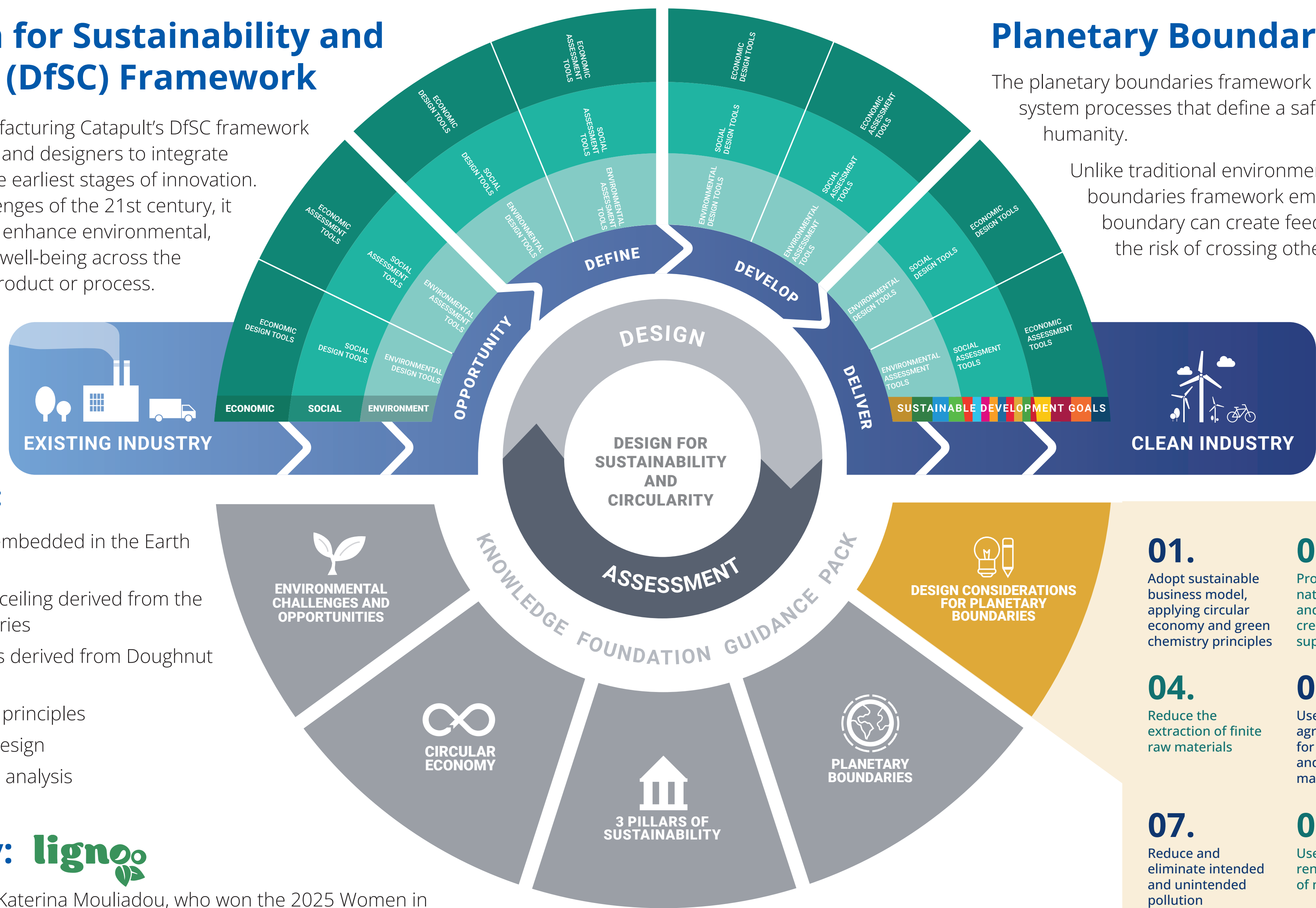


Sustainable, by design

A framework for integrating the nine planetary boundaries into design thinking

The Design for Sustainability and Circularity (DfSC) Framework

The High Value Manufacturing Catapult's DfSC framework empowers engineers and designers to integrate sustainability from the earliest stages of innovation. Tailored for the challenges of the 21st century, it fosters solutions that enhance environmental, social, and economic well-being across the entire life cycle of a product or process.



Planetary Boundaries

The planetary boundaries framework identifies nine key Earth system processes that define a safe operating space for humanity.

Unlike traditional environmental metrics, the planetary boundaries framework emphasises how crossing one boundary can create feedback loops and increase the risk of crossing others.

Core concepts:

- View industry as embedded in the Earth System
- Earth's ecological ceiling derived from the planetary boundaries
- Social foundations derived from Doughnut Economics model
- Circular economy principles
- Human-centred design
- Techno-economic analysis

Case Study: lignoo

Lignoo®, founded by Katerina Mouliadou, who won the 2025 Women in Innovation Award by Innovate UK, aim to develop a sustainable water bottle designed specifically for children aged 1 to 3. The bottle is intended to be:

- **Sustainable:** Made from non-toxic, eco-friendly materials
- **Functional:** Practical and easy for young children to use.
- **Circular:** Designed to be reused and recycled at end-of-life.
- **Child-safe:** Ensuring safety and durability for young users.



