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SIMPLIFIED LIFE CYCLE ASSESSMENT (LCA) STUDY FOR EARLY DESIGN STAGES OF WOODEN EXTERIOR DOOR

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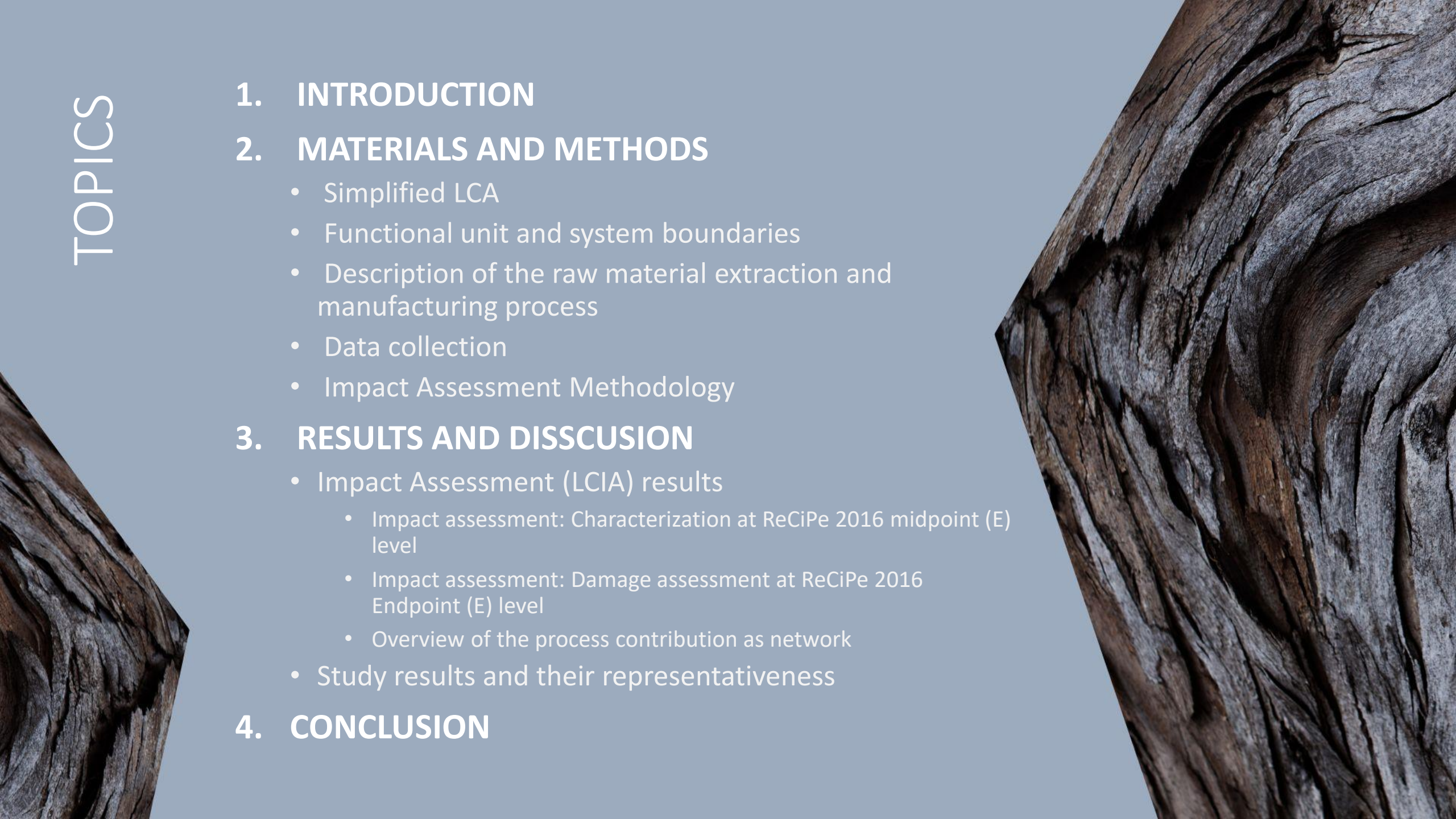
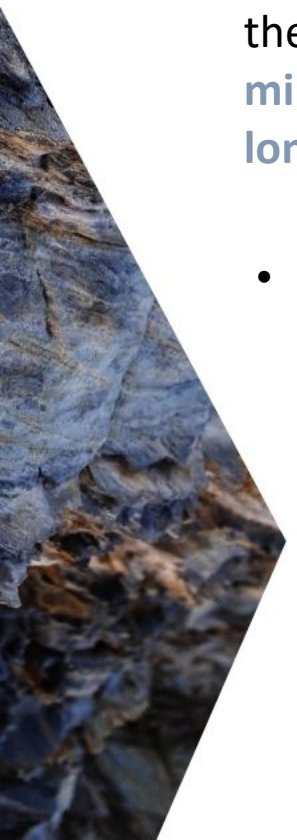


