a pathway that limits global warming to 1.5°C with no or limited overshoot. All pathways use Carbon Dioxide Removal (CDR), but the amount varies across pathways, as do the relative contributions of Bioenergy with Carbon Capture and Storage (BECCS) and removals in the Agriculture, Forestry and Other Land Use (AFOLU) sector. This has implications for emissions and several other pathway characteristics.

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



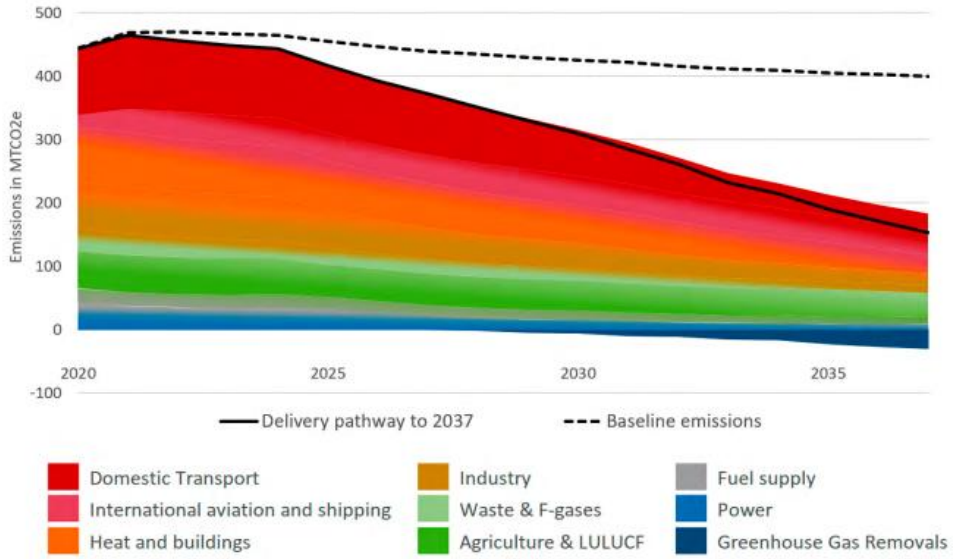
P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

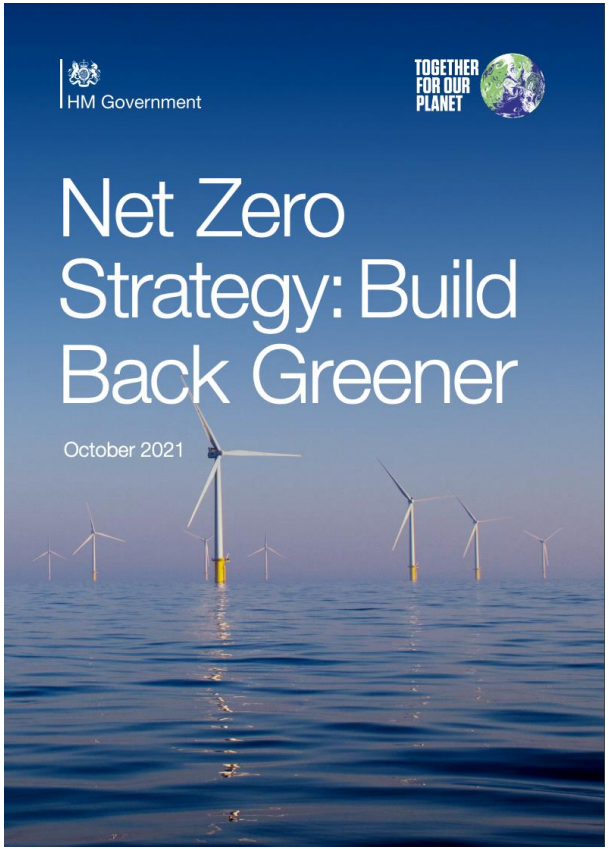
P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

UK: Net Zero by 2050



Source: BEIS Analysis (2021)



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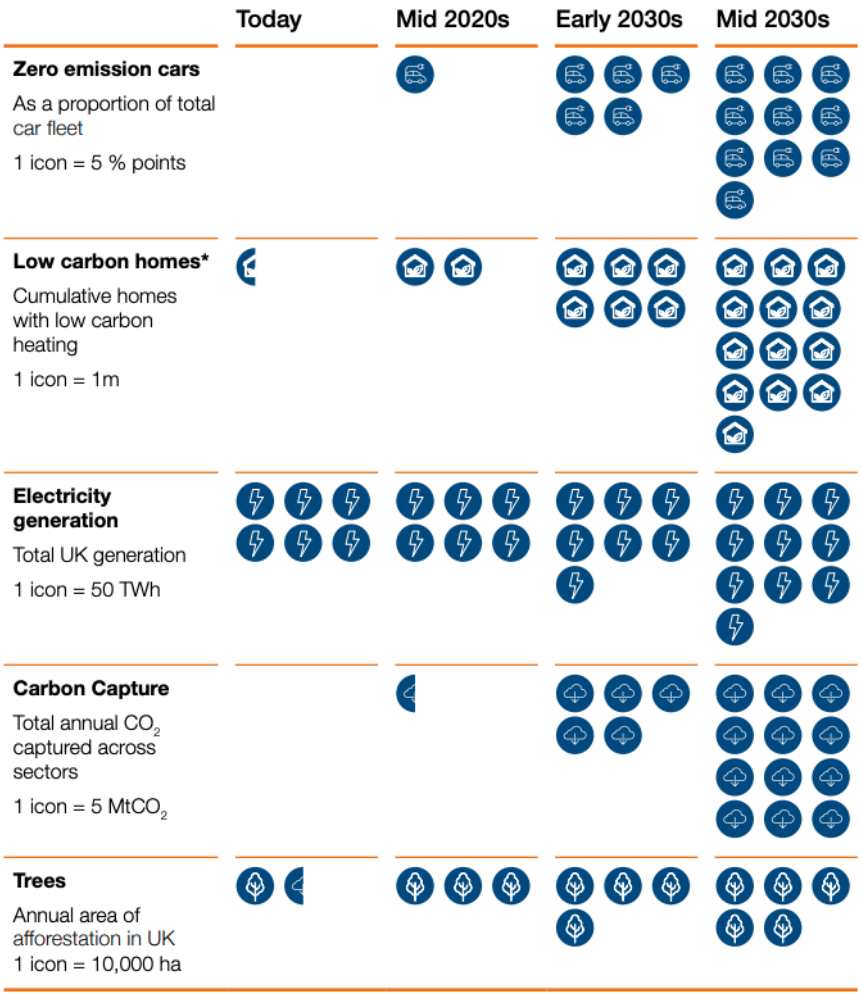
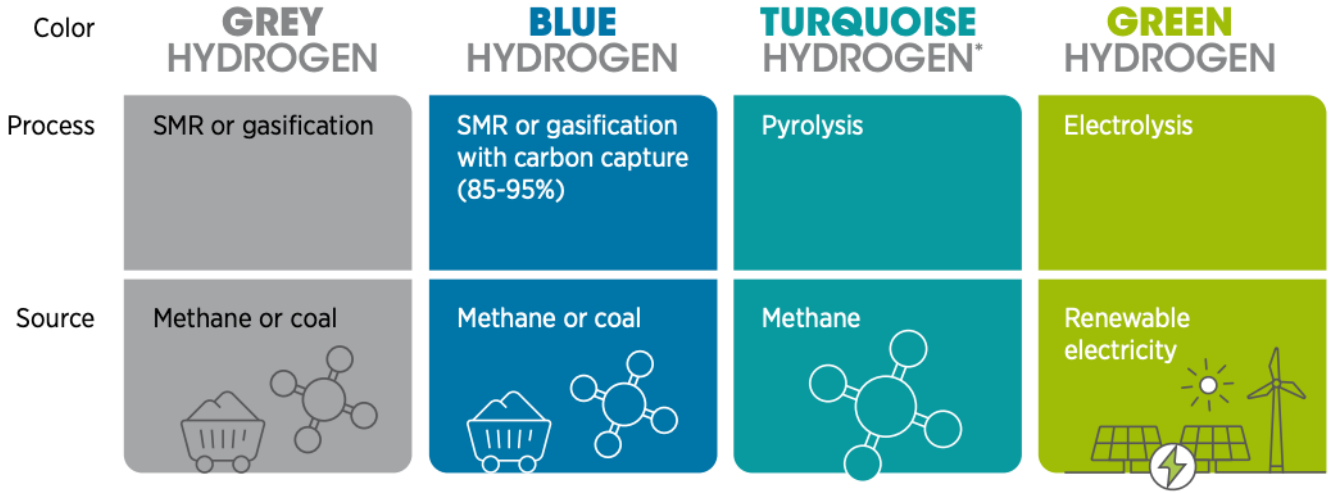


Note: For illustrative purposes, icons represent approximate and rounded figures from our modelling. Where there are ranges, an approximate central point has been shown.
** Homes with low carbon heating includes homes heated by heat pumps, hydrogen or connected to heat networks*



Source: International renewable Energy Agency

Note: SMR = steam methane reforming.
** Turquoise hydrogen is an emerging decarbonisation option.*

