A Work Project, presented as part of the requirements for the Award of a Master's degree in Impact Entrepreneurship & Innovation from the Nova School of Business and Economics.

# Carbon Bridge: Making businesses greener by realizing the potential of biochar – The value chain perspective

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**Abstract**

This work project discusses the development of the impact business Carbon Bridge. Carbon Bridge has the mission of increasing the sale of biochar by raising awareness for it. While doing so it is aiding businesses to reduce their emissions with biochar. The project, guided by the Plan-Do-Check-Act framework, evolved from an initial vision to a multifaceted product which was further developed using the Lean Business Model Canvas. The final product is a website that includes an educational blog, a Python-built impact assessment tool, and a marketplace for biochar. Upon the reflection of this progress, the work extends with a discussion of the value chain of biochar. It is explored how a niche was found within and in which way the chosen angle beneficially differs from previous business ideas. To get a clear understanding of the necessary activities behind the successful functioning of Carbon Bridge, key value-adding tasks are addressed. Consequently, the question of productive choices in relation to resource spendings is discussed, with focus on the lean approach.

**Keywords**

Entrepreneurship, sustainability, biochar, impact innovation, carbon sequestration, impact assessment, innovation, impact, value chain

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**List of Abbreviations**

B2B…….Business-to-business

B2C……...Business-to-consumer

CAC……...Customer acquisition costs

CEO……Chief Executive Officer

$CO_2$……..……..... Carbon Dioxide

MVP……...Minimum-Viable-Product

PDCA……..…… Plan-Do-Check-Act

S&P500……Standard & Poor's 500

SAM……...Serviceable available market

SBE……..School of Business and Economics

SEO……..Search Engine Optimization

SOM…….Serviceable obtainable market

TAM……Total addressable market

TLD…….....Top-level domain

**Part I: collective work**

**On reading this document**

The following pages depict the story of an entrepreneurial journey. As it is the joint effort of three people, the work here presented is divided into a core part written collectively and individuals parts complementing the former. The other individual parts can be found in the respective master's theses of Katharina Brunner and Sara Serra Siebels. To have a guiding structure for the overall process, the Lean Business Model Canvas together with the Plan-Do-Check-Act (PDCA) framework was applied. Explored within the subsequent chapters, the foundational idea of the Lean Canvas is to break down a business idea into a one-page business model (Lean Foundry, n.d.). The PDCA framework aids in achieving this goal by establishing an iterative process that allows improvement through testing ideas in practice and evaluating the outcome.

The journey here begins with a resource that has been around for a long time, and while being almost forgotten, it is now more necessary than ever. By establishing the case for biochar in **1 Introduction: a case for Carbon Bridge** the rationale for this project is simultaneously being found. For grounding the process in existing data and industry expertise, **2 Methodology: frameworks and data collection** explains the paths here taken. The iteration, which is at the heart of the PDCA model, can be traced in chapter **3 Journey: establishing a feasible project**. In having this foundation, it is possible to dive into the process of asking and answering the relevant questions when it comes to starting a business. **Chapter 4 Structure: leveraging the Lean Business Model Canvas** provides information from initial problem definition to the businesses' revenue streams. The group work comes to an end with a reflection on key learnings and experienced limitations in chapter **5 Reflections: learnings and limit**. Finally, it closes with a remark on what might lay ahead in chapter **6 Horizons: Carbon Bridge's future**.

The individual parts extend on three main topics. Firstly, it is critical to understand how Carbon Bridge found its niche within the value chain and the reasoning behind it. Such can be identified in chapter **7 Value chain: finding the right spot (Sebastian Immervoll)**. Secondly, the development of the product is thoroughly explored in the chapter **Product development (Katharina Brunner)**. The third part consists of a detailed discussion of how success can be defined in this relation, and which value the project is able to create. Focusing on a customer centric approach, these considerations are to be found in the chapter **Impact: elevating customer success (Sara Serra Siebels)**.

## 1 Introduction: a case for Carbon Bridge

Addressing climate change is a challenge of increasing complexity and urgency (Zajmi, 2012). The global mean surface temperature is on track to reach a total increase of 1.5 °C, the agreed upon acceptable temperature increase of the Paris Climate Agreement (United Nations, 2015), in the next ten to thirty-two years (IPCC, 2018). Evidence points to the human economic activity as the main impact factor on the environment (Zajmi, 2012). Consequently, firms are confronted with an increasing amount of pressure to acknowledge and address global warming. From policy changes to stakeholder demands, climate change concerns became one of the most significant issues of modern businesses. Management of emissions is a new challenge for managers globally (Lee, 2015). To avoid a global crisis global warming must be limited. Mitigating climate change requires a reduction of atmospheric carbon dioxide ($CO_2$) by reducing emissions but also by taking up and storing $CO_2$ from the atmosphere, so called carbon dioxide sequestration (Hutchinson, et al., 2007).

Biochar emerged as a promising global solution that has the potential to sequester carbon (Matuštík, et al., 2020). Biochar is produced by thermal decomposition of biomass in an environment with limited or no oxygen at high temperatures. This process is most commonly

called pyrolysis. The biochar derived from pyrolysis is a carbon rich product, which resembles charcoal.

*Figure 1: Biochar in bulk (left); Forms of biochar - from powder to coal (right); Pictures taken at Ibero Massa Florestal*

Biochar is suitable for many different applications and industries. It can be used for wastewater treatment, energy production, absorbing pollutants, reducing carbon in the atmosphere and as a soil remediation (Yaashikaa, et al., 2020). The range of application is not only limited to using it in an environmental context but also extents to industrial and construction use cases (Bier, et al., 2020).

Biochar has a significant potential to aid humanity in achieving the Paris climate goals and limit the emissions of businesses and industries, yet currently does not have the scale necessary to facilitate that (Bier, et al., 2020). Biochar producers often mentioned during the team's primary research that a lack of awareness around biochar is a constricting factor in the growth of the industry. This lays the foundation for Carbon Bridge's mission to unfold biochar's full potential, thereby enabling businesses that utilize it to become more sustainable in the process. This is achieved by increasing the awareness and usage of it through making information accessible and finding the most suitable biochar product through Carbon Bridge.

## 2 Methodology: frameworks and data collection

It is an interesting situation for biochar: the product has an extensive legacy, while its current market is widely unstructured. Hence, there is only limited market research available. For

building an understanding of both the overall topic and the product's market, the team applied a two-fold approach. Its starting point was secondary research. Reading through research papers, published articles and interviews, a preliminary knowledge base was established. To see the full picture, these insights were complemented with interviews to gather first-hand experiences of people working in the field of biochar.

### 2.1 Articles and papers: secondary research

To get an understanding of the extent of biochar being covered in research publications and market reports, a quick benchmark test was performed. Using coal as a reference point, 3,570,000 results were found on Google Scholar compared to 433,000 for biochar (Google Scholar, 2023; Google Scholar, 2023). Looking for a coal market report and a biochar market report via Google Search, there are 114,000,000 and 1,250,000 results to be found (Google, 2023; Google, 2023). After getting this first impression of available material, the team started to look for high-quality research papers, initially with a narrow geographical focus. From there on, the members increased the radius and researched additional areas and locations. Such helped in getting a broader perspective of the topic, while also providing space for learning from regional differences. Diving more into the realm of biochar, the group was additionally able to establish contacts with researchers. Through them, access to further reading materials was provided, aiding the understanding of the topic.

### 2.2 Interviews: primary research

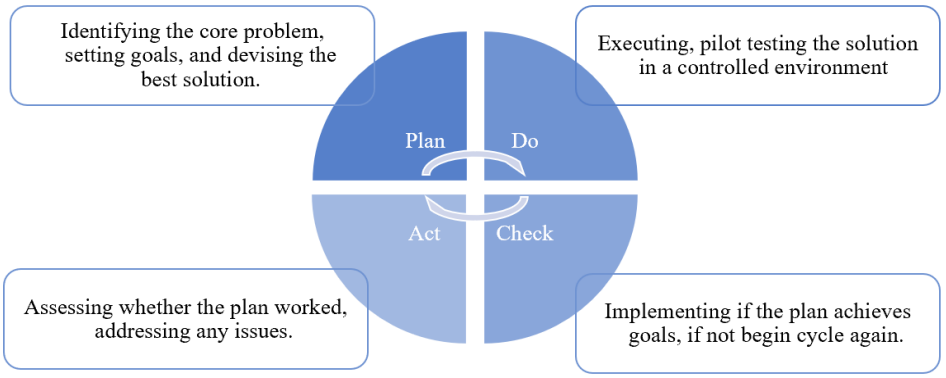
Expert interviews were conducted to better understand the Carbon Bridge customers and their pain points to complement our secondary research on the market. In-depth interviews with industry stakeholders such as Ibero Massa Florestal, LignoCarbon, IconCarbon, Biatex, Arigna Fuels, Bioenergie Frauenfeld AG, bionero, Skånefrö AB, Stiesdal, ProE Bioenergie, Sonnenerde NSR, and Varem Energie. were conducted. This was done to initially test the team's assumptions about the biochar market and in later stages validate the minimum viable

product (MVP). Many of the learnings gathered by the interviews can be found throughout the following document and especially in the individual parts of the thesis in chapter 5, 6 and 7.

### 2.3 Framework: Plan-Do-Check-Act

During Carbon Bridges entrepreneurial journey, the founding team underwent various phases of reassessing ideas and gaining insights from solution testing and setbacks. The Plan-Do-Check-Act framework best illustrates the team’s progress. It is part of the Lean management philosophy and lays the foundation for the continuous improvement of people and processes. The PDCA framework enables the Carbon Bridge team to learn from mistakes and improve the product. The PDCA process comprises of four critical stages: plan, do, check, and act. This initial stage involves thorough planning, addressing key concerns such as identifying the core problem, finding the best solution with the available resources, and determining the goals. Once the plan is agreed upon, the next step is to proceed with its implementation. This second stage involves executing the plan and potentially testing it on a smaller scale in a controlled environment. The checking stage focuses on evaluating the plan's execution to verify if it worked as intended. It involves identifying and rectifying problematic areas and analyzing the root causes of any issues that arise. In the final stage, actions are based on the outcomes of the previous stages. If the plan achieves the set goals, it can be fully adopted. If not, the cycle will begin again. However, it's important to continuously revisit and refine the plan for ongoing improvement. Each stage is integral to the PDCA cycle to ensure continuous improvement.

*Figure 2: PDCA Framework*




Carbon Bridge underwent many cycles, as resource constraints hindered feasible solutions for many challenges. In some cases, heavy market or technological restrictions did not allow the team to progress with their idea. Despite encountering some setbacks, the team regrouped after every setback to discuss alternatives and options, rooted in the conviction of creating an impact. This iterative process allowed for a deep reflection on the team's capabilities and adaptability.