INTRODUCTION



- Rapid industrialization poses obstacles on the path to sustainable development.
  - Sustainable development → industrial production refers to the practice of **utilizing resources efficiently** and **sparingly** to **minimize negative environmental impacts** while ensuring **long-term economic viability**.
    - Such concept aligns with Life Cycle Assessment (LCA) methodology which is now well-known method for **better understanding the production processes**.
      - LCA is becoming one of the most widely applied **scientific** and **industrial methods** for estimating environmental impacts of products and services (Frostel, 2013).

The ISO 14040 standard defines LCA as a compilation and evaluation of the inputs and the potential environmental impacts of a product system throughout its life cycle.

INTRODUCTION

- The **wood industry** has a potential to contribute to a more **sustainable** and **resource-efficient future**.
  - **Wood** → well-known and immensely valuable **renewable natural resource** (with high potential for reusing and recycling, as a source of biomass for energy generation, carbon storage,…).

- **Based on the European Commission it is estimated that over 80% of all product-related environmental impacts are determined during the design phase of a product, but environmental footprint calculations are rarely available to product designers (PRé Sustainability, 2023).**

  - Opportunities to reduce environmental impact present themselves when the **focus is shifted on early design stages of a product**.
  - In recent years, there has been a shift towards a more comprehensive and **holistic approach to sustainability** that encompasses the **entire value chain of a company**.

  - A **simplified LCA**, with an adapted methodology, can be used for **quick assessment of a product**, based on already available information in the planning process.

- The object of this study is practical use of simplified LCA in the early design stages that can improve production process of a wooden product + it will basis for more detailed LCA analysis

MATERIALS AND METHODS

Simplified LCA

- is a more **accessible** and **less resource-intensive** version of the full LCA, designed for situations where a **quick assessment** is needed or when **limited data is available**.
- the focus here is to identify the major contributing **input materials**, **energy** and **fuel use**, and their potential impact on environment

