Towards Absolute Environmental Sustainability in Product Development: A Case Study on a Sofa System

Claus Mølgaard, M.Sc., Ph.D.
MOLGARD APS

Abstract

As industries face increasing pressure to adopt sustainable practices, the development of environmentally responsible products has become a key challenge in the 21st century.

This study explores how a combination of environmental lifecycle screening and absolute environmental sustainability assessment can support the early-stage design and development of physical products. A structured approach is presented, guiding the process from initial brainstorming to the final evaluation of a product's sustainability.

A case study demonstrates this methodology through the development of a new sofa system. Throughout the design process, multiple lifecycle screenings are conducted to optimize material selection and production processes. The results are continuously evaluated by a multidisciplinary team consisting of designers, engineers, marketing professionals, and company owners to ensure sustainability goals are met.

The absolute sustainability of the sofa system is assessed using economic sharing principles (final consumption expenditure). The study demonstrates that an absolutely sustainable product can be achieved within these parameters. Furthermore, it discusses the impact of sales pricing on absolute sustainability and market fairness, highlighting key challenges and considerations for a sustainable product.

Introduction

The starting point for this project was an armchair designed by Eva Fly from BLY DESIGN for the Danish television show "Danmarks Næste Klassiker" (Next Danish Design Classic) in 2022. The armchair was intended to be circular, meaning that it should be made of materials suitable for recycling. On the show, a prototype was presented using thermoplastic, which can be recycled either mechanically or chemically.

Following the broadcast, furniture company N. Eilersen A/S decided to develop the armchair for mass production – see Figure 1.

Molgard ApS was involved in the process and was responsible for both environmental aspects and the mechanical structure. During development, the project team decided not only to work with circularity but also to investigate whether it would be possible to design a product that is absolutely sustainable, or at least to be inspired by absolute sustainability principles as part of the development process.

This paper describes how absolute sustainability considerations can be integrated into a classical product development process, following five key phases:
1. Idea Generation
2. Screening
3. Concept Development
4. Product Development
5. Launch

Methodology

Product Development Process
The development of a chair with moderate complexity typically takes 9–10 months, including production tooling and the launch collection. For example, the Gomo chair developed for Fredericia Furniture began in mid-August and launched in mid-June the following year, a total of nine months.

In this study, time spent working on sustainability-related activities was logged across all five development phases to assess whether incorporating environmental screenings or absolute sustainability assessments caused delays. Time was recorded using both start and completion dates, as well as based on the billed hourly consumption.

Environmental Lifecycle Screenings
Lifecycle screenings were performed at multiple stages of the development process to guide decisions regarding material selection, production methods, and end-of-life strategies.

Absolute Sustainability Assessment
Absolute sustainability was calculated based on the work of Bjørn & Hauschild, focusing on the following midpoint impact categories: climate change, ozone depletion, photochemical ozone formation, terrestrial acidification, terrestrial and freshwater eutrophication, marine eutrophication, freshwater ecotoxicity, land use, and water depletion.

Carrying capacities were allocated using the economic allocation principle described by Ryberg, where the share of the safe operating space is determined by each EU citizen's share of the EU's total final consumption expenditure (FCE). Population and FCE data were obtained from the World Bank.

Biodiversity impact was calculated using the approach of Birgisdóttir et al. in Doughnut for Urban Development – An Appendix, translating midpoint impacts into potential species loss.

Materials

Case 1: Steel / Virgin PUR / PET textile
Case 2: ABS / Oxymesh / PET textile
Case 3: Recycled PS / Recycled PUR / PET knit
Case 4: Veneer / Solvent paint / Recycled PUR / PET knit
Case 5: Veneer / Water paint / Recycled PUR / Rec. PET knit
Case 6: Veneer / Water paint / Oxymesh / Rec. PET knit
Case 7: Veneer / Water paint / Virgin PUR / Rec. PET knit

Figure 1

The reference sales price for a comparable product produced by N. Eilersen A/S was estimated to be USD 1,732 incl. VAT.

