MOVING BIOCOMPOSITES INTO SECOND GEAR

Exploring the potential of long fibre biocomposites
in the mobility and transport industry

Master Thesis
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Master thesis

Integrated Product Design

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Summary

Although biocomposites have been around for some years now, their use is still far from mainstream. Yet, the material properties of biocomposites and their current applications show a lot of potential for more sustainable, lightweight and structural applications in many industries. Long fibre biocomposites show good specific properties and offer unique benefits like high vibration damping. Furthermore, they have a significantly lower environmental impact than aluminium and synthetic composites.

This project was commissioned by NPSP, a company with over 20 years of experience in the biocomposite industry. They experience a rising interest in biocomposites in recent years, but large scale applications are still rare. This project aimed to explore the potential of long fibre biocomposite applications in the mobility and transport industry. These industries feel the need to become more sustainable and the characteristics of long fibre biocomposites show other potential benefits.

After initial material research was performed, nine weeks of project acquisition followed. Six companies participated in a short track of a maximum of two meetings to explore biocomposite potential for their corporation. The results of this process are analysed to obtain insights into what boundaries and opportunities companies see in biocomposites.

From the results can be concluded that interest in biocomposites is present in these industries. The potential benefits of saving weight and opting for a more sustainable material are acknowledged by most companies. The main boundaries currently preventing companies to apply biocomposites are the high perceived risk of applying the material, high costs, a challenging end of life scenario and lack of more 'off the shelf' semi-manufactured biocomposite products.

The current position of biocomposites can be referred to as the so-called 'chasm' in the technology adoption lifecycle (figure 1). At this point, an innovation is accepted in a few small niche markets but needs the acceptance of more mature companies and industries to grow or even survive. Assumed at the start of this project was that larger scale applications would lead biocomposites across the chasm. So after ten weeks of project acquisition, one case was selected to continue with in the second phase of the project.

The process of this project showed that material innovation is a slow process. Reaching a collaboration and develop a biocomposite application in a half year project proved to be optimistic. Since the selected case showed slow progress, more effort could be spent on improving the credibility of biocomposites at NPSP and evaluating new material development opportunities. These efforts led to the development of a website proposal, a new sample set and three development opportunities to enable widespread adoption of long fibre biocomposites.

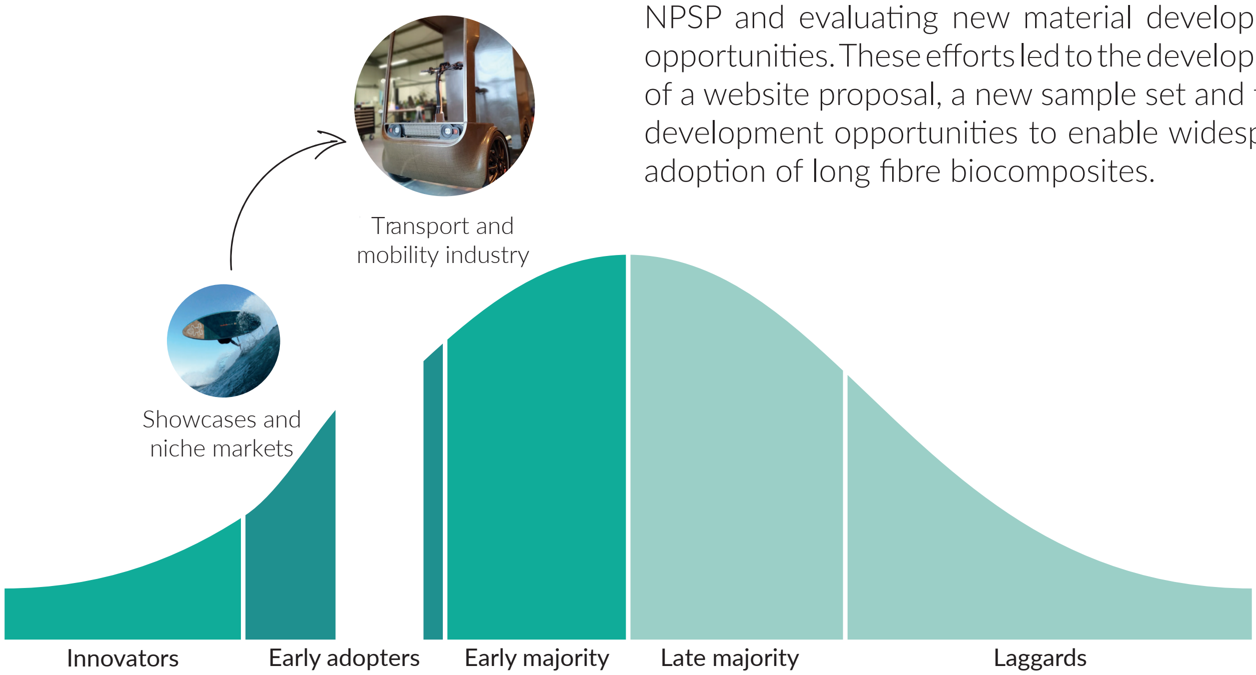


Figure 1: Bicomposite state in the technology adoption life cycle

Introduction

In short, long fibre biocomposites are lightweight, sustainable, have been around since the 1940s and can compete with glass fibre composites in many applications. In a world where environmental awareness and the need for sustainable solutions are rising, many industries could benefit from materials with these properties. Yet, the use of biocomposites is still far from mainstream. This project focuses on biocomposite applications in the mobility and transport industry. The need for more sustainable solutions in this industry is pressing, and biocomposites show a lot of potential by not only be sustainable but also by being lightweight and having other unique, possibly beneficial properties.

The project is commissioned by NPSP, a Dutch company with over 20 years of experience in developing and applying biocomposite materials in various industries. In advance of the project, we set the goal to find a company willing to provide a case to work on for the entire duration of this project. But establishing a collaboration with a client for developing a biocomposite application proved to be a project on its own.

This realization shaped the project into two phases. Since only developing a feasible application of biocomposites would not address the underlying challenging position of the material, this project also aimed to analyse the potential and adoption of biocomposites in the targeted industry. The original project brief can be found in Appendix A.

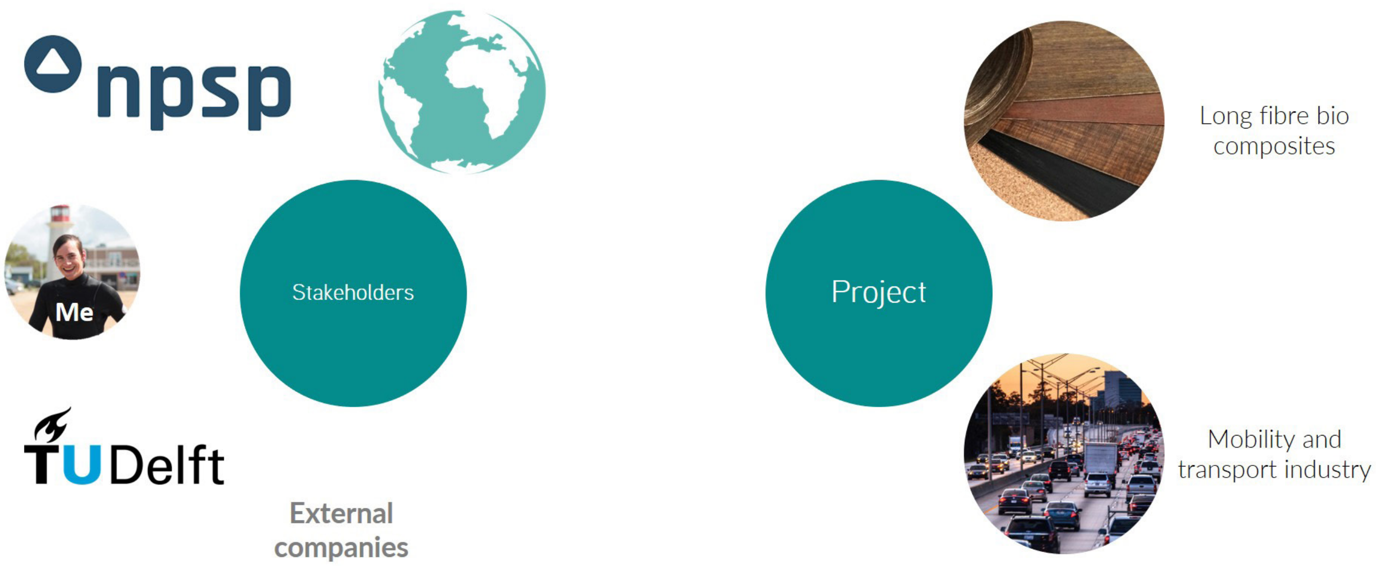


Figure 2: Project context and stakeholders

Project approach

The initial goal set for this project was to develop an application of long fibre composites in the mobility and transport industry that would show the benefits of biocomposites in a more mainstream market. A process with multiple turns adaptions led to the final results of this project. This chapter summarizes the process with a retrospective view.

The goal of this project was first visualized with the position of biocomposites on the technology adoption lifecycle (Figure 1). An earlier Graduation project (Defesche, 2021) at NPSP described how the material is currently at the 'chasm' of this curve. The mobility and transport industry was selected because of the biocomposite potential of biocomposites in these industries and to scope the project.

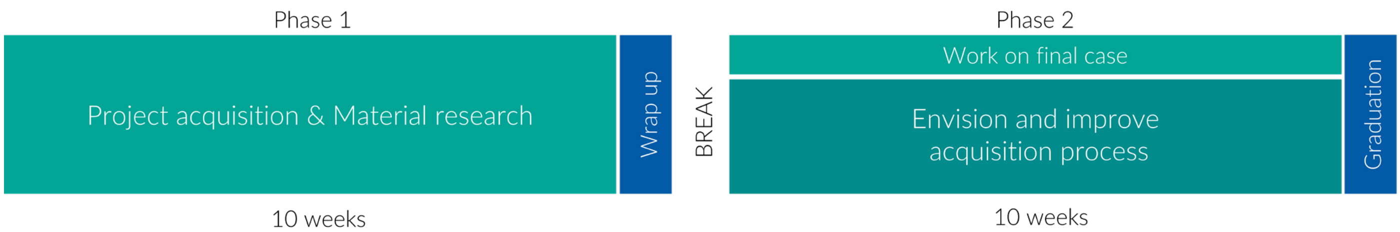
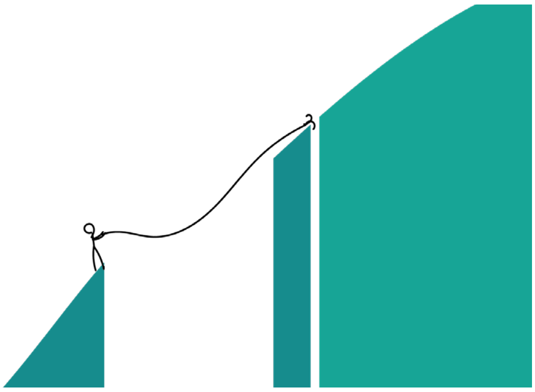
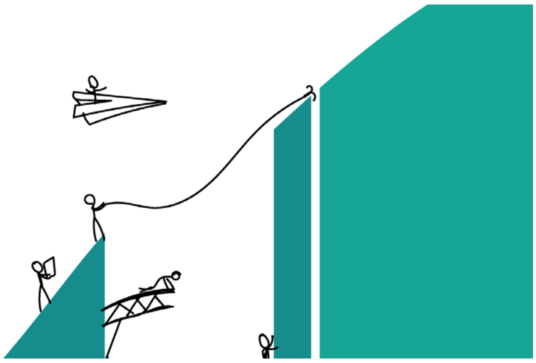


Figure 3: Overview of project divided in two phases

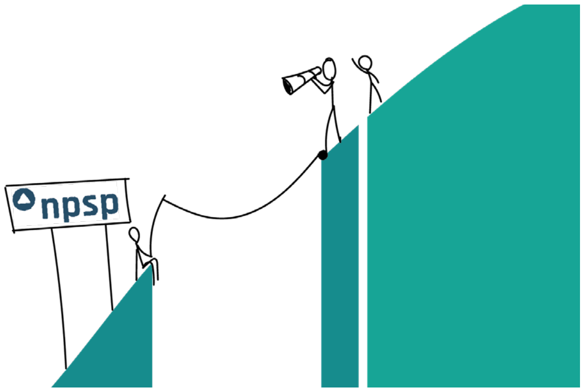
The first approach was to find a client with an interesting and realistic case to show the potential of biocomposites to the industry. It quickly became clear however that finding a case was a project on its own. There were no active leads at NPSP to pursue and establishing contact with companies before the start of the project took weeks.

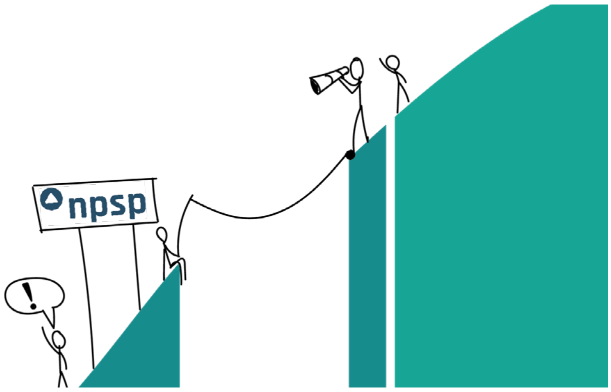




Seeing potential value of taking more time for finding a case and learn from the process led to splitting the project into two phases (figure 3). Nine weeks of material research and talking to six companies from the industry followed.

The acquisition phase resulted in some new leads for possible projects and one was selected to continue with. However, due to an unforeseen mismatch with the company's schedule, it was impossible to work on this case full time. So instead, more focus went to improving the acquisition process and material presentation at NPSP





The project did not result in 'crossing the chasm' or 'moving biocomposites into second gear'. It did result in an analysis of the acquisition process and the current state of biocomposites. Obtained results and insights lead to proposing a redesign of the NPSP website and the physical sample system. Lastly, found opportunities were listed and evaluated.

Report structure

The structure of this report is as follows:

1. Chapter one briefly summarized the obtained material knowledge to get a better understanding of the material, its properties and market position. This was also used to provide companies with information during the acquisition process.

2. Chapter two give a quick overview of NPSP and the materials they use. The materials, knowlegde and services NPSP can offer are important to understand when talking to potential clients.

3. The third chapter describes the process and analysis of the project acquisition. Only two company specific cases are mentioned since most companies participated under a non-disclosure agreement.

4. Chapter four shows the current and envisioned state of NPSP. The metaphor of a fishing boat is used to comprehensively show the envisioned changes.

5. Chapter five presents a partial redesign of the NPSP website to improve the information transfer and guides potential clients into taking action.

6. Changes in the sample system and a new more extensive sample set are proposed in chcapter 6

7. Chapter seven evaluates three material opportunities found in this process. These are opportunities for NPSP to reach more mainstream markets with Long fibre biocomposites.

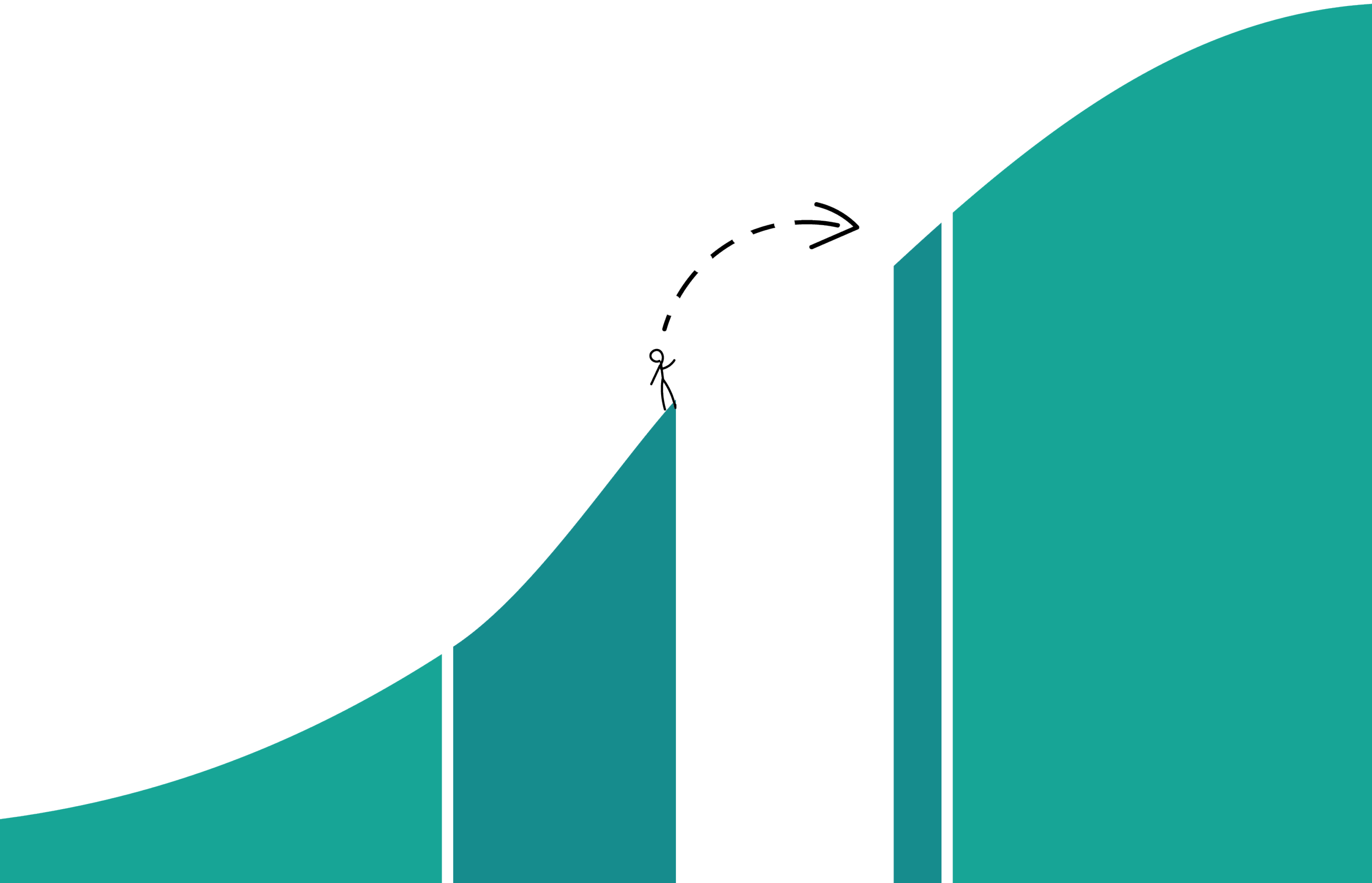
8. The eighth chapter concludes de project and proposes several recommendations.

9. Finally, a personal reflection concludes this report in chapter nine.

1

MATERIAL RESEARCH

To convince companies to consider biocomposites, decent knowledge about the materials is essential



Material research

To convince companies to consider biocomposites, decent knowledge about the material is essential. Besides facts, properties and possibilities of the material, the current state biocomposites adoption, various trends and prospects by experts are reviewed. The information is briefly summarized in this chapter and used during meetings with companies throughout the project. The general presentation slide deck used during these meetings can be found in Appendix B and confidental datapackage B.

1.1 What are biocomposites?

Before diving into properties, facts and other details, it might be wise to start by briefly explaining what biocomposites are, and what kind of biocomposites this project focuses on.

The biocomposite materials referred to in this project show many similarities with 'normal' or 'synthetic' composites. Well know products made from these materials are products like high-end sports equipment, wind turbine blades and large portions of aeroplanes. But also housings of products like power tools are often made of composites to increase the strength and stiffness of these parts.

A composite basically consists of a fibre part and a matrix part. The fibre adds additional properties like increased strength or stiffness to the polymer used as the matrix. Some common fibre types are glass fibre, carbon fibre and aramid fibre, each having different unique benefits. Fibres can be short strands mixed with a polymer to be injection moulded, or long and possibly woven in a specific arrangement to increase its properties. The polymer matrix can be both thermoplastic or thermosetting.

If these basics are understood, the term 'biocomposites' almost explains itself. The composite is made by the same principles as explained above, only one or multiple components are biobased, biodegradable or recycled, making it a 'bio' composite. Examples of biocomposites are synthetic or partly biobased polymers with natural fibres like flax, hemp or recycled denim. Current developments focus on reaching a higher biobased content, enhancing properties and improving the end of life scenarios.

This project focuses on long fibre biocomposites with both thermosetting and thermoplastic matrices (Figure 4). The matrices can be synthetic, partly biobased or fully biobased and can be both thermosetting or thermoplastic. Since the fibres are long, injection moulding is off the table. At NPSP, the thermosetting long fibre composites go by the label Nabasco5010 and thermoplastic variants under Nabasco9010.

Figure 4: Basic components of high end biocomposites

1.2 Properties

This paragraph briefly describes the unique properties of long fibre biocomposites and ends with the listing main benefits and challenges of the material. More material information can be found in the acquisition slide deck (Appendix B and confidential data package B).

Stiffness and density

The clustered material universe shown in figure 5 shows the general position of biocomposites. As can be seen in the graph, biocomposites tend to be slightly lighter than synthetic composites, but also have a lower stiffness. It is still hard to predict from this graph if biocomposites could save weight in an application where good stiffness is required.

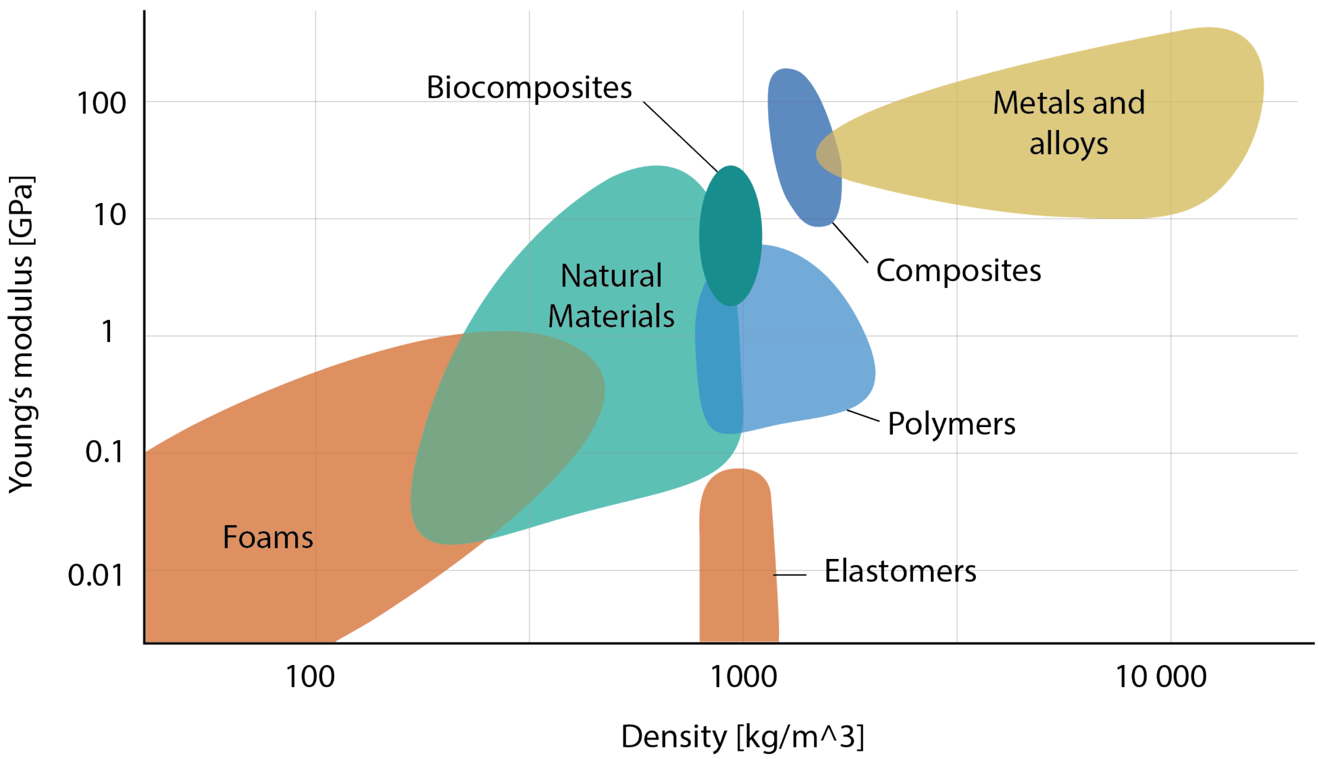


Figure 5: Material universe, Source: Granta CES Edupack 2019

Specific plate stiffness

The relation used in this graph is derived from the bending stiffness formula. It takes the moment of inertia and density into account, so lighter materials can have a larger cross-section at the same weight, increasing the stiffness. This graph compares glass fibre, natural fibres with synthetic resin (N3010) and natural fibres with partly biobased resins (N5010) in multiple versions with each other. Base, Strong, Light and UD are the biocomposite variants NPSP offers. These describe the alignment of the fibre and composite layup. Base, Strong and UD are commingled, woven or unidirectionally aligned in the composite. Light uses a lightweight core made of foam, wood or cork between the fibre layers to create a sandwich. The graph shows an important benefit of biocomposites: They can be lighter than aluminum, steel and glass fibre in stiffness critical applications.

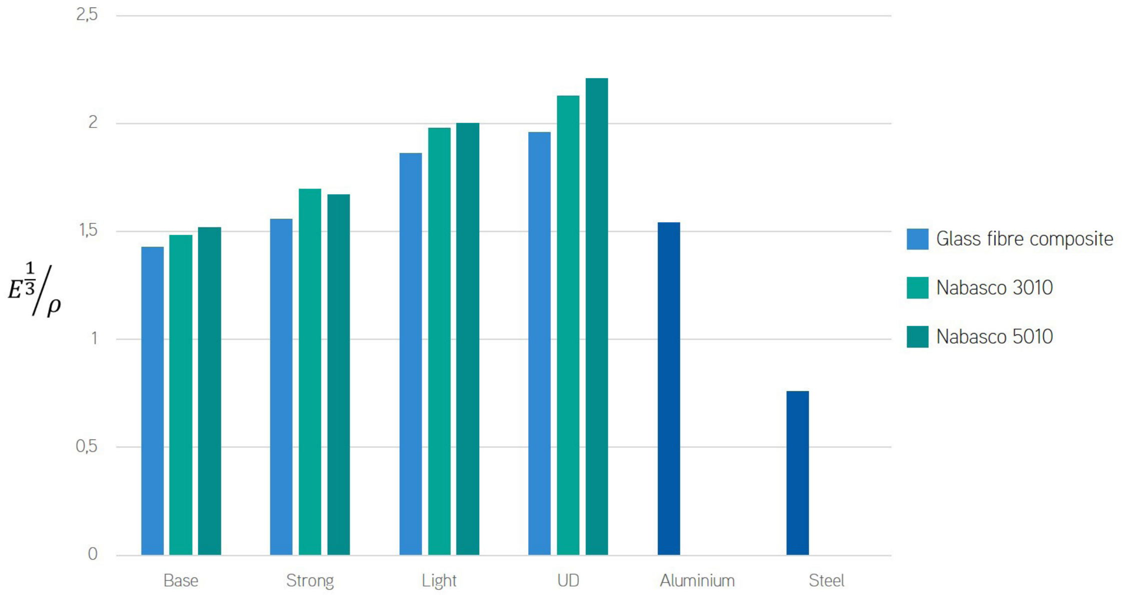


Figure 6: Specific plate stiffness, Source: NPSP

Damping behaviour

The next unique property is the damping behaviour of biocomposites and flax fibre composites in particular. Figure 7 shows the stiffness to density ratio related to the damping loss factor. Research performed on the sound and vibration damping of thermoplastic nonwoven biocomposites (Zhang et al., 2019) displayed that these materials show great potential for interior automotive panels. So for applications where lightweight, stiff parts also benefit from a high damping factor, biocomposites seem to be a suitable and sustainable option. In niche sports applications, flax is applied because the increased damping creates more comfort and is still light and stiff enough for high-end products (Phess31. 2019).

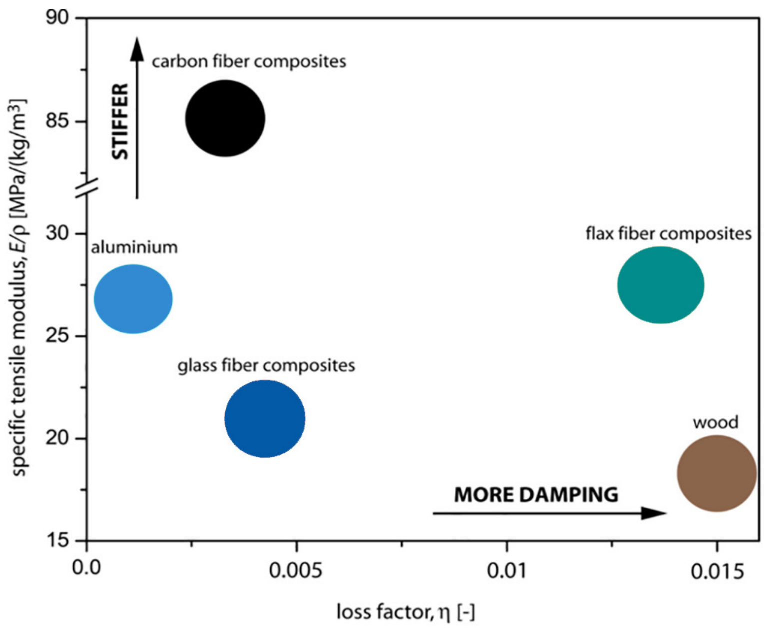


Figure 7: Material damping behaviour, Source: Mathijsen, 2018

Impact resistance and breaking behaviour

Although biocomposites have a lower impact strength than glass fibre composites, biocomposites will absorb more energy during impact (Li et al., 2020). So, they are more likely to permanently deform or 'break', but do this more safely. Synthetic composites like carbon fibre are known for creating sharp edges and splinters if the composite breaks. This behaviour is not present in biocomposites since natural fibres tend to buckle in a high impact scenario instead of breaking. Experiments done with a Formula crashbox made out of flax (figure 8) even showed that the material is ready to meet all regulations to be used in Formula 1 cars and is even saver considering the absence of sharp splinters (Maher, 2020),

Figure 8: Flax composite formula crashbox, Source: Maher, 2020

Sustainability

Since the mobility and transport industry often requires light and stiff materials, this graph (figure 9) also has the specific stiffness on one axis. The embodied energy is placed on the other to show another unique position of biocomposites with the material universe. According to this graph, biocomposites are significantly more sustainable than most high-end and lightweight mainstream materials.