## 3 Journey: establishing a feasible project

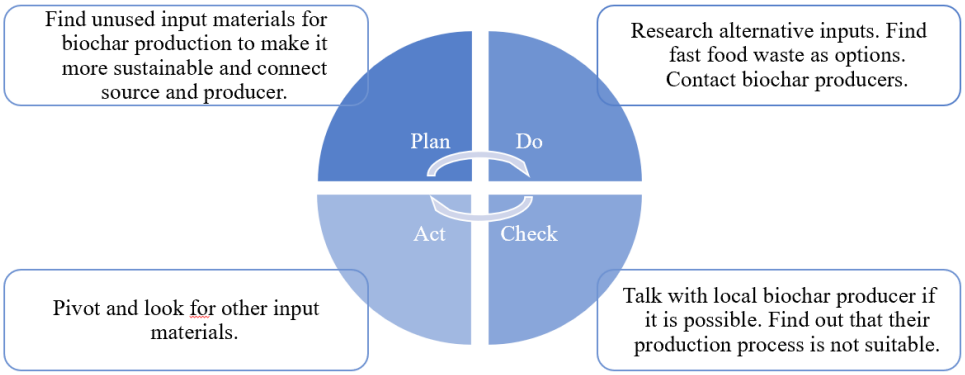
The following chapter will illustrate the different cycles of the PDCA framework the team underwent which led to the starting point of Carbon Bridge's current vision and product. This context is crucial to understanding the reasoning of where Carbon Bridge came from and where it is going.

### 3.1 Cycle 1: A circular economy facilitator – food waste input

The spark of interest in biochar was ignited in the team member Katharina last year during an internship in a climate tech start-up. While the contact with the topic was brief, the concept of biochar stuck due to its immense projected environmental potential. The journey as a group begun in the first semester of the group's master studies as the idea of working with and around biochar was discussed. Working in an emerging market with so much positive environmental potential inspired the team. The first cycle was shaped by looking mainly at the Portuguese biochar market. It is characterized by unexploited feedstock options, the input material for the

production, such as unused agricultural waste or even municipality household waste. Biochar producers use mainly wooden inputs, when sustainably sourced they are leftovers of the paper industry or wooden cuttings from municipalities parks. But this can also lead to unsustainable practices as sometimes trees are grown specifically to be cut down for biochar production. This restricts the sustainable production of biochar as the amount of input materials are limited. Yet, there is a need for biochar as Portuguese soil is relatively dry (Garcia, 2022) and many businesses would benefit from reducing their emissions with biochar in Portugal. The team identified those two loose ends with the desire to connect them ("Plan"). Research on alternatives was conducted and the initial idea was to produce biochar out of food waste, which could have been collected from a fast-food chain restaurant. If this type of input is suitable for biochar production also needed to be confirmed by producers ("Do"). The team had chosen this input because this kind of food waste is already standardized as the composition of the waste rarely changes and is available in significant quantities. The value for the biochar producer was a cheaper input material as the waste is abundant and is otherwise incinerated. The value for the fast-food company would have been that they could have made their waste management more sustainable. During the checking phases, the team realized that the idea is not feasible. While secondary research showed that in general there is a possibility to produce biochar out of food waste, the primary research conducted by the team consisting of interviews with industry experts halted our idea. Ibero Massa Florestal, the primary producer of biochar in Portugal, informed the founders that their production facility would not be suitable to work with such an input due to its moisture content. The team needed to pivot the project according to the production possibilities of the underlying technology ("Act"). The key learning was that we need to conduct a lot of research and consult with experts about what is possible, doing so as early as possible in the process.

*Figure 3: PDCA cycle one - Using fast-food waste as biochar input material*

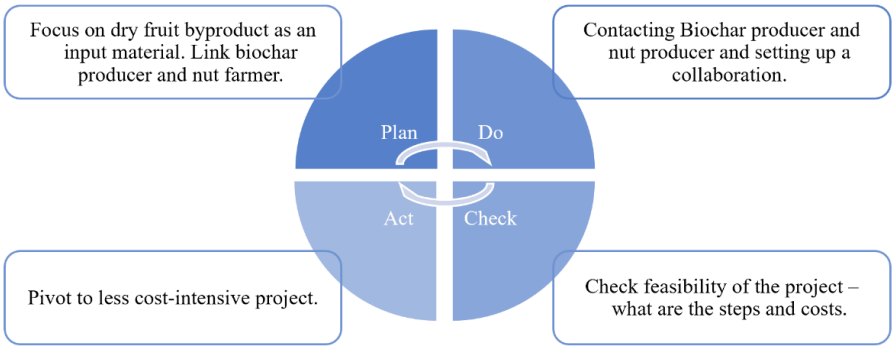



### 3.2 Cycle 2: A circular economy facilitator – nutshell input

The team entered cycle two with the learnings of cycle one as a foundation. The project needed to change according to the production possibilities of the underlying technology. It was decided to focus on dry fruits as they have low moisture contents. The aim was to bridge the missing link between biochar producers and nut producers. An ambition of the project was to become a point of reference for the disposal of agricultural byproducts ("Plan"). The team contacted Ibero Massa Florestal to verify that obtaining biochar out of nut shells would be feasible with their technology. It also had to be confirmed that the producer was willing to do a test run and determine if one can produce biochar out of nutshells specifically out of the hulls. As this was affirmed, the founding team contacted several nut producers. The team collaborated with Vera Cruz, a Portuguese almond producer, and PortugalNuts, an association for Portuguese nuts, on making their operations more sustainable and finding another revenue stream for farmers, in them selling their unused byproduct – the hulls – to us to make biochar ("Do"). In the checking phase, the team analyzed the feasibility of the project after receiving the necessary information, estimations on the costs, and having found collaborators. The idea proved to be too capital-intensive. Making an upfront payment for the acquisition of the unused agricultural byproduct, transporting it to a biochar production facility, transforming it, and then shipping it back to the farmer for application to their soil was not feasible. The estimation of the costs for one hectare

of soil transformed would be 7,753€ (a break-down of the costs can be viewed in Appendix 1). This is not completely unfeasible but indeed it was for the team, as combined savings would not allow the team to go forward with this plan. The founders realized that a pivot to a more feasible project was necessary ("Act").

*Figure 4: PDCA cycle two - Using nut byproducts as biochar input material*

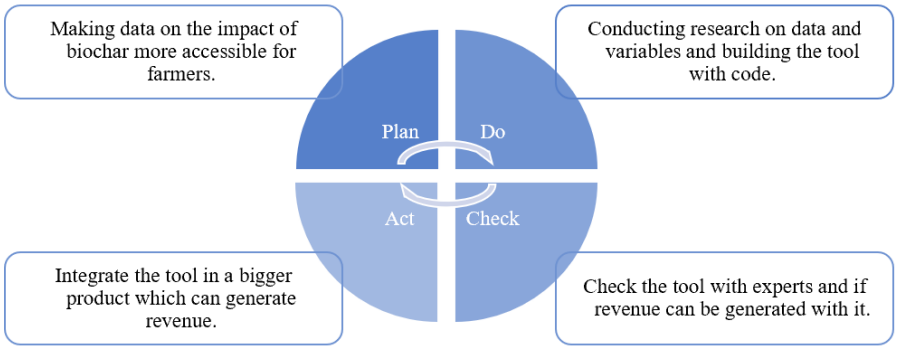



### 3.3 Cycle 3: An impact assessment service

The pivot was grounded in the reasoning of seeking a less capital-intensive project which is feasible for a student team. The class 'Data Science and Innovation' reinforced the team how crucial data is for businesses. Additionally, a workshop on Social and Environmental Evaluations with Graça Fonseca on April 4th, 2023, made the founders realize how crucial data is for sustainable development and how most businesses will be required to report their impact on the planet and society (European Commission, n.d.). A decision was made to include more data on the benefits of biochar in our project as data is not easily accessible to the end user since it is hard to gather and interpret. The idea was to do an impact assessment tool that gives farmers who are contemplating to integrate biochar into their soil a tool to check the potential impact ("Plan"). The doing part consisted of conducting research and building the tool. In the beginning, finding the right research paper and identifying the most relevant indicators and variables was most important. Building on that an algorithm was needed to calculate the impact based on the input of the farmer (see tables for the calculation basis in Appendix 2). This was also translated into Phyton code and then later to an HTML code to create an online version of

the tool (see code in Appendix 3). The verification stage ("Check") of this cycle was done by talking to experts and inquiring about their judgement on the tool. Internally, the team also contemplated on how to monetize the tool and integrate into a business model. As no convincing revenue model could be based solely on the tool the decision was made to keep the tool as it proved to have value as confirmed by experts, but for it to only be part of a bigger product which is able to generate revenue ("Act").

*Figure 5: PDCA cycle three - Impact assessment service for biochar*




In the chapter **From vision to product – the impact assessment tool** it will be explored in depth how this tool was later developed and integrated into the final product of Carbon Bridge.

### 3.4 Cycle 4: A marketplace, marketing, education, and community platform

The last cycle was entered with the team's previous journey in mind. In the founder's own research on biochar and its markets many issues stood out. The lack of awareness of the existence of biochar in the first place limits its sales. Biochar seems to face a marketing issue. Learning about biochar can be difficult as a beginner, it is an abstract concept. It can have many applications from soil amendment to construction material. Yet, an overview on the potential with data and easy to comprehend information is lacking. Finding the most suitable biochar for the user's needs is also a challenge. While there are some companies which list biochar producers, it is not clear which type of biochar is being sold for specific use cases. The team also found that the communication on the topic seems to be not entirely effective. Biochar producers naturally market the product biochar, yet the general public is not aware of biochar

itself and what it does. Consequently, marketing a product that potential users do not know the function or benefit of makes the effort less effective. The product envisioned by the team aims to solve these issues. It will be an aggregator for biochar as it will include a marketplace for biochar, do marketing with a focus on the effects of biochar, decarbonization especially as it is a pressing issue for businesses, educate on biochar suited for beginners including an impact assessment tool, and build a community ("Plan"). The doing consists of building a website which encapsulates all the above. An MVP was built on a website builder and the impact assessment tool was coded. The team decided to do extensive external validation on the MVP and talk to many biochar producers to determine if they see the value in such a website, and later on would be willing to list their product on it ("Check"). As the founders receives a lot of interest and positive feedback it was decided to stick with the idea of a website and further develop it ("Act"). The development of the website and code is further elaborated in the chapter Product development (Katharina Brunner).