Functional unit

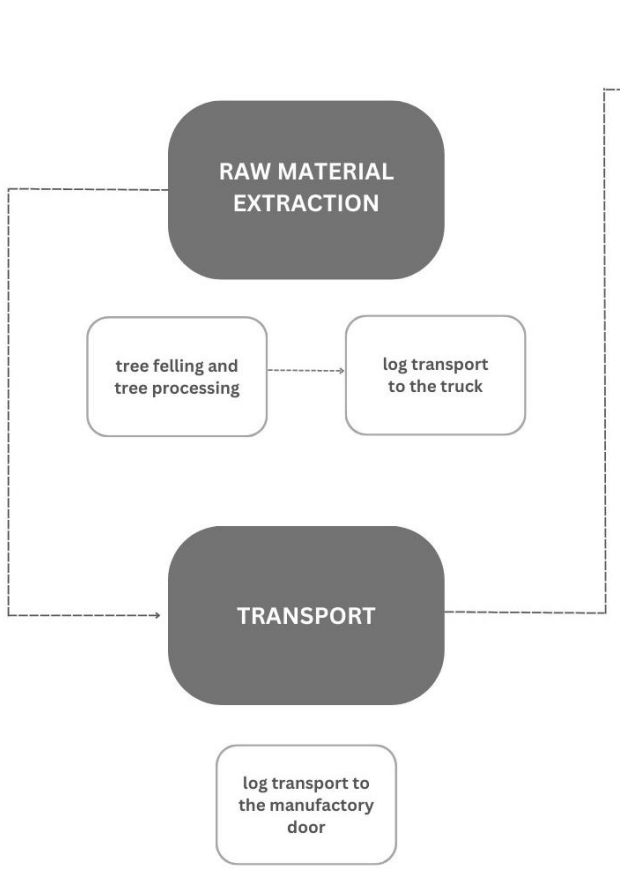
- The functional unit of this LCA analysis is the **wooden exterior door**, which are comprised of a **door leaf** and **door frame**, with its dimensions of 970 x 220 x 60 mm.

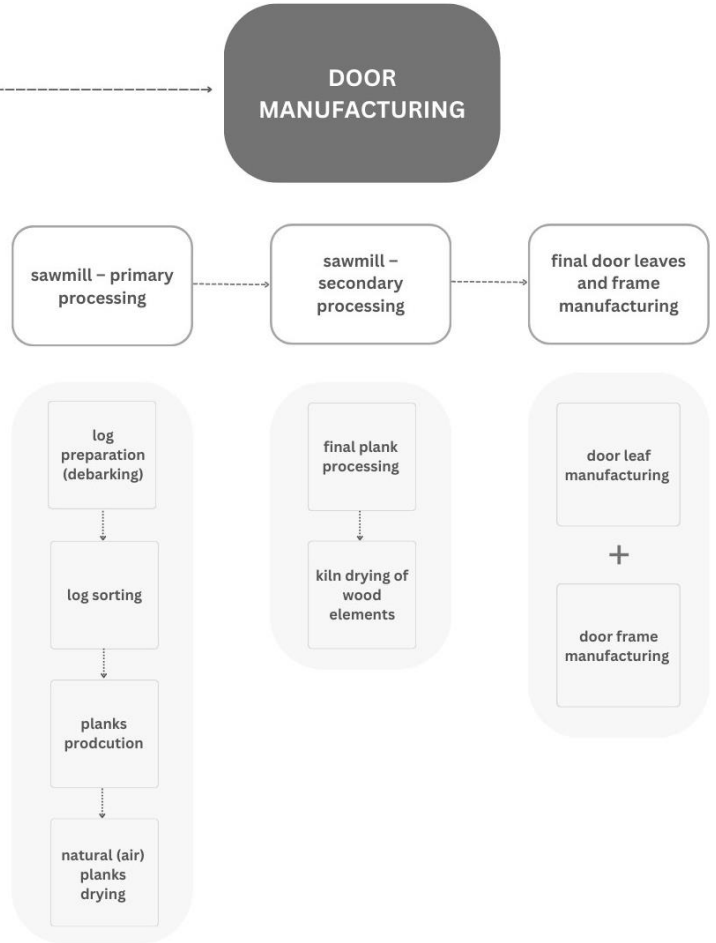
System boundaries

- System boundaries determined for this type of the assessment is **cradle-to-gate approach**, which implies that this is partial wooden product life cycle.
- This approach includes **raw material extraction**, **transportation to the factory gate**, and **manufacturing the product** up until the point of being transported to the consumer.