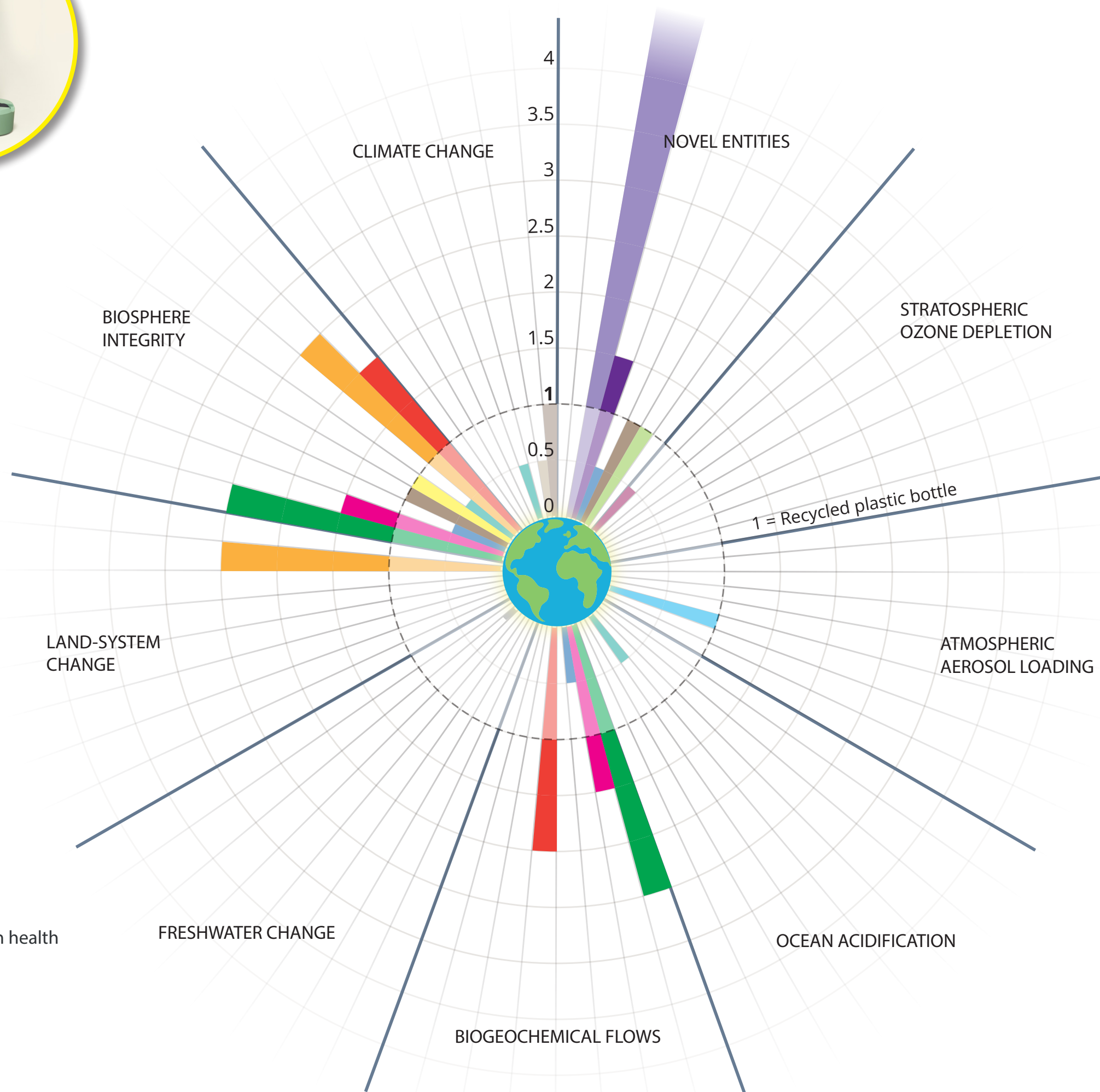
Testing the framework

The design framework was applied to reimagine the Lignoo® bottle with the goal of reducing its impact on planetary boundaries. This required strategic interventions at various stages of the design process:

- Product definition:** The 10 design considerations for planetary boundaries, listed above, were used as focus areas for building the product requirements.
- Design inputs:** Ansys Granta Selector™ software was used to select materials which met user requirements and compare their energy/carbon impact.
- Concept selection:** Three concepts generated were rated against the product requirements relevant to sustainability.
- Concept evaluation:** Earthster LCA software was used to produce a rapid environmental assessment of the chosen concept in different materials, outputting impact scores for a range of categories, not just carbon.
- Planetary boundaries impact:** Impact scores were interpreted and categorised according to the nine planetary boundaries, in order to visualise the impact of the biogenic carbon polymer bottle against the recycled plastic version, shown as baseline value of 1 (See figure, right).

Silicone
TPU
EPDM
FFKM
Aluminium
PA66/6
Polypropylene
PPSU
Stainless steel
Titanium
Co-polyester

- Land use
- Water use
- Climate change
- Resource use, fossils
- Resource use, minerals and metals
- Ozone depletion
- Eutrophication, terrestrial
- Eutrophication, freshwater
- Eutrophication, marine
- Particulate matter
- Acidification
- Photochemical ozone formation, human health
- Ecotoxicity, freshwater
- Human toxicity, non-cancer
- Human toxicity, cancer
- Ionising radiation, human health



This project was funded by the Innovate UK Business Growth and HVM Catapult.

Planetary boundary interpretation, comparing bio-based with recycled plastic bottle (1)

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