*Figure 6: The Carbon Bridge website: carbonbridge.eu*

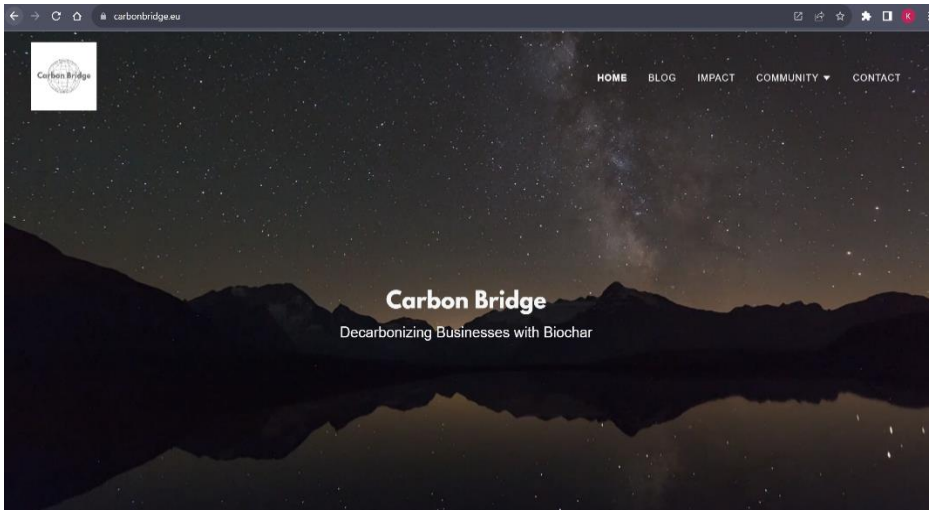
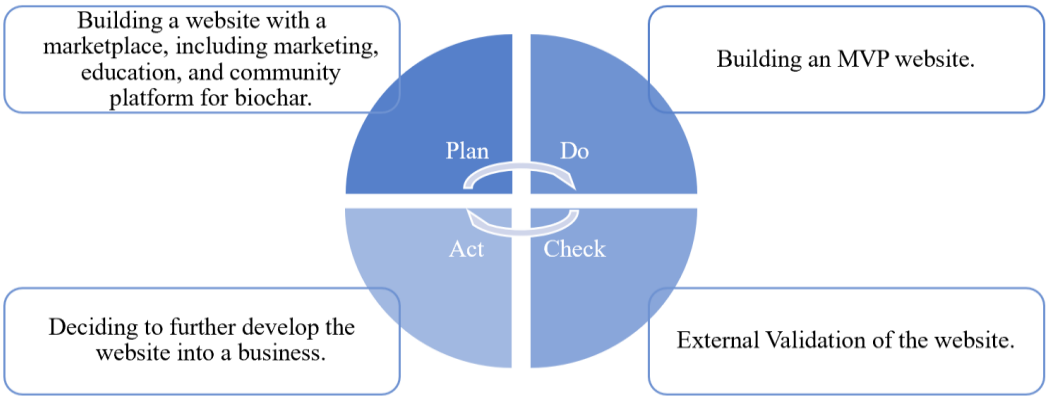


*Figure 7: PDCA cycle four – Website for biochar*

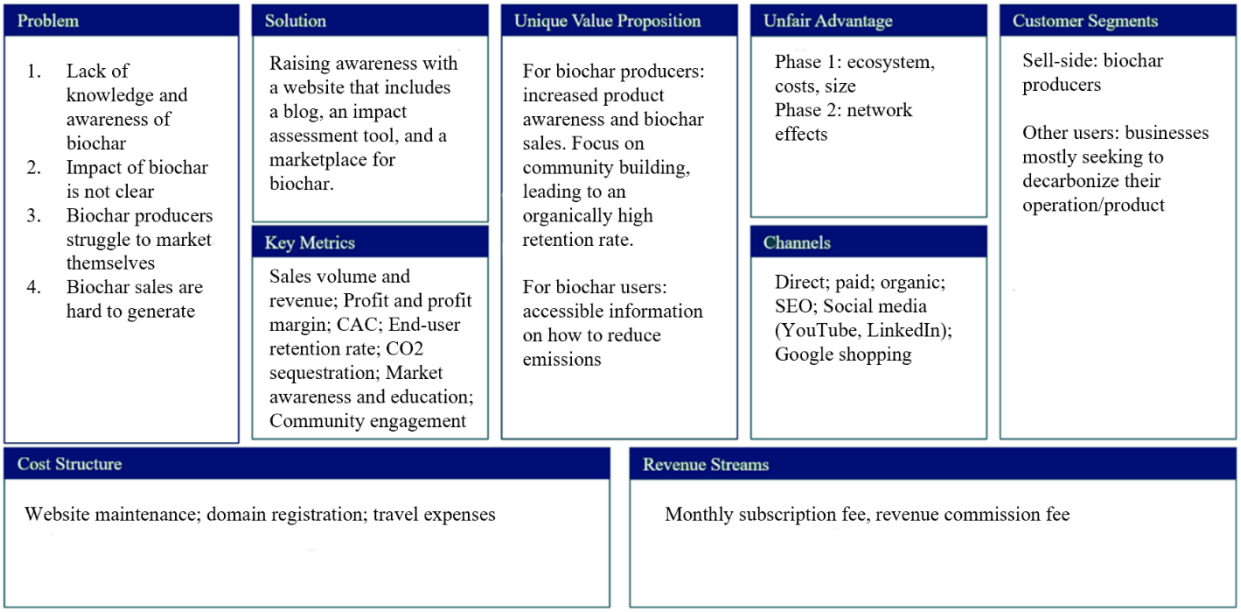



## 4 Structure: leveraging the Lean Business Model Canvas

The Lean Business Model Canvas is used to deconstruct the team's ideas into the key components of the impact business of Carbon Bridge. The Lean Business Model Canvas, created by Ash Maurya, is an adaptation of the Business Model Canvas of Alex Osterwalder. The Lean Business Model Canvas is the chosen instrument for analyzing the team's development as it is designed for start-ups which are operating under conditions of uncertainty and for quick, dynamic changes. The Lean Canvas provides a holistic overview of the business with key components such as value propositions, customer segments, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure covered (Maurya, 2012).

The Lean Business Model Canvas was also compared to the "Disciplined Entrepreneurship" framework by Aulet which is a guide on how entrepreneurs can successfully launch a venture. It presents a 24-step guideline which introduces a systematic approach of bringing products to market (Aulet, 2013). However, the decision to use the Lean Canvas was made as the visual format of the Canvas makes it easy to use, understand, and communicate. It also allows for quick iterations, making it the most suitable lean tool for the team. The following figure displays the Lean Business Model Canvas of Carbon Bridge and the next chapters will cover each aspect of the Lean Canvas in detail.

*Figure 8: Lean Business Model Canvas - Carbon Bridge*




## 4.1 Prevailing issues: pain points

The problem that Carbon Bridge is tackles is sequential: On the one hand, Carbon Bridge is tackling the lack of knowledge and awareness of biochar as a resource itself. The general public is not aware that the product exists. Secondly, the impact of biochar is not clear in terms of environmental, social, and financial benefits. The third and overarching problem, resulting directly from the first two issues, is that biochar producers struggle to market themselves and drive visibility and quality traffic to their websites to generate a sale, as was confirmed by many biochar producers during the team's primary research. The producers are facing the question of how to market a product and its positive impact that no one knows of. Additionally, if a potential user of biochar knows of the product, there is an abundance of biochar types with different specifications which are suited for different use cases. This can be overwhelming for potential consumers of the product. This communication complexity hinders the growth of the market and restricts sales. Biochar has a significant potential to aid us in achieving climate goals and limit the emissions of businesses and industries (Bier, et al., 2020), yet currently does not have the scale necessary to facilitate that due to lack of effective communication.

### 4.2 Healing solutions: product definition

Carbon Bridges solution to the aforementioned issues is formulated in a three-step approach of education, impact awareness, and increasing sales through a marketplace. All aspects are encapsulated in the Carbon Bridge website. Having this unique three-pillar approach is not a nice-to-have but a necessity. It follows the logical order of what? – why? – and where? It initially answers the question of what biochar is. This knowledge base is being supplemented by responding to the question of why it should be used, given the products' beneficial characteristics. Finally, a translation from theory to practice is established, a bridge on its own: the reply to the question of where it can be bought.

### 4.3 Measurements of success: key metrics

In the pursuit of realizing the potential of biochar for making businesses greener, it is imperative to establish clear, measurable key metrics. These metrics not only serve as indicators of Carbon Bridge's business success but also reflect its environmental impact and contribution to sustainable practices. Yet due to the initial stages of Carbon Bridge, where empirical data is yet to be gathered, the focus is placed on defining theoretical key metrics. The key metrics are divided into categories: business performance metrics (1), (2), (3), (4); environmental impact metrics (5); and additional metrics (6), (7). The following table includes sub-metrics under each category and the rationale for their importance to Carbon Bridge.

*Table 1: Carbon Bridge's key metrics*

| ***Key metrics*** | ***Sub-metrics*** | ***Rationale*** |
|---|---|---|
| *(1) Sales volume and revenue* | • Total commission from biochar sales<br>• Number of units of biochar sold | These metrics will provide insight into the market demand and financial viability of Carbon Bridge. |
| *(2) Profit and profit margin* | • Number of renewals (subscribers) | Profitability is essential for long-term sustainability. The margin will reflect |

| | | |
|---|---|---|
| | • Number of paying customers<br>• Net profit earned | our operational efficiency and pricing strategy (considering industry norms). |
| *(3) Customer acquisition costs (CAC)* | • Average cost to acquire a new customer | Evaluating the effectiveness of marketing strategies hinges on a critical metric for Carbon Bridge, where the goal is to strike an optimal balance between efficient customer acquisition and the commitment to sustainable practices. |
| *(4)* End-user retention rate | • Percentage of returning end-users | For Carbon Bridge, it is important that high retention rates reflect end-user satisfaction, which are crucial for establishing a loyal customer base for biochar producers. |
| *(5) CO2 sequestration* | • Estimated amount of CO2 sequestered per unit of biochar | Central to our environmental mission, this metric quantifies the contribution businesses could have in applying biochar to combating climate change. |
| *(6) Market awareness and education* | • Reach and engagement metrics on educational content | Critical for increasing the understanding and adoption of biochar. Effective education and awareness campaigns can drive market growth. |
| *(7) Community engagement* | • Engagement level with customers, partners, and industry experts | A measure of our effectiveness in building relationships and collaborating with key stakeholders, which is vital for our growth and impact. |

**4.4 Exclusivity: value proposition**

Providing a unique value is a way of setting a particular business apart from all the existing ones. To identify the one of Carbon Bridge, the competitive landscape was mapped out and it

was looked at the features of competitors. Doing that, the team identified a chance to gain unique value by rearranging existing features and supplementing them with a new trait.

### 4.4.1 Is there anybody out there: competitive market analysis

As aforementioned Carbon Bridge stands distinguished in the market through its integration of three core pillars: education, impact assessment, and marketplace visibility. This tripartite approach not only addresses key pain points of our group but also establishes a robust value proposition and a distinctive competitive edge.