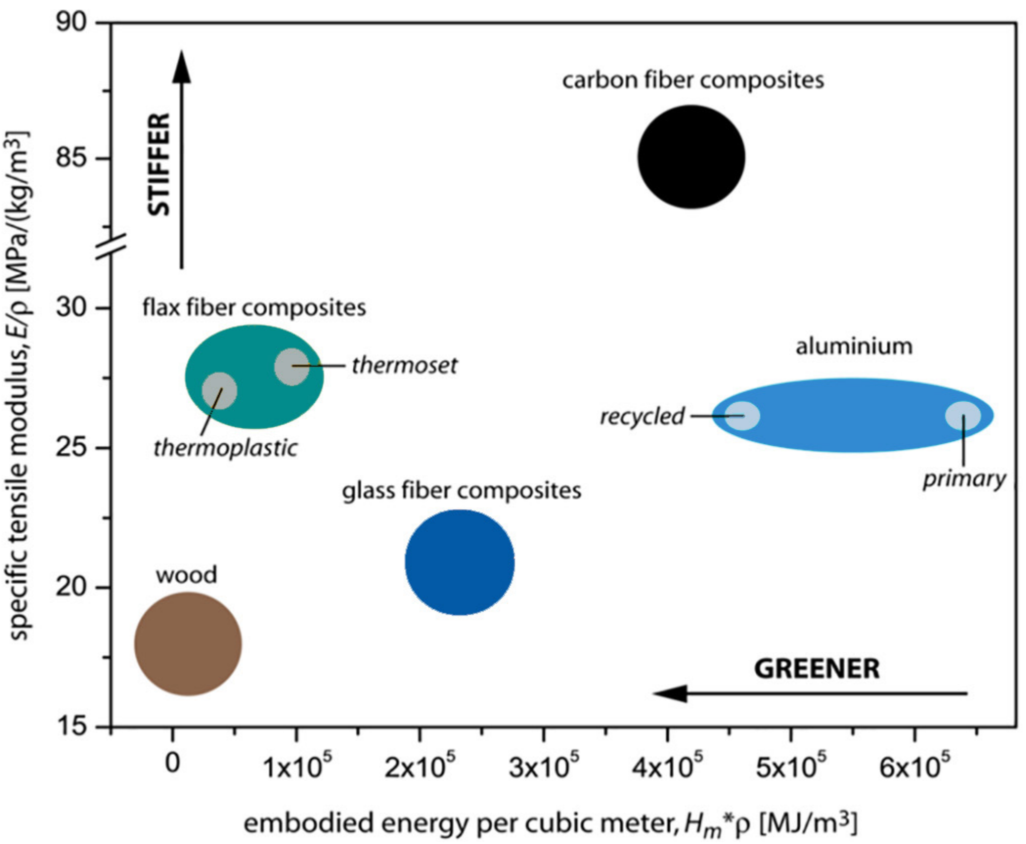


Figure 9: Embodied energy, Source: Mathijsen, 2018

Regarding the end of life of biocomposites, the current benefit over glass fibre is the fact that biocomposites can be incinerated without leaving residues (Akampumuza et al., 2016). Since glass fibre cannot be incinerated, 40% of it is directly sent to landfills (figure 10), leading to roughly 40.000 tonnes of waste annually in Europe alone (Suschem, 2018). A lot of research currently focuses on improving the end of life of thermosetting composite resins. Thermoplastic matrices could be separated from the fibres and reused at the end of life. Biocomposites with natural fibres and biodegradable plastics like PLA have the potential to be completely biodegradable.

Although these options will significantly improve the end of life scenario of composites, it should be noted that current production volumes are too low to set up a general waste management stream for biocomposites. So, a good end of life scenario will need to be managed by the manufacturer or company itself.

Figure 10: Europe has to deal with the disposal of around 3800 wind turbine blades each year. Source: Bloomberg green, 2020

Aesthetics

Closing off with a less technical property, the aesthetics of biocomposites could be addressed as a potential benefit in their application. This is a less objective matter, so the aesthetics of the material cannot be defined as a definite benefit. It is a matter of taste and personal preference. But, it is not uncommon among current applications that the material remains visible to tell and show the sustainable choice within the product. The next page (figure 11) provides an overview of natural biocomposite aesthetics.

Figure 11: Collection of images showing biocompoisite aesthetics

1.3 Production techniques

Manufacturing processes of biocomposites are comparable to those of synthetic composites. An overview of all processes used for producing long fibre composites with corresponding typical batch sizes is given in figure 12.

The most common techniques used by NPSP are vacuum infusion, hand layup and (Light-)RTM. These techniques generally offer high-quality parts that can be very big, often without requiring metal moulds. Thermoplastic composites are manufactured at NPSP by hot press moulding, which is still under development for large scale applications.

Some unique benefits of these processes are:

- The shape and size freedom. Composite manufacturing offers the possibility to merge multiple features into one part, thereby saving costs and lowering the overall amount of parts needed for a product.
- Low amount of post-processing. Apart from trimming the edges, composites parts leave the mould as fully coated, ready to apply parts.
- Composite manufacturing processes are significantly less energy-consuming than for example metal manufacturing processes because less heat and pressure is needed to shape the materials.
- The natural fibres in biocomposites offer the benefit of being safer to handle over synthetic composite fibres.

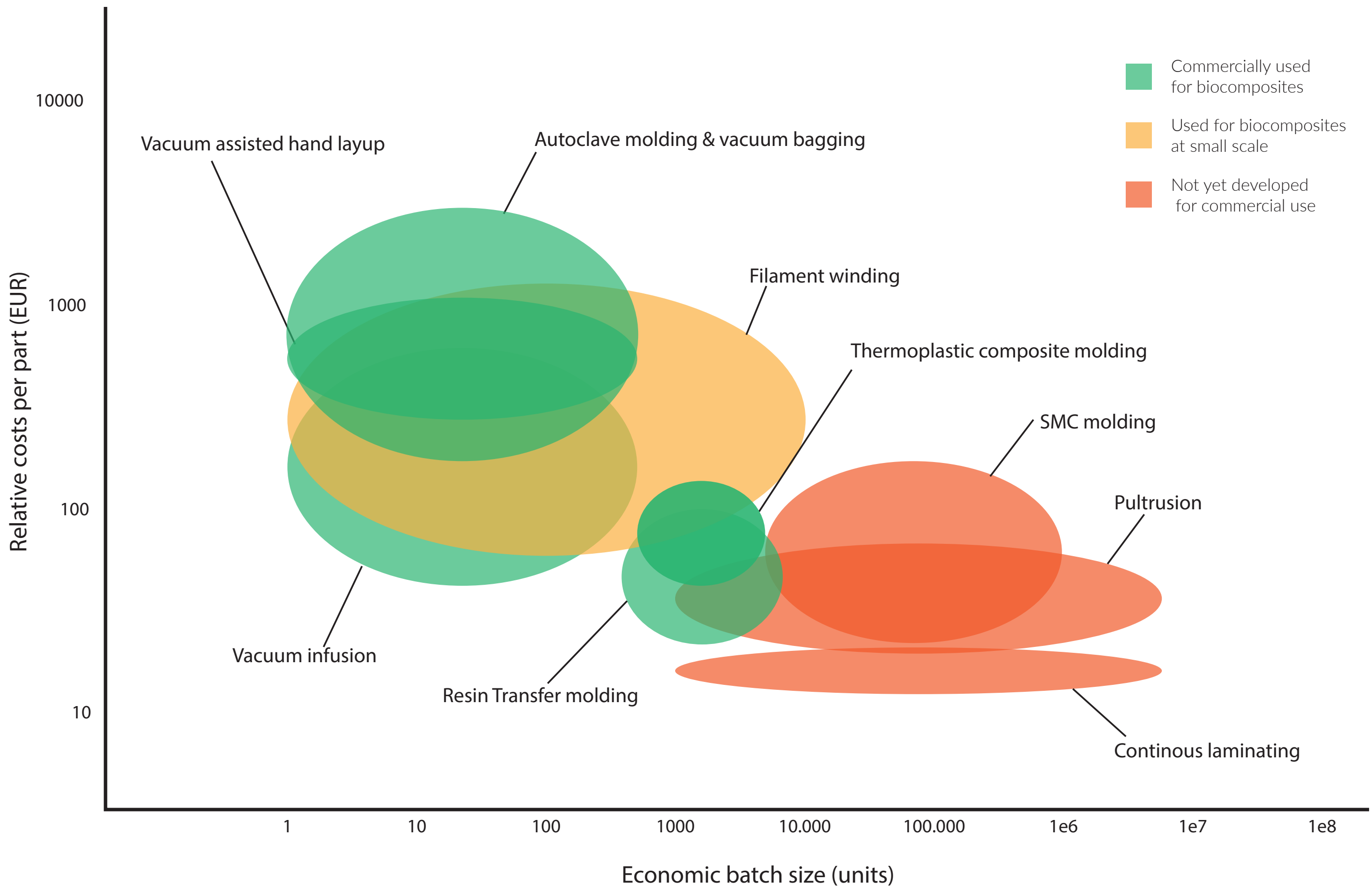


Figure 12: Most common composite production techniques, source: CES Edu Pack, NPSP

1.4 History of biocomposites

To put the current position of biocomposites in perspective, it is interesting to have a quick look at the history of biocomposites. Where many may believe biocomposites are a very novel material, Henry Ford already produced a full car body with the material in 1941 (figure 13). He made a model T concept car with a body made out of hemp fibres and soy resin (Akampumuza et al., 2016). The car was two thirds the weight of the traditional model T and had an engine running on hemp oil. Around the same time, due to the shortage of metals during the second world war, Spitfire aeroplanes were produced with flax fibre composite fuselages (Lucintel, 2011).

Unfortunately, due to the development of more predictable and cheaper synthetic fibres, the growing use of biocomposites collapsed, until rising environmental awareness blew new life into using the material.

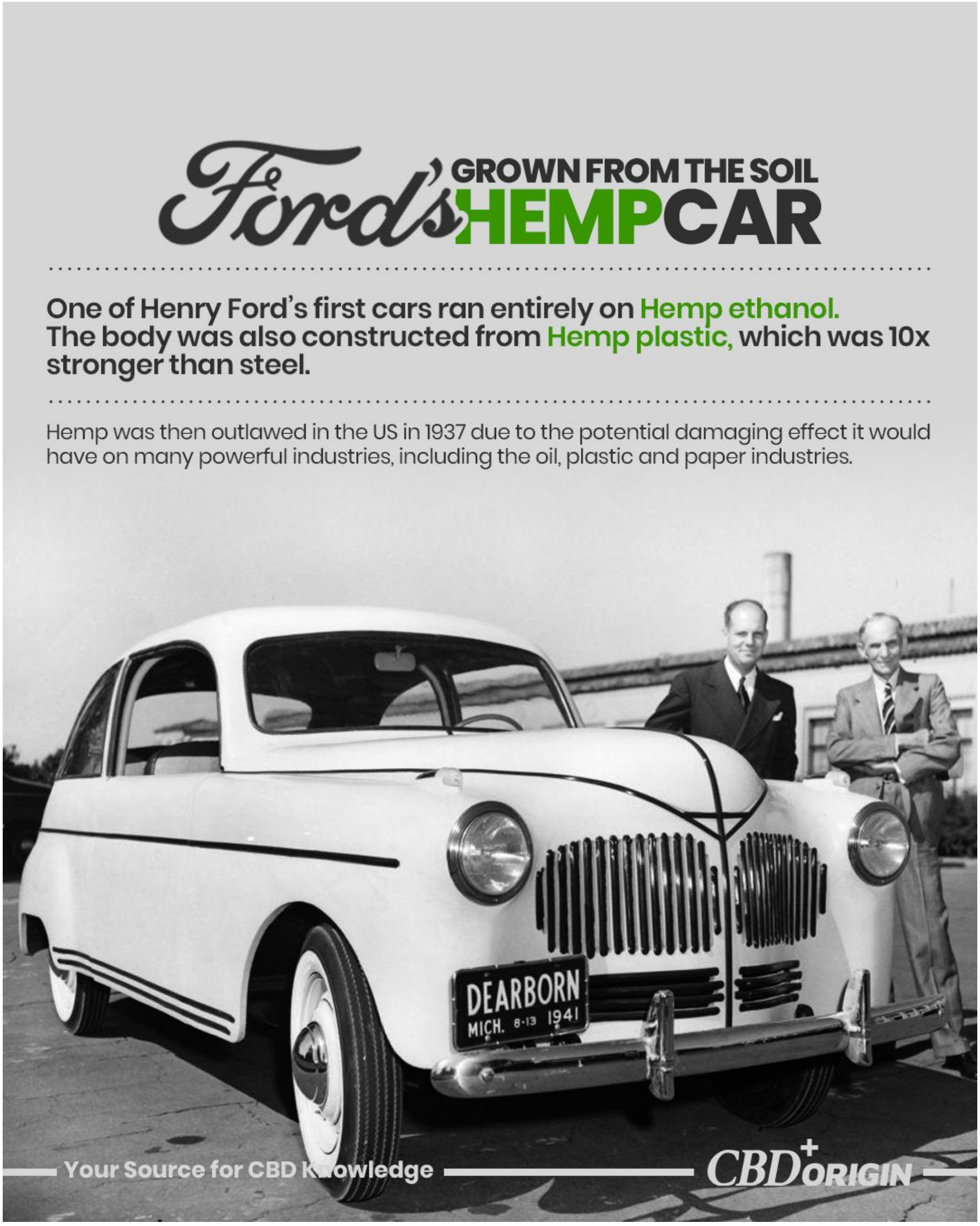


Figure 13: Fords 1941 Hemp car advertisement poster

1.5 Current state of the biocomposite industry

As mentioned before, the main driver of the increasing interest in biocomposites is the sustainability aspect (Saba et al., 2017). It shows potential for many industries, but sticking to mobility and transport, the main benefits of using biocomposites besides being more sustainable are its good specific properties, high vibration damping and unique Aesthetics. The main cons and challenges of using biocomposites for higher-end applications are the high costs, varying properties, moisture sensitivity, lower strength compared to synthetic fibres and lack of fire ratings (Mohanty et al., 2002)(Midani, 2019). A more subjective threshold for companies is the low amount of applications that can be seen 'in the wild'. Currently, less than 2% of all composite applications consist of the biocomposites referred to in this project in 2010. The use of biocomposites has been and still is steadily rising (Shah et al., 2013).

This current position of biocomposite adoption can be referred to as the so-called 'chasm' in the technology adaption life cycle (figure 14). This model shows there is a gap between a market of early adopters and the market of the early majority. The early markets consist of innovative enthusiasts willing to adopt the new technology because they see potential and are willing to accept some hurdles and bumps while implementing and using this technology. Currently, the main applications of long fibre biocomposites are in this segment. Applications consist of niche applications like high-end sporting gear, instruments and design furniture.

More high-end applications of biocomposites in the mobility and transport industry are still at the early adoption state. 'More high-end' is used here because low-end uses of biocomposites are already quite common in the automotive sector (Akampumuza et al., 2016). A fair amount of car manufacturers currently use short natural fibre reinforced plastics as non-visible damping and isolation interior panels and trunks. This project aims at applications of long fibre reinforced plastics to exploit the good specific stiffness in lightweight, demanding applications.

The main differences between the early adopters and early majority market that needs to be understood to reach the majority market are that they need to see relevant examples and want a more mature technology with a low risk of failing. These expectations create the earlier mentioned chasm. The chasm of biocomposites can be seen as follows: Due to high material prices, the low number of proven examples and some material challenges that need research and development to overcome, the early majority is likely to reject or postpone the use of biocomposites. But, without large scale applications of the material, the prices will remain high, no new relevant examples will arise, and budget for research and development remain absent.

Although this may seem like a never ending circle, countless innovations that are now fully integrated into our daily life once crossed this chasm. According to Moore, a focus strategy targeting a first early majority market can lead to a bowling pin effect within the mature market.

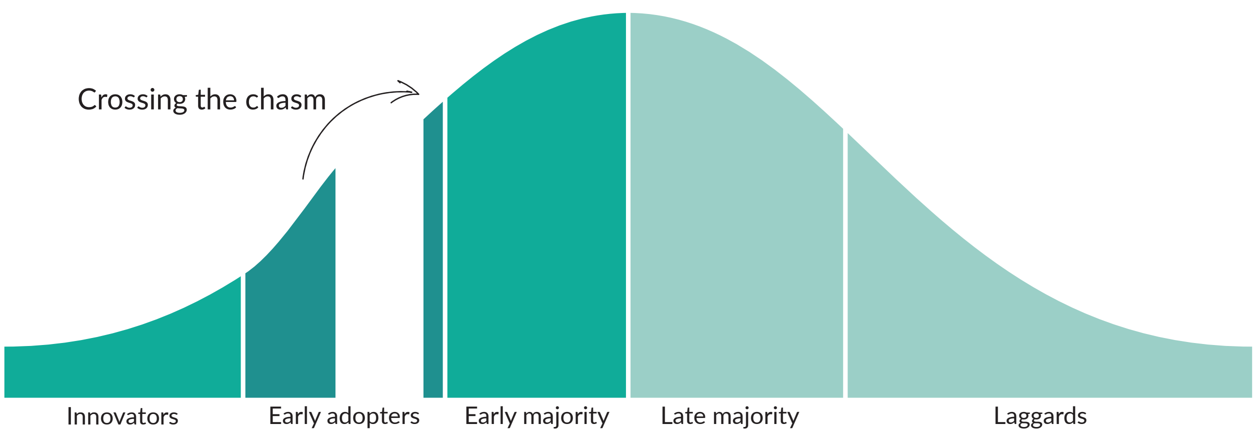


Figure 14: Bicomposite state in the technology adoption life cycle

1.6 Current applications

The collage (figure 9-15) above shows a selection of high end biocomposite applications. Short descriptions of some are given below:

15. Van Eko Bee - full lightweight and structural biocomposite mopet body.
16. EAV cargo bike - biocomposite body panels.
17. Notox surfboards - made with flax composites
18. Mclaren F1 seat - Carbon fibre replaced by biocomposite seat with similar properties
19. Lightweight biocomposite bike saddle
20. Seabubbles water taxi - biocomposite bodypanels
21. Greenboats sailing yacht - biocomposite hull

Figure 22 below, shows a range of commercially available biocomposite products with the consumer price.

Notox Flax surfboard
€ 740 - 1240

Flax carbon hybrid race bike
€ 2500 – 5129

Flax and wood
kiteboard
€ 633

Natural fibre violin
case
€ 139

Flax fibre Guitar
€ 3038

Flax PLA suitcase
€ 349

Flax bike helmet
€ 299

Flax snowboard
binding
€ 411

Hemp sunglasses
€ 145

Figure 22: Range of commercially available biocomposite products

References to all applications shown in this paragraph can be found in Appendix C

1.7 Prospects

Literature about new biocomposite developments or reviews often describe opportunities and boundries for the future of biocomposites. A few of these are listed below.

"Automakers now see strong promise in natural fibre composites"
(Mohanty et al., 2002)

"In the medium term, improvements in the processing characteristics and properties of thermoplastic and thermoset bio-based polymers will facilitate the production of 100% natural, engineering composite materials."
(Quarshie et al., 2014)

"Demand for a better end of life disposal and light weight automotive parts as a gateway to easing on the automotive fuel consumption and thus cutting greenhouse gas emissions will continue to spur an increasing research on the feasibility of natural fiber-based composites in automotives"
(Akampumuza et al., 2016)

"The world is changing and green material is at the forefront due to the depletion of inorganic material such as petroleum and other minerals source. Hence changing to biocomposite materials can fulfil the demands for sustainability in the transportation industry by shifting to renewable, recycled and lightweight materials, considering the requirements of each category of transport vehicles."
(Ilyas et al., 2018)

"Natural fibers are emerging as strong sustainable candidates in the reinforcement of composites due to their unique properties. However, they are still in their early adoption stages and are facing some barriers like compatibility and availability which are preventing them from diffusing into the mass market."
(Midani, 2019)

"The major growth drivers for this market are increasing demand for Wood Plastic Composites (WPC) in the construction industry due to its wood finish like appearance and durability, and growing use of Natural Fiber Composites (NFC) in automotive interiors due to its aesthetics and growing concern for passenger safety."

(Lucintel., 2019)

Summarized from these sources, the following subjects are commonly adressed in future prospects of biocomposites:

Main drivers of biocomposite growth

Commonly mentioned drivers behind why the biocomposite industry will grow in the future are:

- Offering an alternative to depleting fossil based materials like glass fibre
- Being a more sustainable alternative in lightweight (semi-) structural applications.
- Use of biocomposites for their unique properties
- Legislation pushing companies towards using more sustainable materials
- Performed research into improving the properties and processability of biocomposites

Main challenges that need to be faced

- The high price of materials
- Improving compatibility of fibres with polymer matrices
- Improving the end of life of scenarios
- Decreasing variability in properties to become acceptable for more critical applications
- Supply chain of natural fibres needs to become more mature
- Gaining more credibility as a material to be accepted for more applications

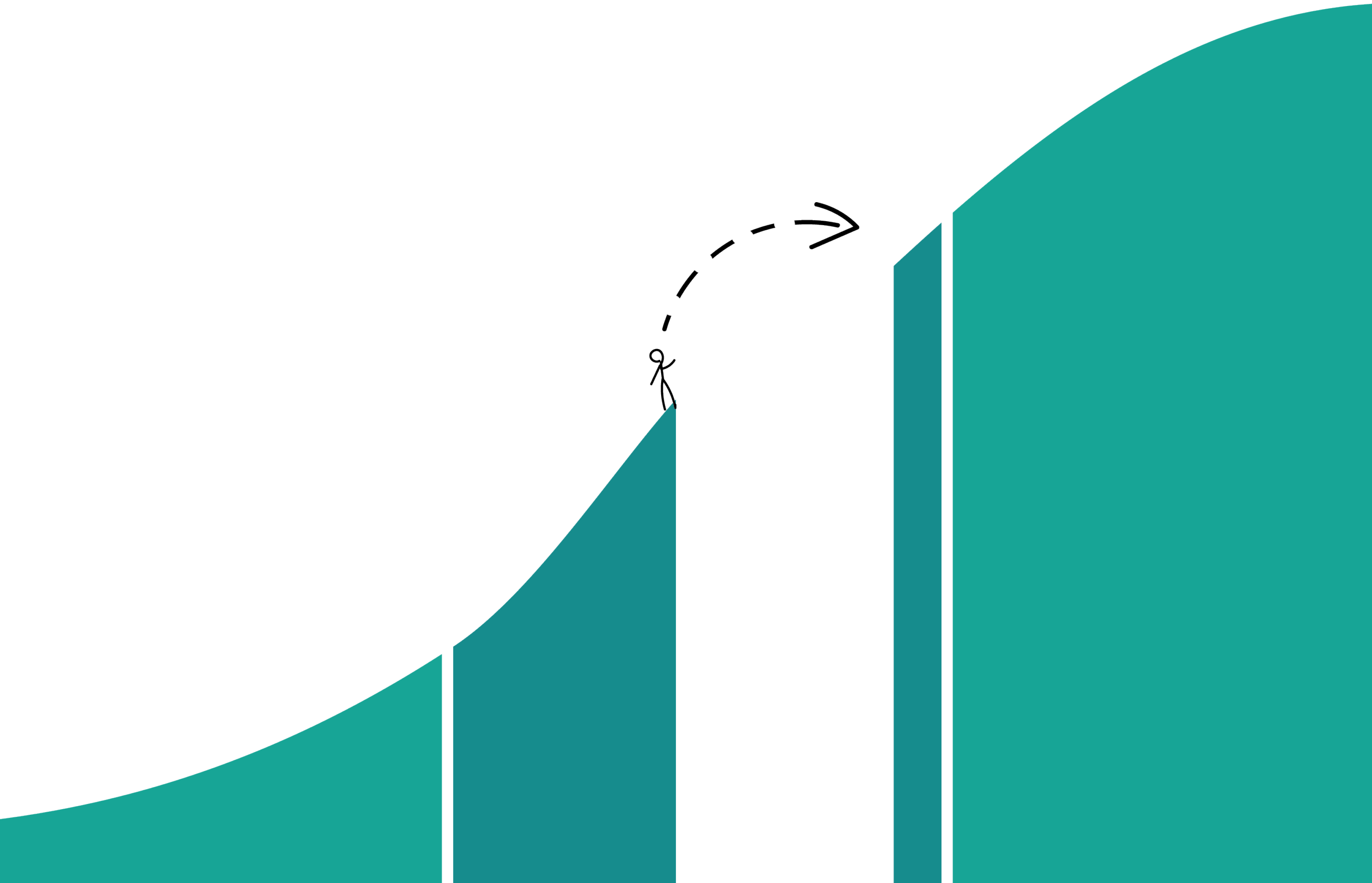
Main areas of development

- Reaching fully biobased composites with good properties and end of life. Effort made to develop resins with higher renewable content and suitable properties for processing. Particular studies aim to improve the properties of present bioplastics like PLA.
- Improving moisture sensivity of natural fibres. This will decrease the negative impact on biocomposite properties in humid environments.
- Lowering costs and improving quality by futher developing the whole natural fibre supply chain.

2

NPSP

Besides the possibilities and limitations of biocomposites, these same values should also be understood for NPSP as a company when targeting companies and selecting cases.



NPSP

Besides the possibilities and limitations of biocomposites, these same values should also be understood for NPSP as a company when targeting and selecting company cases.

NPSP is a Dutch company with over 20 years of experience in the biocomposite industry. They are located in Amsterdam with an office and lab and consist out of a multidisciplinary team of ten people at the time of writing. After trying to specialize in Nabasco 5010 in the early days of the company, NPSP shifted to its current strategy of offering multiple biocomposite solutions and outsourcing the production. NPSP now is active in three domains within the biocomposite industry: material development, product engineering and project realization. NPSP can help clients with developing a new material from their waste streams, up to realizing biocomposite products at serial production.

They currently offer three material ranges ready for application in commercial projects, of which an overview is shown in figure 23. N5010 is the material of focus in this project and also the oldest material range of NPSP. Currently, the N8010 range gets the most interest for commercial applications.

The material composition of the N8010 range is patented, making NPSP essential in realizing products with this material. Furthermore, the production process of N8010 differs from the N5010 and is more suitable for high volume production. The composition of N5010 and its production techniques are not patented by NPSP. In Nabasco 5010 projects, NPSP can offer their expertise, engineering support and product realization and production via partners.

The third range, Nabasco 9010, is composed of a thermoplastic matrix but currently has significantly lower mechanical properties, making its application more limited within the targeted industry of this project. This material is up to 100% biobased and has a better recycling perspective because of its thermoplastic nature.

Besides revenue from commercial projects, NPSP also works on multiple subsidized projects regarding biocomposites material developments. These provide a stable income and enable the company to push biocomposite innovation forwards.