MATERIALS AND METHODS

Description of the raw material extraction and manufacturing process





Assembly of the elementary components and auxilary materials

MATERIALS AND METHODS

Data Collection

- The wooden exterior door production process data was collected from various sources, such as:
  - door manufacturing company employees
  - experts of the field of forestry and wood technology
  - literature
  - LCA database
  - Internet (various product declarations and documents)

Impact Assessment Methodology

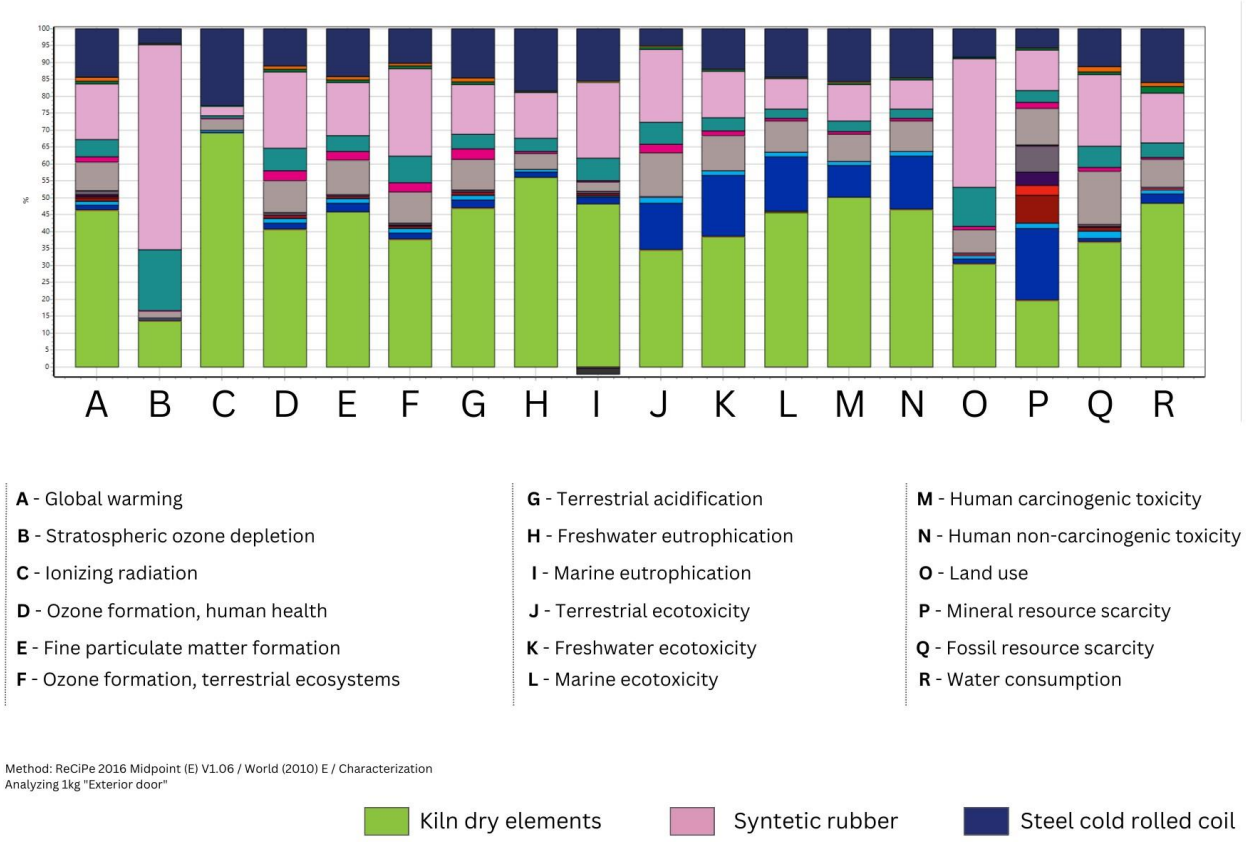
- ***SimaPro*** (version 9.3.0.3, Expert user package) **software** was used in combination with ***Ecoinvent*** **database**
- ***ReCiPe 2016*** was chosen an impact assessment method, which includes both **midpoint** (problem oriented) and **endpoint** (damage oriented) impact categories
- Egalitarian perspective (E) - the most precautionary one