Results

Lifecycle Screening Outcomes
Results from seven lifecycle screenings conducted across different phases are presented in Figure 2.
Climate change, photochemical ozone formation, and biodiversity impacts were found to be close to or exceeding absolute sustainability thresholds. By the end of the concept development phase (Phase 3), all impacts were below the threshold.

During product development (Phase 4), however, the manufacturer was unable to achieve sufficient ergonomic comfort using Oxymesh or recycled upholstery. Consequently, virgin PUR foam was selected for upholstery, increasing photochemical ozone formation beyond the sustainability threshold.

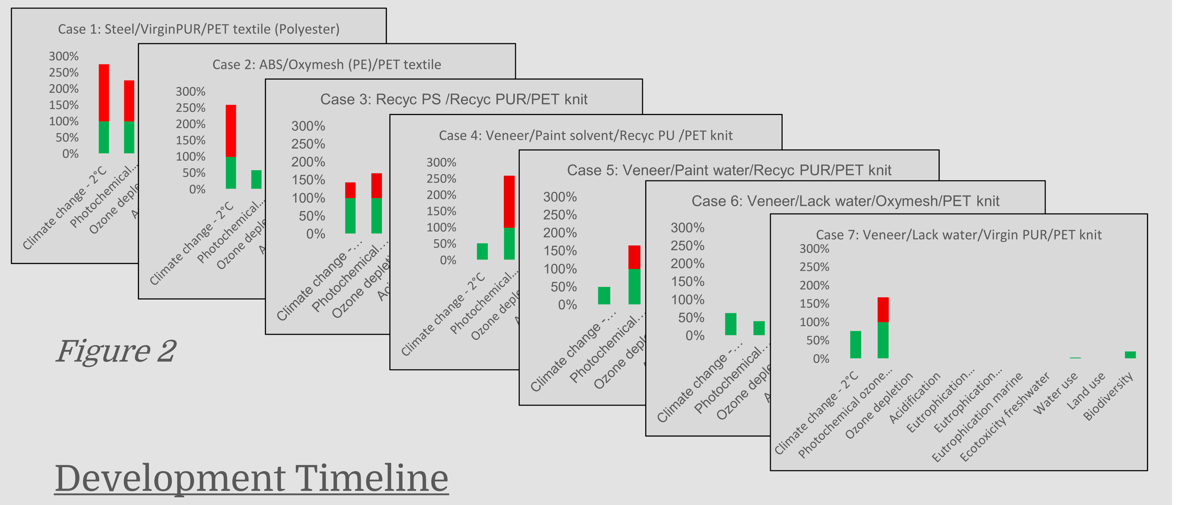

Figure 2

Development Timeline
The product was developed and launched within 287 days and time consumption according to bills was 52 hours – see Figure 3, which falls within the typical development timeframe for a chair of this complexity. The inclusion of absolute sustainability assessments did not delay the project.

Third-Party Verification
A third-party company, MÅLBAR, conducted a CO_2-eq screening of the final product. Their results indicated a climate change impact above the absolute sustainability limit. Their screening included packaging, transportation (Slovenia → DK via truck), and product cleaning during use — factors not considered in the earlier development screenings. These accounted for approximately 25% of the total climate change impact.
Furthermore, their screening used a different database and end-of-life scenario, leading to discrepancies with the internal assessments.