GHG footprint ~10% less than grey H2

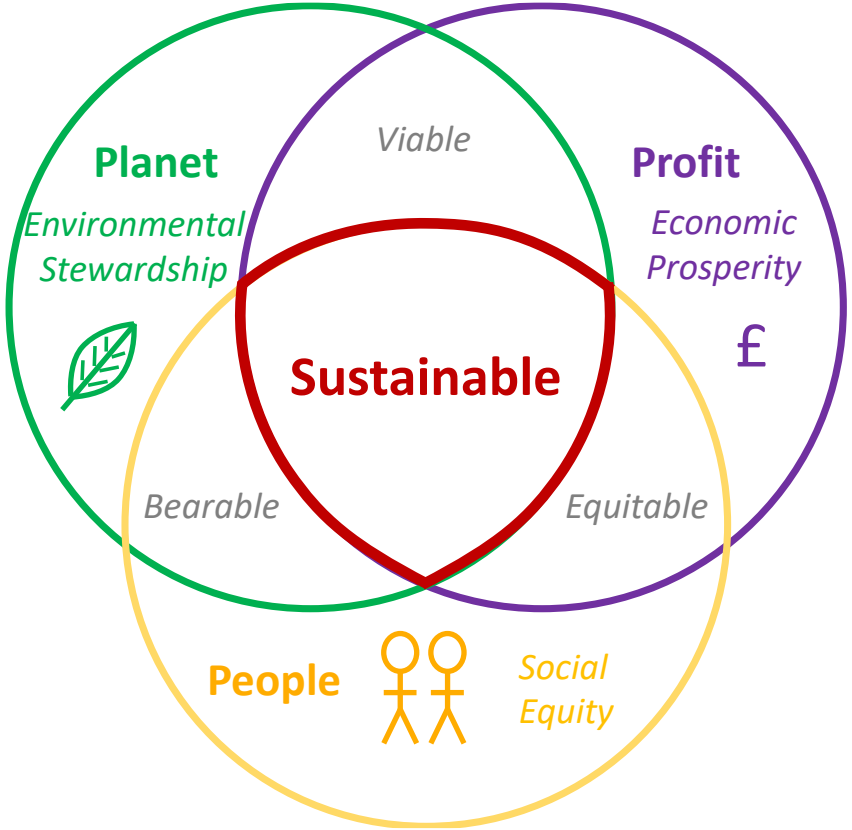
GHG footprint is >20% greater than burning natural gas for heat

Source: Howarth and Joacobson, 2021, How green is blue hydrogen? *Energy Science & Engineering*

Ultimately, green hydrogen is needed:

- Will require an enormous amount of renewable electricity
- Requires large scale manufacturing & deployment of electrolyser technology

How do we measure sustainability?



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Stuart

Are bioplastics really green?

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All current polymers *could* be made from bio feedstocks

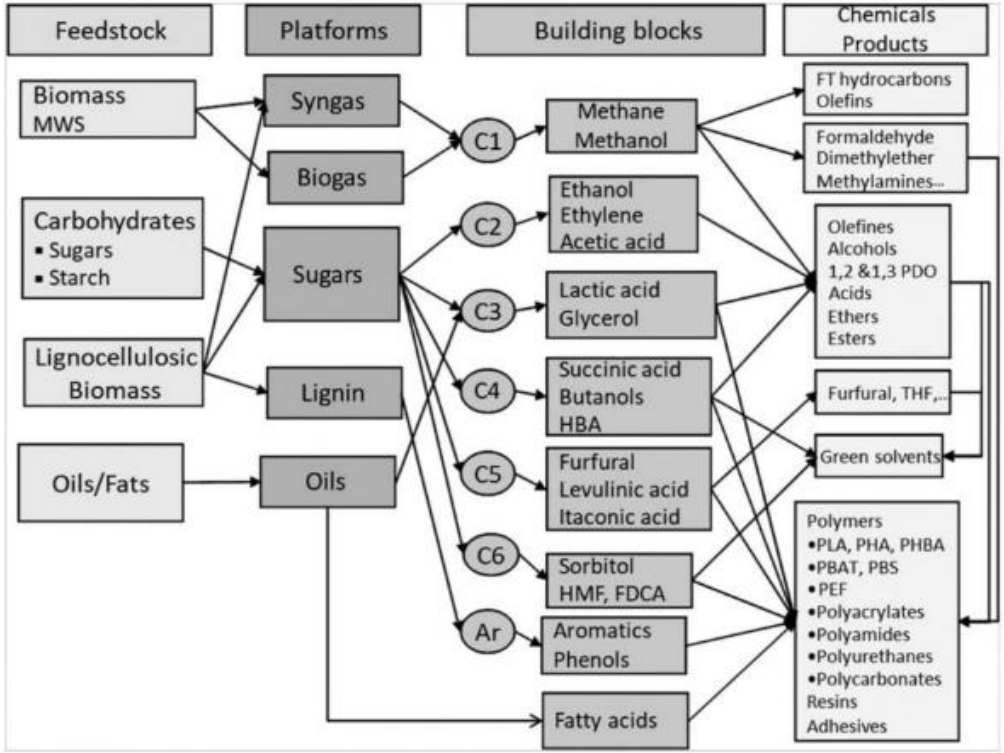
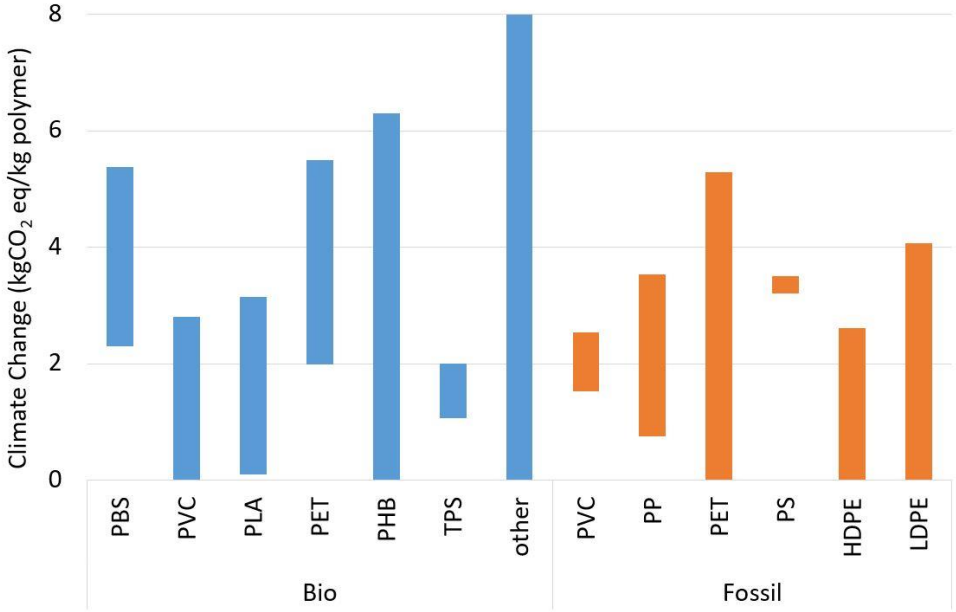


Figure 1.6 Building blocks for organic synthesis in biorefineries.

https://doi.org/10.1016/C2015-0-06856-3

Literature Review of Bioplastic compliance with Product Environment Footprint (PEF) Method

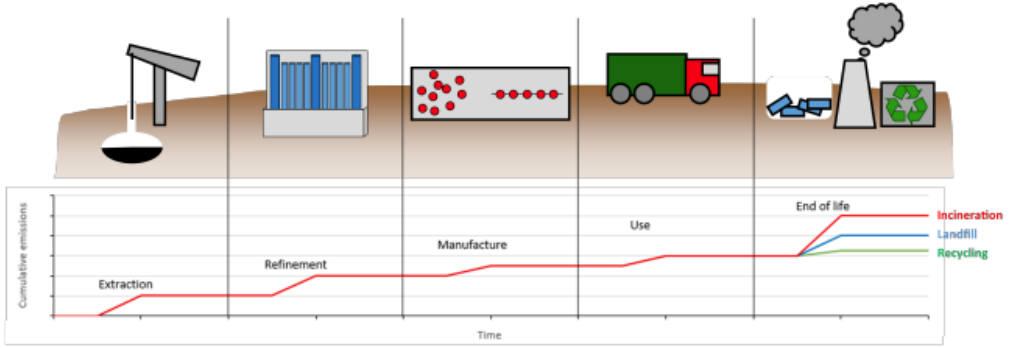
- None of the studies reviewed fully complied
- Large variation in results for same polymer
- Not possible to identify a best performing polymer or type (bio or fossil) in any category
- Variation of 400% in some categories!