In our market analysis within the German target market, we've identified significant players operating across these three pillars. Predominantly, the competition operates primarily as research platforms and consulting firms with a focus on sustainability. However, a comparative overview reveals that none offer a comprehensive solution such as Carbon Bridge:

*Table 2: Carbon Bridge's competitive market analysis*

| | *Educational Purpose* | *Impact Assessment* | *Marketplace Visibility* | *Community* |
|---|---|---|---|---|
| *Biochar Zero* | ✓ | ✖ | ✓ | ✖ |
| *Carbonfuture* | ✖ | ✓ | ✖ | ✖ |
| *EBI Consortium* | ✓ | ✖ | ✖ | ✖ |
| *Carbuna* | ✓ | ✖ | ✓ | ✖ |
| *HempConnect* | ✓ | ✓ | ✖ | ✖ |
| *Klimafarmer* | ✖ | ✖ | ✓ | ✖ |
| ***Carbon Bridge*** | ✓ | ✓ | ✓ | ✓ |

In regards to the horizontal layer of Carbon Bridge's business model, the community aspect uniquely connects across various layers, offering a vertical coherence and a more holistic perspective on value creation. This distinct approach, not evident among competitors, ensures an integrated network of stakeholders and customer segments, fostering a collaborative and

sustainable business ecosystem. This strategic integration demonstrates that while there is competition, Carbon Bridge remains unmatched in offering a holistic solution. Interestingly, current market dynamics show a trend among biochar producers integrating educational aspects into their platforms, aiming to maximize revenue through increased market awareness. Despite this, within the scope of this research, such biochar producers are not considered competitors to Carbon Bridge.

### 4.4.2 Beyond the existing: unique value proposition

Most of Carbon Bridge's competitors follow an educational purpose. A few of them provide an impact assessment, and hardly any of them offer marketplace visibility enhancement. Unlike the competitors, the team sees something missing when there is only educational content, just an impact assessment or solely a marketplace. Such is the reason for the width of the solution, integrating education, impact assessment and marketplace. In that, Carbon Bridge differentiates itself from competition. But the real uniqueness comes from depth. Community is at the core of each of the three features. Climate change mitigation in terms of carbon sequestration is unlike many other transactions. It does not resemble the typical purchase of a good for consumption, it is rather about realizing the consequences of our actions and understanding the bigger picture. Storing carbon through the acquisition of biochar is not an independent process concerning solely the individual, it is by its nature systemic. The effects of less atmospheric carbon have global significance to everybody. Hence, community is a natural trait of carbon sequestration. The unique value of Carbon Bridge is in amplifying this trait within each of the products' features through a relentless focus on a shared community.

Achieving this depth of community in every part of the product has a very tangible impact. It means a higher retention rate for buyers of biochar. Feeling as part of a community and actively engaging with the platform leads to two outcomes. It has positive effects on recurring sales of existing buyers, and it triggers word of mouth, the foundation for new buyers in the future.

### 4.5 What's different: unfair advantages

An unfair advantage allows a business to outcompete other companies providing a similar product or service. The advantage is rooted in a source that is not easily replicable for competitors, leading it to be unfair. For Carbon Bridge, the unfair advantages can be categorized in initial, first phase advantages and the following, second phase advantages.

#### 4.5.1 Phase 1: ecosystem, costs, and size

Carbon Bridge possesses something very few companies share: having a well-known business school on their side. This advantage unfolds in two ways, internally and externally. From an internal perspective, the ecosystem of Nova SBE (School of Business and Economics) provides a pool of great resources for aspiring entrepreneurs. It starts with mentoring, having access to the expertise of professors, grounded in the first-hand experiences of founding a company themselves. Such is a highly beneficial source of value when it comes to receiving feedback and learning from real-world examples. Secondly, there are many departments who can aid in both dealing with questions and establishing contacts with outsiders. A special remark can be made here for Nova SBE's Haddad Entrepreneurship Institute and the Corporate Relations Department. These are valuable addresses for connecting both with people and companies. Externally, Nova SBE allows for signaling. Putting it as a reference for establishing contact with the many European biochar producers, mentioning the name provided additional credibility for the project. Furthermore, it helped in telling the story of how this idea was developed throughout the master's program and why it was chosen to leverage it by making it the master's thesis.

The second pillar for initial advantages is low costs. Carbon Bridge is tailored to a resource-constrained environment. Especially due to the team's boundaries in time and financial capacity, which will be deeply explored in chapter 5 the team looked for ways to deliver the solution with the highest leverage on resources. The result was the platform covering education,

impact assessment and marketplace. Competitors offering marketplace solutions usually handle the biochar transactions themselves, leading to higher margins. Carbon Bridge deliberately decided against processing the physical transactions as it would have led to become considerably more capital-intensive. The chosen approach allows for a maximum leverage when it comes to sales, while keeping costs at a low level. Doing that, the service can be provided at a much smaller price.

The association with the team's university and the minor resource commitment translates into the third initial advantage: small size. While it is large size that is commonly referred to as an unfair advantage as it leads to increased market power, the group sees a clear benefit in the initial small size. Reason for that are the characteristics of the current biochar market. Within a market that is in the process of establishing itself, large size can lead to a huge bet on the wrong path. Being small allows for easier tinkering and adaptation to structural changes. In addition, there is a second part of the small size advantage. Carbon Bridge is hardly known to its competitors. Such is especially beneficial as the long-term unfair capability can grow particularly well through that.

### 4.5.2 Phase 2: network effects

Building a community takes time. There needs to be agreement on a foundational idea everybody shares. Trust must be established, and relationships formed. Organic growth of such does not happen overnight. Such is the reason why the build-up of the project's unique value proposition takes time. But it is this steady enlargement of a sustainable customer base that makes the difference. Starting in a realm largely unnoticed by competition, the team can rely on the factors that grant an unfair advantage in the first place. Simultaneously, it is the chance to experiment on a small-scale with different ways of creating a community. Based on these learnings, Carbon Bridge can aim for network effects in the second phase. The term network effects refers to a situation in which the value of a product or service depends on the number

of users (Stobierski, 2020). For customers of Carbon Bridge, having a larger community means a larger pool of potential buyers of biochar. In that, it leads to an increased willingness to pay for the solution. Having an organically grown community is difficult to replicate, even more so if switching costs prevent people from changing product. Establishing Carbon Bridge as the go-to solution for the industry in the long-run is a path that begins with the first satisfied customers. The way in which the team aims to acquire them is described in the following chapter.

### 4.6 Strategic selling: channels

As Carbon Bridge transitions from its nascent stage to the launch of the MVP and beyond, it becomes essential to consider the role of channels in our sales strategy. In the business context, a 'channel' as defined by (Dent, 2015) serves as a route to market for a supplier. While sometimes the term is used to refer only to the indirect or trade channels, it more accurately encompasses any specific route to market, including direct channels. This comprehensive understanding of channels is fundamental to the development of Carbon Bridge's strategy, as it shows the different ways we use to reach and serve our customers effectively. Therefore, we will delve into our methods for acquiring customers and driving traffic to our website, a critical aspect of our platform's attractiveness. An in-depth analysis of channels will be conducted in the individual part on impact: elevating customer success.

In the short term, our sales strategy is focused on presenting the comprehensive benefits of our platform to potential biochar producers. Therefore, engaging in one-on-one selling, on a direct, personalized approach where we actively demonstrate how subscribing to our platform can improve their market profile. This strategy includes emphasizing the multifaceted benefits of increased market awareness for biochar enabled by our platform and the unique value of our impact assessment tool to encourage potential customers to buy biochar, creating a compelling case for producers to join our platform. Driven by our belief in the growing value of our

platform, we will provide free trials to our first customers. This approach, based on research, has proven to be effective in converting trial users into engaged subscribers (Templeman, 2016). Furthermore, in order to gain traction to our website and prove our value to our main stakeholders, we will be engaging with influencers in the biochar community, who have been using YouTube and other forms of social media platforms to spread knowledge and insights about the benefits and applications of biochar. Acknowledging the 'chicken-and-egg' dilemma, which refers to the challenges of attracting both sellers and buyers to a platform, our approach addresses the interdependency between biochar producers and potential customers on our multi-sided platform. This collaboration will enable us to leverage their established audiences and credibility, thereby effectively amplifying our message and facilitating the achievement of a critical user mass essential for sustaining positive network externalities and further growth (Stummer, Kundisch, & Decker, 2018).

In the medium term, as our brand gains recognition, our strategy will focus on leveraging our established digital presence and working with Search Engine Optimization (SEO) to enhance our online visibility, attract a wider audience, and drive more organic traffic to our platform. Additionally, by implementing robust client management practices, we aim to not only retain existing customers but also to deepen their engagement with our platform. We plan to achieve this through a dynamic cycle of continuous improvement and adaptation, incorporating feedback to refine our offerings. Furthermore, Carbon Bridge will regularly update our community with the latest advancements in biochar through newsletters and blog posts. This strategy not only informs potential biochar purchasers but also supports our ambition to become a leading knowledge resource for biochar producers, thereby enriching our value proposition for all stakeholders.

In the long term, given the still niche nature of the biochar market, we anticipate that word-of-mouth referrals, fueled by our subscribers' positive experiences, will significantly contribute to our growth and market penetration.

Long sales cycles are a reality in the business-to-business (B2B) industry (Jones, 2023), and our strategies need to account for the costs and efforts involved in managing these cycles, as potential customers who do not immediately convert into sales.

Furthermore, it is important to point that this strategy is not static, it is expected to evolve as we move from the initial stage to a full-fledged market presence. Continuous learning, adapting to market feedback, and refining our strategies will be key components of our journey.

### 4.7 The market and its people: customer segments and market analysis

Carbon Bridge is a two-sided platform, with its success hinging on the participation of both groups. The following explains first who these two groups are, and which end users result thereof. Consequently, the market size for the initial beachhead market is being calculated.

#### 4.7.1 Of customers and visitors: market segmentation and end users

Increasing the awareness for biochar is an objective that is beneficial for many different stakeholders. It was a process to find the right target customer for the solution and its associated second group. The array of 12 different options that was identified can be traced in Appendix 4. The process was concluded by deciding on biochar producers in the German market as paying customers. The decision to target German biochar producers is based on a dual rationale that encompasses both empirical and strategic dimensions. Empirically, the extensive outreach initiatives have shown that this group demonstrated the highest level of engagement, evident in their willingness to attend meetings and contributions to market understanding. Strategically, this decision is in line with Germany's prominence as the leading producer, representing approximately 32% (Appendix 5) of the total European biochar production capacity (EBI, 2023). This leadership position not only implies a denser cluster of potential customers, but

also indicates a more mature market landscape conducive to deeper business penetration and the potential for accelerated growth.

The functioning of the business relies on having a second group participate. The Carbon Bridge platform aims to attract people who could benefit from using biochar (from here on referred to as end buyers). They are provided with education on the product and their personal advantages in applying it. Consequently, the platform allows them to connect with sellers of biochar. The decision on who should be initial target in that regard was a direct consequence of the paying customer that was chosen. From the conducted interviews, the team has been able to identify that the most common customers from biochar producers are from following industries: cement production, feedstock processing, wastewater treatment and agriculture. However, due to the range of diversity, it was decided that for the MVP the focus will be on individual farmers and agriculture companies.