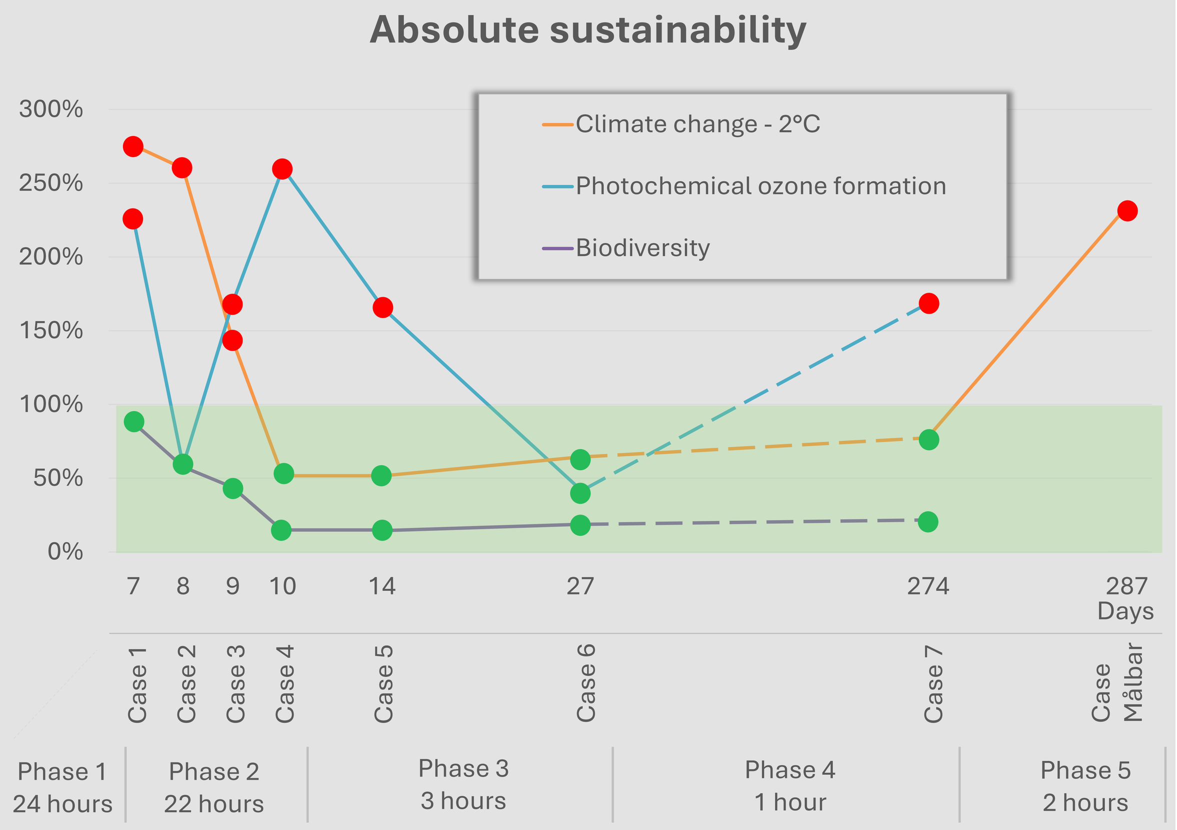

Figure 3

Conclusion

This study demonstrates that it is possible to integrate environmental lifecycle screenings and absolute sustainability considerations into the development of a physical product without delaying time-to-market. Although the final product did not achieve full absolute sustainability due to comfort requirements necessitating virgin PUR foam, the case study provides evidence that absolute sustainability can meaningfully guide decision-making.

Further methodological refinement is needed to improve the precision of early screenings and ensure alignment with third-party verifications.

Recommendations

The results demonstrate that integrating environmental lifecycle screenings and absolute sustainability assessments into product development is feasible without extending the development timeline.

However, discrepancies between internal screenings and the third-party screening suggest that early-stage screenings lack precision. Packaging and transportation impacts should be included even in early phases, despite production location uncertainties.

Future work should consider including uncertainty analysis to better capture the variability of results — but care must be taken to ensure that this does not add significant time consumption or risk delaying the launch.
Commercial considerations also remain important. Companies may be reluctant to adopt methods that significantly extend time-to-market, so any sustainability assessment framework must strike a balance between accuracy, practicality, and speed.

While the application of an economic allocation principle is relevant in this high-end design context, it may disadvantage lower-cost products with comparable functionality, potentially resulting in biased sustainability assessments. Alternative allocation approaches, such as those based on decent living standards or expenditure elasticities, merit further consideration.

Acknowledgements

Bly Studio; Eva Fly & Anne Brandhøj
N. Eilersen A/S
MÅLBAR ApS

Download:
Poster, article, references, appendix