Nabasco 5010

Long natural fibres
with partly biobased
thermosetting matrix

Applied in:
Mobility and transport
Construction
Public space
Furniture

Nabasco 8010

Short natural or recycled
fibres with partly biobased
thermosetting matrix

Applied in:
Construction
Public space
Furniture
Streetsigns

Nabasco 9010

Long natural or recycled
fibres with a 100% biobased
thermoplastic matrix

Applied in:
Indoor products
Sound dampening panels
Furniture
Lamps

Nabasco 10010

Long or short natural fibres
with a 100% biobased
thermosetting matrix

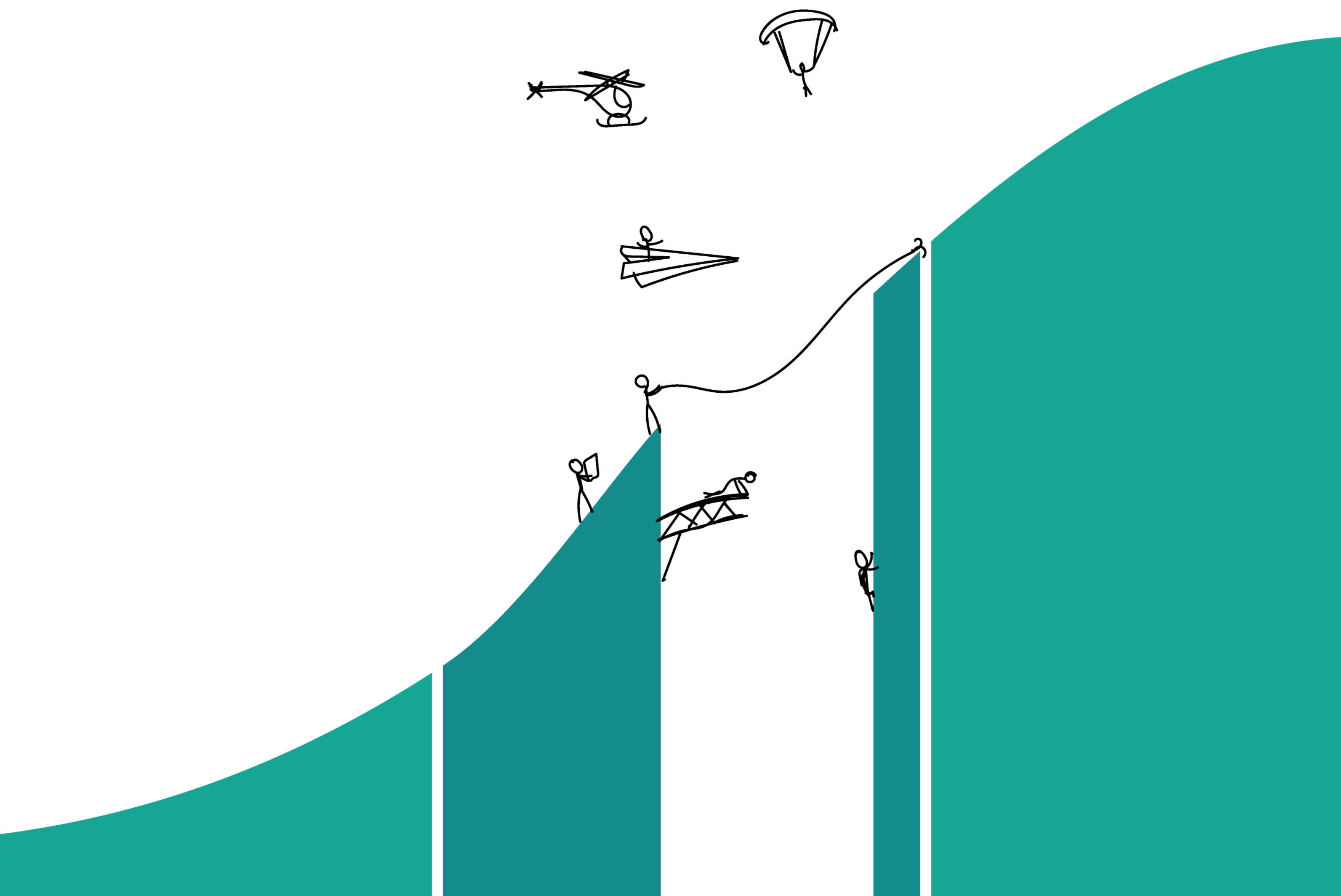
Still in development

Figure 23: NPSP material range

3

PROJECT ACQUISITION

Talk to companies in the mobility and transport industry to evaluate the benefits and challenges of biocomposites, find a final case and analyse this process



Project acquisition

This chapter presents the project acquisition approach, results and insights. Six companies active in the mobility and transport industry participated in this part of the project. Since non-disclosure agreements are signed at the start for more open conversations, involvement and case-specific information of some companies remain confidential.

3.1 Approach

At the start of the project acquisition, a list of companies to contact was made. The formation of this list was based on application visions from a previous project at NPSP (Defesche, 2021), conversations with NPSP and intuition. All companies on the list are active in the mobility and transport industry and vary from small to big, young to old, business to business and business to consumer companies. The companies are based in the Netherlands or surrounding countries.

The companies were contacted by phone or email with a brief explanation about the project and the possible benefits of biocomposites for their products (Appendix D). Contact with some companies was already established in advance of the project. Others were contacted during the project. After a few weeks of establishing contact, six companies had agreed to participate in the project. Non-disclosure agreements were signed with all companies to enable a more open conversation about biocomposite applications. Of the six companies, Noria and Dutchcampers approved to be named as participants in this project and allowed me to share some insights from the process.

Besides performing actual project acquisition for phase two of this project and NPSP, the goal was also to analyse the process. To do so, a process was needed to compare and find similarities and differences between companies and give structure to the analysis. This process went through some iterations. The final version is shown in figure 24. Two meetings about the potential of biocomposites were proposed to each company. These meetings and an additional questionnaire (Confidential data package A) were used for the analysis. The first meeting aimed at identifying the general potential of biocomposites for the corporation and possibly scoping to a specific case. In the second meeting, results of a short case potential evaluation were presented to the companies and further collaboration was discussed.

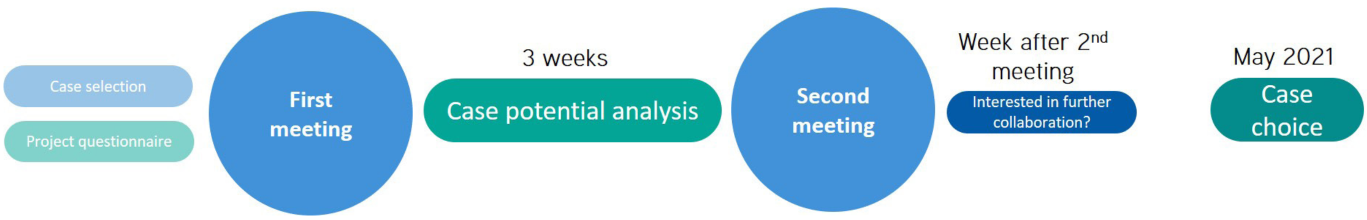


Figure 24: Acquisition process of this project

3.2 Results

This paragraph will present the results of the acquisition analysis according to the stages of the followed process (figure 24). Since shared information and participation of companies was confidential in this project, only general results will be presented here. Specific company and case descriptions can be found in the confidential data package C.

1. Establishing contact

Of the ten companies contacted to participate in this project, six agreed on participation. An introductory meeting was needed in some cases. Of the six participating companies, two had already been in contact with NPSP and two others were contacted before the start of the project.

2. First questionnaire or interview

The first meeting started with an interview which was later replaced by a questionnaire to shorten the agenda of the meeting. The questionnaire consisted of questions related to their participation in this project and beliefs and knowledge of biocomposites. After an introductory meeting and filling in the survey, one company had to drop out because this project did not match with their development timeline.

The majority of the companies rated 'interest in biocomposites from within the company as the most important reason to participate. They had varying knowledge about biocomposites at the start of this project.

To get an insight into the general beliefs about biocomposites, the companies were asked to order a set of reasons why they would, or would not apply biocomposites. Summarized results are shown in figures 25 and 26. The answers were quite distributed, limiting the value of the presented pie chart diagrams. Saving weight and being more sustainable were rated as slightly more important and technology readiness and costs are seen as the main thresholds preventing them to apply biocomposites.

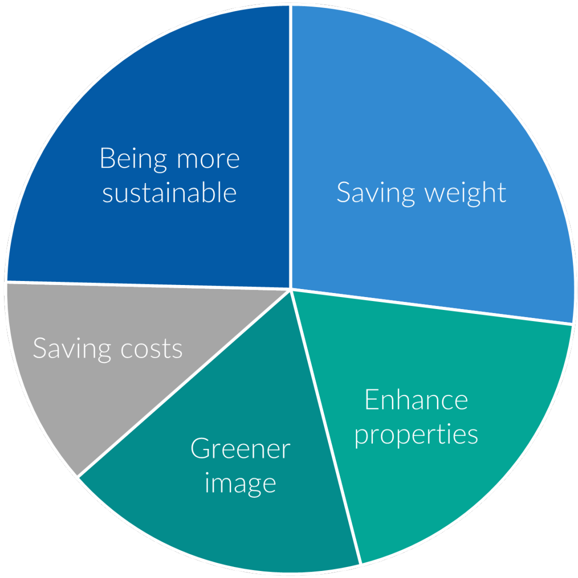


Figure 25: Rated importance of reasons to apply biocomposites

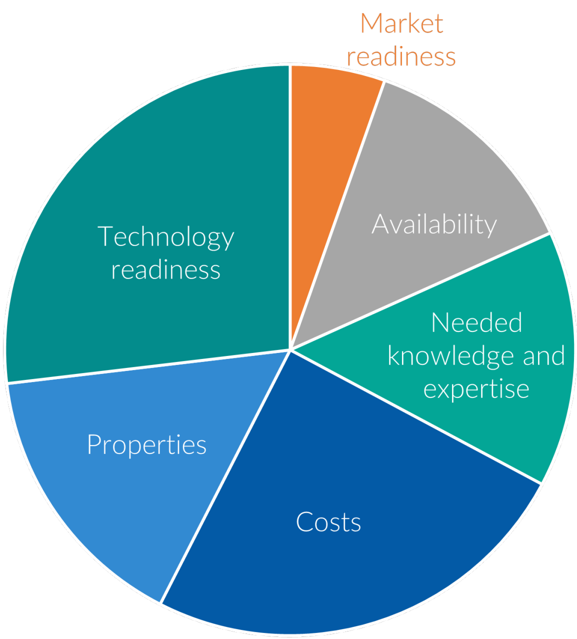


Figure 26: Rated importance of reasons not to apply biocomposites

3. First meeting

To improve the first meeting, companies were asked to think of some possible applications upfront to act as a bedrock for the meeting. This resulted in one company not bringing anything, one having some ideas and one with a short presentation. The amount of preparation by the companies did relate to how far they got in the process. Two collaborations ended after the first meeting. The first one ended due to the low relative advantage they would get from applying biocomposites. The other company saw potential in the material but demanded a product with very high-quality standards that needed to compete with the mass-produced glass fibre version.

4.,Case analysis

Three of the five first meetings resulted in one or multiple cases to analyse for biocomposite potential and a list of questions to answer in the second meeting. In a nutshell, the following analyses were done for the second meeting:

- Designing a very first version of a part to showcase the benefits of applying biocomposites.
- Making visual visions of what an application would look like supplemented with examples.
- A short analysis in the state of biocomposites made by pultrusion.
- A general analysis into the state of the biocomposite industry.

5. Second Meeting

Results of the short analyses and requested information were presented to the companies in the second meeting. The general format of this presentation provided the companies insights into what their application would look like, what benefits biocomposites brought to the case, what challenges still needed to be addressed, what the production options are, what similar had been done before and what kind of industry they would collaborate with.

6. Second phase interest

After having a second meeting with three companies, two remained interested in collaborating for the second phase of this project. The third company remained an active lead for NPSP but could not match the timeline of this project.

3.3 example cases

Some companies agreed to lift the confidentiality and allowed to present the results in this report. So, in this paragraph, the results of the collaboration with Noria and Dutchcampers is elaborated.

Noria

Noria is a start-up company located in Delft. The company develops collecting devices for floating plastic in canals. The devices are part of their service which identifies, collects and disposes or recycles the drifting plastic. After an introductory meeting, the cover of one of the devices was selected as a case for this project. Functional prototypes of the device are currently tested and show promising results. So, the next step is to develop a design suited for serial production.

Since this design was not at a materialization stage yet, the aim for this case was to design a concept of the cover that showed the possible benefits of biocomposites. A producible concept (figures 27 and 28) was presented in the second meeting. The concept showed how biocomposites could be applied to create a lightweight, long lasting cover with natural aesthetics and high shape freedom. Relatively high material and production prices could be countered by an easier and faster assembly process and low maintenance. At the time of writing, Noria is still interested in biocomposites and also evaluates other application areas.

Figure 27 and 28: Exploded view and render in context of biocomposite cover concept

Dutchcampers

Dutchcampers builds pickup campers (figure 29) and laminates and sells lightweight sandwich panels to various industries. Since Nabasco 5010 is suitable to be used in sandwich panels, this was the obvious focus for the meeting with Dutchcampers. The results of the meeting acknowledged the potential of a biocomposite sandwich material. The outside of their campers are completely from sandwich panels. Although they have the luxury and skill to produce a custom sandwich panel for each part to save weight, the outside box is still the single heaviest part of the build. A sandwich skin lighter than glass fibre and cheaper than carbon definitely has potential in this market according to Dutchcampers. But currently, there are still some drawbacks that make considering the material unrealistic:

- The currently used glass fibre skins have a very high quality standard.
- The sandwich lamination process is optimized for skins that arrive on a roll with a certain width and diameter.
- The production technique used to create the glass fibre skins is not yet developed for biocomposites.
- The glass fibre skins are mass-produced with a continuous process in high quantities, making the product very cheap.

These drawbacks meant the end of collaboration in this project but it did provide a tangible list of challenges that would need to be face to make Nabasco 5010 into a credible sandwich skin material. It also resulted in reaching out to a composite skin manufacturer. Since they also acknowledged the potential of biocomposite sandwich skins, a possible collaboration between them and NPSP is being discussed at the time of writing.

Figure 29: Example of a Dutchcampers pick up camper, source: Dutchcampers.nl (2021)

3.4 Final Case

Due to confidentiality agreements, no specific details of the final case may be shared here. A detailed description of the final case-related activities can be found in confidential data package D. The case was selected on estimated potential and personal preference for the type of case-related activities. The activities focused on finding the desired material look and feel for the application and evaluating the producibility. Due to an unforeseen timing mismatch, the collaboration got put on the back burner towards the end of the project. This yet again showed how material innovation needs to fit in the schedule of a company.

3.5 Evaluation

The process is evaluated in this paragraph in chronological order of the acquisition process.

Reaching a collaboration

During initial contact, interest in biocomposites was present in most companies. Looking back at the involved companies, I believe the chances of them taking initiative in researching and considering biocomposite applications were quite small for most of them.

The three companies that stayed involved during this process all started with an introductory meeting. This could lead to the logical conclusion that companies with higher interest are willing to invest more time and are also more cautious to participate at the start. The proposed process of this project acted more as a guideline for the analysis than the actual way most company meetings went. This was probably because each project is different and because collaboration means multiple parties are involved, each having their ideas about the project.

Dropouts

Some summarizing quotes from the companies that dropped out during the process are presented below. Since details about the actual companies cannot be given in this paragraph, the quotes are anonymous. In short, the reasons for dropping out during this project were:

- The lack of off the shelf high quantity availability of the material
- The lack of property and surface quality standards
- Wrong timing within the development process of a product to consider biocomposites
- High risk and threshold to change to biocomposites compared to potential benefits.

"If a sandwich skin has possible putholes or cannot be delivered on a roll, we have no use for it"

"A new skin which is comparable with glass fibre but lighter, more durable and cheaper than carbon would be very interesting."

"We could hunt down every gram we can save in a design but you have to remember that sometimes, products are really being abused"

"The switch to composites already has a high threshold for us, biocomposites even higher because you don't see many applications in the wild yet".

"Since our production partner knows little to nothing about this material, considering a biocomposite application would be more realistic at a later stage of development".

In cases where the unique properties acted as marginal benefits, the supplementary high price and risks of implementing an unknown material make the application of biocomposites very unlikely. In really small electric vehicles, for example, saving weight was not as high on the priority list as assumed. In cases where the vehicle already has a satisfactory range and no other unique properties of biocomposites could be utilized, the relative advantage became very minor. Adding the risks of applying an unknown material and possibly increasing costs makes the pursuit of a biocomposite application at this stage is far from logical.

In cases where the material properties seemed very promising, quick loss of interest appeared in cases where the required production techniques or standards were not (yet) in place. A very large market that could benefit from biocomposites for example is the production of lightweight sandwich panels. While at first, it may look like this only requires simple flat sheets of biocomposite, this market actually requires spotless surface quality and the development of a continuous production technique to even consider competing with the current options.

Overall, premature loss of interest by companies within this project was mainly due to the, in their eyes, immaturity of the material. There are not many comparable applications, the material does not seem directly appliable, and prices of their products are likely to increase for benefits that still need to prove themselves.

3.6 Utilized opportunities for biocomposites

In retrospect, the following opportunities for biocomposites helped with the successful acquisition.

Companies dealing with weight and financial budget

The combination of aiming to minimize weight as well as costs was present at three of the companies involved in this project. From the perspective of this project, making decisions with these optimization factors provides an opportunity for biocomposites. Saving weight with biocomposites with the added benefit of becoming more sustainable is allowed to be a bit more expensive because it can save costs somewhere else in the design or the product life cycle. It creates a positive feedback loop where saving weight could for instance allow to decrease the battery size, which saves costs on one of the most expensive parts of an electric vehicle.

Genuine desire to become more sustainable

In most cases of this project, sustainability was of importance, but not the main driver to consider the application of biocomposites. The from the questionnaire obtained answers showed that saving weight was most often rated as the number one reason to apply biocomposites. The final decision whether to apply a certain material, however, is always made with a mixture of criteria and interests. But some companies in this project did show the intention to generally be sustainable, even if it would imply some additional costs. This creates an added value for biocomposites but is also a challenge since these companies also have more wishes and requirements for the sustainability aspect. Since biocomposites still have a challenging end of life scenario, staying cutting edge on these developments is key for these companies.

3.7 The encountered challenges of biocomposites

Opposite to the opportunities, challenges of biocomposites also presented themselves during the process.

Sustainability

A benefit that should be useable in all cases should be the sustainability aspect of biocomposites. But even though many companies currently desire and try to become more sustainable, material innovation is just one of many factors that can be improved within a product or corporation. This strongly relates to the challenging position of thermosetting biocomposites in terms of sustainability. Although the material is indeed a significant improvement over glass fibre, being only partially biobased and lacking a desirable end of life scenario can make the sustainability of biocomposites into an argument rather than a benefit.

Risks involved with new material

Applying a new or unknown material always comes with some risks for a company. That is why comparable use cases and material data and examples are essential. Unfortunately, biocomposites only have a small amount of beyond showcase high-end applications, making the risks of application in structural or critical parts simply too high. A new material slowly gaining more acceptance is not uncommon in material innovation. Glass fibre composites for example also took decades before reaching structural applications (Nagavally, 2017). This project also encountered that products that are subjected to heavy use are preferably designed with predictable material behaviours. In some cases, this is heavily use oriented, but others could also face supply chain or production risks. Every potential application comes with its own set of risks and benefits that need to be addressed to assess its true potential.

Niche market

In 2010, about 2% of the composite market consisted of plant fibre composites, of which roughly one-third of this market is claimed by transportation (Shah et al., 2013). The percentage of long fibre biocomposites within this part is unknown. Since a fair amount of automotive companies apply short fibres in non-visible, sound deadening panels at high production volumes (Mohanty et al., 2018), the share of long fibre biocomposites can be assumed to be under 50%. Since the mainstream automotive corporations are big and hard to enter, entry of NPSP in this market is unlikely and maybe not even desired. Lastly, this project only focused on companies in North-West Europe. From this listing can be concluded that this project is situated in a niche.

3.8 Key insights on the acquisition process of biocomposites

In retrospect of all activities of this project, some key insights about the current position of long fibre biocomposites and their value at NPSP are summarized here.

The material innovation process

From this project and general material innovation history (figure 30) can be concluded that material innovation takes time. New materials must show significant potential advantages, meet requirements and grow acceptance before application is considered in many industries. And even if a material is considered by a company, material innovation seldom has a high priority and costs are an important factor at the end of the line. The company culture and the function of the contact persons also made a difference in the collaboration. Some engineers could ask in-depth material related questions and get convinced of the potential purely by material characteristics. But more business orientated people quickly moved to supply chain and final product price related questions. Company culture often expressed itself in how decisions are prepared and made.

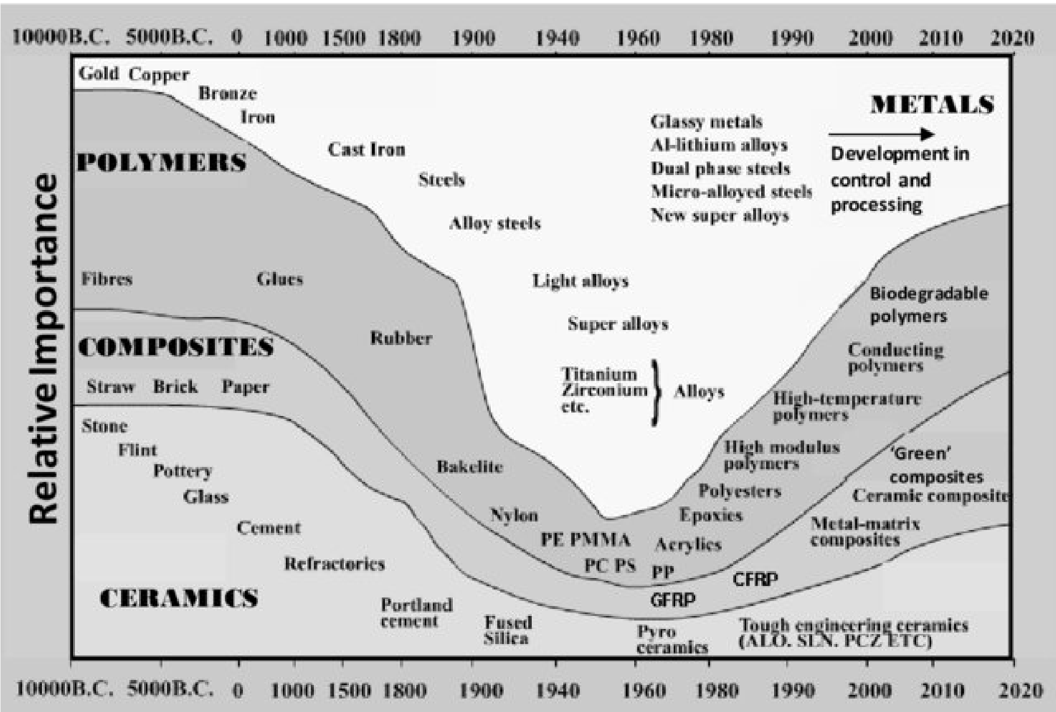


Figure 30: Brief timeline of engineering materials development, source: Shah et al., 2013

Niche market Considerations

As mentioned in the previous paragraph, long fibre biocomposites at NPSP, combined with their current production techniques are of interest for a small niche market. According to literature (Paragraph 1.7) and opinions of contacted companies, there definitely is potential for more sustainable composites and renewable composites in many industries. But, Long fibre biocomposites and their currently limited production techniques make up for a very small portion of this prospected market.

This niche of high end sustainable composite applications does exist but, from an outsider perspective, NPSP is likely not appointed as the market leader. Since its establishment, Bcomp (a Swiss natural composite fibre supplier) has targeted and entered niche market after niche market with their products. Their strategy shows many similarities with the strategy described by Geoffry Moore on how to cross the chasm. They moved from the very small niche of high-end skis, to more high-end sports equipment, to the motorsport industry and seem to keep expanding within these markets and beyond. Bcomp being a material supplier makes them a possible supplier for NPSP instead of a competitor. But from the perspective of a company that considers a high-end biocomposite application, Bcomp is most likely seen as the company to call first. Still, NPSP has a lot of expertise in this and other areas of biocomposites, making them very valuable for clients that not exactly know what they are looking for.

The relative advantage trade-off

The main thing companies try to get straight early on in the process is the relative advantage of biocomposites for their application. This trade-off is different for every case. Figure 31 shows the most common aspects present in trade-offs encountered in this project. At the start of this project, the list of companies to contact for participation were largely based on a method created in an earlier graduation project at NPSP (Defesche, 2021). This method was created to find the most promising product ideas for a long fibre biocomposite application. In retrospect, it can be said that this method indeed predicted potential advantages for biocomposites quite well, but this project showed many more possible disadvantages beyond the fittingness of the material properties for the application. These affected the relative advantage negatively in most of the cases. An overview of possible application areas within a typical light electric vehicle is reviewed with the insights obtained in this process (Appendix E). This shows how, after taking into account, material characteristics, acceptance and relative advantage the cargo box shows the most potential to apply biocomposites.

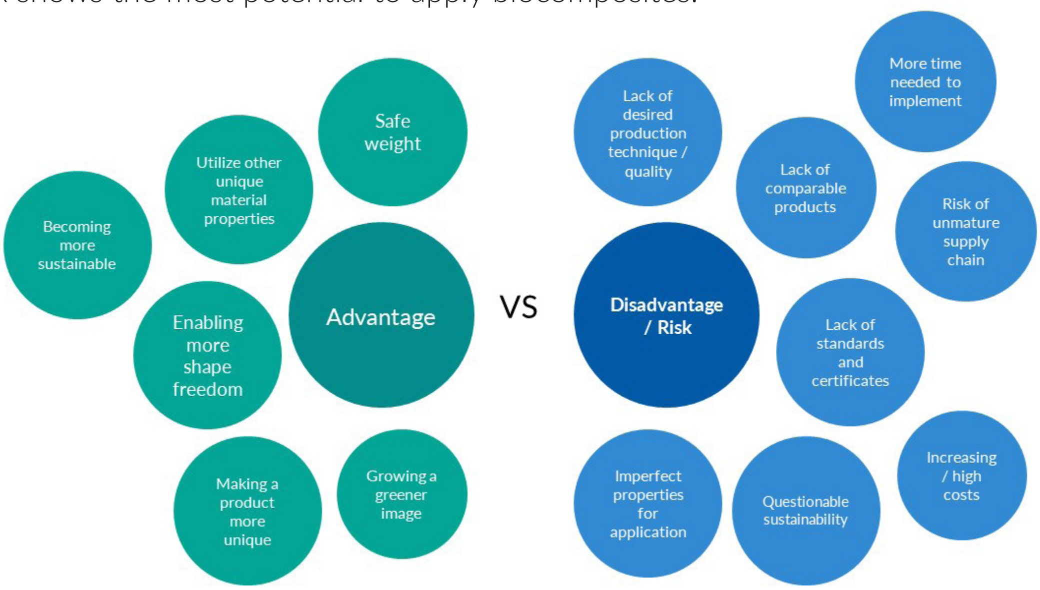


Figure 31: Overview of aspects encountered in relative advantage trade-offs

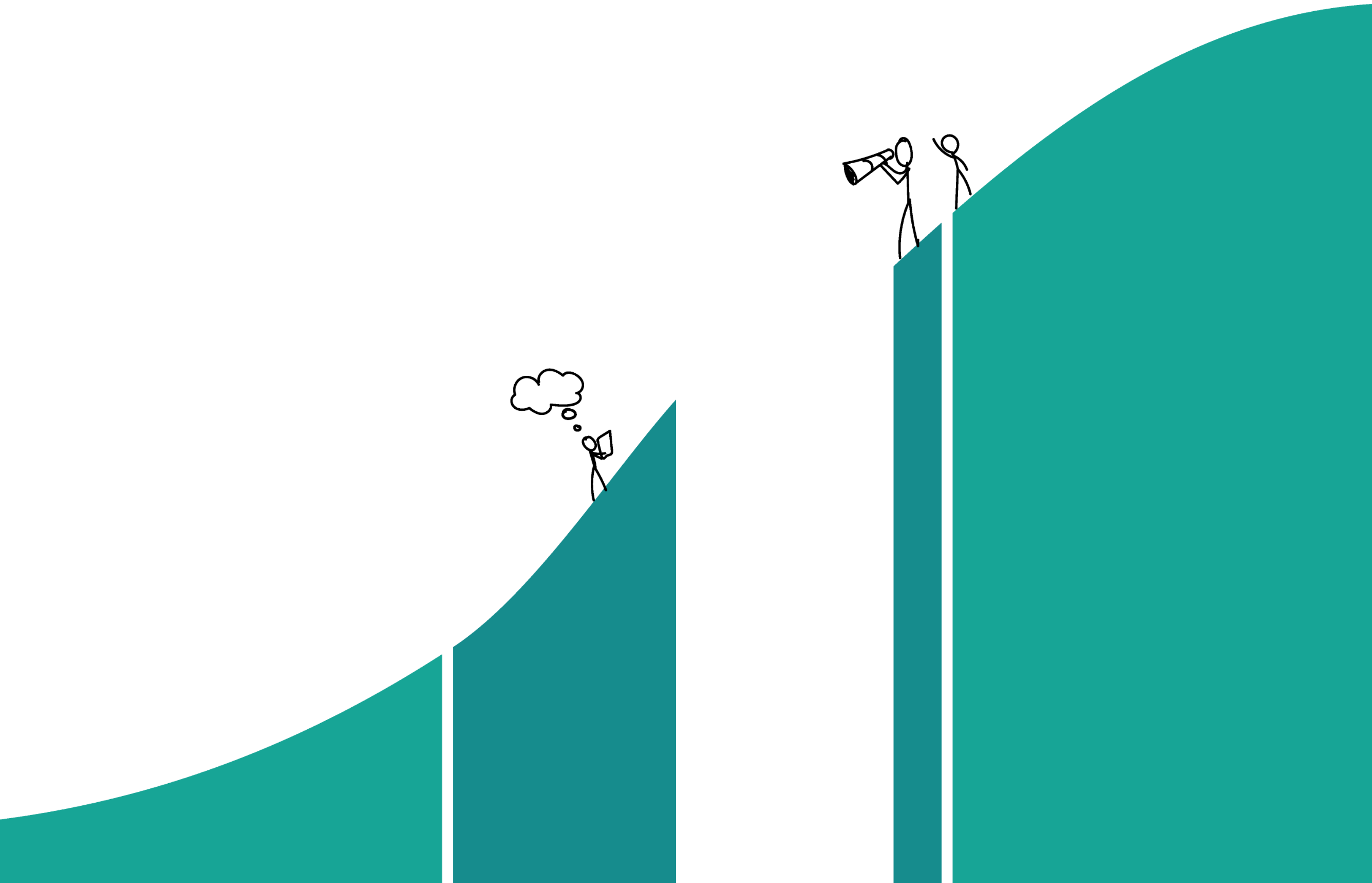
The position of Nabasco5010

Although the Nabasco5010 materials were the start of NPSP and they have a lot of expertise in this area, it seems to get further away from the company's core. On one hand, it seems like the true potential of the material will be acknowledged soon by the markets of interest and many applications will follow. But on the other hand, this process is happening for over a decade and is just very slow. At the moment this would happen, NPSP still holds a sub ideal position in this market. Without a market leader position or any material or process patent, they are mainly the connecting party, taking a small portion of the profit. So before really high production volumes are realized, both the profit made from these projects and the sustainable impact is limited. The position of Nabasco 5010 could be improved by (co)developing high volume production techniques or creating a unique part in the process which makes NPSP essential for creating certain products.