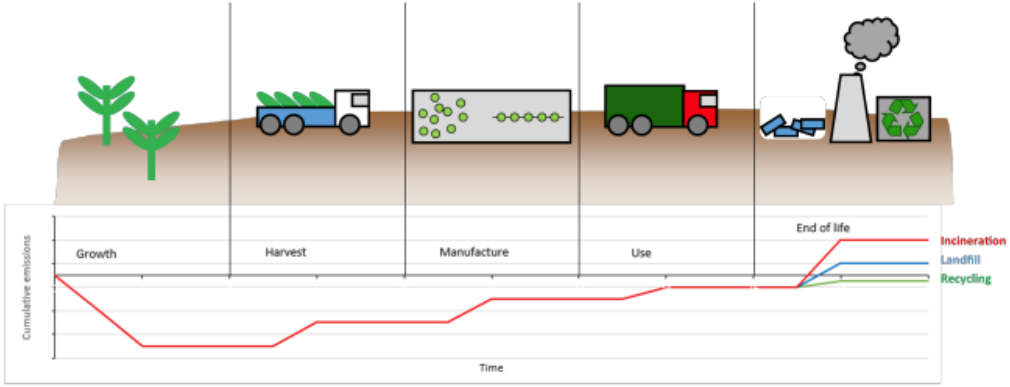


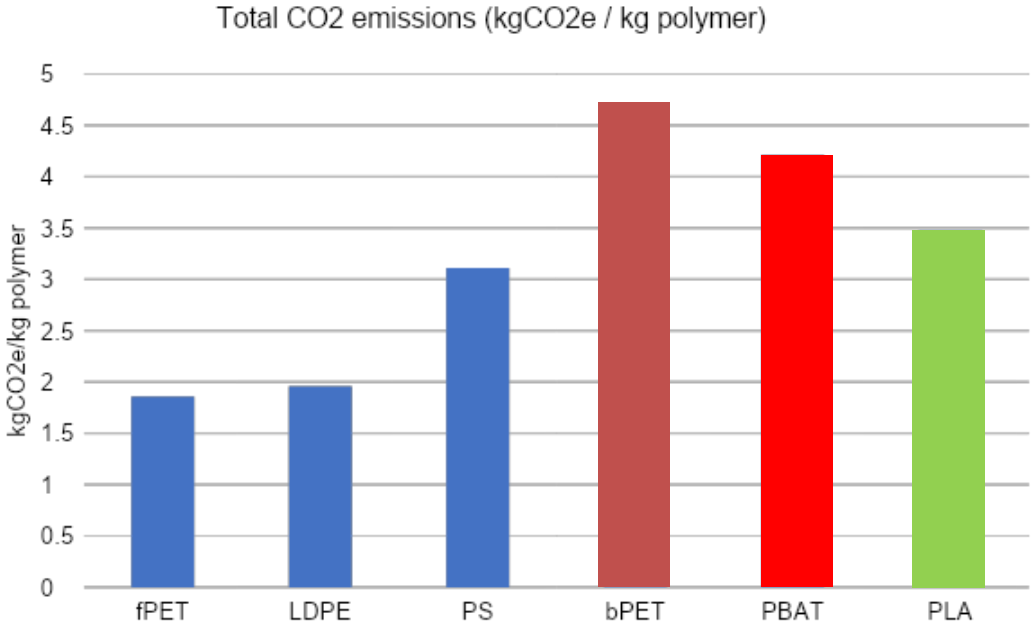
Walker & Rothman, 2020, *J Cleaner Production* 121158

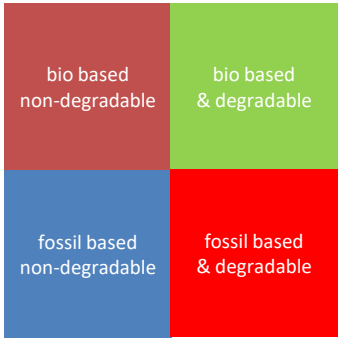
We encourage LCA practitioners to adopt the PEF method

Fossil v bio-based plastics



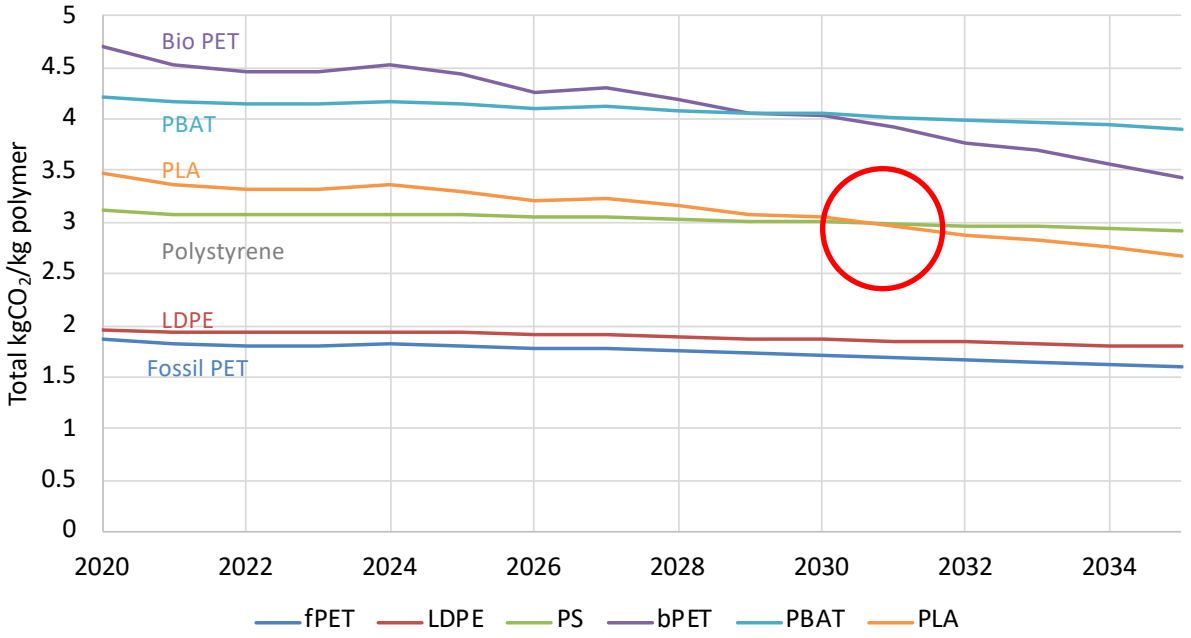




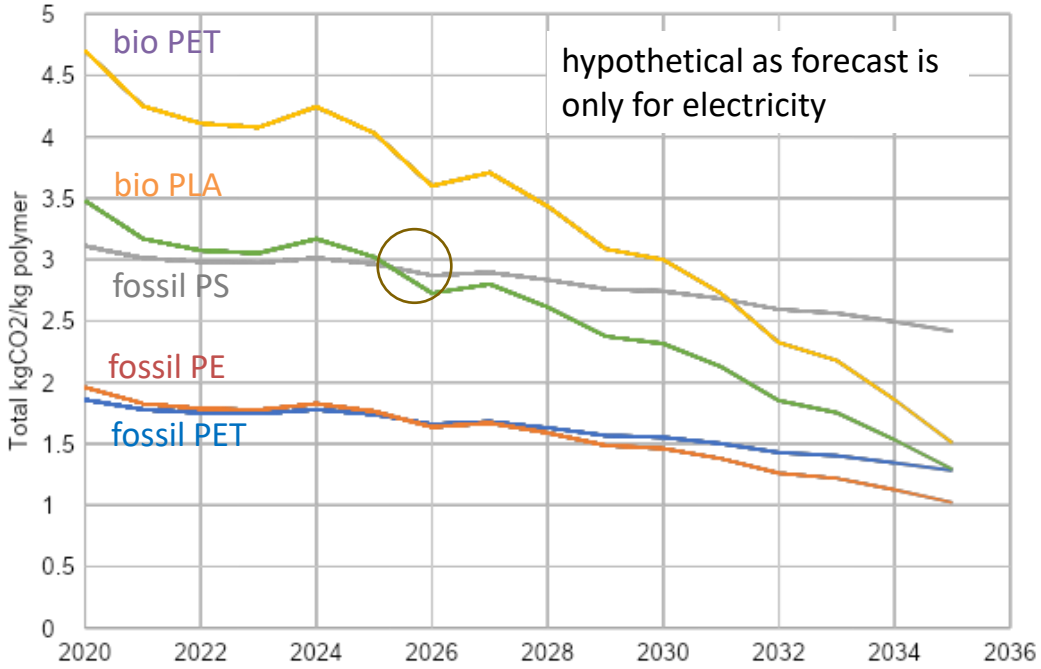


Decarbonising Electricity

Total CO_2 emissions ($kgCO_2e$/kg polymer) assuming electricity decarbonisation at BEIS forecast rate



Total CO_2 emissions for electricity + heat decarbonisation at 2x BEIS forecast rate

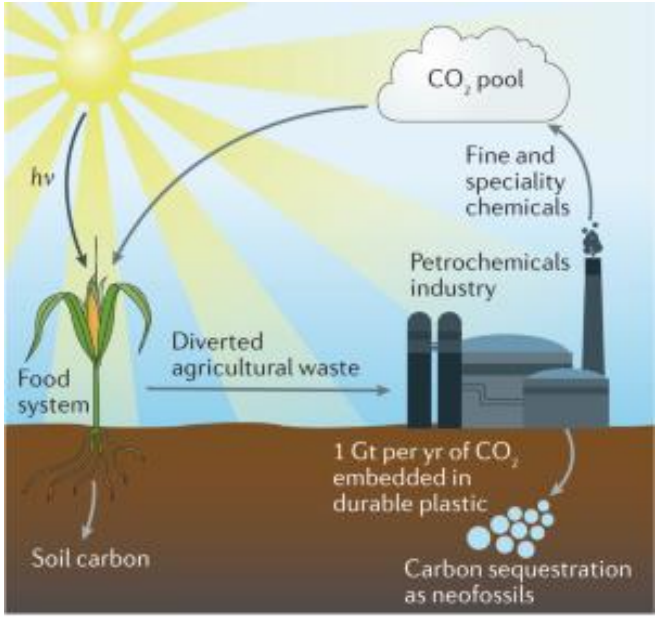


Could to make sense to replace PS with PLA in 2025

But bio PET is only better than fossil with H_2 heat!