RESULTS AND DISSCUSION

Impact Assessment (LCIA) results

Impact assessment: Characterization at *ReCiPe 2016* Midpoint (E) level

- ***ReCiPe 2016*** method, at midpoint impact category level, includes **18 characterisation factors**.
- Figure displays the **percentages of environmental impacts** of the different materials and processes used for manufacturing the (1 kg of) exterior wooden door with respect to the various midpoint impact categories.
- It is evident that the highest impact, for almost all impact categories, is accounted to the process of getting **kiln dry elements**

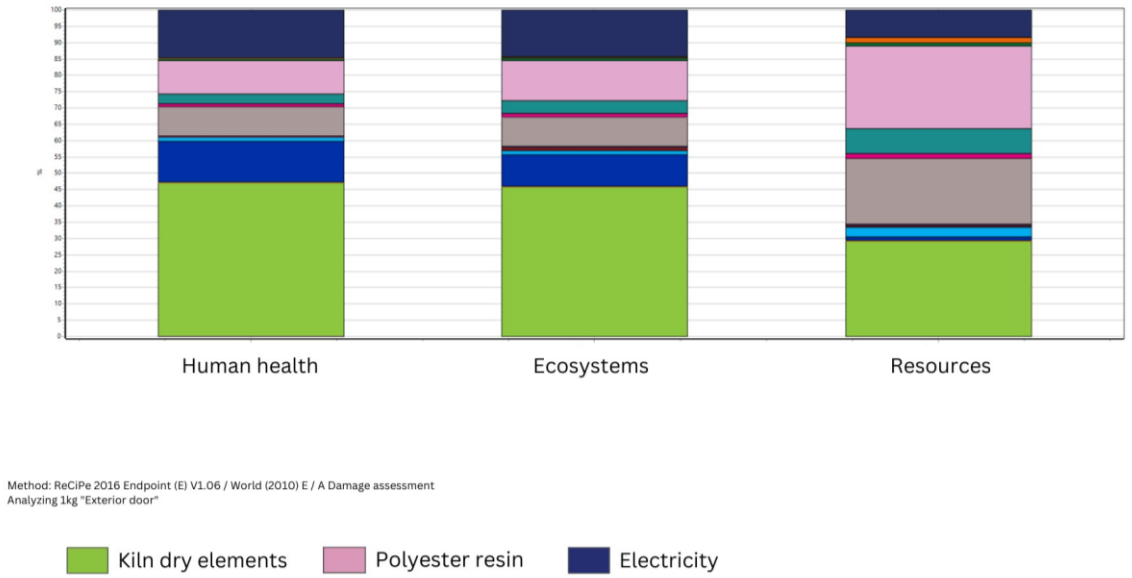


RESULTS AND DISSCUSION

Impact Assessment (LCIA) results

Impact assessment: Damage assessment at *ReCiPe 2016* Endpoint (E) level

- Three **endpoint categories** (damage to human health, ecosystems and resources) are comprised of cumulative midpoint categories multiplied by damage factors.
- Figure 3 shows that the **production of kiln dry elements** also has the largest contribution to human health, ecosystems and resources