4

ENVISIONING THE FUTURE OF PROJECT ACQUISITION AT NPSP

How to efficiently catch more fish



Envisioning the future of long fibre biocomposites at NPSP

4

After experiencing the acquisition process first hand with several companies, pursuing one project for another nine weeks and evaluating this process, the obtained insights are gathered here and used to sketch a vision for the near future for NPSP. The metaphor of a fishing boat is used to explain the current position of NPSP and the envisioned future position

4.1 The current situation

As described in chapter 2, NPSP offers multiple materials types and is active in material development, product engineering and project realization. They fulfil the need of a client by offering expertise, technical support and production of the actual products via partners.

The patent of NPSP on the Nabasco 8010 formula makes them an essential player in projects with this material. In the case of Nabasco 5010, NPSP connects the dots and can still offer expertise and technical support. Drawbacks of the Nabasco5010 business model are the challenging properties of the material, limited possibilities with current partners and the presence of more business-focused competitors in a seemingly small niche. Beyond client based projects, subsidized projects are also part of NPSP's activities. These projects push the possiblities of biocomposites, and provide NPSP more financial stability.

Transferring the current position of NPSP in the fishing boat metaphor (figure 32) shows us that NPSP is a boat with many fishing lines (for different materials in different sectors and different project types). Having lots of different baits and tactics (materials and project types) onboard increases the chance of catching something but also makes it hard to focus on one specific area.

Nabasco 8010 (central bait) can be seen as the most successful bait for profitable projects since this bait is unique (the composition patent) and is successful in the fishing area (targeted industries). Nabasco 9010 (bait on the left) also attracts a lot of interest but is still less profitable than Nabasco 8010.
For Nabasco5010 (most right bait), the bait is not very different from the competitors, making the fishing strategy (expertise and partners) the main strength. Furthermore, the amount of fish that can actually be caught with Nabasco 5010 is smaller than it may seem. This difference results in the boat being more active in fishing spots for the Nabasco8010 material. But, having many other ways to catch fish on board leads to the boat being in a central position, to remain active in every area.

Besides material as bait, NPSP also fishes for subsidized projects. This could be compared to fishing without bait, hoping to find new promising materials and techniques (treasure chest). Some of these hooks might be very close to catching a treasure for NPSP, but others might show very limited potential and therefore waste valuable time (the boot).

From a distance, NPSP is boat with many strategies and expertise on board, and different baits in the water. This leads to a versitile set of activities but also creates a challenging situation to strategize and focus as a company.

Figure 32: Fishingboat metaphore of current situation

4.2 The envisioned scenario

Figure 33 shows the envisioned version of the NPSP fishing boat. This vision represents a near future situation, so in general, the image is comparable. The first difference is how the fishing rods are manned. The lines with Nabasco 8010 and 9010 get more focus and there is one unmanned new line. This line represents some new passive acquisition methods to make the acquisition more efficient.

These new methods consist of a website with comprehensive material information and a semi-autonomous customer journey for potential clients. The idea behind these is to provide more information to interested potential clients and persuade them to take action. Material selection and innovation at companies happens at a specific moment and is often of low priority. So, having information ready for them to find when they need it is more efficient than focusing on active acquisition.

The Nabasco 5010 is no longer used as bait on a manned fishing rod but holds an equal position to the other materials on the unattended line. This saves time that may be spent on improving the market position of Nabasco 5010.

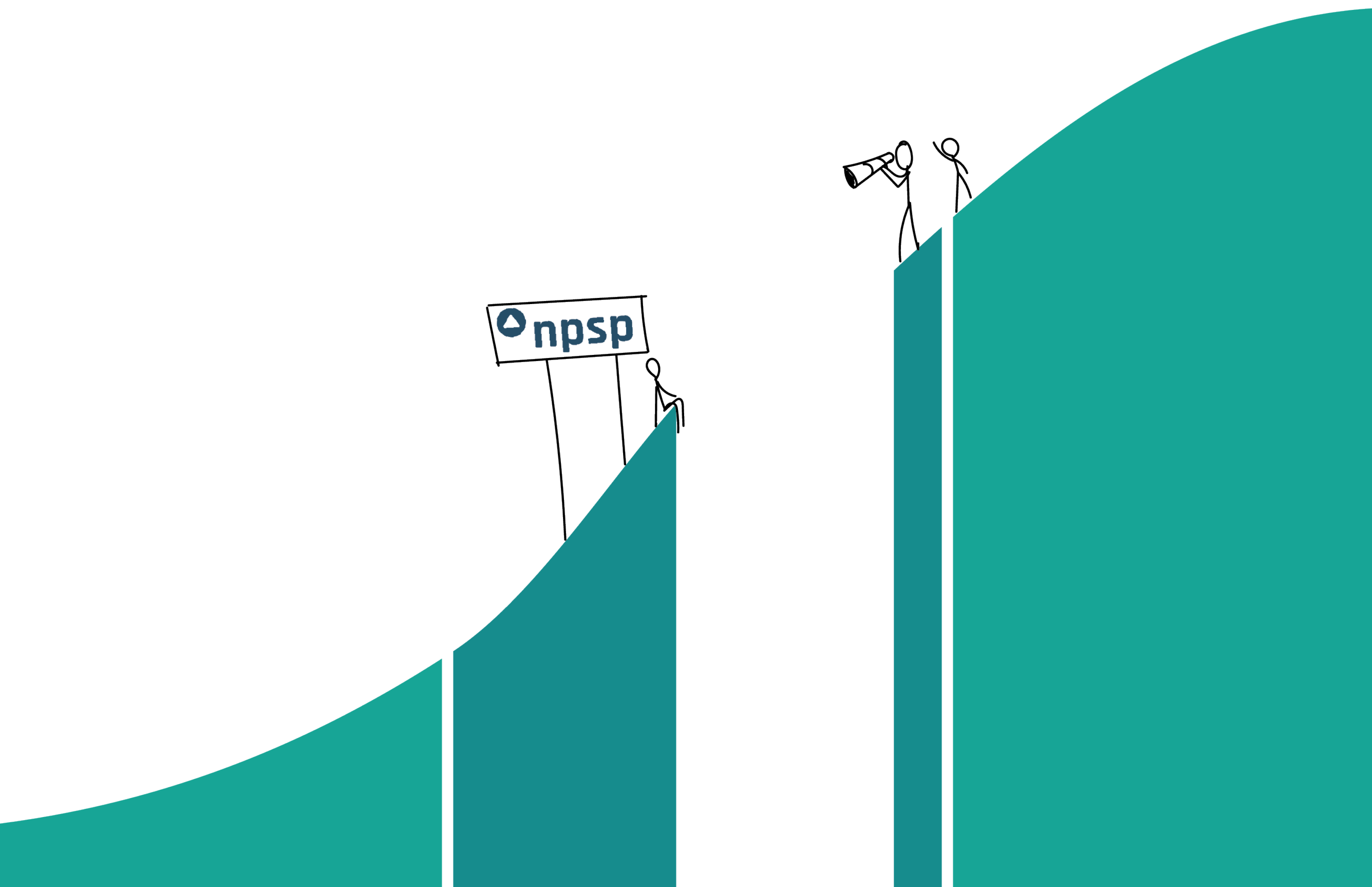
Figure 33: Envisioned fishing boat situation

The envisioned scenario facilitates a more efficient acquisition process and presents NPSP as a more professional and credible partner to potential clients. In time, these and other changes in the company's structure should lead to more revenue and makes NPSP less dependent on subsidized projects. This enables them to focus all material developments on improving the Nabasco ranges. Developing materials with unique compositions or processes create a more favourable business model, leading to more potential revenue. Multiple opportunities for NPSP came to the surface during this project. These are described and evaluated in chapter seven.

5

WEBSITE PROPOSAL

Create interest and desire in the materials and filter and structure new project leads



Website proposal

The acquisition activities of this project showed the amount of effort needed to educate and convince potential clients of what biocomposites could offer them. Deciding to improve this led to several ideas, with the common aim to provide potential clients with more information upfront. Initially, an interactive 'biocomposite material selector' was created to find the ideal material with an application in mind. The proposed new website could be linked to npsp.nl and contains a database with all materials and options to filter and select the most promising material. However, after generating a first working model, the decision was made to provide additional material information on npsp.nl instead. The following advantages of improving the current NPSP website instead of building a new website made it clear to proceed with a website proposal:

- The Nabasco materials are the centre of what NPSP does, so providing information on these materials on their website makes more sense.
- Since NPSP aims to become more commercial, the materials should be presented like proven materials and be accompanied with enough information to create interest and desire from potential clients.
- NPSP is already active on three domains: the company website, a webshop and a collaborative website for the Nabasco street signs. Launching yet another domain would create a more complex and coherent company image for outsiders.
- Reaching the goal of improving the acquisition process is more efficiently and possibly more effectively met by supplementing and adapting the current website instead of building a new one.

5.1 Visiting the proposed website

Npsp.nl recently went through a complete redesign, so the layout and style are contemporary and clear. The website proposal aims at making the materials easier to find and providing more information. Secondly, the AIDA model (figure 34) is applied in the redesigned parts, guiding an interested website visitor towards taking action, resulting in a new lead on NPSPs radar. All redesigned pages can be found in Appendix F or confidential data package E in full size. This paragraph shows what changes are made and how the AIDA model is incorporated.

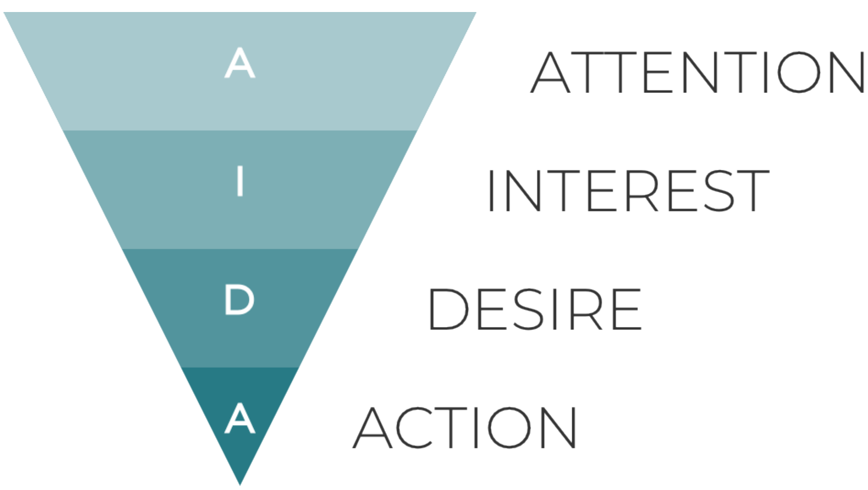


Figure 34: The AIDA model, source: Odekerken (2020)

Materials added in menubar

Attract

Starting at the homepage (Figure 35), a few changes aim to attract visitors to the materials. Right away, the materials can be found under the menu item 'materialen'. This item replaces 'Duurzaam' in the old menu bar since the page behind this item could easily be added to the submenu under materials (Appendix F) Scrolling down, the already existing material overview is enriched with more information and pictures of use cases, to build initial interest.

Overview of materials with picture of application, material oneliner and three most important property icons

Figure 35: Homepage redesign

Interest

Clicking on the ‘materials’ item in the menu redirects visitors to a new overview of the materials (figure 36). This overview contains a bit more information compared to the homepage. This page is likely to be revisited most often after having browsed through npsp.nl before. This is exploited by adding the calls to action to this page.

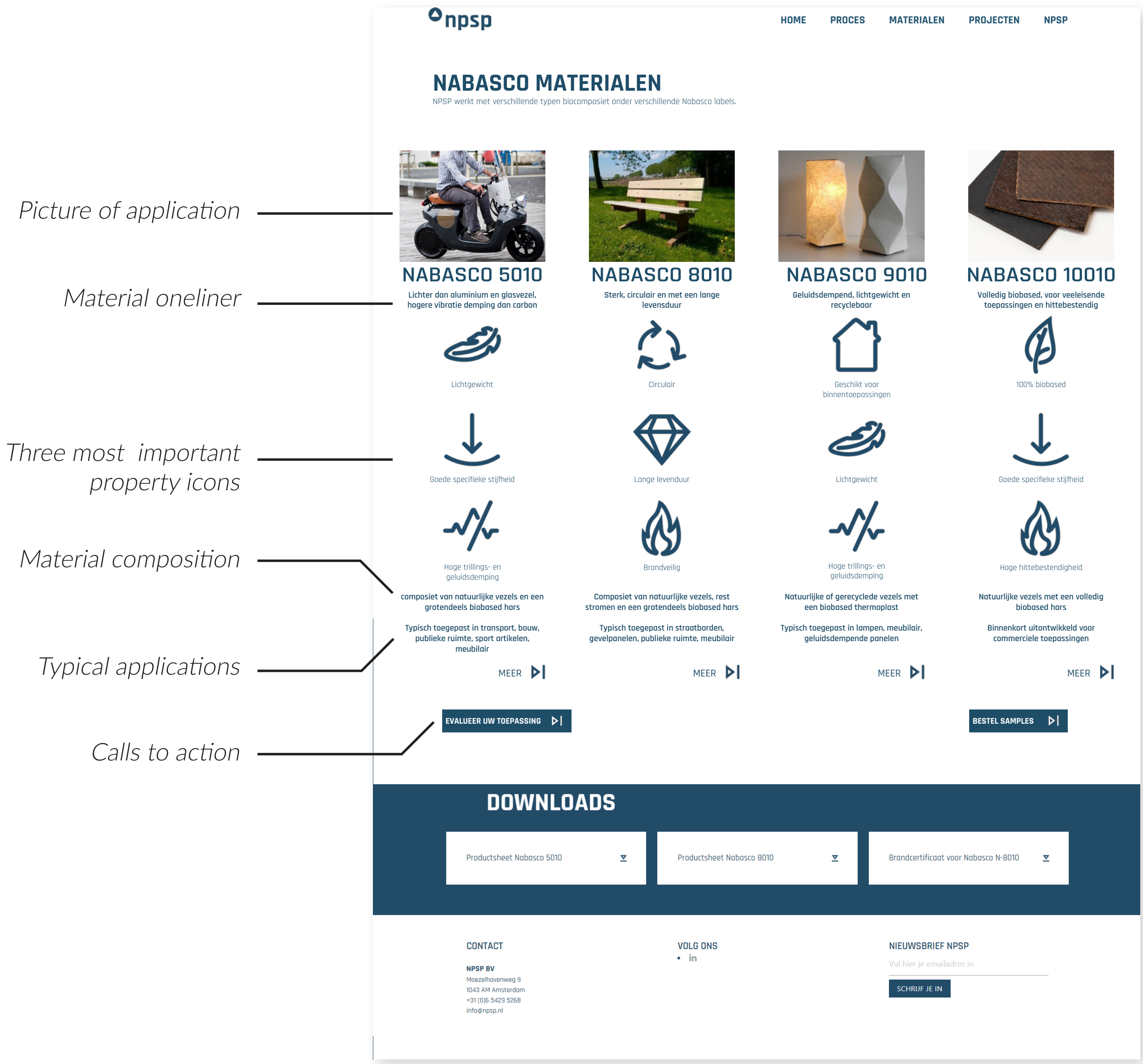


Figure 36: New material overview page

Interest leading to desire

The new specific material page (figure 37) provides enough information to make an envisioned application in a visitor’s mind more tangible. A one-liner and attractive icons present the unique selling points of the material. Next, an overview of the possible variants, important information to assess an application and possible finishes of the end product are provided.

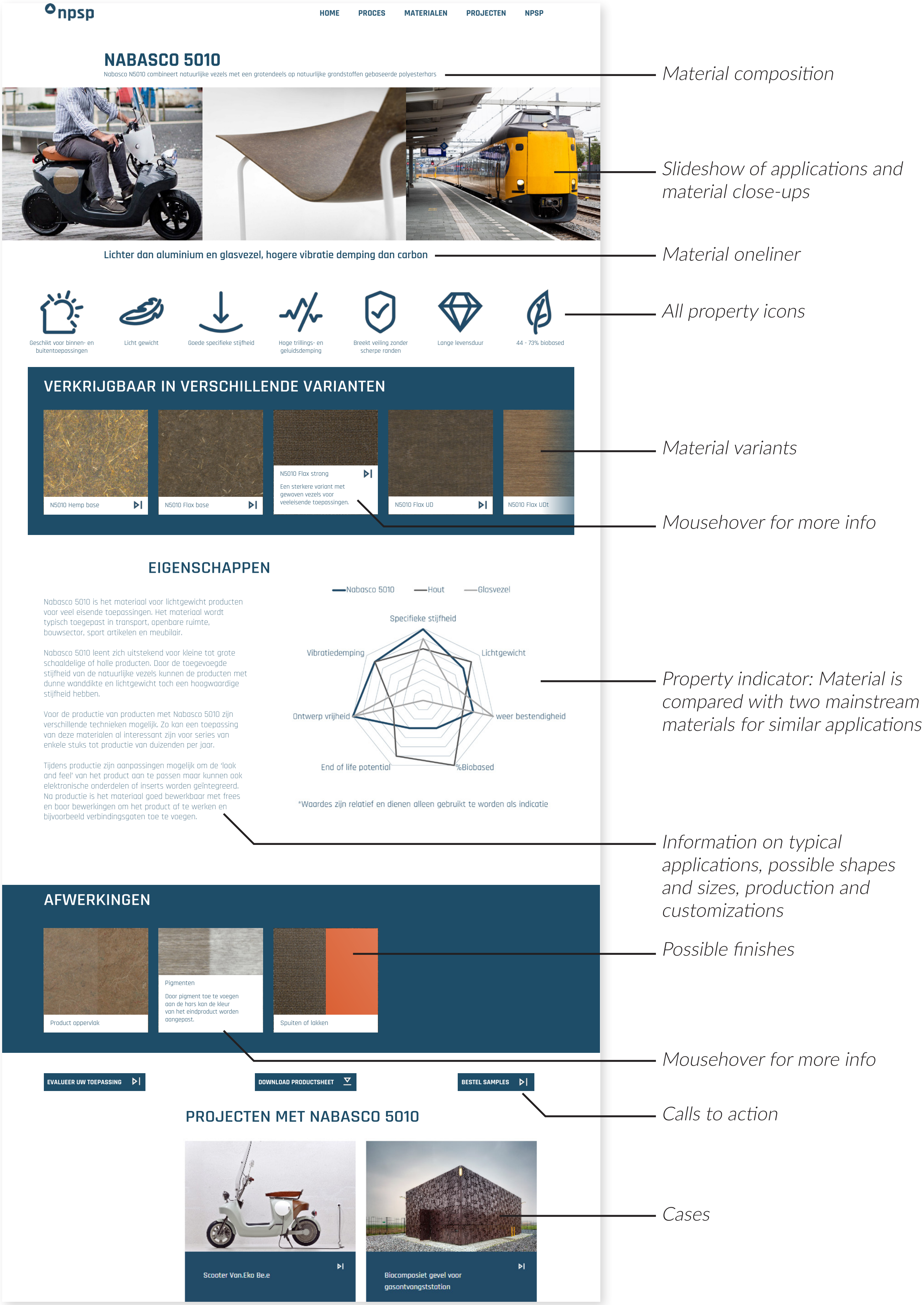


Figure 37: Homepage redesign

Calls to action

Having consumed the information of the material page, the last step is to persuade visitors into taking action. Besides visiting the already existing contact page and downloading the product sheet, two new options are proposed as buttons to click on at the bottom of the material overview and the material pages. One button is added to link to the sample webshop, a second one links to a new feature on the website: The application evaluation tool (FIgure 38). This is a small form to fill in with an application in mind, so NPSP can quickly assess the potential of the request. The questions within this form are based on biocomposite application criteria made by Defesche (2021) and conversations with multiple people from NPSP. The full form can be found in appendix G. Summarized, it consists of the following questions:

- Start by giving a short description of the project and leaving an email address for further contact.
- Rating the benefit of unique biocomposite characteristics on a scale of 1 to 7.
- Rating struggle with the challenges biocomposites on a scale of 1 to 7.
- Selecting a specific material in case there is a specific interest in one nabasco range
- Selecting the estimated production volume of the application
- Selecting in which activities of the project NPSP could support.
- Indicating the timeframe of the project.
- Room for further remarks

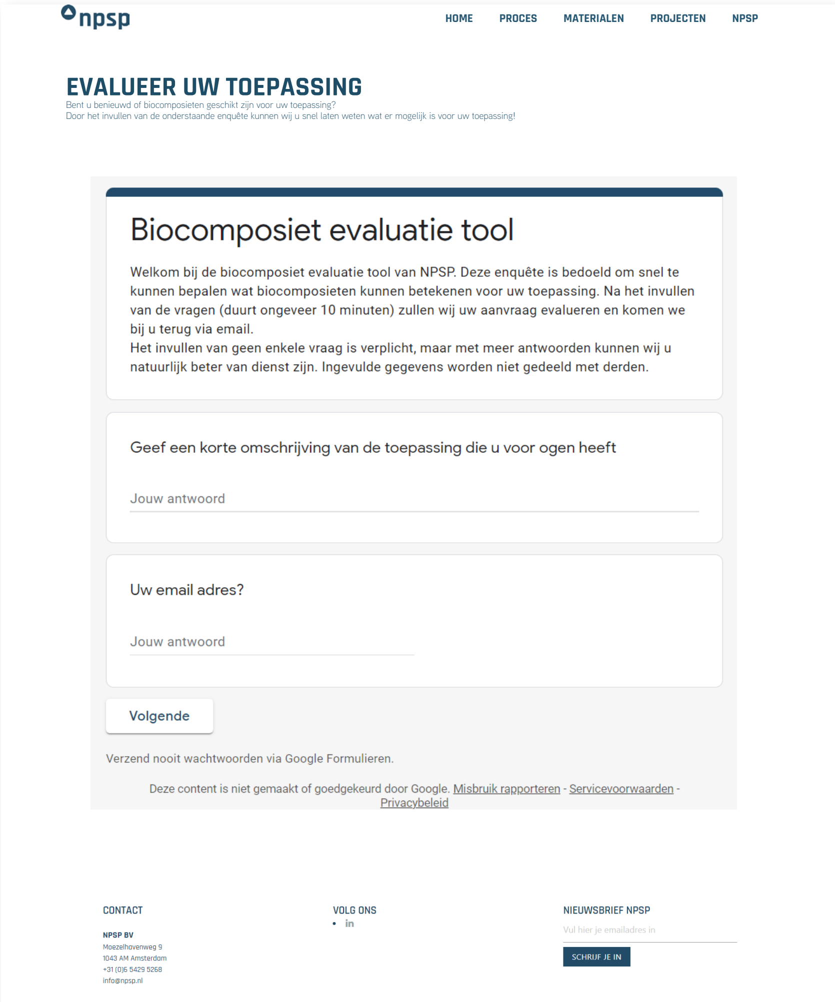


Figure 38: New material overview page

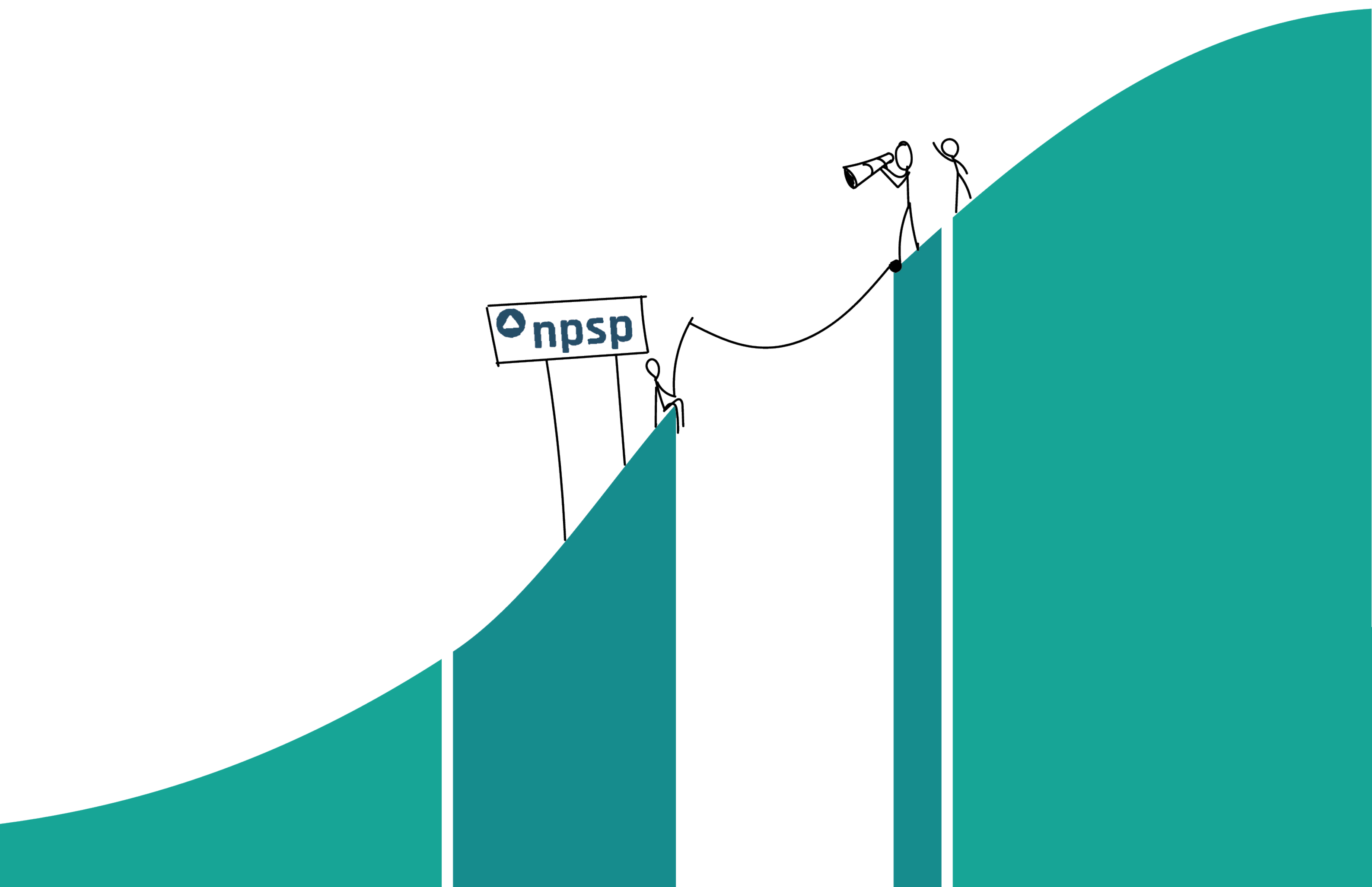
5.2 Implementing this proposal

To ensure easy integration of these changes and additions in the current website, the web developer of NPSP was included in this process. The proposal does not include highly innovative features in terms of web design, only two new pages are needed and the menu is easily changed. The application evaluation tool runs on google forms and will send an automatic email to NPSP once a new request is submitted. Questions can easily be added over time to improve the form. Requests can be downloaded as excel files and added to the lead system of NPSP.

6

MATERIAL SAMPLES

Introducing the ‘NPSP in a box’ sample set and making samples part of a costumer journey



MATERIAL SAMPLES

Besides information and pictures of the materials provided on the website, real-life evaluation of materials is essential in material innovation. NPSP has a wide variety of samples portrayed in the showroom and currently offers one sample set in their webshop. This project found some possible improvements for the way NPSP works with samples.
First, a new sample extensive sample set is proposed which contains a comprehensive set of all NPSP can offer. Within this set, efforts are made to improve the material perception of the samples and a 3D sample is added. Detailed production methods of the samples can be found in confidential data package F. Furthermore, a way to combine the samples with the website proposal to create the start of a customer journey is outlined.

6.1 'NPSP in a box' sample set

This bigger sample set is proposed to showcase all NPSP can offer in a comprehensive box (figure 39). Besides showing the materials, it also gives insight into possible material surfaces, customizations and 3D applications.