Neo Fossils - Burying bioplastics

- How much plastic – 300 million tonnes – 0.3 Gt/year
- How much agricultural waste – 20 Gt/year
- If we used defossilized energy to make non-degradable plastic from agricultural waste
- We could sequester ~ 1 Gigatonne of CO_2 per year, every year
- Make fossils from plastic, not plastic from fossils…



Ryan & Rothman, 2022, *Nature Reviews Chemistry*, **6**, 1-3

Are Electrolysers the future of hydrogen production?

An example from DTU…

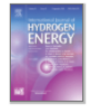
Life Cycle Assessment of Electrolysers

"The objective of this study is to evaluate and compare the potential environmental impacts of the three H_2O electrolysis technologies. The scope of this study starts with the acquisition of the raw materials used for the components of the electrolysis cells. The material for the components of the cells is processed by different machining techniques [indicated in figures]. After their lifetime, the electrolysis stacks are decommissioned, and landfill is considered as the main waste treatment due to the data availability.

Herein the functional unit is taken as 1 m^2 of the stack area, taking into account the non-active area of the stacks as well"

ELSEVIER

International Journal of Hydrogen Energy
Volume 45, Issue 43, 3 September 2020, Pages 23765-23781



Life cycle assessment of H_2O electrolysis technologies

Guangling Zhao, Mikkel Rykær Kraglund, Henrik Lund Frandsen, Anders Christian Wulff, Søren Højgaard Jensen, Ming Chen, Christopher R. Graves

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https://doi.org/10.1016/j.ijhydene.2020.05.282

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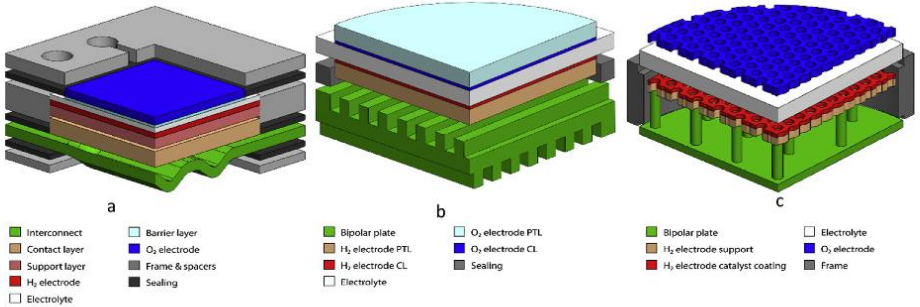

Fig. 1 – Simplified electrolysis SRU configuration used in the analysis. SOEC (a), PEMEC (b) and AEC (c). Dimensions not to scale.

Life Cycle Assessment of Electrolysers

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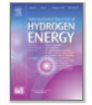

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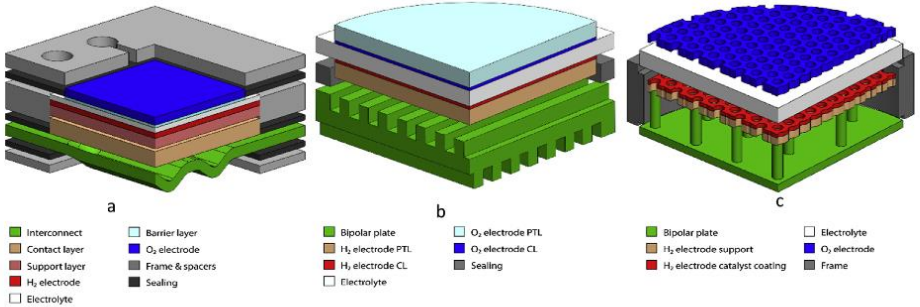


Fig. 1 – Simplified electrolysis SRU configuration used in the analysis. SOEC (a), PEMEC (b) and AEC (c). Dimensions not to scale.

Life Cycle Assessment of Electrolysers - Results

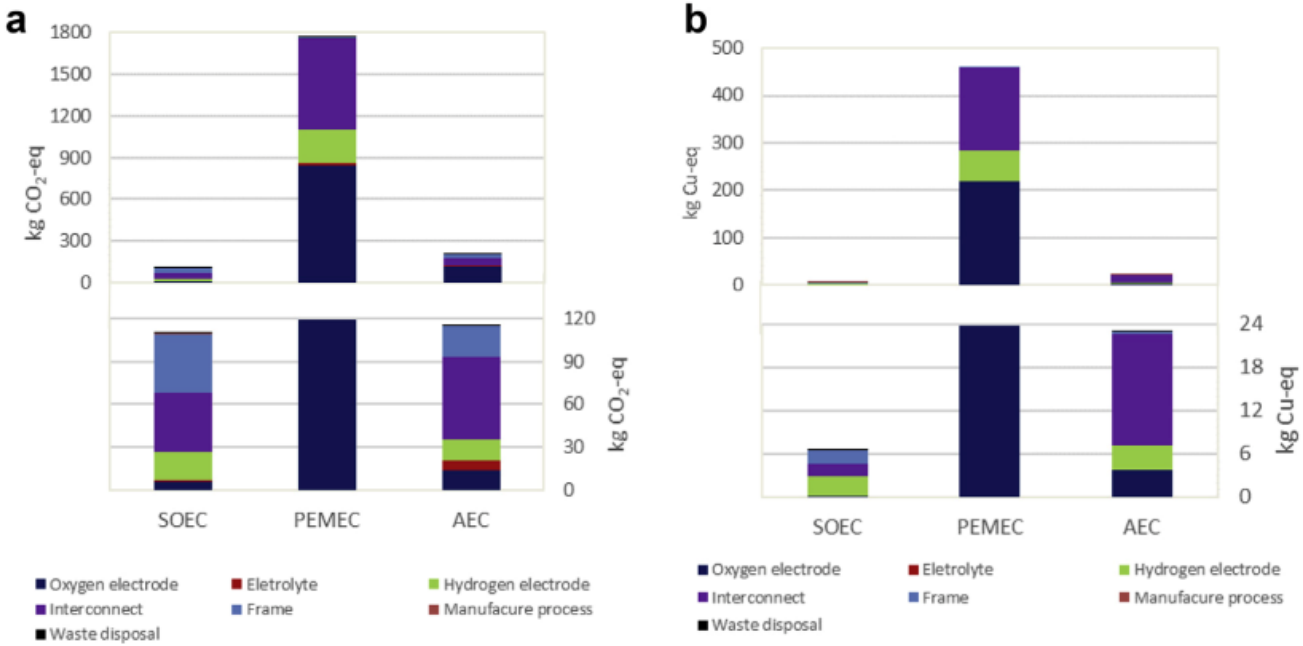
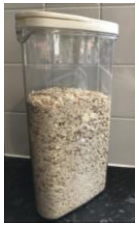
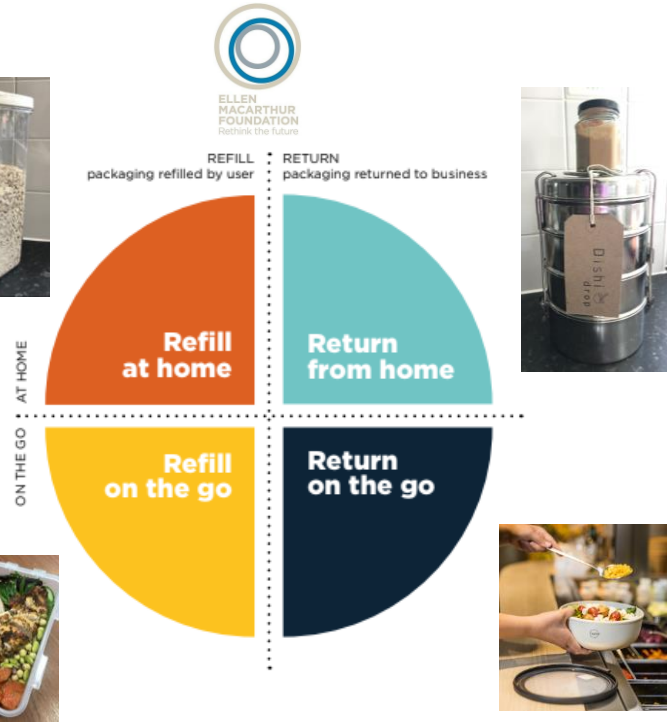


Fig. 5 – a LCIA results of GWP of three H_2O electrolysis technologies. b LCIA results of MRSP of three H_2O electrolysis technologies.

Reuse: Many Happy Returns

Reuse





- ☑ Less raw material
- ☑ Less waste

- ? What about washing?
- ? What about the transport emissions and logistics?
- ? Will people engage with the system?


Harriet


Tom


Rorie


Sarah

Packaging: Willingness & Acceptability

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Which products are people willing to reuse?