Breaking it down to the individual level, there are three different end users on the platform. On sides of the paying customer, it is the biochar facilities' product manager. For the end buyers, it is two primary user groups: individual farmers and purchasing managers of agriculture companies. Product managers initially use the platform to set up the presence of their respective brand. From there on, the community functions lead to a continuous engagement. Both sets of action are directed towards the goal of increasing biochar sales for the company. The decision-making unit comprising the individuals who effect the buying decision can be separated in champion, primary economic buyer, and veto power holder (Aulet, 2013). Both the champion, as the one who wants to have the product, and the primary economic buyer, as the one who can buy it, are represented by the product manager. A veto can be put in force through the action of the company's CEO (Chief Executive Officer). End buyers leverage the platform through learning more about biochar, the benefits obtainable through applying it, and at which localities to buy the product. For individual farmers, end user and decision-making unit overlap

completely. It is in every case the individual who benefits from applying biochar to the soil to improve its conditions. While there are initially no costs for platform participation on the buyer-side, the decision-making unit will become relevant as soon as new revenue streams are put into place. Purchasing managers of agriculture companies can be considered both end user and primary economic buyer in terms of the decision-making unit. The champion can be identified as the company's sustainability officer, who aims to enhance the environmental impact through carbon sequestration. Finally, a veto can be exercised by the director of the purchasing department.

Since it is the biochar producers who are paying for the product, the team directed its further efforts in understanding the paying customer towards them. Based on the conducted interviews, a persona profile was created: Dr. Martin Becker (appendix 6). An experienced environmental chemist with over two decades in the field, Dr. Martin Becker has continuously evolved alongside the industry, shaping his vision for GreenChar Solutions around innovative, market-driven applications of biochar. His professional commitment is evident in his focused approach, which includes expanding market reach, influencing policy for more favorable conditions for biochar production, and relentlessly advocating for collaboration with industry to overcome market and regulatory challenges. This combination of experience and dedication makes Dr Becker's profile, effectively synthesizing the collective insights of industry experts into a single, actionable character. His aim is set up the presence of the respective brand on the Carbon Bridge website. From there on, the community elements lead him to active participation with the objective of enhancing biochar sales for his company.

### 4.7.2 Opportunity quantification: market size

To achieve a balanced estimation of total addressable market (TAM) that is both conservative and reflective of realistic market potentials, Carbon Bridge adopted a comprehensive approach,

integrating both bottom-up and top-down analyses. In this two-sided marketplace, only one side is paying for the product, therefore, the TAM is based on the revenue generating side.

**Bottom-up analysis: counting noses**

The bottom-up analysis begins by identifying the number of biochar facilities in Germany, which, in turn, informs about the number of potential paying customers, represented through product managers. Through the comprehensive research efforts, aimed at establishing a robust database for outreach initiatives, the team successfully identified 16 biochar production facilities in Germany among the 58 potential (appendix 7) contacts.

**Top-down analysis: market overview**

To complement the bottom-up analysis, the group looked at the overall growth and trends in the European biochar market. With an estimated 180 production plants at the end of 2023, cumulative production is projected to exceed 50,000 tons (EBI, 2023). Germany's leading position in the European biochar market translates into a substantial presence of biochar-producing companies, with expectations of around 58 plants being operational by the end of 2023. The average price of biochar at €800 per ton serves as a crucial data point in understanding the revenue streams of these facilities. Based on these figures and assuming each facility in Germany sells their products at the market rate, therefore, generates a combined annual revenue of €15,232,000. For a deeper understanding of this calculation, as a productivity factor and other measurements have been taken into consideration, please refer to appendix 8. Through applying a baseline monthly subscription fee of €89 per customer combined with a commission fee for the provided services to the amount of 7.5% of revenues, the TAM for the initial market stands at an estimated €1,203,000. While this figure seems small compared to market sizes of many other industries, it is important to remark that the European market for biochar is currently in establishment. The expected three-year compounded annual growth rate of 68% between 2020 and 2023 is one indicator thereof (EBI, 2023). As certification of biochar

is becoming more and more relevant, the website will only offer visibility to certified biochar. According to the study conduced by (EBI, 2023), from the total production capacity available by end of 2023, almost 70% is product certified. Therefore, the serviceable available market (SAM) is calculated at €842,100. Going back to the bottom-up analysis, assuming to obtain the 16 out of the 58 biochar producers, the serviceable obtainable market (SOM) is €235,788.

*Table 3: German biochar market (TAM, SAM, SOM)*

| | |
|---|---|
| *Number of biochar production facilities (2023)** | 58 |
| *Expected total production capacity** | 28,800 t |
| *Average price per ton of biochar** | 800 €/t |
| *Commission fee* | 7.5% |
| *Subscription fee (12 x €89)* | €1,068 |
| ***TAM (EUR/year)**** | **€1,203,000** |
| *Product certified*** | 70% |
| ***SAM (EUR/year)**** | **€842,100** |
| Number of serviced biochar production facilities | 16 |
| ***SOM (EUR/year)**** | **€235,788** |

*based on assumptions & primary research **factual data from EBI Market Report

It is imperative to note that these calculations are based on current market dynamics and projections, and should be periodically revisited and adjusted in accordance with evolving market conditions and emerging data.

### 4.8 Outflows: cost structure

Given that Carbon Bridge operates a two-sided platform, where biochar producers are the paying customers and a diverse user base forms the marketing audience, this dual dynamic is crucial to comprehend. It significantly impacts our company's profitability and long-term viability, influencing our strategic approach and the CAC calculations.

In the first year following the MVP launch of Carbon Bridge, we anticipate a significant initial investment in in brand building and market penetration. As aforementioned in previous chapter, will prioritize one-on-one selling to biochar producers, a strategy suited to the niche nature of

the market and tailored to meet the specific needs of these producers. While this personalized approach is expected to yield higher conversion rates, it will also lead to higher acquisition costs. Simultaneously, we will implement broader marketing strategies targeting potential users of biochar, focusing on educational content and awareness campaigns about biochar's benefits. This dual strategy of direct selling to producers and widespread marketing to users is anticipated to drive modest customer acquisitions for both segments, leading to a higher cost structure in the first year. This significant initial investment in sales and marketing is essential for establishing a solid foundation for Carbon Bridge, ensuring clear understanding and appreciation of our platform among both biochar producers and users. A detailed analysis of these upcoming strategies will be included in the section on elevating customer success.

Consequently, our fixed costs to date have amounted to €20,98 and have primarily covered IT infrastructure expenses such as monthly website maintenance, accounting for €15,99 and a yearly domain registration of €4,99. Additionally, the company has benefited from significant cost savings by not incurring expenses for salaries and office space at this stage. Variable costs include travel expenses, which were essential for visiting biochar producer sites and gaining first-hand knowledge of their activities. Thus far, our total expenditure has reached € 171,60.

### 4.8.1 How much is it: product pricing strategy

A firms' profitability is highly sensitive to the prices set for their offerings. Hinterhuber & Bertini (2011) showed that a 2% increase of prices for a subset of S&P500 (Standard & Poor's 500) companies enhances operating profitability by 14%. The pricing strategies companies might apply can be divided into three different types: cost-based, competition-based, and value-based. In agreeing on the right strategy for the services offered by Carbon Bridge, the founders evaluated market conditions, competition, and the unique setting of the company.

Carbon Bridge operates in the B2B segment. In that, the number of potential customers is commonly more limited compared to services offered in a business-to-consumer (B2C) market.

While there are high growth rates for the number of biochar production plants in Germany, with an expected increase of 16 production sites from 2022 to 2023, the market in general is currently in development (EBI, 2023). As participants need to adjust for increasing competition, the landscape of it might change substantially.

To establish a benchmark for potential prices, the strategies of competitors can allow for valuable clues. Online retailers offering marketplace solutions typically apply commission fees based on revenues. The fees charged commonly account for up to 20% of revenues (Engine Themes, 2017). Providers of impact assessments typically allow for service packages dependent on the customer's need. Given this tailored approach, their pricing is calculated through a demand-based method. While other competitors offer educational content through their website, information is freely available. Hence, the content is not used as a base for a recurring revenue stream.

A third consideration should be performed in relation to the status quo of Carbon Bridge. The value of the service provided depends on platform traffic, being converted into buyers of biochar. Due to the recency of the platform, this customer base needs to be established first. In addition, it is important to note that the number of monthly platform visitors will vary, leading to potential seasonal effects. Therefore, given the nature of the business, large upfront payments are not feasible.

Considering this information, the team decided to emphasize a value-based pricing strategy, accounting for the volatility associated with website traffic. The trade-off between establishing a sustainable revenue stream and lowering barriers for potential customers by offering a no-cure-no-fee pricing model led to a two-fold strategy. To participate on the platform, biochar producers must pay a monthly subscription fee of €89. The price, which is discounted initially to attract test users, is set low enough to mirror the expected willingness-to-pay. Simultaneously, it is high enough to associate value with the provided services. The

subscription fee is complemented by a revenue commission fee. This fee is established at 7.5%, with initial discounts for test users. Having this performance-based component makes it possible to enhance trust in Carbon Bridge as costs only occur with successful sales obtained. Combining the two, the pricing strategy allows for a reliable revenue stream in terms of subscriptions, while commission fees based on transactions complement the former.

### 4.9 Inflows: revenue streams

Carbon Bridge as a platform solution relies exclusively on its online presence and the leverage in sales it offers to customers. As indicated in the preceding chapter on pricing, there are two revenue streams: subscription fees and revenue commission fees.

#### 4.9.1 Stream 1: subscription fees

Every biochar producer wanting to be listed on the Carbon Bridge marketplace must pay a monthly subscription fee of €89. An ongoing subscription in combination with a pricing that displays value is estimated to have positive effects on customer engagement levels. As the platform is centered around community, it is critical that customers feel they have an active role in the process, something a monthly financial commitment further emphasizes. Moreover, subscription fees are a predictable revenue stream for Carbon Bridge. That is especially important in the beginning as costs to attract buyers are immediately incurred while the occurrence of first sales is expected to take more time. The financial significance of subscriptions will decline over time as the second revenue stream becomes more prominent.

#### 4.9.2 Stream 2: revenue commission fees

While subscription is the foundation, commission is the extension. This performance-related pricing of 7.5% of revenues allows customers to protect their downside, which is an important argument to attract early adopters. Furthermore, the scheme makes it possible for Carbon Bridge to benefit from the mediated sales. While this revenue stream is more volatile in the beginning, an established community base and insights into the consumption patterns of the

members will smooth out the achieved earnings. Commission fees will become the major source of revenues as the sales per customer increase over time.

## 5 Reflections: learnings and limitations

As Carbon Bridge was the first entrepreneurial endeavor for the entire team the journey consisted of several pivots and many learnings. The team reflected and concluded that the knowledge and experience gained in the field of entrepreneurship makes the project on a personal level successful. The theory of the master's program was complemented with the practical experience of the beginning of founding a business. From a business perspective the founders acknowledge the current limitations when it comes to approval. A successful broad external validation which includes signed Letters of Intent indicates that the team is on the right track. Yet, as sales determine if a business can be sustained, the ultimate judgement on the business' success can only be determined in the future due to the limited time available for successful implementation.