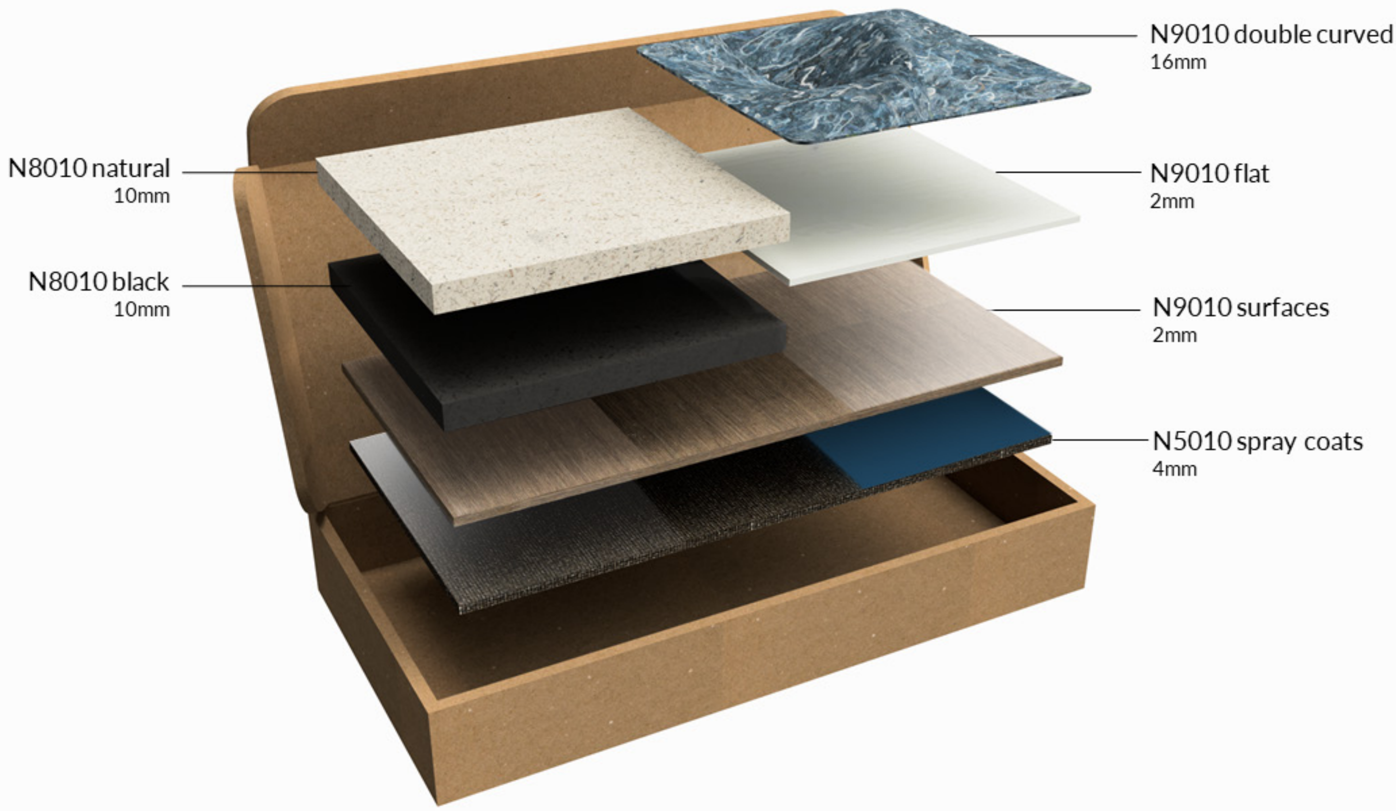


Figure 39: NPSP in a box sample set exploded view render

Material surface and customizations

The rectangle samples in the set aim to show different surfaces and customizations to show possibilities beyond the material itself. A custom aluminium moulding plate was made to produce samples with multiple surface finishes (figure 40). The materials can be pressed with this plate or laminated on it to transfer the surface of the plate to the sample.

The surface finishes give a range of possibilities and are inspired by the research performed on biocomposite material perception (Karana et al., 2014) (Defesche, 2021). These investigate how fibreness, roughness and reflectiveness of the material influence the perceived quality and naturalness of the material. It was concluded that to create a material perceived as high quality and natural, it should have high visible fibre content and a matte and smooth finish. The final plate transfers a light-textured, matte and satin finish to the samples (figure 41).

Figure 40: Aluminum plate with, from left to right, a textured, mate and satin finish

Figure 41: N9010 jute sample pressed with aluminum plate

Adding pigment to the resin and spray coating are two possible customizations to include in the sample set. Figure 42 shows a sample with white pigment and various surface layers acting as a 'foggy' layer on top of the fibres. A high gloss rectangular sample could be spray coated with a full-colour and transparent matt spray coat like shown in figure 43 to display spray coat options. Since these require the most effort to produce and are the most expensive, only one is included in the sample set. Which one can be dependent on stock or client preference.

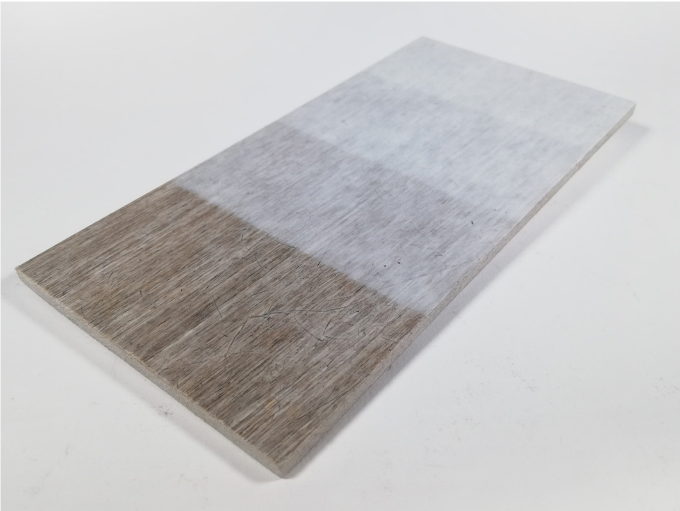


Figure 42: N5010 Flax UDtape sample with white pigment

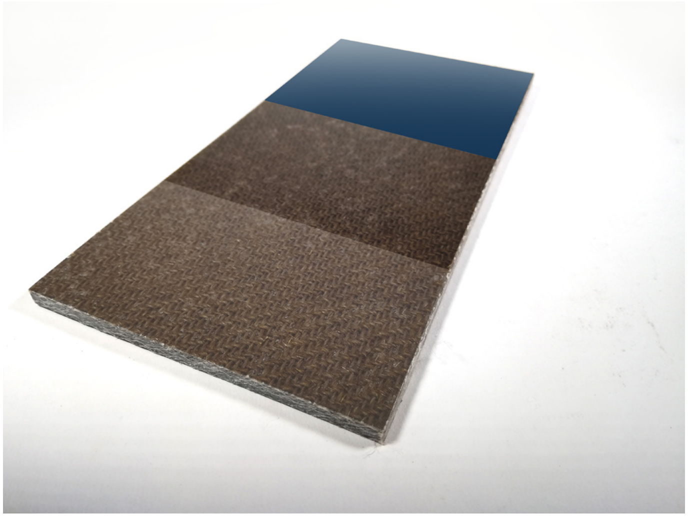


Figure 43: Envisioned N5010 sample with different spraycoats

3D sample

The 3D curved sample is selected from an exploration of shapes. The sample should be interesting to hold and turn to assess the reflections and material detail. The sample will be 10 by 10 cm and should have a low height to easily fit in the box. The selected shape (figure 44) combines all double curved surface versions, a sharp edge and a rounded edge. The shape does not have a front and backside and balances on several edges instead of laying flat on a surface.

A two-sided aluminium mould was designed to create the part with both thermoplastic and thermosetting composites. The lower part of the mould consists of two parts, allowing for easy demoulding. The mould is designed with a 1 millimetre part cavity to create a thin and elegant sample. However, by adding more material and managing the pressure of the press correctly, samples up to roughly 5 millimetres can be created. The moulded is produced and the first set of thermoplastic samples are successfully made and shown in figure 45.

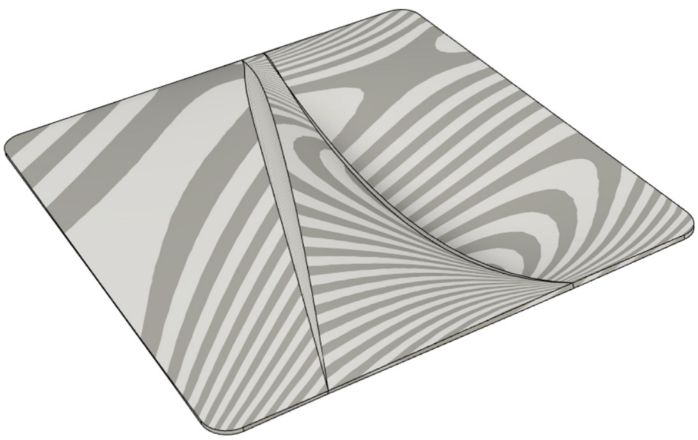


Figure 44: Selected shape for 3D sample

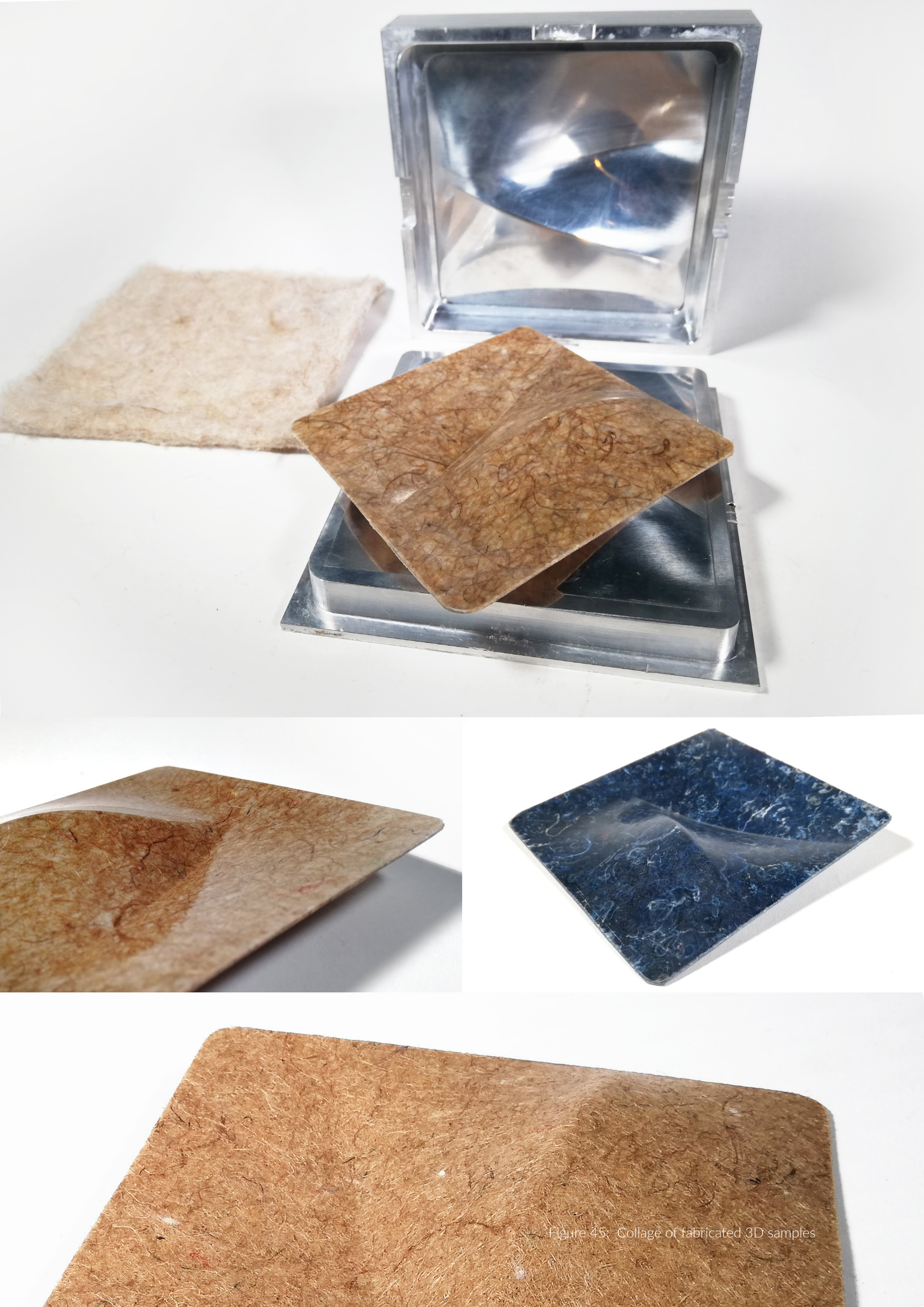


Figure 45: Collage of fabricated 3D samples

Costs considerations

Although the primary goal of the sample set is not to make a profit, the costs of this sample set should be considered. This set holds a certain value for the end customer and has a fixed production cost. If these turn out to be very far apart, the effort of making these sets could go to waste because they will not get sold. Furthermore, the real value of the set should be its ability to convince potential clients to engage in a project with NPSP. This is very hard to predict upfront and is highly dependant on the type of client.

A rough price estimation (appendix H) resulted in a predicted price around 65 euros for the production of the samples, packaging and shipping. The set will be sent in a custom size cardboard box. This box fits in the postal mail to save on shipping costs.

6.2 Website integration and customer journey

Besides the more extensive sample set, other changes in the sample system could improve the acquisition process and create more of a customer journey for potential clients. The first proposed change is to provide the possibility to order individual samples. This saves costs for the client and better suits their demand. It benefits NPSP in two ways: Orders of specific samples makes the system more efficient, and NPSP gets a better insight into which materials are most popular. Since some samples may not always be available or more expensive to make, some items on the webshop could be available on request instead of ready to order. For some samples, the option of ordering a flat or a slightly more expensive 3D sample could be integrated.

If all materials are available as individual items in the webshop, these could be linked with the material variants shown in the proposed material page design. The name printed on the sample should also correspond with the names provided in the webshop and website for more clarity (figure 46).

To gather more information from clients that order samples, the automatic order confirmation email could contain a suggestion to fill in the application evaluation tool (Figure 38). This creates a rich amount of information about a potential lead for NPSP.

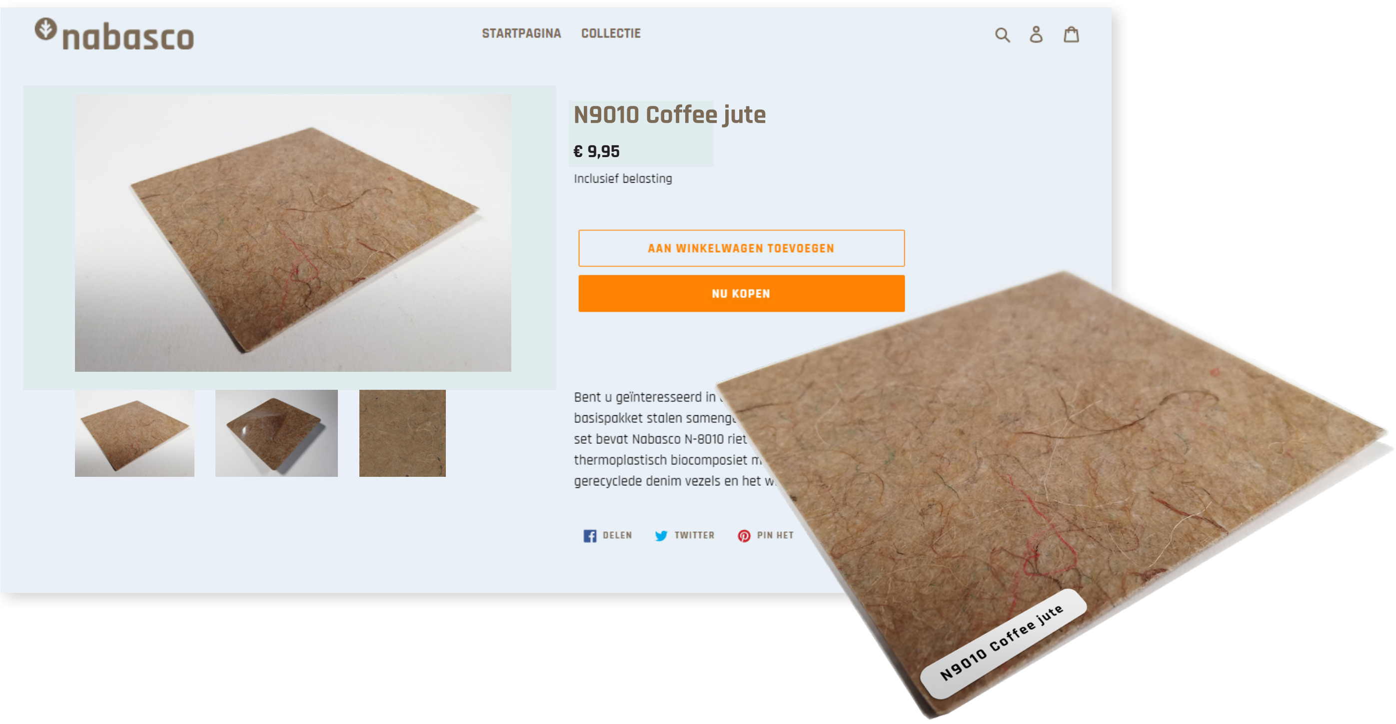
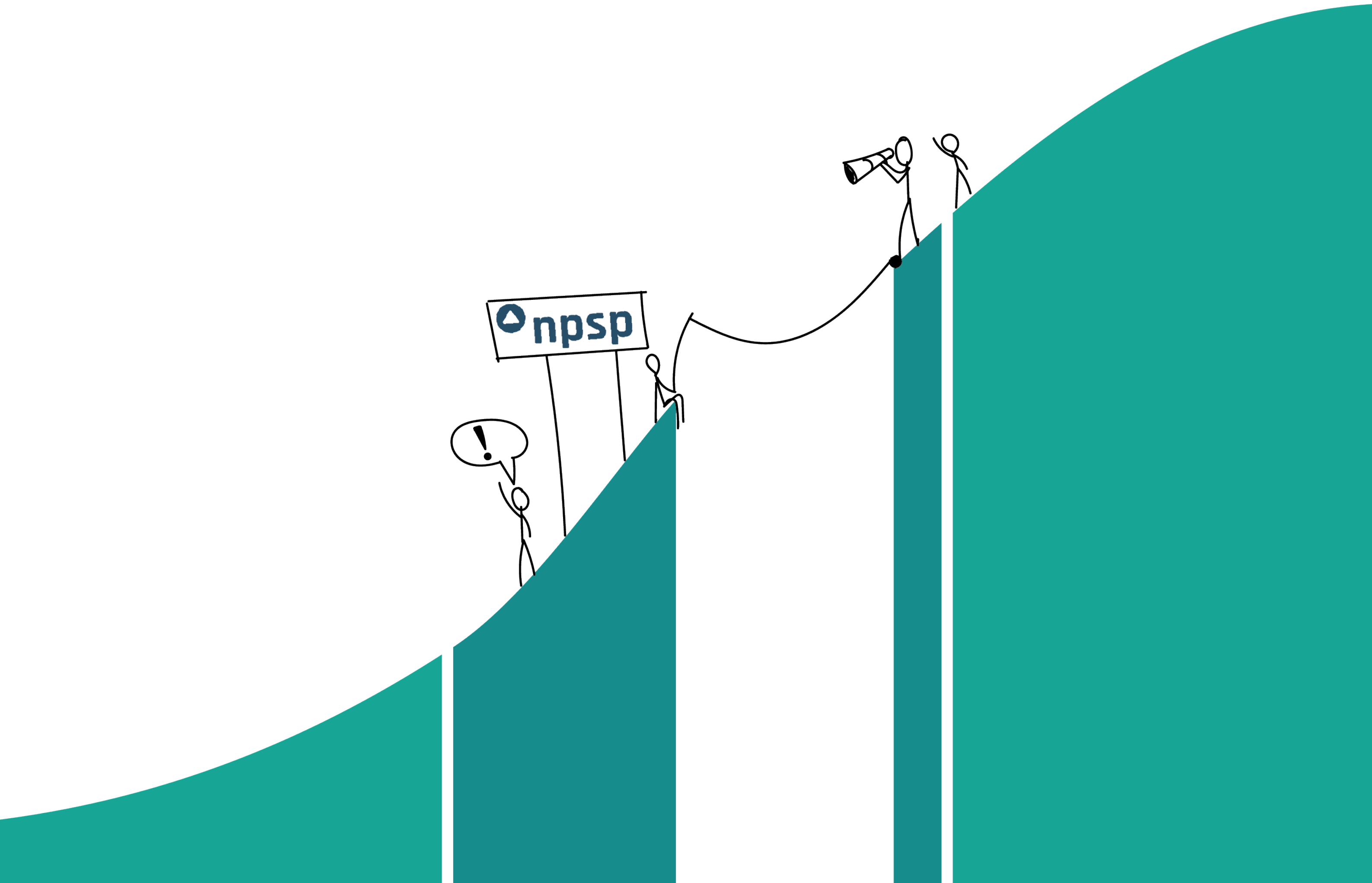


Figure 46: Single sample webshop page and corresponding names

7

MATERIAL OPPORTUNITIES

Material development opportunities for long fibre biocomposites found in this project



MATERIAL OPPORTUNITIES

Besides new leads and acquisition improvements, multiple development opportunities for biocomposites and NPSP were identified during this project. The most promising opportunities are discussed in this chapter and evaluated on actual potential by the 'market development strategy checklist' (Moore, 2014). This checklist can be used to estimate if a new technology, accompanied by a market strategy, can cross the technology adoption chasm. The checklists consist of the following factors that influence the potential of the new opportunities:

- Target market
- Reason to buy
- The product
- Partners and allies
- Distribution
- Pricing
- Competition
- Positioning
- Expansion to other markets

All three opportunities are assessed with this checklist. A summary of the assessment for every opportunity is given in the following paragraphs. The full results of the assessment can be found in Appendix I. According to Moore's methods, one small target customer or market should be selected in this step. But, within this project, an overview of possible target markets is given to show the overall potential of the proposed opportunities.

7.1 Nabasco 5010 pultrusion

Biocomposite pultrusion was suggested as a potentially interesting technique by one of the participating companies in the acquisition phase. Pultrusion is a continuous composite manufacturing process used to create profiles (figure 47) with very high fibre content. Fibres are pulled through a resin bath, followed by a heated die to shape the fibres into profiles of the desired shape. Pultruded composites are typically used to make a variety of beams, tubes, rods and custom shapes. The main benefits of composite profiles over metal ones are their light weight and excellent corrosion resistance (CES Edupack, 2019). According to the literature on biocomposite pultrusion (Linganiso et al., 2014) (Fairuz et al., 2015), the technology looks feasible and is successful on small scale, but there is still a lot of work to be done to optimize the process. The additional benefits of biocomposite pultrusion would be the lower weight than glass fibre, vibration damping and sustainable aspect. Pultrusion is a continuous process suitable for high volume production and it is one of the least energy-consuming composite manufacturing processes (Aktas et al., 2010).

Figure 47: Variety of pultruded profiles, Source: IndiaMART.com, 2021

Checklist assessment

Biocomposite pultruded profiles if produced with decent quality, could replace pultruded glass fibre applications where low weight, vibration damping and sustainability are an advantage. Pultruded biocomposites are not yet available at a commercial scale, so no competitors are currently known. NPSP is in contact with a possible manufacturer and can offer material expertise and market knowledge in a possible partnership. Since the process is continuous, large quantities could be produced at relatively low prices for biocomposites. The first markets to evaluate actual potential would be public space applications like posts for street signs and lampposts, and non-structural, lightweight applications in transport and mobility. If the product gains more credibility, (semi-) structural applications could be pursued in the already mentioned industries and in construction.

7.2 Nabasco 5010 continuous lamination

Biocomposites could offer significant benefits when applied in skins for sandwich panels. These are predominantly made by a process called continuous lamination. Like pultrusion, continuous lamination starts by guiding fibres through a resin bath. These fibres come from a roll and can be woven or nonwoven. After being impregnated by resin, a rolling press and oven follow to create the final product (CES Edu pack, 2019). Biocomposites skins could replace glass fibre and thereby save weight and increase the sustainability of the panel. Adding biobased core materials would further increase the sustainability of these panels.

Figure 48: Example of synthetic sandwich panel, Source: LZpanels.com, 2021

Checklist assessment

Like evaluated in the acquisition stage, lightweight biocomposite sandwich panels show high potential in the light (electric) vehicle sector (also see appendix E). The additional costs of going for biocomposites are opposed by the benefits of lower weight, vibration damping, safe breaking behaviour and being more sustainable. Mainly the sustainability and weight saving aspect are of interest because of the sustainable image that needs to be maintained and the fact that saving weight also means added range. Having made the first contact with a big composite skin manufacturer place NPSP in a delicate position. The potential profit is high but building a trustworthy partnership is very important. Sandwichpanels are also widely used in big transport vehicles, recreational vehicles and construction industry.

7.3 Developing High(er)-end Nabasco 9010

Normal and biocomposites with a thermoplastic matrix are gaining interest because of their higher recycling potential. Thus, offering a Nabasco 9010 variant with mechanical properties closer to the Nabasco 5010 range could have a lot of potential. Thermoplastic biocomposites can be produced in sheets or by thermoplastic moulding. This manufacturing process requires a preform of fibre and matrix. This preform is then heated and pressed into shape in a cold or heated mould (CES Edu Pack, 2019). A heated mould has the benefit of creating a better surface but does require longer cooling times or a more complex mould system (Derbali, 2019). The process starts being affordable around a batch size of 500 parts and is suitable for medium to high production volumes. At larger volumes, thermoplastic injection onto the part could be integrated into the process to instantly add features like assembly pins and ribs.

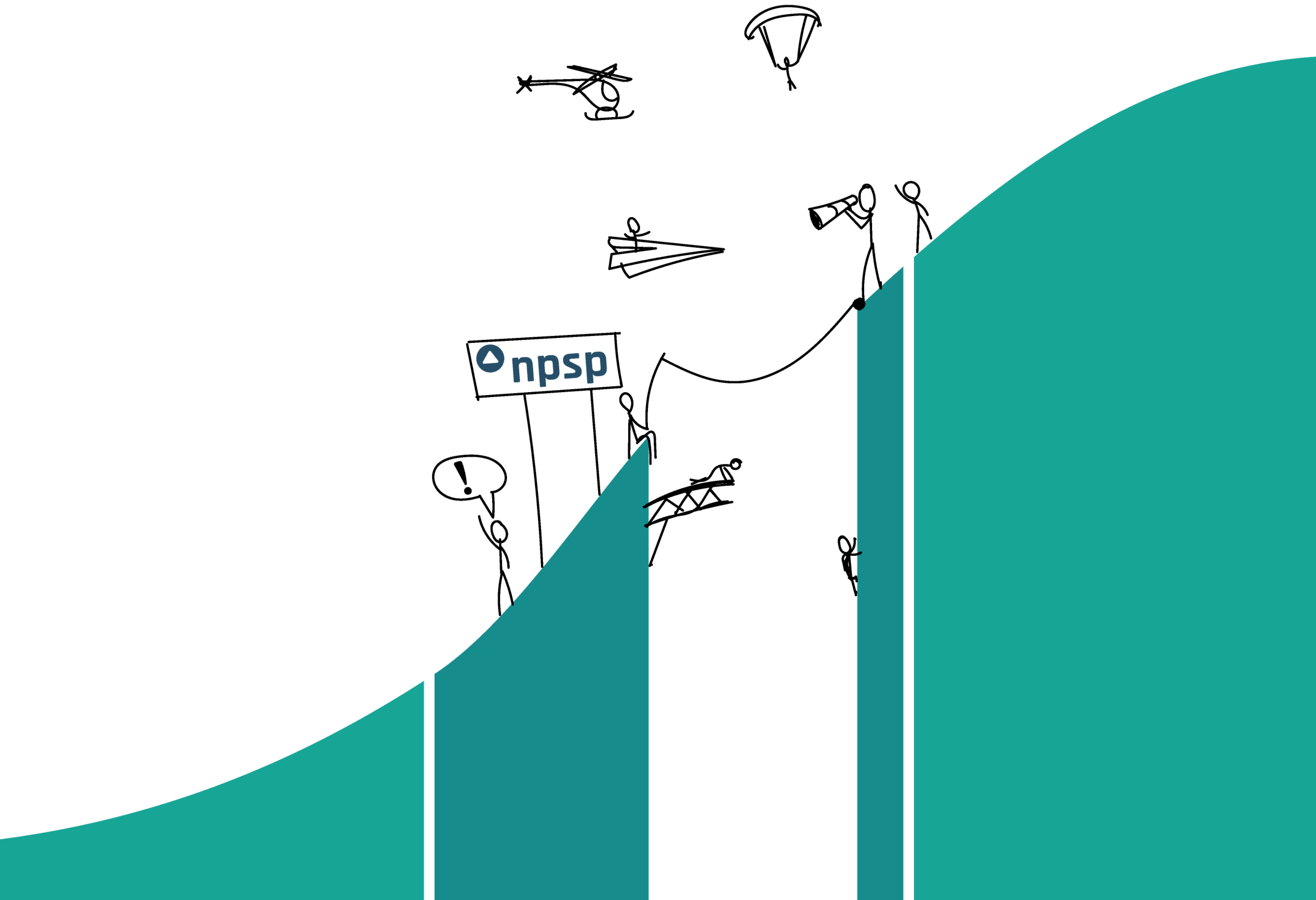
Checklist assessment

Replacing thermosetting composites with an up to 100% biobased thermoplastic biocomposite has a lot of potential. The advantage of this biocomposite solution exceeds Nabasco 5010 by having better recycling potential and lower costs. Still, possibilities are limited by the thermal stability of the thermoplastics, but enough potential applications remain. Finding a production partner for this material probably needs to go hand in hand with a launching customer, since the process is expensive for low production quantities. This improved Nabasco 9010 could replace Nabasco 5010 together with Nabasco 10010 in the long term.