What would you do with the packaging of this product?
(N = 276)

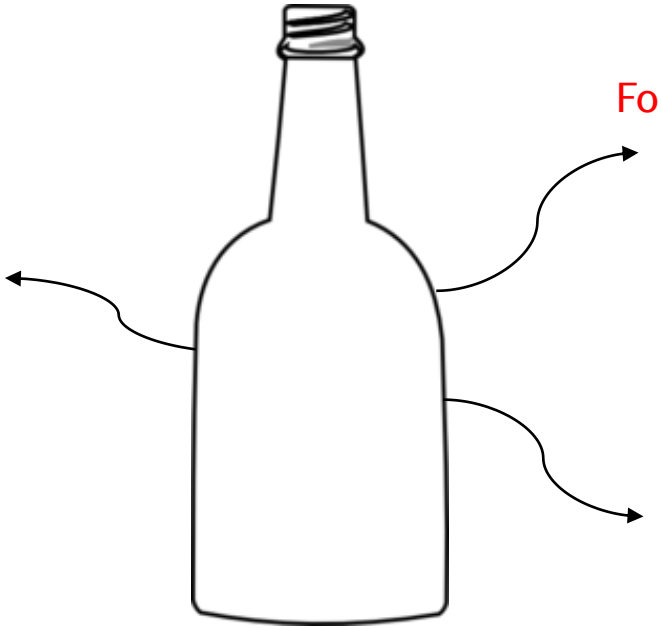
- **Put it in the bin** 34%
- **Put it in the recycling** 53%
- **Reuse it** 13%
  - **Refill it** 6%
    - **At home** 4%
    - **On the go** 2%
  - **Return it** 1%
    - **From home** 0.5%
    - **On the go** 1%
  - **Repurpose it** 6%

Greenwood et al., 2021, *Sustainable Production & Consumption*, 27, 1688

What factors influence what people are willing to reuse?

Aspects of the packaging

Packaging material
Packaging format
Dispensing method
Closure type
Packaging window
Resealable
Easy to Open



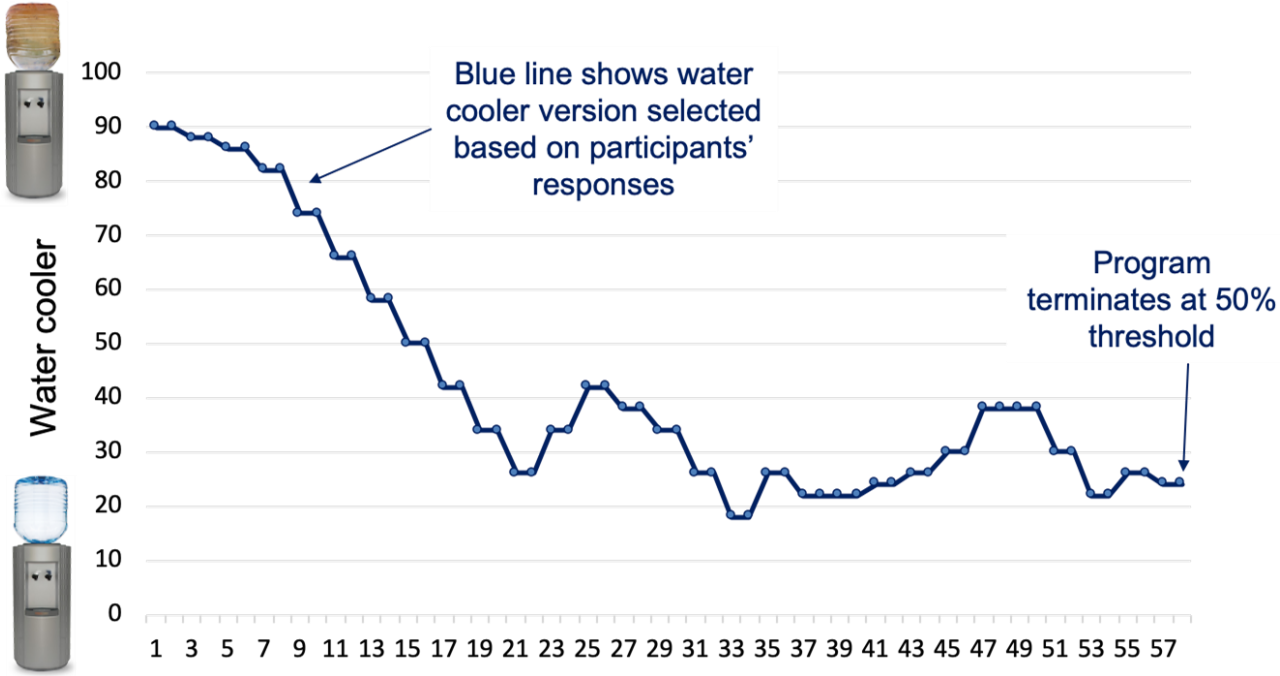
Nature of the contents

Food vs. home care v. personal care
Raw food
State of matter
Shelf-life
Frequency of purchase

Appearance of the packaging

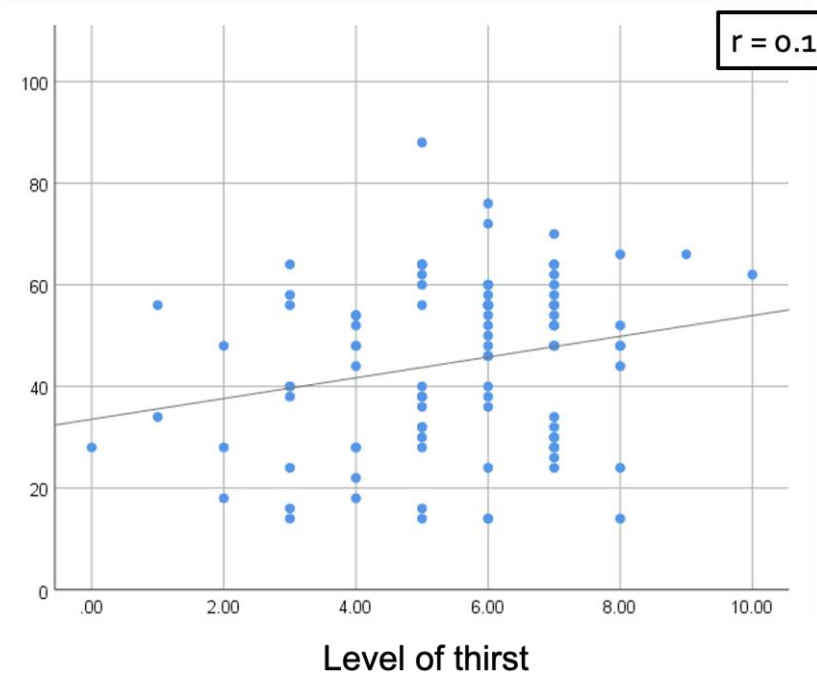
Change in appearance over time
Durable
Easy to clean

Would you be willing to have a drink from ***this*** cooler?

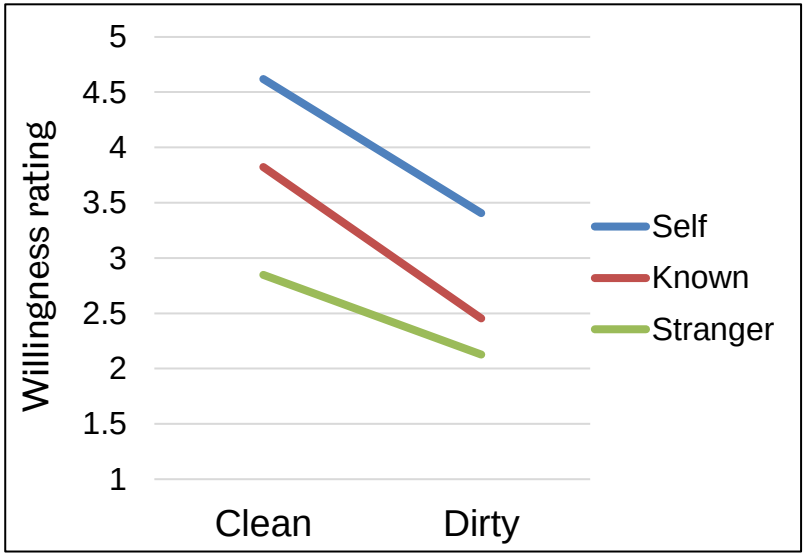


Willingness to reuse and thirst…

Water cooler



Packaging reuse:



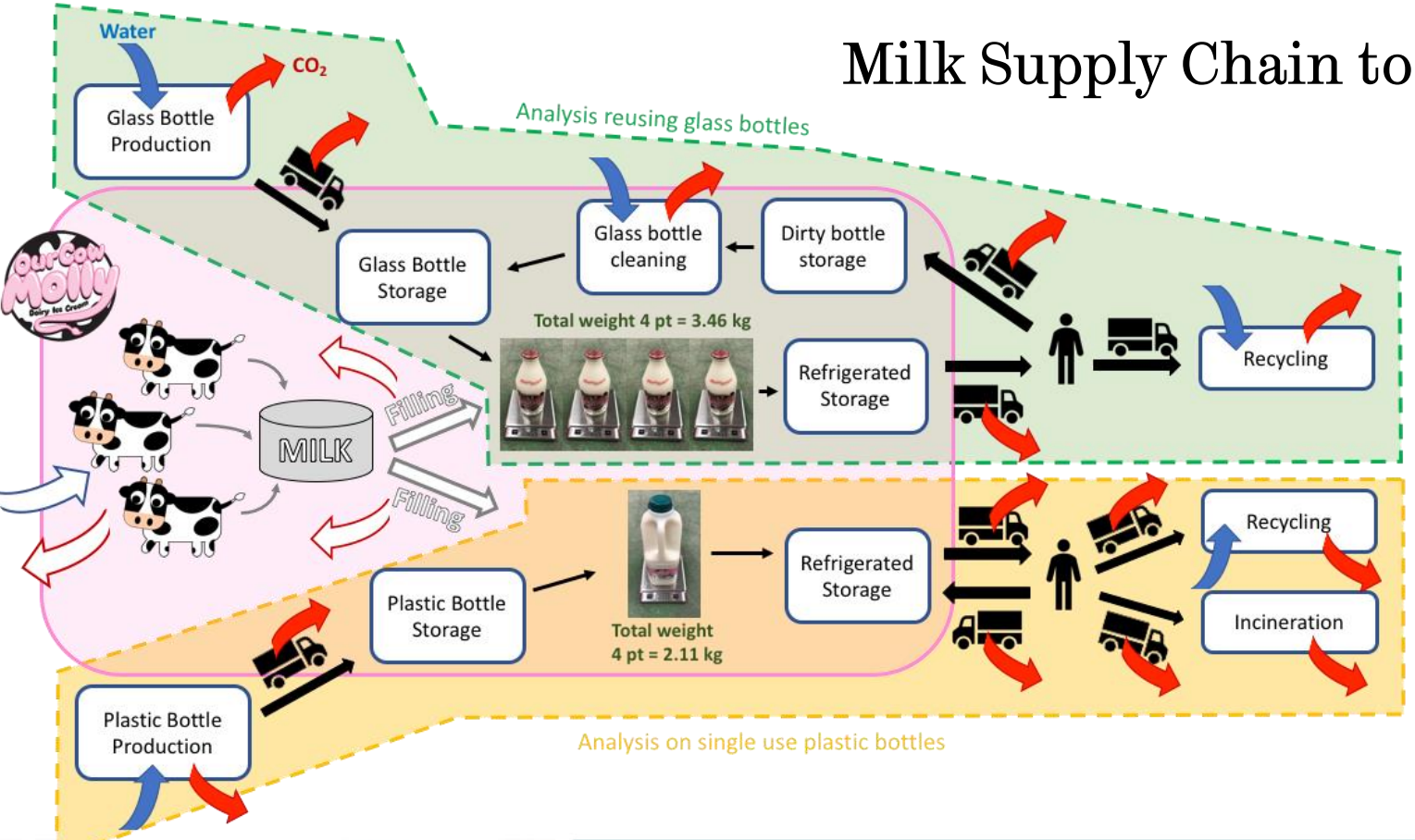
Tomasz

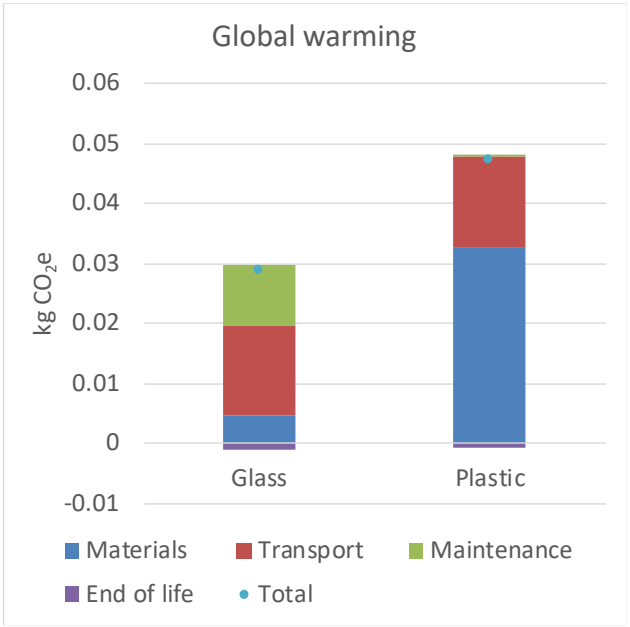
Stuart

Rukayya

Milk

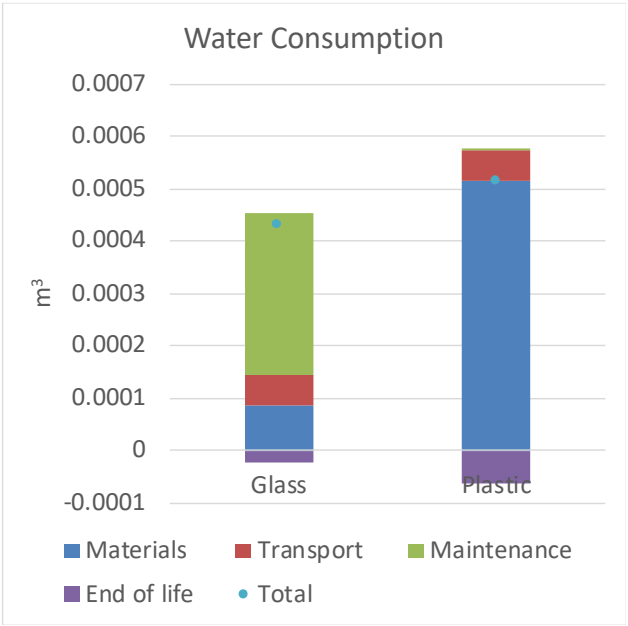
Milk Supply Chain to Customers





Glass bottles need to be used ~15 times to be even with plastic on global warming potential

Results given per pint of milk



If you buy 4 pints of milk in glass it is ~ 15% more expensive than a single 4 pt plastic bottle

Are you prepared to pay extra to be more sustainable???

Unpublished results - Confidential

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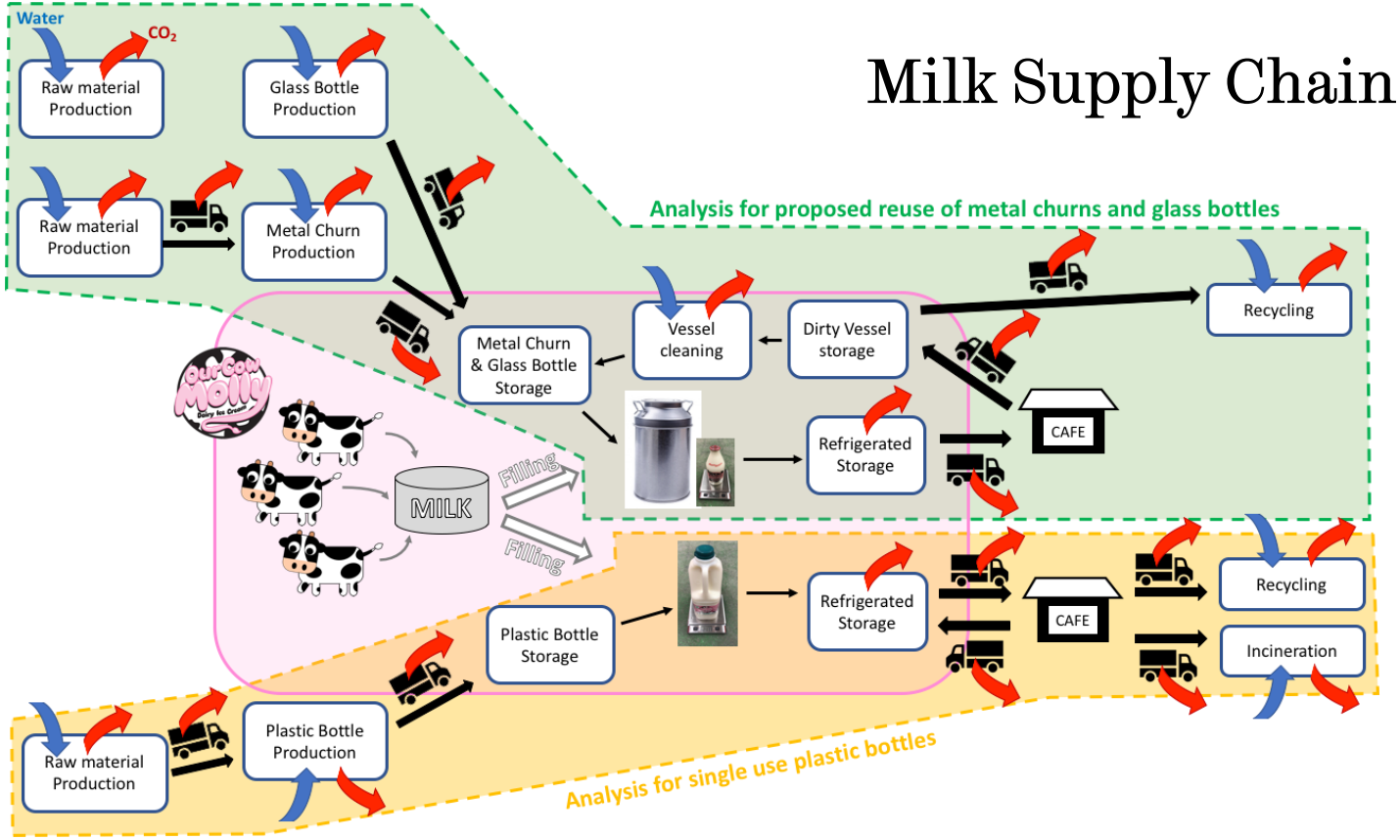
Milk Supply Chain to Cafes