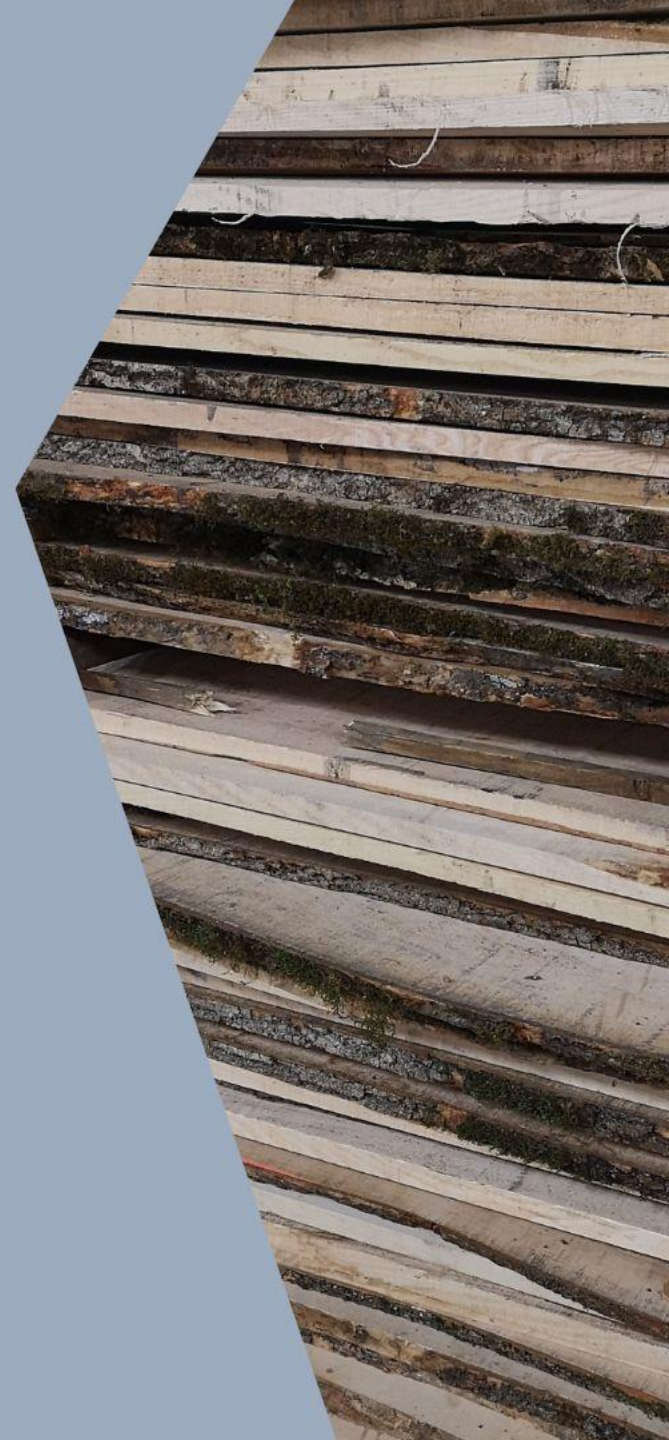
RESULTS AND DISSCUSION

Study results and their representativeness

- Analysing the results of both sets of impact categories of the *ReCiPe 2016* method it is evident that the **kiln dry elements have a biggest impact**.
- Results such as these are understandable due to the fact that production of mentioned elements is quite complex and lengthy process → they represent one of the final stages for the door assembly
    - It is also important to mention that the wood **co-products** and **residues** generated in this production process are **not documented** in this study → such products could potentially have notable effects on the results.
    - During the study development, it was not always possible to do the calculations with the precise amount of wood mass, due to the **lack of the data** (for example the loss of the moisture from the wood that caused the change of the mass).
        - The results of this study will be the foundation for conducting the **more detailed LCA analysis** that will include **use** and **disposal phase**. It is also important to amplify that this LCA analysis did not go under any revision, and therefore the real name of the product (and production company) is undisclosed