In the following table each team member reflected on their three most impactful learnings along the journey.

*Table 4: Key learnings of each team member*

| **Sara Serra Siebels** |
|---|
| 1) Although cold email campaigns are often time-consuming and initially yield few responses, persistence is key. As we found out even a small number of engaged participants can open doors to significant opportunities. This emphasizes the importance of perseverance in building a network of interested and valuable contacts. |
| 2) Starting interviews by seeking to understand the interviewees' needs was an effective way to engage them. Prioritizing active listening over direct selling, fostered a more open dialogue, capturing their interest and setting a collaborative tone for the interaction. |
| 3) Constantly adapting to feedback, making a product tailored to the needs of the customers is more demanding than expected. During our journey we had to learn that not everyone can be pleased. |
| **Sebastian Immervoll** |

| |
|---|
| 1) Act and wait for the response. We often get caught up in preconceptions, limiting ourselves without putting these assumptions for a test. Overcoming this initial barrier by putting ideas just into practice allows for a great insight: that there is a lot of things possible. |
| 2) It is neither as good nor as bad. There are days where you do not get as far as you wish, you experience several obstacles, and it feels like it cannot be done. On the next day, everything works out, progress is way better than expected and it feels like it must stay this way. Both is temporary, so focus on the process. |
| 3) Things take longer than expected. It is important to account for that and to make good use of your time when you feel most productive. Personal note: I thought I would have written this paragraph here earlier… |
| **Katharina Brunner** |
| 1) Don't be afraid of doing something you never did before. Everything will be new especially using code was a novel task for the team but one cannot give up before trying it. Learning new skills and being overwhelmed is part of the journey. |
| 2) Talking to people was crucial for us. A lot of insights were gathered especially as it is such a young and unexplored market. You will only really know what the pain points are if you talk to the ones affected. |
| 3) The entrepreneurial journey won't be linear or easy. Especially setting up a business with impact is more complex. Finding a working business model which aims to solve a societal/environmental is an immense challenge but still worthwhile and rewarding to pursue. |

**6 Horizons: Carbon Bridge's future**

In writings these lines, it is less than a month until the defense of this project is to happen. The four weeks in between will be used to sort certain things out, enhance the perspective on the overall progress by raising the gaze from details and devote time to the development of the product. The defense as a next landmark in the entrepreneurial path is going to be leveraged for insights of people that allow for learnings from an outside perspective. It is then that the team will come together to assemble all the key pieces collected while working on this project of Carbon Bridge to decide on how to shape its future. Having this well-functioning team with

shared perspectives and complementary skills, an advancing knowledge of the segment, the established network of producers interested in the product, and environmental issues that scream for change, the stage is set. It was the realization that as soon as paying customers are listed on the platform, it means one is bound for the ride. With clear excitement for this ride, the team wanted to be sure of the actions it took. Therefore, the decision on which step to take next is going to be settled deliberately at the start of the year. The team is looking forward to it.

## Part II: individual work

## 7 Value chain: finding the right spot

In the process of establishing this project, several constraints were to be faced. Capital-wise, in terms of time and in relation to know-how. When it comes to Carbon Bridge, it was critical for the team to make the most out of existing resources. Therefore, decisions had to be taken on what to target and how to leverage the teams' focus in the best way possible. The subchapters presented here are important to understand why certain choices were made and how they allowed creating a product that adds value for the customers of Carbon Bridge. While chapter 3 describes what path led towards the final product, the following pages explain why this place was reached and what sets it apart from all previous iterations.

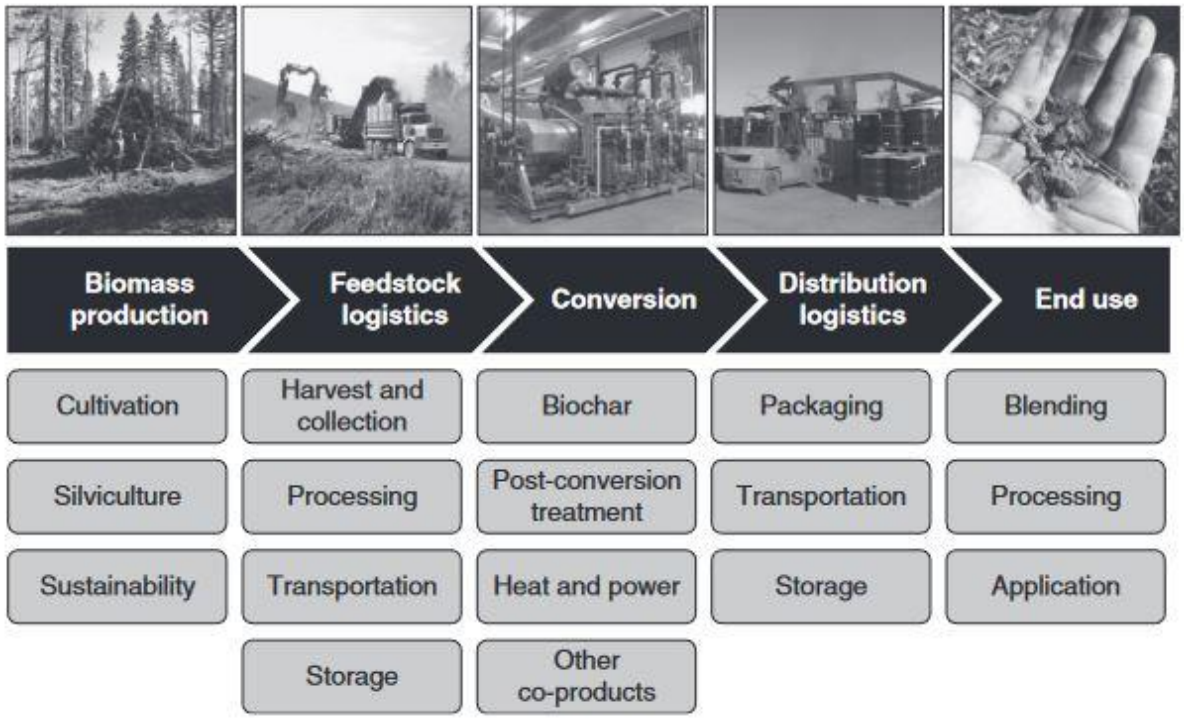
The chapter **7.1 The chain and its part: identifying a niche** begins by providing a context on the value chain of biochar. Through looking carefully at each step of this sequence, valuable matches between requirements and capabilities are identified. This leads in turn to the explanation of how an ideal spot within the value chain was found. Consequently, a reflection on how this position differentiates beneficially compared to initial ideas is carried out. Narrowing down on the large picture, **7.2 The part and its activities: determining key value-adding tasks** dives into the company's very own value chain. It emphasizes the set of actions that are required for Carbon Bridge to provide value to its customers. Drawing on links from **4 Structure: leveraging the Lean Business Model Canvas** it allows to form a clearer understanding by bringing together the relevant parts. Additionally, it sets the foundation for the discussion of chapter 6 Product development. Given the established awareness for the necessary activities to allow for the projects' success **7.3 The activities and its resources: allocation of (in)tangibles** draws on these insights to create productive choices. Both financially as well as on a non-financial basis, the chapter explores how different objectives

and associated tasks were considered and prioritized. In addition to that, it is analyzed how the commitment of resources helps Carbon Bridge to foster its position within the value chain.

### 7.1 The chain and its part: identifying a niche

Looking at a small, black piece of biochar, it seems like a simple product. But behind this carbon-rich output a customer may apply to the soil, there is an array of operations taking place. The supply chain of biochar, which acts as the foundation for the value to be added for the customer, consists of five major steps (Anderson et al., 2016). A visual representation can be found in figure 9. It all begins with the production of biomass. Depending on the input material, the biomass here referred to might be trees or food crops in agriculture. The second step within the process is defined by feedstock logistics. These range from initial harvesting and purification to storage and eventual transportation of the biomass. Consequently, the conversion from input material to biochar is taking place. Besides biochar, heat, power, and physical by-products are the results of the production process. Included within this step is additionally the post-conversion treatment of the product. To leave the production site, the fourth pillar within the supply chain consists of distribution logistics. Packaging, storage, and transportation to the final customer are elements thereof. The last of the five components is the application of biochar. Through processing and blending with other materials, the product that started with the production of biomass eventually allows for usage.

*Figure 9: The supply chain of biochar (Anderson et al., 2016)*




This supply chain consists of a multitude of stakeholders, with several potential contributors of value. In respect to the starting point of the supply chain, biomass production, the source for biomass might be a public forest governed by a local authority. A private company could be involved in collecting the forests' residual logs and transporting them to the production plant of the biochar company as part of the feedstock logistics. After the conversion process from initial feedstock to biochar took place in step three, the producer might handle the transportation of the final product through contracting an external delivery service for distribution logistics. At the end of the supply chain, the customer receives the biochar ready for potential blending and its eventual application.

The first source of value is to be found in the characteristics of the biomass. Depending on its type and features, various sorts of biochar are obtainable (Chen, et al., 2017). Input providers can influence the value for the end customer by putting procedures into place that safeguard quality standards. In terms of tree logs as feedstock material, silviculture as the management of forest composition and growth is an example thereof. Companies responsible for harvesting

can add value by screening the biomass and collecting only the material that is sufficient for pre-defined standards of the producer. Such is especially critical as differences in input quality lead to variations in features of the final product. In consequence of the production method, biochar facilities transform biomass into a product with increased value: biochar. It differentiates itself from the preliminary input in terms of its capability for long-term carbon sequestration and the customer-related benefits ranging from increased water retention in agricultural settings to insulation advantages in the construction industry. At the end of the value chain, the step of distribution logistics adds value through potential packaging innovation and customer-centric delivery terms.

At the beginning of this piece of work, chapter 3 thoroughly discusses the pivots that were taken while this project progressed. The ideas at different points in time targeted several parts of the value chain. From contributing value by establishing a new input material to handling distribution or allowing for fine-tuning of the biochar's characteristics through a software model, a multitude of options was considered. The product concepts changed radically over time due to the learnings gathered by talking to industry experts. The common characteristic of all former cycles and ideas was their capital-intensity. An examination of the value chain shows the large requirements for investment when it comes to the individual parts. From availability of land for biomass production, the operation of harvesting machinery and production plants for biochar transformation to the ownerships of transportation means, all these steps ask for large financial commitments. Given the severely restricted resources, the team concluded that capital-intensive parts of the value chain were out of reach for now. Instead of uncompromisingly trying to overcome this barrier, the group decided to walk past it by contemplating possibilities of providing a service in an asset-light manner.