Blazejewski et al., 2021 *Sustainable Production & Consumption* **27** 1030-1046

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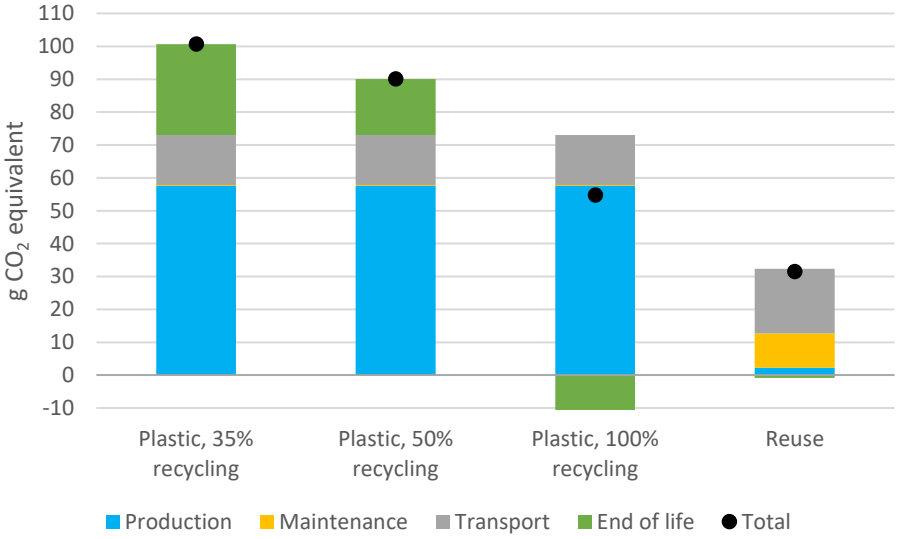
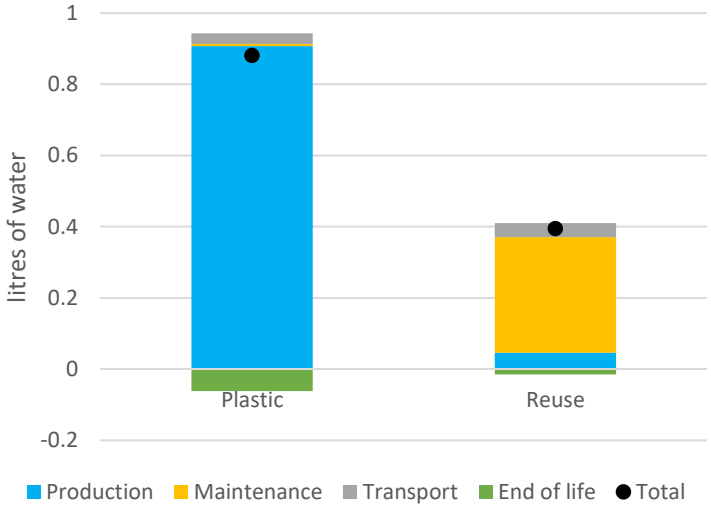
Global Warming Potential



Water Consumption



Both graphs give results per litre milk

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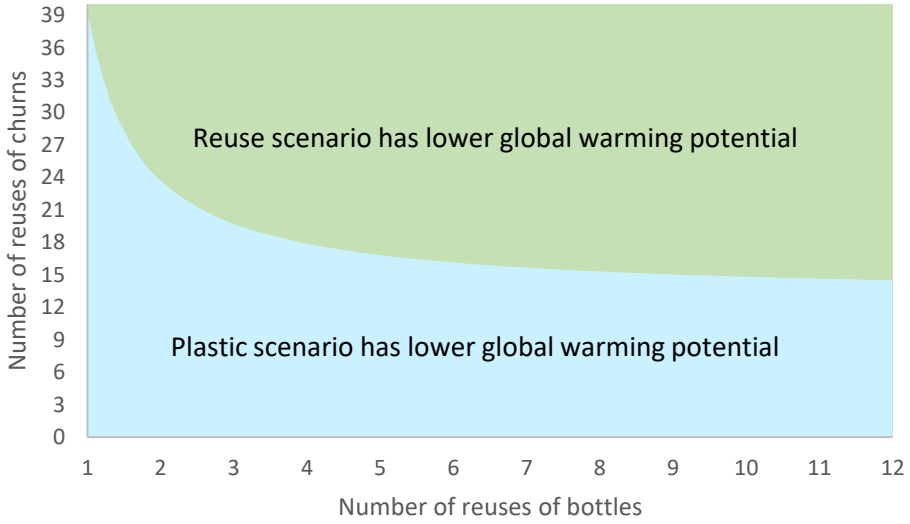
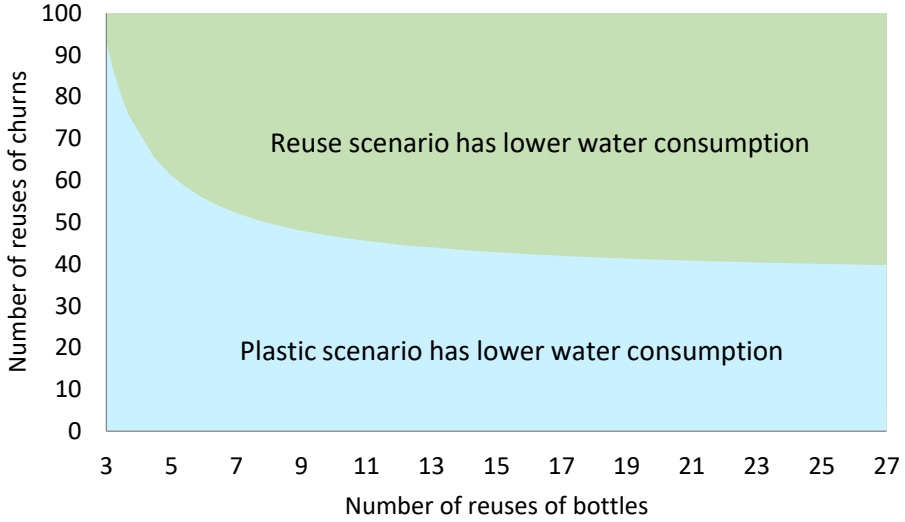
Help Transform Tomorrow.

How many reuses are needed?





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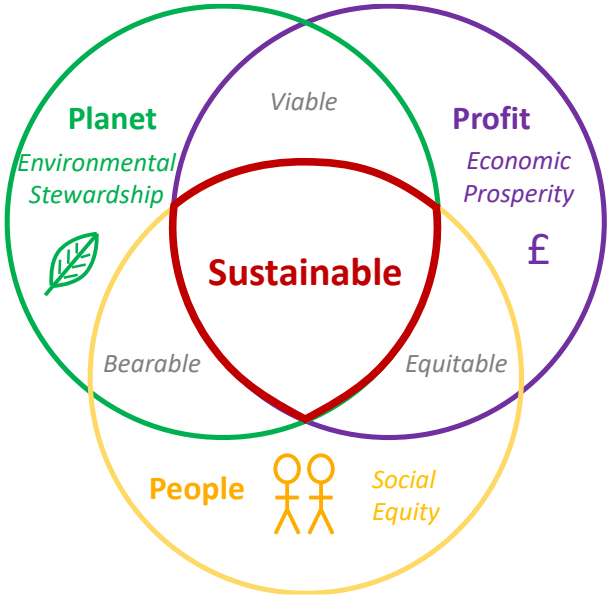
Sustainability is a balance!

- Finding the ‘best’ or ‘most sustainable’ solution can be tricky
- Quantification of sustainability is important
  - Whole system analysis
- To meet net zero targets we all need to work together