CONCLUSIONS

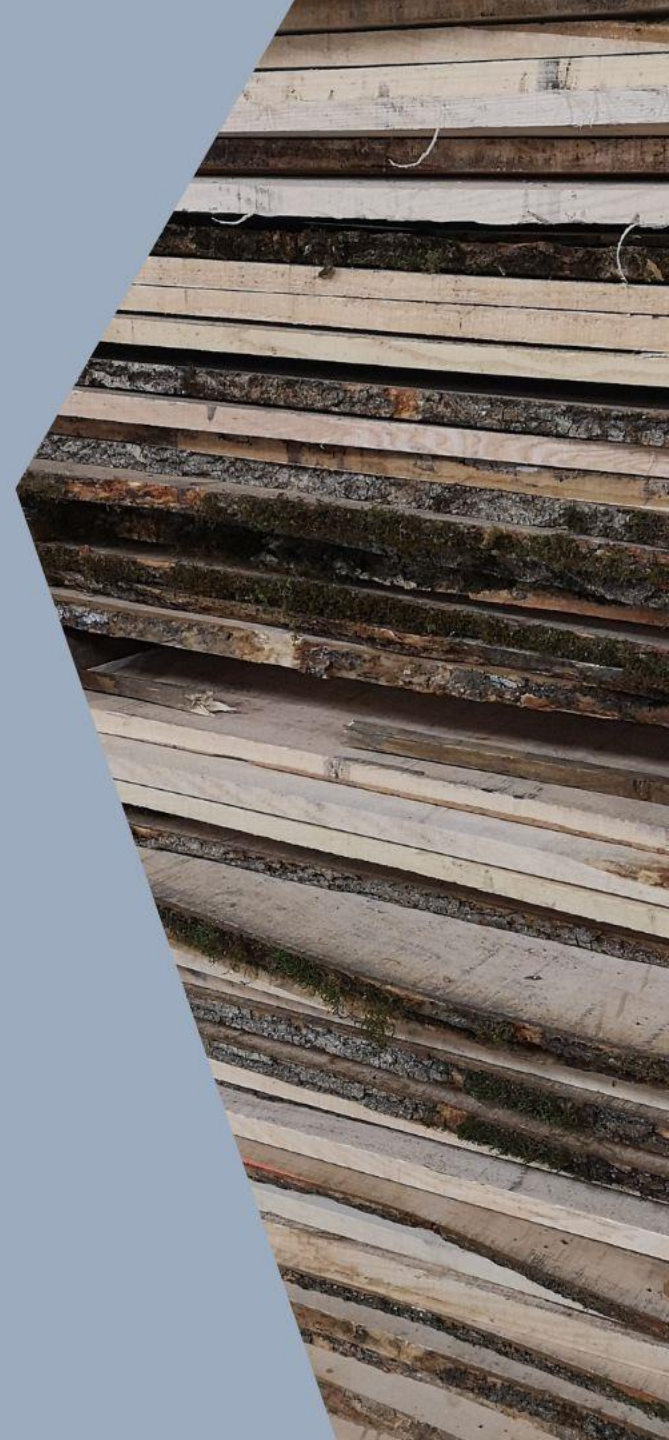
- **Simplified LCA** can be a valuable tool, especially for organizations or individuals with limited resources, time, or expertise in conducting a full LCA.
- It allows for a preliminary assessment of environmental impacts and can help **raise awareness** and **initiate discussions** around sustainability considerations. However, it's important to recognize its **limitations** and that more detailed assessments may be necessary for comprehensive and accurate evaluations.
- In door production, the drying process has proven to have the most significant impact on the environment.
- Therefore, it would be necessary to analyse and optimize the drying process, including the implementation of new and more efficient regimes that would shorten the duration of the process and reduce energy consumption.
- Furthermore, it would be beneficial to consider special drying methods such as **vacuum** and **high-frequency drying**.



CONCLUSIONS

- The production processes, transportation vehicles and machinery have a significant impact on the environment. Replacing older, inefficient machinery with energy-efficient models reduces energy consumption and greenhouse gas emissions.
- Using environmentally friendly components also lessens the negative effect.
- The combination of these measures can potentiate a **creation of more environmentally friendly products and materials**, especially in a case of wooden product manufacturing.

- Impact assessment and improvement suggestions should also consider other factors beyond environmental impact, such as **social** and **economic aspects**.
- **A holistic approach that takes into account sustainability from multiple angles is crucial for creating truly sustainable and responsible product designs.**



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THANK YOU FOR THE ATTENTION