8

CONCLUSION AND RECOMMENDATIONS

How this project contributed to the move into second gear



8. Conclusion and recommendations

The projects aim was to explore the potential of long fibre composites in the mobility and transport industry. These industries were selected because the material characteristics showed great potential and the aim was to reach more mature material applications. At the start, finding and developing an application was assumed to be the way to reach more mainstream markets or 'cross the chasm'. It turned out that biocomposite reaching a mature material takes much longer than this six-month project. Even the goal to find and develop a case in the targeted industries proved to be very ambitious. The process and results of the project showed that besides new applications, multiple factors contribute to the path towards the mature markets. Since project acquisition did not lead to a full time project, efforts were also made to improve the credibility and positioning of NPSP and their materials.

Project acquisition

Finding new applications in more mainstream markets to grow material acceptance

Credibility

Improve the material presentation and acquisition process to gain more credibility.

Material positioning

Evaluate current material market positions and pinpoint materials development opportunities for more mainstream markets.

8.1 Project acquisition

From the process of this project, it can be concluded that the interest in biocomposites is present in the mobility and industry. The main benefits of applying biocomposites are the sustainability and lightweight aspects of the materials. Within this project, parts with real structural importance were not proposed by any company. Mostly, companies planned to save weight, become more sustainable and exploit its unique aesthetics. Most companies did not expect to cut costs by going for biocomposites. But some cases did show potential to cut on the whole product price (including post-processing, transport, assembly and lifetime). Cases handled during this project did not reach the point to evaluate how much a biocomposite application is worth more. This could still be a final bottleneck where many potential applications are turned down.

Six companies participated in the project. Three of these are still active leads for NPSP at the time of writing. Since outcomes of these leads are still hard to estimate, no conclusions can be yet be drawn on if spending this much time on project acquisition is worthwhile for NPSP.

The main insights obtained during this process are:

- Material innovation is rarely vital for a company to succeed. This slows down the process because of other higher priorities and makes it a part of product development with a lower risk acceptance.
- Timing cold acquisition right requires good research and some luck. Knowing if a company is at a material selection stage or is possibly in need of something that biocomposites can offer increases the chances of success.
- The relative advantage of the material is considered at an early stage. Costs are part of this consideration but are likely to become more important further down the process.

8.2 Credibility

Gaining more credibility could be seen as a preparation to cross the chasm. Active project acquisition proved to be a slow and time consuming process. This project proposed several ways to improve the efficiency of this process. The website proposal, application evaluation form and changes in the sample system could result in two main benefits for NPSP: Saving time and looking like a more credible potential partner. NPSP can be seen as a biocomposite knowledge centre and can offer many services to potential clients. The proposed improvements aim to show this to website visitors and lower the threshold to get in touch with NPSP.

Website

The website proposal shows more material information and aims to attract, inspire and create a desire for the materials by browsing through the pages. Additionally, a better link can be created between npsp.nl and the webshop (nabasco.nl). The option to order individual samples and the application evaluation tool should act as low threshold options for potential clients to take action. The actual performance of these improvements still has to be tested in practice. At the time of writing, the website proposal is sent to the website developer and is likely to be implemented in the website.

Material samples

With similar intentions as the website proposal, a bigger sample set was developed to present a comprehensive overview of what NPSP has to offer. Besides materials, the set also presents possible finishes and a 3D sample to assess reflection and shape freedom. The set would be shipped in a shallow rectangular box to fit the elongated samples and to save shipping costs. Next to this sample set, NPSP is also advised to enable individual sample orders. This should be easy to implement and has the benefits of better suiting client wishes, saving samples and gaining more insights in the popularity of the materials. To save material and costs, the elongated samples could be changed to square ones. Extra thought should be put into how these can be efficiently produced. An evaluation of the value of the set for clients and its realistic selling price should be performed before implementation. The collection might be more suitable for company visits if the price turns out to be too high. The 3D sample could be implemented in the individual sample ordering system by offering some samples flat and in 3D. In that case, the additional effort of making the 3D sample should be integrated into the price. I would still advise switching to the elongated box since, for larger sample orders, it fits more than the currently used box and is cheaper to ship. For small orders, a more shallow square box would be optimal.

8.3 Material positioning

This project intended to focus on Nabasco 5010 applications and to explore the potential of larger-scale applications in more mature markets. One conclusion that can be drawn from the project is that Nabasco 5010 might not be suited for a 'mainstream material' position. It proved to be very hard to find applications that perfectly match the material characteristics and the current production techniques are challenging to scale for high volume production. So currently, the material may be more suitable for niche applications like sporting gear.

The found development opportunities could improve the market position of Nabasco 5010 for mainstream applications. New partnerships, subsidies or time to raise capital for these opportunities are required before actual development can start. So, a more thorough evaluation of the proposed opportunities should be performed before taking action.

8.4 Thoughts on the chasm

Moore's theory on the chasm in the technology adoption lifecycle is referred to multiple times in this project. And although it helped with structuring the process and led to new insights, caution must be taken in directly applying this theory in material innovation. Crossing the chasm, according to Moore, is an essential early step for a business to survive. Yet, NPSP already exists for 20 years, making radical changes to quickly cross the chasm at this moment unreasonable.

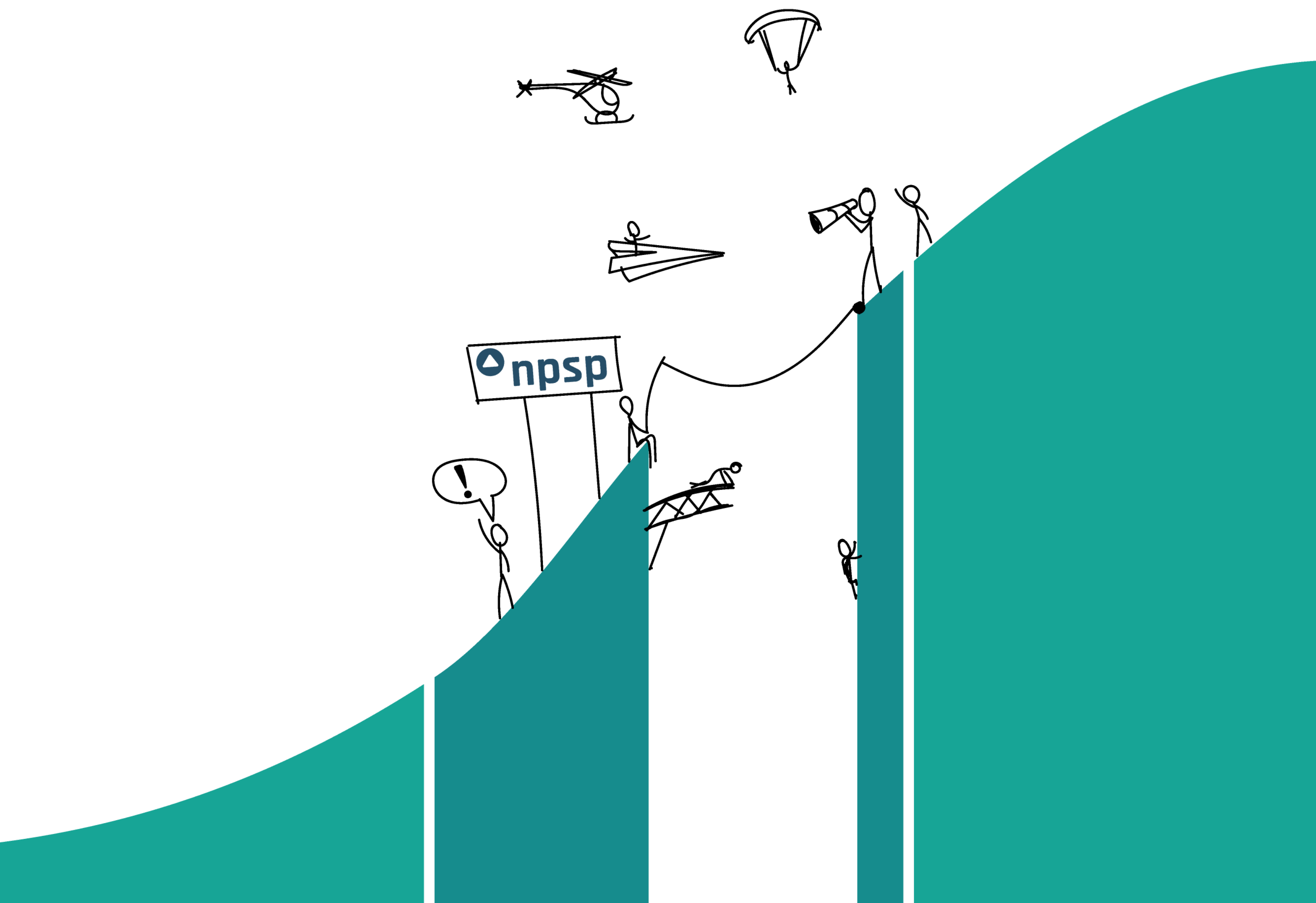
The adoption process of Nabasco materials cannot be compared with smartphone-like mass adoptions. So perhaps, the chasm NPSP currently faces is a smaller one, and no sudden mass adaption should be expected after crossing it. It could represent the need for NPSP to become more commercially orientated. Increasing the revenue from commercial projects could, in time, allow NPSP to fund their independent research and development and enable them to focus on the most promising opportunities. NPSP is already making good steps in this transformation and this project could be considered as another step in this process.

Some advised preparations for this transition would be to have a clear roadmap of which materials and technologies will be pursued if enough capital is grown for independent R&D. Having a vision of which materials and services NPSP could offer in five to ten years would be a good start to plan toward the future. Brainstorms about these matters with the whole company are also advised to motivate everybody for the same goal. The market development strategy checklist of Moore with a few adoptions might be a good tool for this kind of sessions.

9

REFLECTION

How naive optimism and a (too) flexible project scope lead to an interesting and educational project



9. Reflection

Six months ago, I set up this project to learn more about materials and production, and to gain more industry experience. And now I can comfortably say I succeeded in these goals. But evenly important, I learned a lot about myself as a person and as a designer. I will reflect on my learning curve in this project and my qualities and pitfalls as a person and a designer.

Learning curve

During this project, I experienced constant shifts in my perceived knowledge. Figure 49 roughly visualizes how, even though my actual knowledge rose steadily, my perceived knowledge was all over the place. Starting off with a classic Dunning-Kruger effect, I believed my material knowledge was descent, all companies would be on board, and it would be hard to choose a final case with so many options. How differently it went made me realize I was so far from being an expert.

New developments and many insights during the process led to a fluctuating curve of my perceived knowledge. Realizing that the perceived and actual knowledge are often not aligned did show me how much I did learn, and how these curves are likely to continue for the rest of my career.

Naive optimism

A newly discovered quality of me is that I am a naive optimist. Although this may not even sound like a quality for some, I am happy to be one. My naive optimism made me start this project with a very different and possibly unrealistic end goal. And it enabled me to talk to most companies with the belief of resulting in an actual application.

It does cause some disappointment, but it also takes me on a journey by starting projects way larger and more complex than I could have imagined by believing 'it will just work out'.

There is definitely a danger in being a naive optimist, but as some people close to me could agree, it does 'just work out' for me quite often. In this project for example, even though it worked out differently than expected, I am still happy with the project and satisfied with the outcomes.

Agility

Another quality of me that proved to be very useful was my agile way of working. I was flexible enough to quickly accept changes in the project and was able to work on many different aspects at the same time.

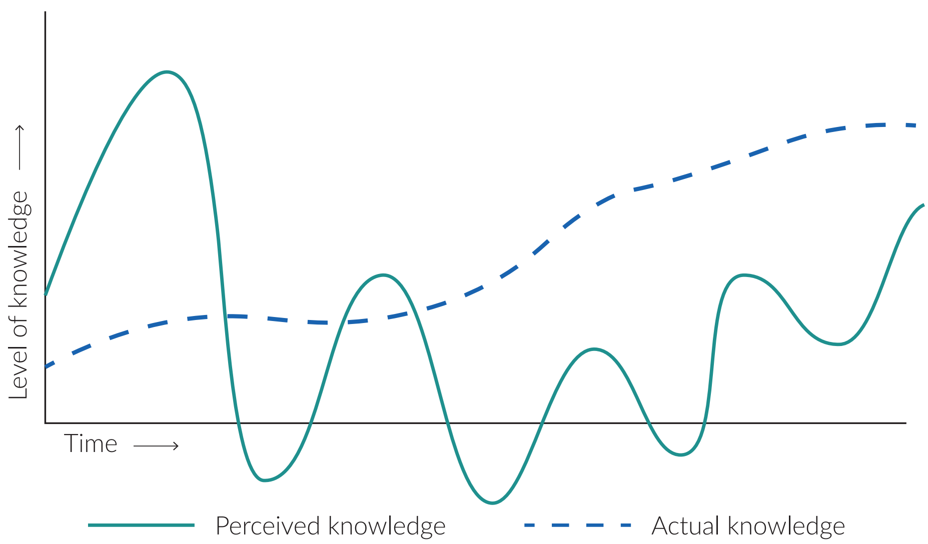


Figure 49: Estimation of perceived and actual knowledge levels over time during this project.

Broad skillset

This project pushed the boundaries of what my designer skillset was able to provide. Like building a piece of furniture that suddenly needs a tool you have not worked with for years or even some you have to acquire first, this project needed skills way beyond my original comfort zone. I do not want to call myself an expert on (most of) these skills, but I did reach a point where I am comfortable using them. For example, this project brought an end to six years of me neglecting graphic design. Combined with my agile way of working, I enjoyed more versatility on a daily basis in my work.

How these qualities are also my biggest pitfall

This project also showed me how being an agile naive optimist with a broad skillset can lead to chaos and frustration. Being agile and enjoying versatile work means I am often open to new activities. Having a broad skillset and assessing these activities as a naive optimist further increase the chance I will engage in this new activity.

Shortly before my midterm, I experienced one moment where this tendency led to chaos. While still dealing with company meetings and cases, it was time to start the underexposed part of documenting for a midterm report. This turned out to be the one ball too much for me to keep in the air, but like a juggler performing on stage, I tried to make this go unnoticed by the audience.

I also believe that the nature of this project was the perfect trap for this pitfall. Eventhough i am aware of how much i did do, i cannot help to think about everything i could have spend more time on, other activities i could have dove or the people i could have interviewed.

Points of improvements

As mentioned in the juggler metaphor above, I tend to mainly show the balls I do have in the air and go well and underexposed the balls I might have dropped. Managing the number of activities I engage in better is one way to prevent a ball from falling, but addressing a fallen ball with people I work with properly is also key to improve this pitfall.

Beyond preventing moments of chaos, I could also improve engaging in even fewer activities to be more focused on the most important ones. I do have to mention that a lack of focus has been a very frustrating issue at some points in the process. This also made me realize that I often make a planning, but I rarely stick to them. They are more to revisualize the bigger picture for me from time to time. This did not have significant negative influence on this project since I worked alone. But is should be aware of this when working in teams since schedules are of more importance then.

I should also watch for engaging in too many activities that are not in line with what I enjoy most as a designer. I did many different things in this project, and I enjoyed the majority of them. But in the end, I need enough time to do what I do best: Working on physical matters. Designing and developing the mould and eventually making samples for me are most exciting and motivating.

Final thoughts

In the near future, i would like to work on projects which are a bit more scoped to allow myself to have more focus. This project showed that working on sustainable developments acts as a good motivator for my work so i would like to work in an environment where sustainability is important (although that should be everywhere). I liked being active in a small company where you notice a lot of what is happening and you are basically one big team.

I am thankful for how much I learned in this project. The project enabled me to gain a lot of 'real world' experience as a designer and learned me a lot about myself. I look forward to putting my design skills into practice and im feeling naively optimistic about the future.

10 11

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Appendix A: Project brief

Personal Project Brief - IDE Master Graduation

TU Delft

Moving biocomposites into second gear — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 01 - 03 - 2021 — 16 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

This project will focus on the application of biocomposites in the mobility and transport sector.

Involved stakeholders are NPSP, external companies from the sector willing to participate, myself and the TU Delft.

NPSP is my graduation company. They develop and apply biocomposites in various industries. Application within the mobility and transport sector has high potential and could improve the sustainability of the sector. Yet, realizing a big scale application of biocomposites in this sector proves to be challenging.

To get in direct contact with this challenge, i want to get in contact with several external companies that could potentially benefit from a biocomposite application. These companies should be active in the mobility/transport industry and willing to cooperate with this project. Figure 2 shows an overview of the companies I currently have selected to contact. I'm hoping to actually start a collaboration with about half of them to keep it manageable. Some choice factors for this selection were: Electrically driven, need for lightweight durable structures, currently using composites, difference in company scale and promotion green image and operating in different markets. Further research may lead to changes in this selection to make the project more valuable.

I would like to graduate on a project were I as a designer operate as the bridge between different industries to enable sustainable change by getting biocomposites closer to big scale applications in this industry.

The TU Delft ensures my project conforms to the academic guidelines and makes me a capable designer.

Big opportunities for this project are the pressure and need for companies in the mobility and transport sector to become more sustainable. Besides legislation, companies also realise the value of a green image. Synthetic composites are already commonly used in this sector, making the step to biocomposites more approachable.

Biocomposites will probably always be limited by the fact that they cannot compete on performance with carbon fibre, which unfortunately is commonly used in this industry. Also, companies in this industry are very careful with sharing information and changes will be harder to implement in big organisations. To still get enough valuable information out of the companies I speak to, clear terms and and NDAs are probably needed.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation

TU Delft

introduction (continued): space for images

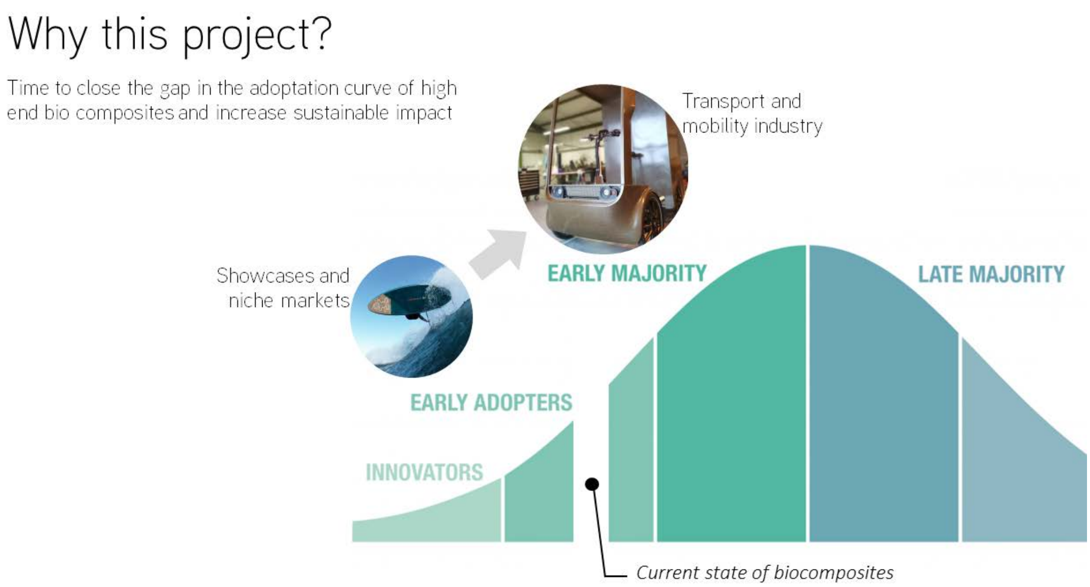


image / figure 1: Current state of biocomposites in the adoptation curve.

Current companies of interest

Confidential

image / figure 2: These currently are the companies i want to get in touch with

TU Delft

Personal Project Brief - IDE Master Graduation

PROBLEM DEFINITION **
Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The world of transport and mobility is changing rapidly but is still far from sustainable. In the process of becoming more sustainable, a trending topic in this industry is saving weight. Less weight means less fuel or power consumption, which often leads to lower CO2 emissions and a longer range of the vehicle.

Searching for ways to save weight has led to the increasing use of synthetic fibre composites. Fibres like carbon enable very lightweight, high performance and durable parts. But other than saving weight, these materials are far from sustainable, and therefore, will likely not be the long-term sustainable solution the industry needs.

Biocomposites could however, with increasing technical performance, rising biobased fraction and developing recycling possibilities, be a future proof solution for this industry

I will identify and research the long-term factors that limit or discourage the use of biocomposites in this industry and try to come up with a strategy to find cases and convince companies to make the sustainable change to biocomposites.
To do so as best as I can within this project, I will:
- Research the possibilities of the material by analysing the material and existing cases.
- Interview several companies that may or may not consider the use of biocomposites in their products
- Develop a feasible application of biocomposites for one of the interviewed companies.

The project will focus on the application of high end (long fibre) biocomposites within the mobility and transport industry.

ASSIGNMENT **
State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

At the end of this project, I will have developed a new, high end biocomposite application for one of the companies I collaborate with. The whole process will enable me to come up with a vision and/or strategy for NPSP on how to approach this industry, with added materials to support this process.

The vision and/or strategy I want to deliver will be based on material research, analyzed cases, interviews and my own developed application. I will design a sort of brochure of the material to send to the companies and iterate on its content and format during this project. Because nothing says more about a material than actually feeling it, I will also design and create a set of samples that shows the material properties that are of interest for this industry.

The application I want to deliver should be feasible, viable and desirable and take bio composites one step closer to high impact applications to contribute to the sustainable future of the mobility and transport sector. The application should be substantiated by prototypes. The scale of the chosen application will determine if making full scale prototypes is feasible.

Initials & Name H Klein Schiphorst Student number 4451880

Title of Project Moving biocomposites into second gear

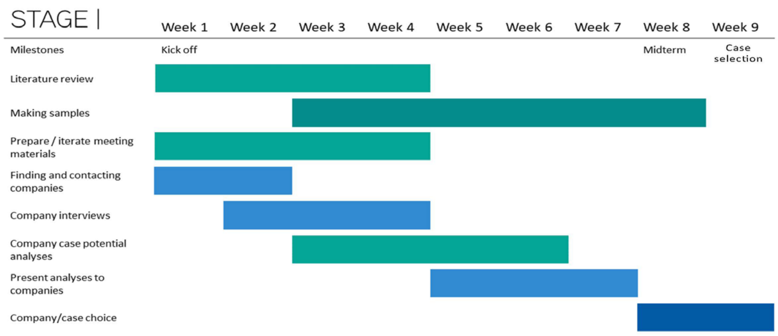
Personal Project Brief - IDE Master Graduation

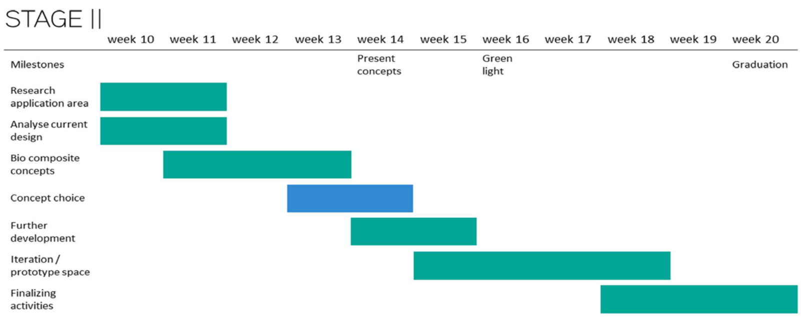
TU Delft

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 1 - 3 - 2021 16 - 7 - 2021 end date





In general, my project will consist of two parts. The first part will exist out of researching the material and existing cases, and interviewing companies, leading to an overview of possible applications and a vision and strategy that should help NPSP with finding and setting up projects in the mobility and transport industry.

After establishing an initial collaboration with the companies, a first meeting will take place. This meeting focuses on the possibilities of biocomposites and discussing their opinion on the material and possible cases within the company. When this leads to more interest in the material's potential, a second meeting will be planned for which I will further analyse the potential of the discussed cases. After these second meetings, one application (from one company) will be chosen to continue with in the second stage.

In the second part of the project, I will develop an application of bio composites for one of the companies I spoke to in the first part. This company should be willing to participate, have a case that presents the strengths of bio composites in the targeted industry and is realistic to develop within the given time.

(The blue bars in the planning refer to more external company dependent activities. Green represents activities i can perform individually or with NPSP).

Initials & Name H Klein Schiphorst Student number 4451880

Title of Project Moving biocomposites into second gear

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I set up this project out of my fascination for new sustainable materials and manufacturing techniques. Experiencing the unique properties of high-end composites first hand as a passionate (wind)surfer and at the same time learning about the negative impact they can have on the environment made me realize the potential of biocomposites.

I want to use and expand my material and manufacturing knowledge to apply this material within the mobility and transport industry, because even small sustainable changes in this industry can have a big impact. Furthermore, I want to challenge myself and gain more industry experience by talking to multiple companies. This will give me several opportunities to try and sell my project and myself as a designer without an already established collaboration like in most courses so far.

I see my graduation as a great opportunity to learn more about matters beyond the final stages of a design process and work with real companies and cases, whilst still having the guidance and facilities of a student.

FINAL COMMENTS

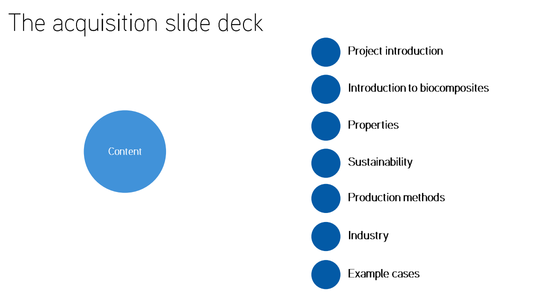
In case your project brief needs final comments, please add any information you think is relevant.

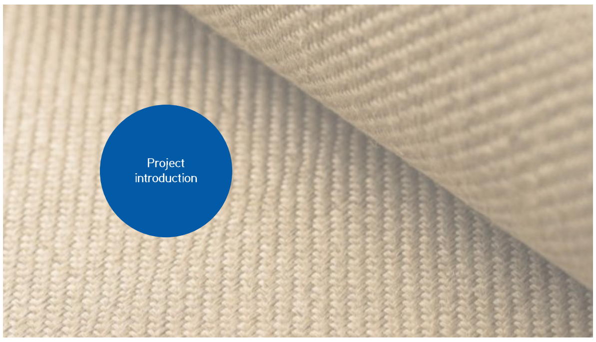
Initials & Name H Klein Schiphorst Student number 4451880

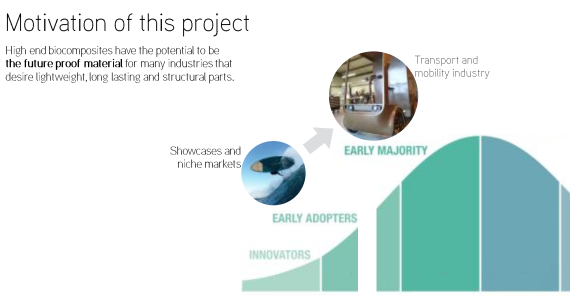
Title of Project Moving biocomposites into second gear

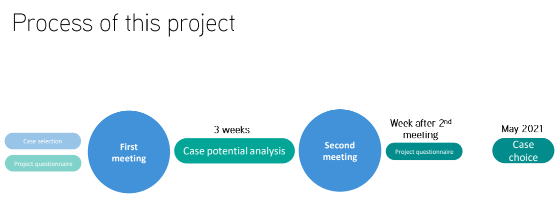
Appendix B: Acquisition slide deck

The pptx file of this slide deck can be found in the confidential data package









Appendix B: Acquisition slide deck

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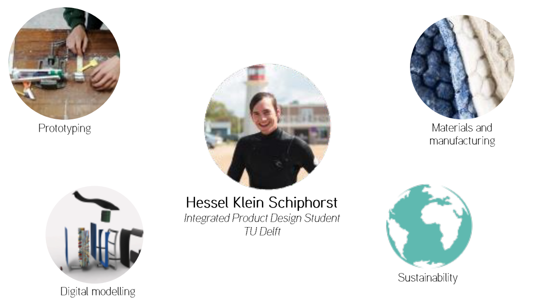
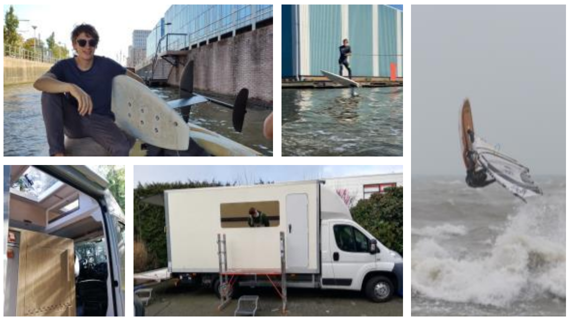
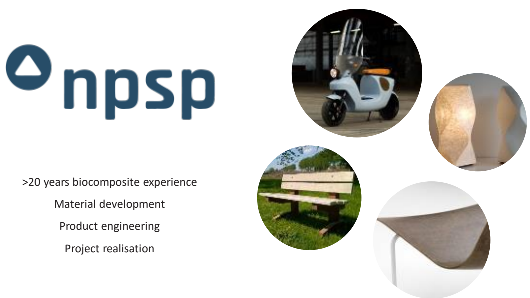
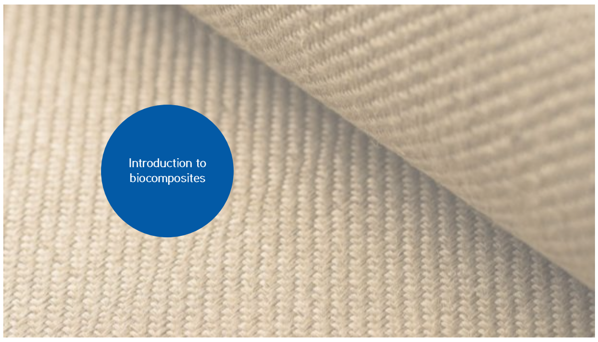








Appendix B: Acquisition slide deck

What are biocomposites?