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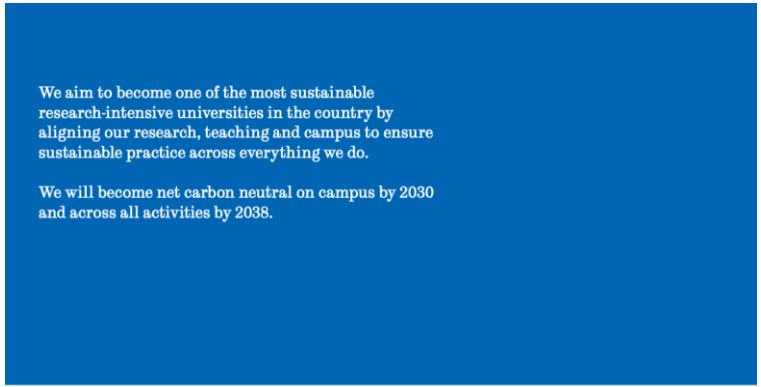
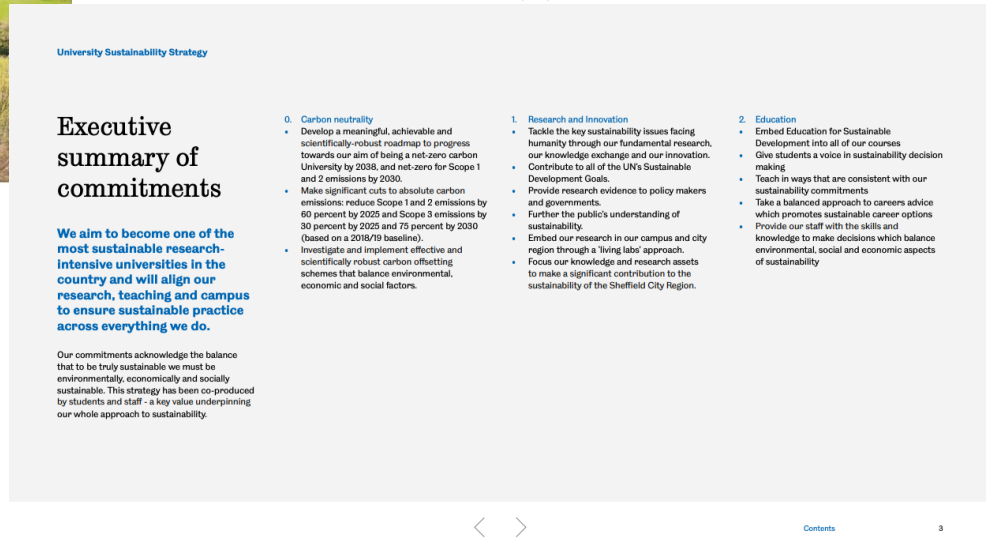
Sustainability at the
University of Sheffield

Sustainability Strategy

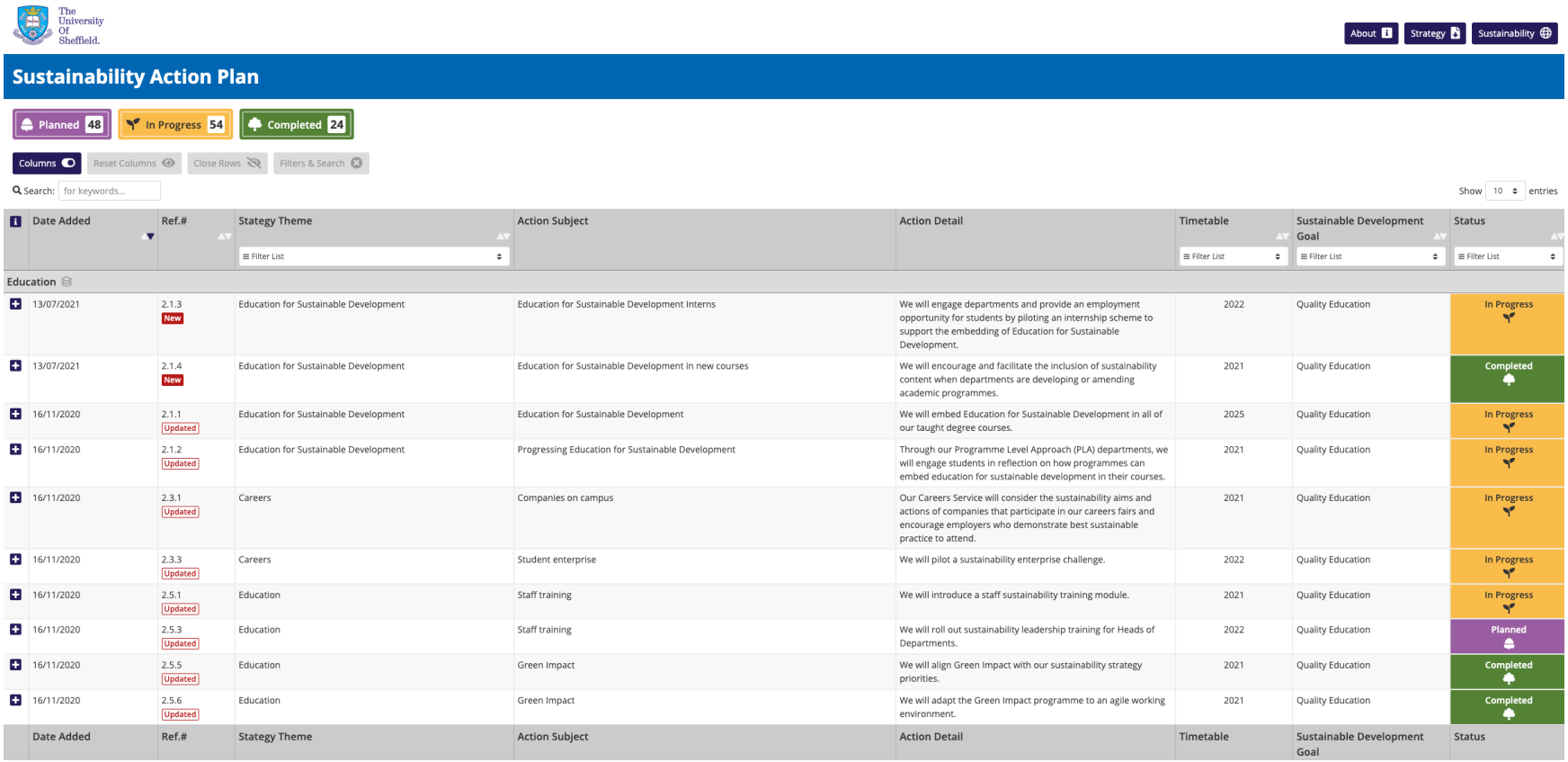
https://www.sheffield.ac.uk/sustainability/strategy





https://www.sheffield.ac.uk/sustainability/sustainability-action-plan

Action Plan



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About | Strategy | Sustainability

Sustainability Action Plan

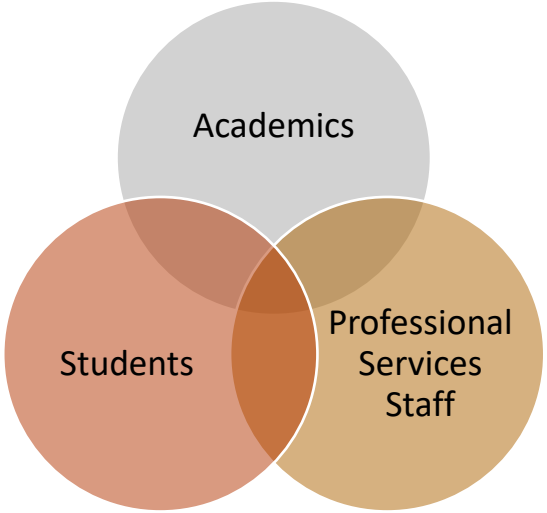
Planned 48 | In Progress 54 | Completed 24

Columns | Reset Columns | Close Rows | Filters & Search

Search: for keywords... Show 10 entries

Date Added	Ref.#	Stategy Theme	Action Subject	Action Detail	Timetable	Sustainable Development Goal	Status
Filter List		Filter List			Filter List	Filter List	Filter List
Education							
13/07/2021	2.1.3 New	Education for Sustainable Development	Education for Sustainable Development Interns	We will engage departments and provide an employment opportunity for students by piloting an internship scheme to support the embedding of Education for Sustainable Development.	2022	Quality Education	In Progress
13/07/2021	2.1.4 New	Education for Sustainable Development	Education for Sustainable Development in new courses	We will encourage and facilitate the inclusion of sustainability content when departments are developing or amending academic programmes.	2021	Quality Education	Completed
16/11/2020	2.1.1 Updated	Education for Sustainable Development	Education for Sustainable Development	We will embed Education for Sustainable Development in all of our taught degree courses.	2025	Quality Education	In Progress
16/11/2020	2.1.2 Updated	Education for Sustainable Development	Progressing Education for Sustainable Development	Through our Programme Level Approach (PLA) departments, we will engage students in reflection on how programmes can embed education for sustainable development in their courses.	2021	Quality Education	In Progress
16/11/2020	2.3.1 Updated	Careers	Companies on campus	Our Careers Service will consider the sustainability aims and actions of companies that participate in our careers fairs and encourage employers who demonstrate best sustainable practice to attend.	2021	Quality Education	In Progress
16/11/2020	2.3.3 Updated	Careers	Student enterprise	We will pilot a sustainability enterprise challenge.	2022	Quality Education	In Progress
16/11/2020	2.5.1 Updated	Education	Staff training	We will introduce a staff sustainability training module.	2021	Quality Education	In Progress
16/11/2020	2.5.3 Updated	Education	Staff training	We will roll out sustainability leadership training for Heads of Departments.	2022	Quality Education	Planned
16/11/2020	2.5.5 Updated	Education	Green Impact	We will align Green Impact with our sustainability strategy priorities.	2021	Quality Education	Completed
16/11/2020	2.5.6 Updated	Education	Green Impact	We will adapt the Green Impact programme to an agile working environment.	2021	Quality Education	Completed
Date Added	Ref.#	Stategy Theme	Action Subject	Action Detail	Timetable	Sustainable Development Goal	Status

Working together



Divestment

- Student campaign lead to 2015 pledge to divest from fossil fuels
- Divestment completed in May 2019

Reducing campus wide single-use plastic usage

- Campus cups/reusable coffee cup initiatives (2017-18 - Coffee Revolution was first on campus to introduce a levy for disposable cups)

UoS Clean Energy Switch

- Student campaign working with sustainability staff at the SU and University
- Electricity switch announced May 2020