Besides these reflections on the financial standpoint, the second consideration the team took in terms of locating the business idea within the value chain of biochar was know-how. None of

the founders has a background in environmental sciences, nor is there a shared extensive history in biochar. The groups' first touchpoint with the topic was the result of Katharina's previous experience in climate-tech. Building on that, a foundational understanding for biochar was established. The characteristics were studied, potential benefits analyzed, and the market environment evaluated. Such was achieved for once by reading research papers and online publications. Complementing these efforts, all the hours spent in meetings with biochar producers, farmers and recycling companies substantially helped in getting a clearer picture of the subject. Nevertheless, the people behind this project are students in Impact Entrepreneurship and Innovation. As those, their core capabilities are rooted in business. This fact was always highlighted, arguing for the benefits of a closely linked cooperation between environmental sciences and business, where the combination of both leads to enhanced results.

*Table 5: Estimated factors of production and know-how requirements in the value chain of biochar*

| | *Biomass Production* | *Feedstock Logistics* | *Conversion* | *Marketing* | *Distribution Logistics* |
|---|---|---|---|---|---|
| *Capital Requirements* | High | Medium | High | Low | Medium |
| *Labor Requirements* | Low | Medium | High | Low | Medium |
| *Land Requirements* | High | Low | Medium | Low | Low |
| *Know-How Requirements* | Agriculture | Agriculture/ Business/ Logistics | Agriculture/ Engineering/ Business | Agriculture/ Business | Business/ Logistics |

Throughout the series of calls with various representatives of biochar companies, both their requirements and the team's potential paths in tackling them became clearer. The most emphasized issue of biochar producers has always been the lack of awareness for their product. Combining information on the value chain with the pain points of biochar producers and the

availability of resources, a decision on the way forward could be made. It was therefore decided that the project's angle will be at the intersection of conversion and distribution logistics, namely in marketing. Table 5 shows an extended picture of the value chain depicted in figure 9, incorporating the value contribution of marketing initiatives. For reasons of clarity, end use is being excluded. The table displays estimates on the requirements of factors of production in relation to each other. In addition, it shows the know-how that is most important to each of the steps. Biomass production and conversion have a high demand for capital, with logistics for both feedstock and distribution estimated at a medium requirement. Labor need is the highest for conversion, followed by a medium classification for both logistics types. Biomass production is estimated to have a low necessity for labor. When it comes to land, biomass production is the most demanding. It is next to conversion with an expected medium level of need for land. Compared to that, feedstock logistics and distribution logistics pose the smallest requirements for land. Adding know-how to the factors of production, the two most prominent themes are agriculture and business. The beginning of the value chain is characterized by the emphasis on agriculture-based knowledge, while progressing through the chain leads to an increased focus on the business part.

Finally considering marketing, it becomes evident that the requirements in terms of factors of production are low compared to all other value-adding activities within the value chain. Tailored online marketing strategies can be asset-light when carefully conducted. There is only a minor need for labor when it comes to marketing initiatives. In addition, the requirements for land are almost non-existent. Referring to know-how, the emphasis is on the business side of the endeavor, supplemented with a basic understanding of the underlying topic of agriculture. All these elements are in favor for the positioning of Carbon Bridge. It is tailored to the most articulated pain point in terms of biochar producers. It is in the realm of the team's studies and

backgrounds. And it is aligned with the requirements of resources given the constraints faced here.

Finding a niche within the value chain, it consequently had to be reflected on how to deliver the marketing to increase the sales of biochar producers. Would it be through the emphasize on proof of concept by testimonials, spreading awareness by creating a petition, starting a social movement, visualizing the products' impact, or placing bags of biochar in high-frequented public spaces? While several options seemed both interesting and capable of sparking interest for biochar, it was critical to create something that allowed for a lasting impression, translating into an ongoing business. It was therefore decided to build a platform solution incorporating elements of initial ideas while establishing sustainable revenue streams. For a detailed understanding, chapter 6 explores the solution in-depth.

Having a product deeply rooted in the most critical pain point of customers made the team confident in the placement of Carbon Bridge as a marketing company for a commodity that drives the transition of companies to sustainability. In accepting resource-driven and know-how-based restrictions, the team could enhance their focus on what they can do best.

### 7.2 The part and its activities: determining key value-adding tasks

Carbon Bridge aims at increasing the revenues of biochar producers on a sustainable basis. For this goal to materialize, several activities must be in place. The number of actions required to provide value for customers can be structured as four different categories: platform, content, marketing, and community. In the following, each of the activities will be explored in detail to identify where, at which time and how much effort needs to be put, ensuring a successful delivery of value.

The foundation for everything else is the setup of a website. It was started by choosing a website builder aligned to the project's needs, establishing a first layout. In parallel, the domain www.carbonbridge.eu was created. Given the three-fold concept of educational area, impact

assessment and marketplace, the website had to be structured accordingly. The team used pre-existing elements to put these ideas into practice. For the educational part, a common area for blog posts with informational content was created. In terms of the impact assessment, an interface allowing visitors to give input, resulting in the generation of an output file, was designed. For the third pillar, a common marketplace structure was established. Here, various offers for biochar can be displayed, the different characteristics of products compared, and finally the product bought through the customer's website. This set of features acts as the overall structure. For those features to become valuable, it is necessary to complement them with content, which leads us to the second pillar of activities.

To comply with the logical order of education, impact assessment and marketplace, the first area where content is required is the blog. With its emphasis on objective information, writing the relevant posts will be based on existing research. Furthermore, there will be research publications featured for additional in-depth knowledge. Building on that, stories of people who already apply biochar will be displayed. For the regular creation of content, there will be continuous observing of advancing research in the segment of biochar to provide platform visitors with state-of-the-art insights. In addition, there will also be a continuous look-out for early adopters of biochar to gather their perspectives and incorporate them through blog posts. The impact assessment on the other hand is less dynamic. Grounded in existing research, its metrics allow visitors to determine the effects of biochar application for them. Since its value is derived from the foundational objectiveness of research and the reliance on consistency, the content is expected to change solely for two reasons. Either there is value in establishing additional metrics for visitors to better understand the impact of biochar, or underlying research becomes rejected. It is therefore that the team will monitor upcoming research not just for creating new educational content, but additionally to ensure that the provided impact assessment is up to date.

The dynamic third part of the platform is the marketplace. While its basic promise of allowing visitors to find the biochar they need will remain, there will be continuous updates on both existing offers and the displaying of new customers' products. If there are any changes in the underlying products of customers, they will be immediately incorporated. Such include for instance new prices or the existence of special offers.

Having both a structure in place and this frame filled with valuable content, the third pillar is about getting people onto the website. As the platform acts as a two-sided market with sellers of biochar and its potential buyers, there is the need to attract both parties. Here, the activities differentiate between the two groups. Biochar producers are fewer in numbers, it is easier to localize them and therefore, targeted strategies relying on direct marketing are more effective. The buy-side is a more diverse group. While united through the same application of biochar to the soil, they differ in their backgrounds. In consequence, marketing strategies here need to be adapted to the circumstances of each of the end user groups. A detailed discussion of the proper measurements related to marketing and sales can be found in the **chapter Impact: elevating customer success (Sara Serra Siebels).** The three-step sequence of educational content, impact assessment and marketplace is the horizontal explanation of the product. It raises awareness for biochar on a general level first, follows by clarifying the benefits of its application on an individual basis and ends by offering places to buy the product. The vertical aspect to it, which is the fourth type of activities necessary to provide value to the customers of Carbon Bridge, is community. Given the unique value proposition established in **4.4.2 Beyond the existing: unique value proposition**, the focus on community within each of the three steps is the direct consequence. After an indication of how to attract both customers and visitors to the platform, it is important to discuss how to retain the latter. If this is achieved, it acts simultaneously as the reason for customers to continue using the service given the pool of potential buyers of biochar. As the platform acts as a place of continuous engagement rather

than a one-time transaction, every feature is assembled with this goal in mind. When it comes to the first pillar of educational content, emphasis is placed on the creation of similarities. Visitors ought to immediately see the connection between the content and their individual circumstances. Such is achieved by focusing the content creation on common threads and through providing success stories of others already using biochar. In that, the materials offered are always written in a user centric way. The impact assessment as second part of the sequence is already leading to engagement through the allowance of user input. These levels are further increased by putting the individual contribution into perspective. Such can be achieved through providing a comparison to the output of other platform visitors. Here, the use of visualizations in terms of regional impact maps and the display of the visitor's contribution to net zero are intended. Each of these activities aids in creating a sense of community. The marketplace is consequently aimed to be more than just a necessary intermediary between supply and demand. Leveraging the personal component, it allows for relationships between people having biochar and others looking for it instead of transactions between companies. That is achieved by providing individual descriptions for each of the producers listed on the platform. Furthermore, pictures are utilized for visitors to have something to relate to.

Together all the activities from starting the platform and creating its features to putting user-targeted content and attracting biochar producers and potential buyers at the same time are necessary to deliver on what Carbon Bridge aims for: increasing revenues for biochar producers.

### 7.3 The activities and its resources: allocation of (in)tangibles

Acting within an environment of limited time, capital, and know-how, it is important to decide on the most productive uses of these resources. When it comes to the activities required to provide value for the customers of Carbon Bridge, every step seems reasonable to allow for commitments. But not all of them need equal resources, nor do they immediately.

Briefly referred to before, marketing within this area requires both business elements and a foundation in environmental sciences. In that, the members of the group considered the option to get someone with domain-specific knowledge in biochar for the team. Here, the group talked to Nova SBE's Haddad Entrepreneurship Institute, where they emphasized their readiness to establish connections with potential candidates in the environmental sciences departments of the university. While possibly gaining an important edge when it comes to information, this option was kept open for later stages as the team first wanted to be clear about the exact requirements for the product. Since it proved to be sufficient to meet with representatives of biochar companies to receive answers to important emerging questions, the team decided to reconsider this question after quantifying the acceptance of the prototype.

With the distinguished features of the product surfacing through the set of calls with biochar producers, product development considerations became prominent. The platform approach made it necessary to create a website offering the three-step approach of education, impact assessment and marketplace the team had envisioned. Anticipating that earlier in the process, a preliminary connection to 42 Lisboa, a programming school in Lisbon, was established. As the platform should be tested through a prototype, the team decided to create it themselves. Since functionality could be limited for presenting the concept, the usage of a website builder for this very first version of the product was sufficient. Nevertheless, the option to use external help in the development of the prototype was kept in mind if there were critical questions or unsolvable tasks. Since the platform is the very core of the business, having an external developer somewhere within the product's further progress will be a both necessary and advantageous spending of resources.

Questions regarding team composition or just the leverage of external help are critical for success of an entrepreneurial endeavor as the complementation of skills, knowledge or other intangible assets plays a major role. While the reflections here led to the conclusion that the

capabilities were ideal for the moment and spendings in that matter could be spared for more productive points in time, some productive expenditures were necessary.

The first purchase performed was a website domain. Since free domains feature the name of the website provider, the expenditure was necessary to secure a credible web appearance. Since the .com top-level domain (TLD) was already in use, the team decided to apply the .eu TLD. That led to the final www.carbonbridge.eu domain. In addition to these costs, a monthly subscription for the website hosting was agreed upon. While these expenditures were kept at a low level, it is estimated that improvements in functionality and increased traffic will lead to higher costs in the future.