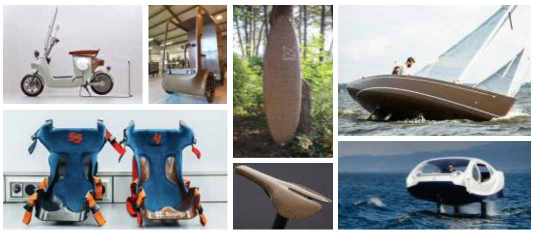
Long natural fibres, woven of randomly aligned

Thermosetting or thermoplastic matrix, synthetic or (partly) biobased

High-end biocomposite product

Brief history of biocomposites

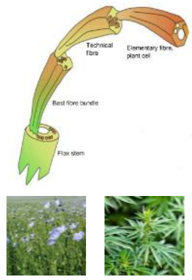
Current state of Biocomposites



Fibres

Flax and Hemp

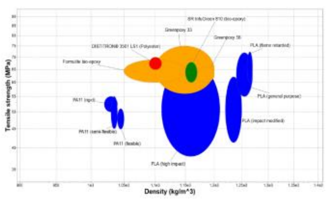
- Good fit for biocomposites
- Designed to be stiff by nature
- Wood like and long fibres
- Non food crop
- Minimal use of pesticides
- Grow well in Europe



Resins

Thermosets
- Polyester
- Epoxy
- Bio epoxy upto 52% biobased
- 100% biobased Furan resin (experimental)

Thermoplastics
- Traditional (recycled) thermoplastics
- PLA
- PA11



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NABASCO®

Nabasco 5010

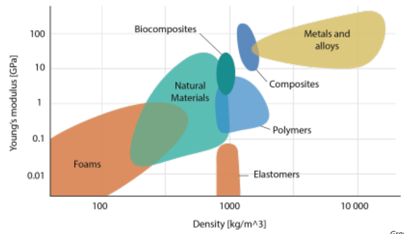
Nabasco 8010

Nabasco 9010

Nabasco 10010

NPSP.nl

Properties: General



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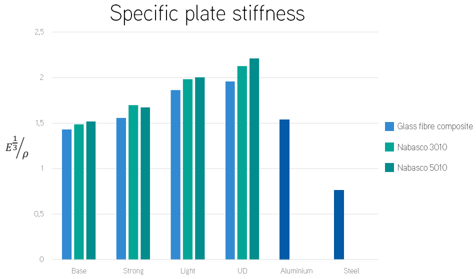
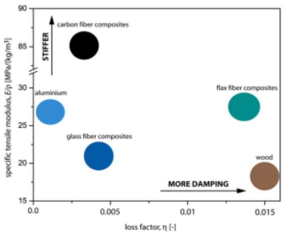
Specific plate stiffness

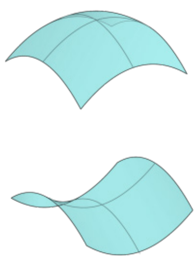


Properties: Damping



Mathijsen, D. (2018). The renaissance of flax fibers. *Reinforced Plastics*, *62*(3), 138-147.

Compared to glass fibre



Optimization range compared to glass fibre parts

Weight: Up to 25% lighter than glass fibre composite

Performance: Up to 25% thicker at the same weight = increased stiffness

Properties: NPSP Nabasco

N-5010		Base /b	Strong /s	Light* /l	UD /u	Fire /f	
EIGENSCHAP	EENHEID						NORM
Soortelijk gewicht	kg/dm³	1,21	1,31	0,87	1,26	n.v.t.	ISO 1183-1
Dikte laminaat	mm	2 - 15	2 - 15	4 - 40	2 - 15	n.v.t.	
Treksterkte	Mpa	45	140	69	244	n.v.t.	ISO 527-4
Specifieke treksterkte	kN m/kg	37	107	79	194	n.v.t.	ISO 527-4
Trekstijfheid	Gpa	6,2	10,5	5,3	21,6	n.v.t.	ISO 527-4
Specifieke trekstijfheid	MN m/kg	5,1	8,0	6,1	17,1	n.v.t.	ISO 527-4
Max. rek	%	1,5	4,3	5,5	3	n.v.t.	ISO 527-4
Biobased	Volume (%)	44	57	74	53	n.v.t.	± 2%
Brandnorm		n.v.t.	n.v.t.	n.v.t.	n.v.t.	n.v.t.	

NB: Waarden gemeten op kamertemperatuur. Alle waarden zijn ter indicatie.
** Afhankelijk van de samenstelling van de sandwich (waarden gebaseerd op 4 mm sandwich).*

NPSP Datasheet

Appendix B: Acquisition slide deck

Benefits

Technical
- Lightweight
- Good specific properties
- Long lasting
- Fatigue resistant
- Vibration damping
- Thermal insulation
- Non conductive

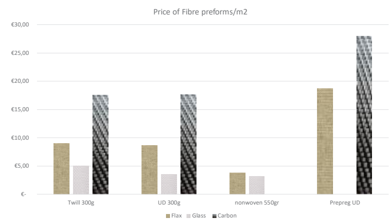
Social
- Safe breaking behaviour
- Safe to handle
- Aesthetics
- Significantly more sustainable

Challenges

- Lower strength than Glass and carbon fibre
- More variability in properties
- Needs moisture protection
- Can handle lower temperatures
- Not completely biodegradable

- Higher price (due to less mature market)

Costs - material



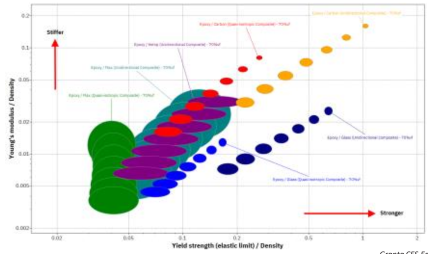
NPSP

Properties: Comparison

Material	**Density** [Kg/m3]	**E-modulus** [GPa]	**Tensile Strength** [Mpa]	**Embodied Energy** [MJ/kg]
Flax	1360	5 - 22	45 – 245	60
Hemp	1370	5 - 22	45 – 245	65
Carbon	1550	69 – 150	550 – 1050	670
Glass fibre	1850	15 – 28	138 – 240	120
Aluminium	2700	70	280 - 570	190
Bamboo	680	17	160 – 320	34

Granta CES EduPack 2019, NPSP Nabasco 5010

Properties: Specific strength and stiffness



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Sustainability

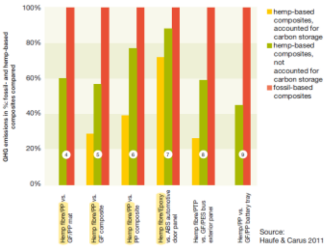
- Fibres are grown and processed in Europe
- Collect CO2 during growth
- Need little to no pesticides
- Not grown for food production


Flax fields

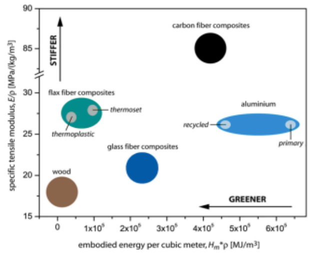

Glass fibre production plant

Appendix B: Acquisition slide deck

Sustainability: Green house gas emissions



Sustainability: Embodied energy



Mathijsen, D. (2018). The renaissance of flax fibers. *Reinforced Plastics*, *62*(3), 138-147.

Sustainability: End of life

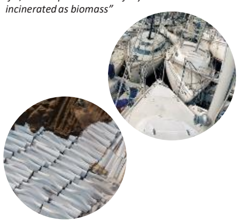
"Where Glass fibre composites currently end up as landfill, biocomposites can be fully incinerated as biomass"

Thermosetting composites

- Grind down to filler (downgrade)
- Full incineration possible
- Resin developments aiming at full circularity

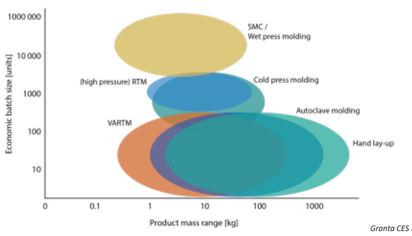
Thermoplastic composites

- Melt and reshape (reuse)
- Melt and separate (recycle/biodegrade)
- Biodegrade



Zini, E., & Scandola, M. (2011). Green composites: an overview. *Polymer composites*, *32*(12), 1905-1915.

Production methods



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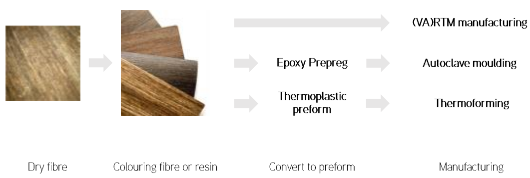
Material and production



Low volume production: 1 – 500 pcs

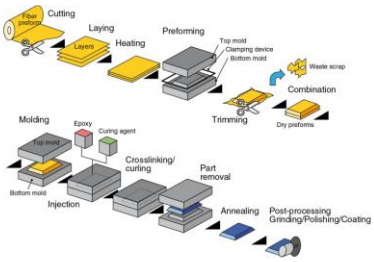
Hand layup

Autoclave moulding

Vacuum Assisted Resin transfer moulding

Medium volume production: 500 - 5000

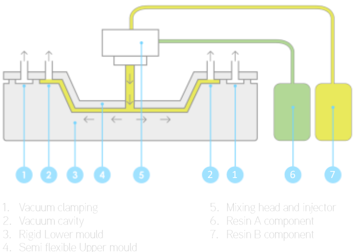
(High Pressure)
Resin Transfer moulding



Light RTM / VARTM

- Composite Moulds
- 50 – 1000 pcs/year

https://www.youtube.com/watch?v=vM3eYbLF91I&t=1s

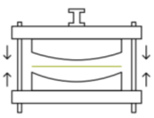


Thermoplastic composite moulding

STEP 1

Heating preform

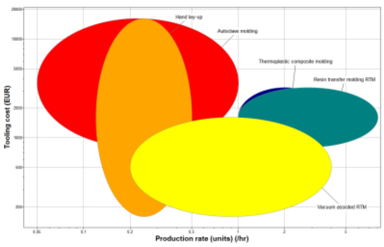
STEP 2



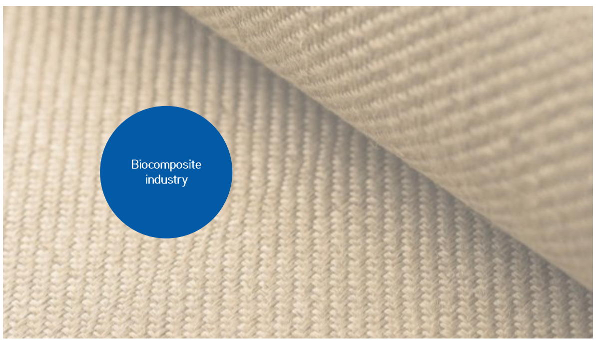
moulded in press

High volume option: Back injection

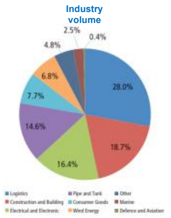
Costs - production

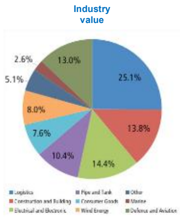


Granta CES EduPack 2019



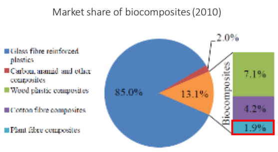
Composite market

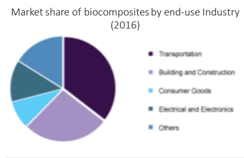




Biocomposite industry

Market share

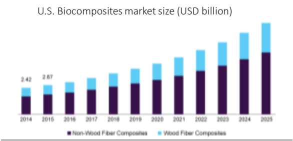




Sources:
- www.grandviewresearch.com
- Shah, D. U., Schubel, P. J., & Clifford, M. J. (2013). Can flax replace E-glass in structural composites? A small wind turbine blade case study. Composites Part B: Engineering, 52, 172-181. doi:10.1016/j.compositesb.2013.04.027

Biocomposite industry

Market size forecasts



In 2020:	Market size (USD billion)	CAGR (%)
Biocomposites	19.6	14.2
CF composites	17	12.4

Sources: www.grandviewresearch.com
www.marketsandmarkets.com
www.marketdataforecast.com

Biocomposite industry

Fibre production (2013)

Table 1. Comparison between plant fibers and E-glass [1].

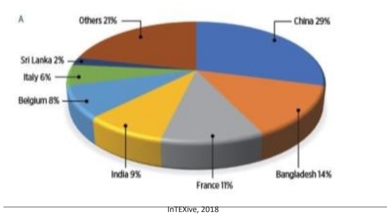
	Properties	Plant Fibres	E-Glass Fibre
Economy	Annual global production [tonnes]	31,000,000	4,000,000
	Distribution for FRPs in EU [tonnes]	Moderate (40,000)	High (600,000)
	Cost of raw fibre [£/kg]	Low (~0.5-1.5)	Low (1.3)
Technical	Density [gcm^{-3}]	Low (~1.3-1.5)	High (2.6)
	Tensile stiffness [GPa]	Moderate (~30-80)	Moderate (73)
	Tensile strength [GPa]	Low (~0.4-1.5)	Moderate (2.0-3.5)
	Tensile failure strain [%]	Low (~1.4-3.2)	Low (2.5)
	Specific tensile stiffness [GPa/gcm^{-3}]	Moderate (~20-60)	Low (27)
	Specific tensile strength [GPa/gcm^{-3}]	Moderate (~0.3-1.1)	Moderate (0.7-1.3)
	Abrasive to machines	No	Yes
Ecological	Energy consumption [MJ/kg of fibre]	Low (4-15)	Moderate (30-50)
	Renewable source	Yes	No
	Recyclable	Yes	Partly
	Biodegradable	Yes	No
	Toxic (upon inhalation)	No	Yes

≈ 0,025% of plantfibres for composite applications

Shah, D. U., Schubel, P. J., & Clifford, M. J. (2013). Can flax replace E-glass in structural composites? A small wind turbine blade case study. Composites Part B: Engineering, 52, 172-181. doi:10.1016/j.compositesb.2013.04.027

Biocomposite industry

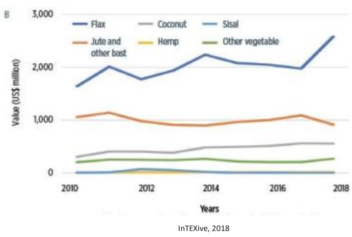
World production of vegetable fibres (excluding cotton) by country



Source: www.compositesworld.com

Biocomposite industry

World consumption of vegetable fibres (excluding cotton)

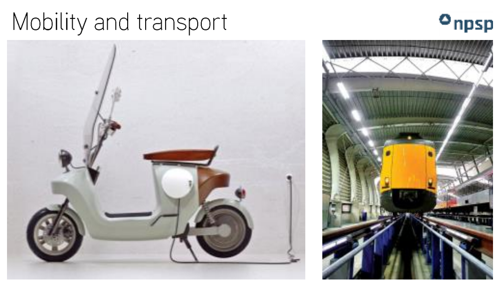


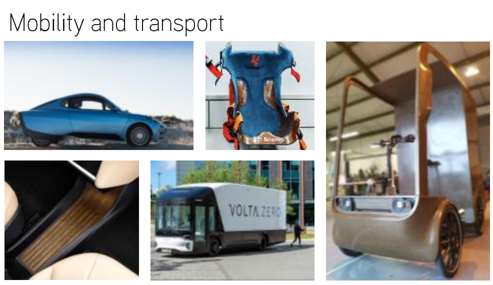
Source: www.compositesworld.com


Cases


Start of NPSP in 1998
npsp

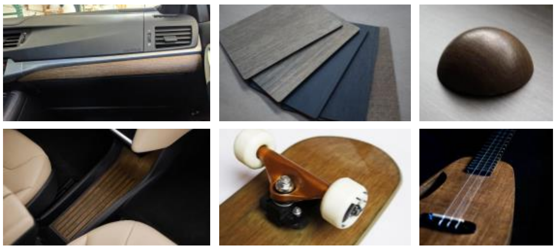

Outdoor and construction
npsp


Mobility and transport
npsp


Mobility and transport
VOLTA ZERO


Appearance Examples

Appearance Examples



Case: Flax cargo bike

eav

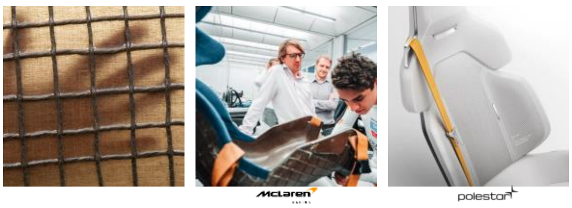
Case: Flax zodiac boat floor

DEHONDT Composites

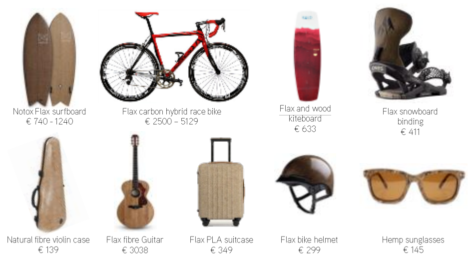
Case: Flax paddle and kayak

MELKER

Case: Powerribs reinforcement

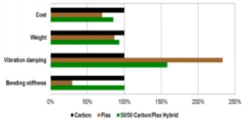


Commercially available products



Case: Carbon/Flax hybrid door panel

Composites Evolution

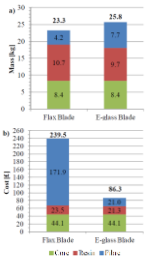


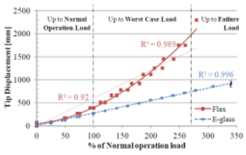
	Carbon	Flax	Carbon/Flax Hybrid
Laminate density (g/cm^3)	1.5	1.3	1.4
Thickness (mm)	2.8	3.2	2.7
Flexural modulus (GPa)*	47	12	44
Flexural strength (MPa)*	870	180	560
Damping loss factor**	0.012	0.028	0.019

Case: Safe breaking crash structure

ycom

Case: Flax vs glass wind turbine blade





Shah, D. U., Schubel, P. J., & Clifford, M. J. (2013). Can flax replace E-glass in structural composites? A small wind turbine blade case study. *Composites Part B: Engineering, 52*, 172-181. doi:10.1016/j.compositesb.2013.04.027

Appendix C: Current applications

High end applications

9. Van Eko Bee - full lightweight and structural biocomposite mopet body
   Retrieved from https://www.vaneko.com/
10. EAV cargo bike - biocomposite body panels
   Retrieved from https://www.eav.solutions/copy-of-fleet-100
11. Notox surfboards - made with flax composites
   Retrieved from http://www.notox.fr/en/fair-boards/fair-materials/
12. Mclaren F1 seat - Carbon fibre replaced by biocomposite seat with similar properties
   Retrieved fromshttps://www.mclaren.com/racing/team/natural-fibre-sustainable-composite-racing-seat/
13. Lightweight biocomposite bike saddle
   Retrieved from https://www.bcomp.ch/news/a-fully-recyclable-bicycle-saddle-with-amplitex-fabrics/
14. Seabubbles water taxi - biocomposite bodypanels
   Retrieved from https://www.plasticstoday.com/automotive-and-mobility/bioresins-and-composite-materials-deployed-seabubbles-flying-water-taxis
15. Greenboats sailing yacht - biocomposite hull
   Retrieved from https://green-boats.de/materials/

Consumer products:

- Notox Flax surfboard
  Retrieved from http://www.notox.fr/en/2014/10/15/quantum-range/
- Flax carbon hybrid race bike
  Retrieved from http://cozybeehive.blogspot.com/2008/01/bio-composite-race-bicycle-part-1.html
- Flax and wood kiteboard
  Retrieved from https://www.koldshapes.com/boards/polar/
- Natural fibre violin
  Retrieved from https://www.facebook.com/AtelierDuerinck/photo/a.1064563993576031/1699915876707503/?type=3&theater
- Flax fibre guitar
  Retrieved from https://www.blackbirdguitar.com/collections/guitars/products/el-capitan
- Flax PLA suitcase
  Retrieved from https://projectkin.com/sustainable-travel-luggage/
- Flax bike helmet
  Retrieved from https://www.reussir.fr/textile-et-composite-la-double-fibre-du-lin
- Flax snowboard binding
  Retrieved from https://www.jonessnowboards.com/bindings/541-3475-apollo.html
- Hemp Sunglasses
  Retrieved from https://hempeyewear.com/collections/sunglasses-1/products/halley

Appendix D: Project Email

Beste,

Mijn naam is Hessel, ik ben student industrieel ontwerpen aan de TU Delft en ben op dit moment aan het afstuderen bij NPSP. Ik mail jullie over een mogelijke samenwerking met _bedrijf_ voor mijn afstudeerproject.

(Hierboven verwijzen naar eventueel eerder contact.)

Mijn opdracht is gericht op de toepassing van biocomposieten in de mobiliteit en transport industrie. Ik benader verschillende bedrijven in deze sector om het te hebben over de eventuele toegevoegde waarde die biocomposieten kunnen leveren. Ik doe dit vanuit NPSP, een Nederlands bedrijf dat gespecialiseerd is in de ontwikkeling en toepassing van biocomposieten.

Wij zouden graag met jullie in gesprek gaan aangezien het materiaal zich uitstekend leent om metalen en glasvezel onderdelen en constructies te vervangen, vaak tegen een lager gewicht, en met een aanzienlijk lagere belasting van het milieu. Zo zouden we samen kunnen kijken of we _product_ lichter en nog duurzamer kunnen maken!

(Specifieke benaderingsrede en voordelen hierboven bijvoegen)

In de bijlagen is meer informatie te vinden over mij en dit project.

Ik hoor graag of jullie open staan voor een eventuele samenwerking!

Met Vriendelijke Groet,

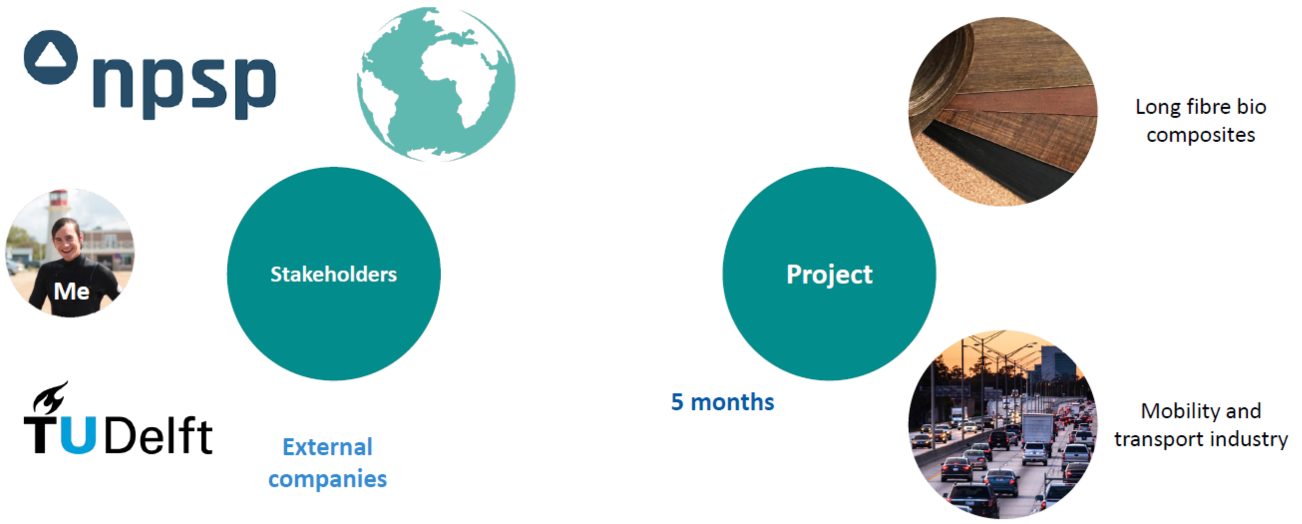
Hessel Klein Schiphorst
+[redacted]

Appendix D: Project Email

Email attachment: Project 2pager

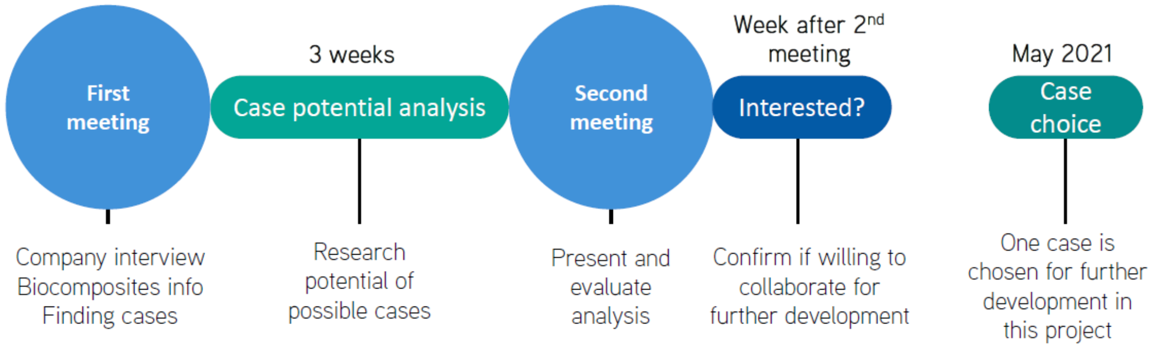
Moving biocomposites into second gear

An industrial design graduation project about finding biocomposite applications in the mobility and transport industry



Project goals and planning stage I

- Talk to several companies to gain insights in application readiness and potential for biocomposites.
- Collaborate with companies to provide a quick overview of possible biocomposite applications and benefits.
- Find a fitting case for further development in stage 2 of this project (2.5 months).



Appendix E: LEV application areas

	 Other outside parts	 Interior parts	 Structural parts	 Bodywork	 Box
Potential biocomposite advantages	Lightweight, aesthetics	Lightweight, aesthetics, vibration damping, safe breaking	Specific properties, vibration damping, lightweight, safe breaking	Lightweight, aesthetics	Lightweight, aesthetics, vibration damping, insulation specific properties
Cons	Parts are often standardized. Not logically chosen to apply nice aesthetic to	If driver is not the one who buys the vehicle, interior design stops at being comfortable and efficient. Land feel does not need to be high quality	Biocomposites still lack examples of these applications to become trustworthy for critical and structural applications. Variable properties do not help	Parts that are prone to damage during use need to be tough and cheap to replace. These parts are often used for brand identity, so natural aesthetics are likely to be hidden.	Material needs to be available on standardized roll and have a high surface quality.
Potential	Very small, unlikely for companies to invest in for more sustainable alternatives	Very small as long as driver experience is approached from only functional point of view	Not likely in the near future, possibly earlier for smaller vehicle types, although weight savings will be less significant	Small, with vacuum forming being a much cheaper option. More interesting for bigger or more mechanically demanding panels	Highest, although glass fibre will remain as a cheaper option, weight savings could be significant and costs can be lowered by developing continuous production

Appendix F: Website pages

Homepage

npsp

HOME PROCES MATERIALEN PROJECTEN NPSP

BIOCOMPOSIETEN

ONTWIKKELING EN REALISATIE VAN BIOBASED EN CIRCULAIRE MATERIALEN EN PRODUCTEN

SERIEPRODUCTIE: NABASCO

BIOBASED VERKEERSBORDEN MET HET OOG OP DE TOEKOMST

NPSP ontwikkelt en levert innovatieve milieuvriendelijke composiet materialen en producten voor openbare ruimte, bouw, design en mobiliteit. We gebruiken zoveel mogelijk biobased en circulaire grondstoffen, die na een lange levensduur circulair kunnen worden hergebruikt.

We realiseren samen met onze partners mooie oplossingen in biocomposieten en gebruiken hightech productietechnologie voor alledaagse toepassingen in natuurvezel versterkte kunststoffen. Daarbij willen wij een leidende rol spelen in de verduurzaming van de leefomgeving door de milieubelasting aantoonbaar terug te dringen en deskundig advies te bieden.

NIEUWS

MATERIAAL

25 FEBRUARI 2021 MEER

NABASCO®SIGN HOOGWAARDIG EN ZEER MILIEUVRIENDELIJK BIOBASED CIRCULAIR VERKEERSBORD

Pol Heteren en NPSP presenteren het meest milieuvriendelijke en hoogwaardige verkeersbord dat laat zien dat topkwaliteit en duurzaamheid goed samengaan.

MEDIA

20 AUGUSTUS 2020 MEER

NPSP AND PARTNERS ON GERMAN INTERNATIONAL TV

Circularity requires us to rethink and redesign the flow of resources – such as building materials, water, food, and energy – that drive urban activity. @DeutscheWelle covered COMPRO; a project that focuses on recovering resources from wastewater.

MATERIAAL

19 OKTOBER 2019 MEER

NABASCO BIOCOMPOSIET MET HOGE BRANDVEILIGHEIDSKLASSE

Brandveiligheid is niet meer weg te denken bij ontwerp en beheer van gebouwen. Voor de bouw in het algemeen, maar speciaal voor de utiliteitsbouw, heeft NPSP de Nabasco 8010 Fire ontwikkeld. De Nabasco Fire is een biobased en circulair materiaal met klasse B-s1, d0 conform de brandnorm voor de bouw NEN-EN 13501-1. Onderzoeks- en adviesbureau Peutz heeft het materiaal in haar laboratorium getest en gecertificeerd.

PROCES

MATERIAALONTWIKKELING

LAAT EEN BIOBASED MATERIAAL ONTWIKKELEN OP BASIS VAN UW RESTMATERIALEN

PRODUCTENGINEERING

LAAT UW PRODUCTEN (IDEE) ONTWERPEN IN EEN BIOBASED CIRCULAIR MATERIAAL

PROJECTREALISATIE

REALISEER UW PROJECT IN BIOBASED COMPOSIET MATERIAAL

SERIEPRODUCTEN SHOP

STIJLVOLLE BIOBASED PRODUCTEN

NABASCO MATERIALEN

Nabasco 5010

Lichter dan aluminium en glasvezel, hogere vibratie demping dan carbon

Lichtgewicht / Goede specifieke stijfheid / Hpge trillings- en geluidsdemping

Nabasco 8010

Sterk, circulair en met een lange levensduur

Circulair / Lange levensduur / Brandveilig

Nabasco 9010

Geluidsdempend, lichtgewicht en recyclebaar

Geschikt voor binnentoepassingen / Hoge trilings- en geluidsdemping / Lichtgewicht

Nabasco 10010

Volledig biobased, voor veeleisende toepassingen en hittebestendig

100% biobased / Goede specifieke stijfheid / Brandveilig

DOWNLOADS

Productsheet Nabasco 5010

Productsheet Nabasco 8010

Brandcertificaat voor Nabasco N-8010

CONTACT

NPSP BV
Moezelhavenweg 9
1043 AM Amsterdam
+31 (0)6 5429 5268
info@npsp.nl

VOLG ONS

- in

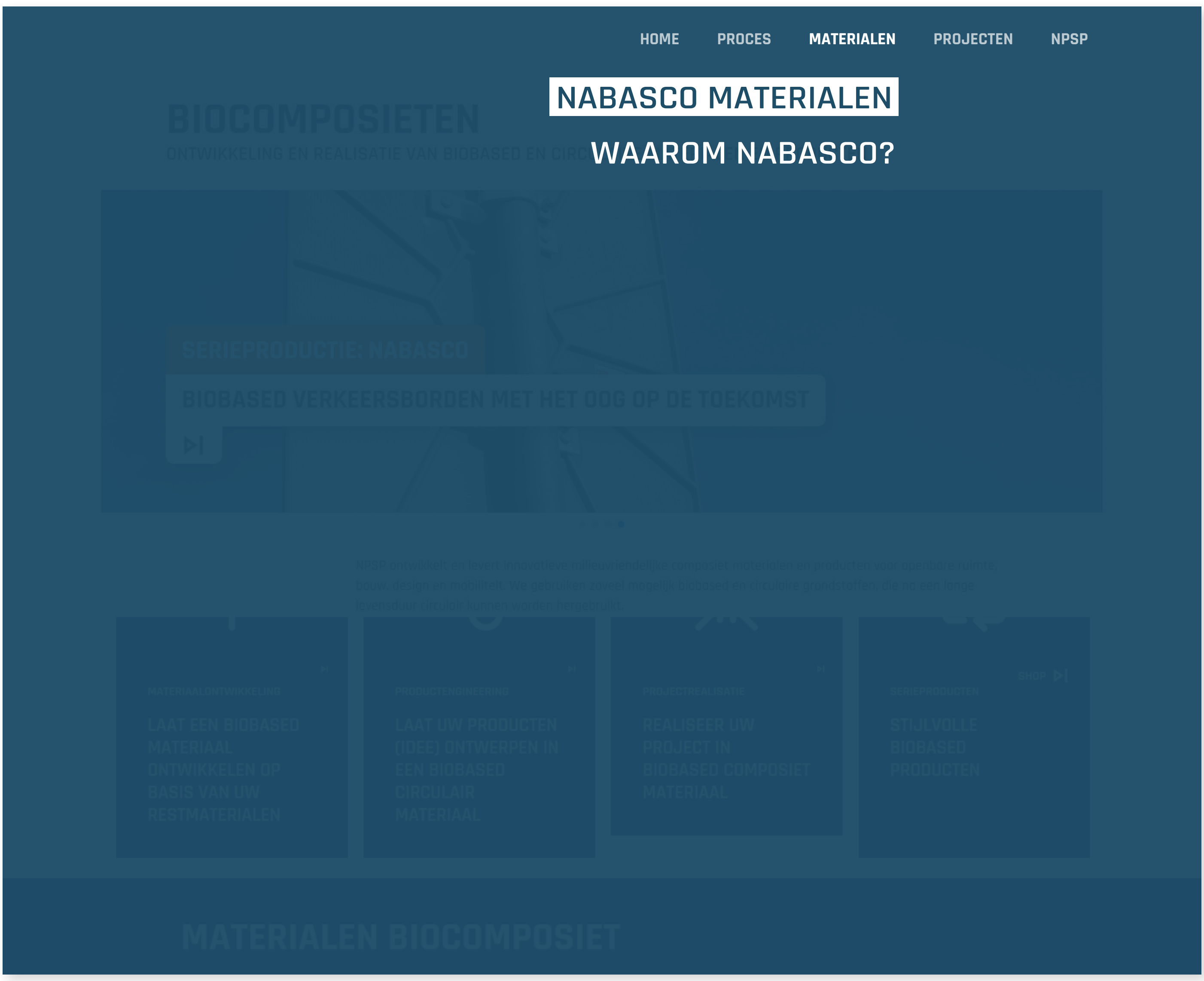
NIEUWSBRIEF NPSP

Vul hier je emailadres in

SCHRIJF JE IN

Appendix F: Website pages

Menu



Material overview

Appendix F: Website pages

Nabasco 5010 page

npsp

HOME PROCES MATERIALEN PROJECTEN NPSP

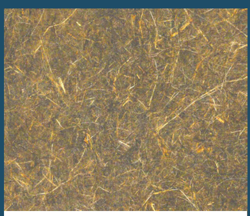
NABASCO 5010

Nabasco N5010 combineert natuurlijke vezels met een grotendeels op natuurlijke grondstoffen gebaseerde polyesterhars

Lichter dan aluminium en glasvezel, hogere vibratie demping dan carbon

- Geschikt voor binnen- en buitentoepassingen
- Licht gewicht
- Goede specifieke stijfheid
- Hoge trillings- en geluidsdemping
- Breekt veiling zonder scherpe randen
- Lange levensduur
- 44 - 73% biobased

VERKRIJGBAAR IN VERSCHILLENDE VARIANTEN

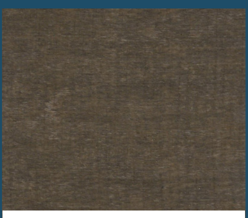


N5010 Hemp base

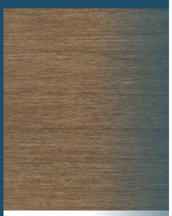
N5010 Flax base

N5010 Flax strong

Een sterkere variant met gewoven vezels voor veeleisende toepassingen.



N5010 Flax UD



N5010 Flax UDt

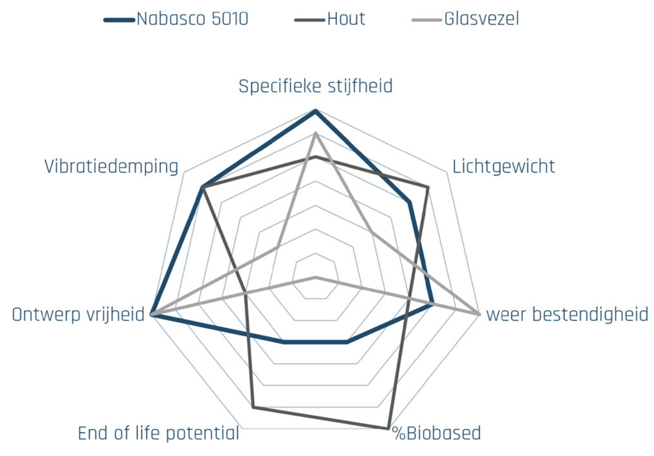
EIGENSCHAPPEN

Nabasco 5010 is het materiaal voor lichtgewicht producten voor veel eisende toepassingen. Het materiaal wordt typisch toegepast in transport, openbare ruimte, bouwsector, sport artikelen en meubilair.

Nabasco 5010 leent zich uitstekend voor kleine tot grote schaaldelige of holle producten. Door de toegevoegde stijfheid van de natuurlijke vezels kunnen de producten met dunne wanddikte en lichtgewicht toch een hoogwaardige stijfheid hebben.

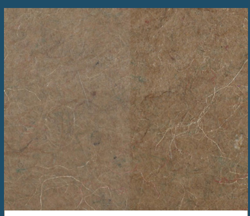
Voor de productie van producten met Nabasco 5010 zijn verschillende technieken mogelijk. Zo kan een toepassing van deze materialen al interessant zijn voor series van enkele stuks tot productie van duizenden per jaar.

Tijdens productie zijn aanpassingen mogelijk om de 'look and feel' van het product aan te passen maar kunnen ook elektronische onderdelen of inserts worden geïntegreerd. Na productie is het materiaal goed bewerkbaar met frees en boor bewerkingen om het product af te werken en bijvoorbeeld verbindingsgaten toe te voegen.

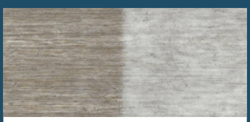


*Waardes zijn relatief en dienen alleen gebruikt te worden als indicatie

AFWERKINGEN

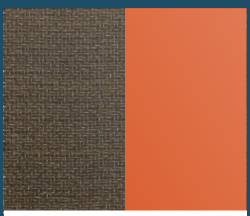


Product oppervlak



Pigmenten

Door pigment toe te voegen aan de hars kan de kleur van het eindproduct worden aangepast.



Spuiten of lakken

EVALUEER UW TOEPASSING

DOWNLOAD PRODUCTSHEET

BESTEL SAMPLES

PROJECTEN MET NABASCO 5010

Scooter Van.Eko Be.e

Biocomposiet gevel voor gasontvangststation

Appendix F: Website pages

Nabasco 8010 page

Appendix F: Website pages

Nabasco 9010 page

npsp

HOME PROCES MATERIALEN PROJECTEN NPSP

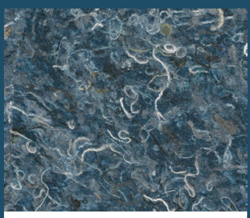
NABASCO 9010

Nabasco N9010 combineert natuurlijke of gerecyclede vezels met een biobased thermoplast

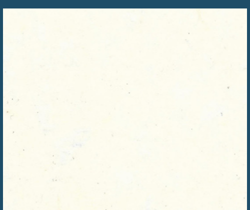
Geluidsdempend, lichtgewicht en recyclebaar

- Geschikt voor binnentoepassingen
- Lichtgewicth
- Hoge trillings- en geluidsdemping
- Breekt veiling zonder scherpe randen
- Tot 100% biobased

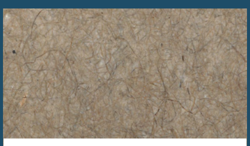
VERKRIJGBAAR IN VERSCHILLENDE VARIANTEN



N9010 Denim

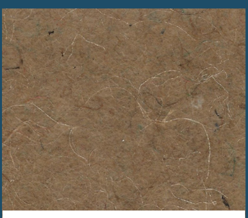


N9010 Viscose



N9010 Hemp viscose

N9010 Viscose, PLA met viscose en hennep vezels



N9010 Coffee jute

EIGENSCHAPPEN

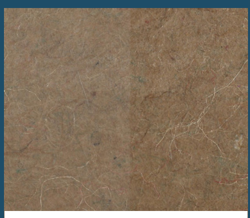
Nabasco 9010 is een thermoplastisch biocomposiet voor binnen toepassingen. Typisch toegepast in lampen, meubilair, geluidsdempende panelen.

Het materiaal is verkrijgbaar als dunnen (laminaat) sheet of als vormdelen.

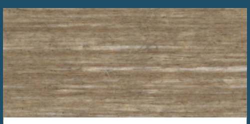
Voor de productie van producten met Nabasco 5010 zijn verschillende technieken mogelijk. Zo kan een toepassing van deze materialen al interessant zijn voor series van enkele stuks tot productie van duizenden per jaar.

Tijdens productie zijn aanpassingen mogelijk om de 'look and feel' van het product aan te passen maar kunnen ook elektronische onderdelen of inserts worden geïntegreerd. Na productie is het materiaal goed bewerkbaar met frees en boor bewerkingen om het product af te werken en bijvoorbeeld verbindingsgaten toe te voegen.

AFWERKINEN

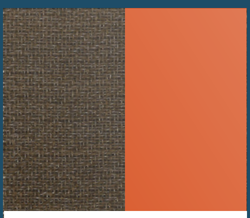


Product oppervlak



Custom blends

Voor grotere series kan een custom blend van vezels worden gemaakt voor een unieke uitstraling.



Andere thermoplast

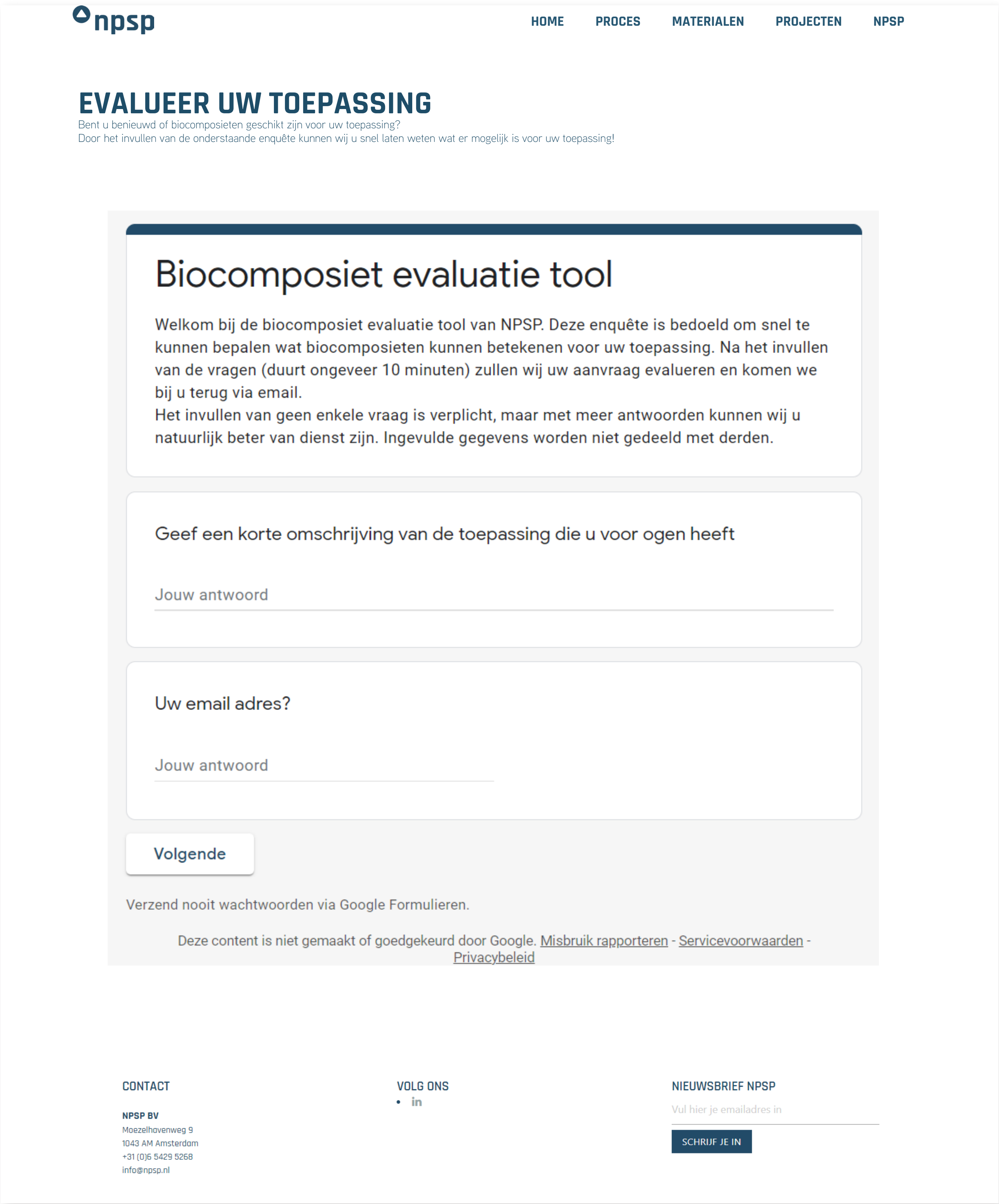
EVALUEER UW TOEPASSING | DOWNLOAD PRODUCTSHEET | BESTEL SAMPLES

PROJECTEN MET NABASCO 9010

Lamp Cascadanza

Appendix F: Website pages

Application evaluation tool



npsp

HOME PROCES MATERIALEN PROJECTEN NPSP

EVALUEER UW TOEPASSING

Bent u benieuwd of biocomposieten geschikt zijn voor uw toepassing?
Door het invullen van de onderstaande enquête kunnen wij u snel laten weten wat er mogelijk is voor uw toepassing!

Biocomposiet evaluatie tool

Welkom bij de biocomposiet evaluatie tool van NPSP. Deze enquête is bedoeld om snel te kunnen bepalen wat biocomposieten kunnen betekenen voor uw toepassing. Na het invullen van de vragen (duurt ongeveer 10 minuten) zullen wij uw aanvraag evalueren en komen we bij u terug via email.
Het invullen van geen enkele vraag is verplicht, maar met meer antwoorden kunnen wij u natuurlijk beter van dienst zijn. Ingevulde gegevens worden niet gedeeld met derden.

Geef een korte omschrijving van de toepassing die u voor ogen heeft

Jouw antwoord

Uw email adres?

Jouw antwoord

Volgende

Verzend nooit wachtwoorden via Google Formulieren.

Deze content is niet gemaakt of goedgekeurd door Google. Misbruik rapporteren - Servicevoorwaarden - Privacybeleid

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info@npsp.nl

VOLG ONS

- in

NIEUWSBRIEF NPSP

Vul hier je emailadres in

SCHRIJF JE IN

Biocomposiet evaluatie tool

Welkom bij de biocomposiet evaluatie tool van NPSP. Deze enquête is bedoeld om snel te kunnen bepalen wat biocomposieten kunnen betekenen voor uw toepassing. Na het invullen van de vragen (duurt ongeveer 10 minuten) zullen wij uw aanvraag evalueren en komen we bij u terug via email.
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Geef een korte omschrijving van de toepassing die u voor ogen heeft

Jouw antwoord

Uw email adres?

Jouw antwoord

Volgende

In hoeverre zijn de volgende eigenschappen voordelig voor uw toepassing?

1: helemaal niet belangrijk tot 7: zeer belangrijk

Weerbestendigheid

1 2 3 4 5 6 7

Lange levensduur

1 2 3 4 5 6 7

Hoge trillings en/of geluidsdemping

1 2 3 4 5 6 7

Lichtgewicht

1 2 3 4 5 6 7

Hoge mechanische eigenschappen

1 2 3 4 5 6 7

Hoge vormvrijheid

1 2 3 4 5 6 7

Hoge hittebestendigheid

1 2 3 4 5 6 7

Thermische isolatie

1 2 3 4 5 6 7

Veilig breukgedrag

1 2 3 4 5 6 7

Natuurlijke uitstraling

1 2 3 4 5 6 7

Duurzaamheid

1 2 3 4 5 6 7

Unieke uitstraling

1 2 3 4 5 6 7

Waterbestendigheid

1 2 3 4 5 6 7

Vorige Volgende

In hoeverre zijn de volgende eigenschappen nadelig voor uw toepassing?

1: helemaal niet nadelig tot 7: zeer nadelig

Hoge(re) product kosten

1 2 3 4 5 6 7

Gebrek aan materiaal certificaten

1 2 3 4 5 6 7

Lichte variatie in mechanische eigenschappen

1 2 3 4 5 6 7

Risicoweging van jonge supply chain

1 2 3 4 5 6 7

Heeft u interesse in een specifiek materiaal van NPSP?

- Ik ben het meest geïnteresseerd in Nabasco 5010
- Ik ben het meest geïnteresseerd in Nabasco 8010
- Ik ben het meest geïnteresseerd in Nabasco 9010
- Ik ben benieuwd naar welk materiaal het meest geschikt is voor mijn toepassing
- Anders:

Vorige Volgende

Ontwikkeling van de toepassing

Wat is het beoogde productievolume van uw toepassing?

- 1 tot 100 producten per jaar
- 100 tot 500 producten per jaar
- 500 tot 1000 producten per jaar
- 1000 tot 2000 producten per jaar
- 2000 tot 5000 producten per jaar
- Meer dan 5000 producten per jaar

Bij welke ontwikkelingsstappen kunt u ondersteuning van NPSP gebruiken?

- Materiaal ontwikkeling
- Product engineering
- Project realisatie
- Anders:

Op welk termijn vind de ontwikkeling van uw toepassing plaats?

- Nu en één jaar
- Nu en twee jaar
- Nu en meer dan twee jaar
- Anders:

Heeft u verder nog informatie die ons zou kunnen helpen om uw toepassing te evalueren?

Jouw antwoord

Vorige Verzenden

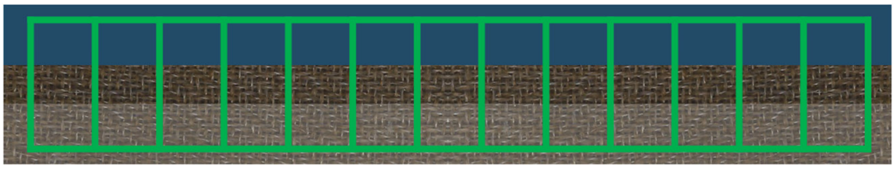
Appendix H: Sample set price estimation

N5010 spray coat sample

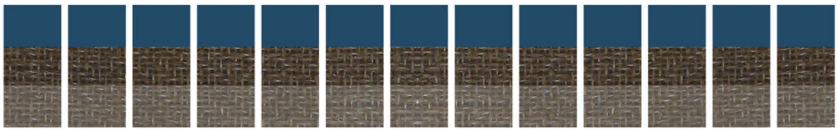
Price estimatimation is based on production with vacuum infusion on a glass plate in the NPSP lab. Production goes as follows:

Make sample on glass with gelcoat layer 140x30 cm

Spraypaint 1/3 in color, 1/3 matte



Cut in strokes of 10x20cm



13 samples

Labor

action	time [min]	waiting [h]
fibre cutting	10	
drying		1
Gelcoat 1	15	
Gelcoat		2
Gelcoat 2	15	
Gelcoat		2
Preparing infusion/vacuumba	30	
impregnating fibres	15	
closing bag	10	
curing		10
Total	95	

Materials

costs	layers	m2	price/m2	price	weight [gr	price/kg
Sample area		0,42				
Flax twill 300	4	1,68	9,02	€ 15,15	504	
Nonwoven550	2	0,84	3,8	€ 3,19	462	
Infugreen810				€ 35,57	1932	18,41
Gelcoat				€ 10,17	300	33,9

Total

				price	weight
					3198
Total material costs				€ 64,08	
Painting and cutting				€ 50,00	
man hours				€ 47,50	
Total				**€ 161,58**	
price/sample				**€ 12,43**	

Estimated price/sample is between 10 and 15 euros

Appendix H: Sample set price estimation

N9010 3D sample		
cycle time [min]		20
material price [eu/m2]	€	4,00
surface of sample [m2]		0,0144
layers		3
Labor [30eu/h]		10
material	€	0,17
Total	**€**	**10,17**
Estimated price is around 10 euros		

N9010 surface sample		
cycle time [min]		5
material price [eu/m2]	€	4,00
surface of sample [m2]		0,0264
layers		3
Labor [30eu/h]		2,5
material	€	0,32
cutting	€	5,00
Total	**€**	**7,82**
Estimated price is around 8 euros		

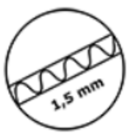
Regular samples

The remaining samples included in the set are 3 of the five samples for the currently available set. This set is avaibable for € 29,95, meaning that one sample costs about 6 euros. So, for these three samples, a price of 6 euros for each is used in this rough estimation.

Box

The box is a custom size with a black print on the top like the current sample set. The box will cost around € 2,50 and shipping costs € 4,10 within the Netherlands

GEEN startkosten!



Postdoos
- Enkele golf 1,5 mm
- Bruin/bruin
- Zwart/grijs bedrukt

210mm x 110mm x 25mm
(binnenmaat, Lengte x Breedte x Hoogte)
50 stuks

Per stuk (excl. btw) € 2,45
Volumekorting -

Totaal € 122,50
Totaal incl. BTW € 148,23

Actuele levertijd 10 - 11 werkdagen

<- Quotation from doosopmaat.nl
https://www.doosopmaat.nl/bestellen/type/type_postdoos?-aantal=1000&lengte=290&breedte=195&hoogte=80&kwa-liteit=E&kleur=bruin%2Fbruin&bedrukt=1&gclid=Cj0KC-Qjw5uWGBhCTARIsAL70sLL29LxGVMgMX-wtFCyFFpL-QfXb0PtOcA1ZU76PLcbCdcdqvYZWG6wQaAuaFEALw_wcB

Brievenbuspakje+	v.a.	€ 4,10	+ Toon details
Pakket	v.a.	€ 6,75	+ Toon details

Current shipping costs from post.nl
https://www.postnl.nl/tarieven/Pakket/NL/0-350g

Appendix H: Sample set price estimation

Total

Item	price
N5010 spraycoat sample	€ 12,43
N9010 surface sample	€ 7,82
N9010 3D sample	€ 10,17
N9010 regular sample	€ 6,00
N8010 sample 1	€ 6,00
N8010 sample 2	€ 6,00
Box	€ 2,45
Shipping costs	€ 4,10
15% Margin	€ 8,25
Total	**€ 63,21**

The estimated costs of producing and shipping this sample set is around 65 euros.

Appendix i: Opportunities assessment

	N5010 pultrusion	N5010 continuous lamination	High-end N9010
Target market(s)	Building and infrastructure, lightweight (semi-) structural applications in transport sector.	Sandwich panels applied in transport, LEVs and construction	Applications of synthetic composites or thermosetting biocomposites where sustainability is pressing and thermal stability is less critical.
Reason to buy	Lighter and more sustainable than glass fibre and metal profiles. High vibration damping, natural aesthetics and safe breaking behaviour. Cheaper than carbon fibre.	Lighter and more sustainable than glass fibre sheets. High vibration damping, natural aesthetics and safe breaking behaviour. Cheaper than carbon fibre. An even more sustainable solution if combined with wood or cork cores.	Sustainable composites with a better end of life perspective. Unique biocomposite characteristics. Fast and high volume production benefits of thermoplastic manufacturing methods.
Whole product	Bicomposite pultrusion is not yet fully developed, but NPSP has made contact with a company that has developed the process to be almost ready. NPSP could offer its expertise to finish the technology and its market knowledge to get the product to clients.	NPSP can already produce sandwich panels on small scale or in 3D curved products. Upscaling this into a continuous process has some challenges.	NPSP is developing ways to produce thermoplastic composites in higher volumes. Increasing the mechanical properties by optimizing the fibre/matrix ratio and integrating woven fibres enables and expansion in the possible application. If the amount of applications grows and a recycling surface is developed, the lifecycle can be closed and the product becomes even more sustainable.
Competition	Currently, biocomposite pultrusion is not available on commercial scale	Not yet on commercial scale, sandwich skin producers are experimenting.	Multiple parties are developing similar solutions and first commercial applications are close. Still, the potential market of this product is big enough for NPSP to join.
Partners and allies	NPSP has contact with a possible production partner that is developing the technology	First contact has been made with a possible production partner. Partner is possibly capable of realizing and marketing the product without NPSP so the relation should be managed carefully.	Material is currently supplied by a party capable supplying higher volumes as well. A manufacturing partner still has to be found.
Distribution	Some application areas could be reached via existing sales channels of for example the N8010 street signs.	Contact with first potentially interested clients is already made.	Offering a thermoplastic material capable of replacing some thermosetting biocomposite products enables NPSP to start in their existing client base.

Appendix i: Opportunities assessment

	N5010 pultrusion	N5010 continuous lamination	High-end N9010
Pricing	The continuous nature of the process will offer a relatively low price for biocomposites. The low corrosion resistance could extend the lifetime beyond lifetimes of metal, lowering overall costs. Lastly, additional value of the other unique benefits and the sustainability is dependent on the application and client	The continuous nature of the process will offer a relatively low price for biocomposites. Offering a product cheaper than carbon but lighter than glass fibre has high value for applications where low weight is desired. Since the skins are produced first and then made into a sandwich panel by another partner, final price should be managed carefully. Lastly, additional value of the other unique benefits and the sustainability is dependent on the application and client	The N9010 material and process are already cheap compared to the N5010. Raising the production volume will lower the price even further. The fully biobased and recyclable nature of the material supplemented by the unique characteristics should also bring some additional value.
Positioning	NPSP presents itself as an ‘we do it al’ biocomposite company and is active in many industries. If they are the first to market this material/technology and supply is stable, NPSP is credible to sell this product.	NPSP presents itself as an ‘we do it al’ biocomposite company and is active in many industries. The market of skins alone is more logically reached by the skins manufacturer, making the position of NPSP to profit from this market more delicate.	Credibility must be built with smaller or less demanding applications before high-end applications are pursued. Since the material could replace thermosetting biocomposites as well, NPSP could start with market the material in its own client base.