A second part of costs incurred were in relation to the biochar manufacturing process. While the team could establish all relevant communications online, it felt important to get a tangible perspective on the matter dealt with. Given the country of residence, it was decided to pay a visit to the closest biochar producer in Portugal, Ibero Massa Florestal. Located 50 kilometers south of Porto, it was a six-hour trip back and forth from Lisbon. The visit, which is documented in Appendix 9.1 was highly valuable. A tour throughout the production site, explanations of the production process from beginning to end and the possibility of having an in-person discussion of important questions were highly worth the time.

In addition to these initial financial commitments, it is necessary to highlight non-financial commitments too. The team behind this project contributed a significant amount of its time for three key endeavors: meetings with biochar producers, reading of research material related to biochar and conceptualizing and creating a prototype of a platform. Indifferent of weekday or weekend, number of other meetings or to-do’s, the team used every chance to talk to biochar producers to find out more about them. Initially it was about testing preliminary assumptions, then it was about going into more details, looking for differences between producers and lastly for receiving feedback on the presented prototype. Commonly scheduled as 30 minutes

meetings, the discussions often lasted close to an hour. Such provided valuable room for additional insights and the possibility to ask follow-up questions. Supplementary to the information gathered through meetings was the time devoted to research papers, articles and legislation. Especially due to the pivots taken, different angles of the topic of biochar had to be explored. While this journey took time, it allowed for a more thorough understanding of the topic, looking at it from different perspectives. A third key task that required time was the prototype. Having both pain points and a potential solution in place, the question of how to deliver it best needed to be solved. Referring to the functions, both the educational part and the impact assessment were planned for early in the process. As it was concluded that a revenue stream should be associated with a third functionality, it was reflected on which feature would provide the best fit. While a marketplace feature was initially discarded due to the resource-demand, the idea of providing it on a meta-level showed that it was possible keeping up with the framework: doing it lean.

For the future, the devotion of both time in creating and financial resources in acting-out marketing and sales strategies are the most critical aspects of allocating resources. These activities are at the core of the business as community is the most valuable asset. A second important part is the refinement of the platform. As explained in chapter **7.2 The part and its activities: determining key value-adding tasks**, the educational area and the marketplace are dynamic environments that need to be on top of current developments. Here, both time and capital needs to be devoted to meet these requirements. In the end, the extent to which resources need to be deployed depends on what is to be achieved. The questions of the future of this entrepreneurial project was addressed at the very end of the group part in its final chapter **6 Horizons: Carbon Bridge's future**.

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**Appendix**

## Appendix 1: Costs of initial business idea

The aim was a 4t biochar production, allowing for approximately one hectare of soil application. We therefore needed around 20t of input resources. The biggest chunk of the overall costs would have been the one for production. Considering an average conversion rate of 20%, these add up to 5.332€. The second largest part is monitoring and research with 840€.

| PHASE 1 - Q2 2023 | |
|---|---|
| **Type** | **Costs** |
| Input | € 6 |
| Facility Transportation | € 438 |
| Production | € 5 332 |
| Distribution | € 438 |
| Monitoring & Research | € 840 |
| Salaries | € 0 |
| Administrative Costs | € 200 |
| Accounting Fees | € 0 |
| Legal Fees | € 500 |
| Customer Aquisition | € 0 |
| **Total Expenditures** | **€ 7 753** |

*Breakdown of costs for phase 1 of Terra Preta*

Transportation and distribution by truck, going from the farm to the biochar facility and back, are calculated to be at 438€ each. The legal fees for contracting and setting up the business are estimated at 500€. Further costs are caused through administration (200€) and input resources (6€). Overall, the second period is characterized by the total costs of 7.753€.

# Appendix 2: The basis for the impact assessment tool

## Input: Impact Model - Variables and Sources

| Variable | Average metric | Impacts which variables | Source |
|---|---|---|---|
| **Hectares of land cultivated** | Input from Farmers | Amount of biochar needed | |
| **Crop type** | **The average increase in crop productivity was**<br>**30.3 % legume crops**<br>**28.6 % vegetables**<br>**13.9 % grasses**<br>**8.4 % maize**<br>**11.3 % wheat**<br>**6.6 % rice** | Effect on crop productivity | Liu, X., Zhang, A., Ji, C. et al. Biochar's effect on crop productivity and the dependence on experimental conditions—a meta-analysis of literature data. Plant Soil 373, 583–594 (2013). https://doi.org/10.1007/s11104-013-1806-x |
| **Soil type** | Water storage potential<br>coarse-textured soil: 45% saved<br>medium-textured soil: 21% saved<br>fine-textured soil: 14% saved | Water storage potential | Razzaghi et. al. (2019) - Does biochar improve soil water retention? A systematic review and meta-analysis |
| **Region** | North or South of Tagus river | Soil Acidity -> Crop Yield with biochar | https://projects.iniav.pt/infosolo/ |
| **Ph level** | **4.6 - 5.5 = North of Tagus river**<br>**5.6 - 6.5 = South of Tagus river**<br><br>**The ideal level of PH should be between 6 and 7.5 . The increase in crop productivity was also greater (30.2 %) in acid soils (pH<5.0) than in neutral soils., crop productivity responses were generally negative (−7.9 % on average) with non-alkaline (pH<7.0) biochars though generally positive with alka- line biochar (pH>7.0 )** | Crop yield with biochar | https://projects.iniav.pt/infosolo/ |
| **Current fertilizer spend per year** | Input from Farmers | Costs savings potential | https://store.carvaozero.pt/ |
| **Price for biochar** | 1.2€ per kg | Costs saved | |
| **Water consumption in l per year** | Input from Farmers | Water storage potential | 400€ per 1m^3 -> x0,33 conversion = 333 kg for 400€ -> 1.2€ per kg |

## Output: Impact Model - Variables and Sources

| Variable | Average metric | Impacts which variables | Source |
|---|---|---|---|
| **Quantity of biochar needed** | 5t / hectare (Recommendation) | 1. Hectares of land | Duration: decrease of effects -0.013% per day in first two years = -9.5% in this time<br>https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcbb.12266 |
| **Costs saved** | (1.2€*quantity needed)/LTV-current fertilizer spend per year | 1. Quantity needed 2. Price for biochar | https://store.carvaozero.pt/<br><br>400€ per 1m^3 -> x0,33 conversion = 333 kg for 400€ -> 1.2€ per kg<br><br>https://www.theglobaleconomy.com/Portugal/fertilizer_use/<br><br>190 kg per hectar in 2020<br><br>https://www.statista.com/statistics/1316044/global-monthly-fertilizer-prices-by-category-urea-potash-phosphate/<br>average price of fertilier ( for december 2022) was 572,81 per metric ton -> 0,57281€ per kg<br><br>-> 190 x 0,57281 = 108,83€ per hectare<br><br>6000/108,83 = 55 years until break-even |
| **Carbon Stored** | 1 tonne of biochar applied - 1,45 tonne of Carbon stored | 1. Quantity needed | Agegnehu et al. (2016) Benefits of biochar, compost and biochar-compost for soil quality, maize yield and greenhouse gas emissions in a tropical agricultural soil.<br>Blanco-Canqui et al. (2020) Soil carbon increased by twice the amount of biochar carbon applied after 6 years: Field evidence of negative priming.<br>Cooper et al. (2020) Effect of biochar and compost on soil properties and organic matter in aggregate size fractions under field conditions. |
| **Crop yield productivity** | The average increase in crop productivity was<br>30.3 % legume crops<br>28.6 % vegetables<br>13.9 % grasses<br>8.4 % maize<br>11.3 % wheat<br>6.6 % rice<br><br>pH Level:<br><br>4.6 - 5.5 = North of Tagus river<br>5.6 - 6.5 = South of Tagus river<br><br>The ideal level of PH should be between 6 and 7.5 . The increase in crop productivity was also greater (30.2 %) in acid soils (pH<5.0) than in neutral soils., crop productivity responses were generally negative (−7.9 % on average) with non-alkaline (pH<7.0) biochars though generally positive with alka- line biochar (pH>7.0 ) | Region<br>pH level<br>Crop type | Liu, X., Zhang, A., Ji, C. et al. Biochar's effect on crop productivity and the dependence on experimental conditions—a meta-analysis of literature data. Plant Soil 373, 583–594 (2013).<br>https://doi.org/10.1007/s11104-013-1806-x<br><br>https://projects.iniav.pt/infosolo/ |
| **Water Saved** | Water storage potential<br>coarse-textured soil: 45% saved<br>medium-textured soil: 21% saved<br>fine-textured soil: 14% saved | Soil type<br>Water consumption l per year | Razzaghi et. al. (2019) - Does biochar improve soil water retention? A systematic review and meta-analysis |

# Appendix 3: The code for the impact assessment tool

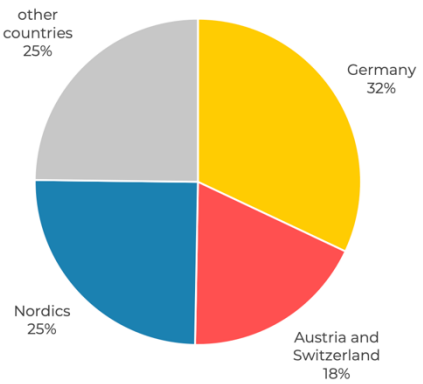
```
<!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <link rel="stylesheet" href="https://fonts.googleapis.com/css?family=Montserrat">
    <style>
      body {
        font-family: 'Montserrat', sans-serif;
        background-color: #f5f5f5;
        margin: 20px;
        text-align: center;
        font-size: 16px;
      }

      h1 {
        color: #333;
      }

      .report-container {
        background-color: #f9f9f9;
        padding: 30px;
        border-radius: 10px;
        box-shadow: 0 0 10px rgba(0, 0, 0, 0.2);
        margin-bottom: 30px;
        max-width: 600px;
        margin-left: auto;
        margin-right: auto;
      }

      label {
        display: block;
        margin-bottom: 8px;
        font-weight: bold;
      }

      input,
        margin-bottom: 16px;
        box-sizing: border-box;
        border: 1px solid #ccc;
        border-radius: 6px;
        font-size: 16px;
      }

      input[type="button"] {
        background-color: #276221;
        color: white;
        padding: 14px 24px;
        border: none;
        border-radius: 6px;
        cursor: pointer;
        font-size: 18px;
        transition: background-color 0.3s ease;
      }

      input[type="button"]:hover {
        background-color: #1c4e33;
      }

      #reportOutput {
        margin-top: 20px;
        font-size: 18px;
      }
    </style>
  </head>
  <body>
    <h1>Impact Report Generator</h1>
    <div class="report-container">
      <form id="reportForm">
        <label for="hectares">Number of Hectares of Land:</label>
        <input type="number" id="hectares" required>
        <label for="soilAcidity">Soil Acidity (pH):</label>
        <input type="number" id="soilAcidity" required>
        <label for="cropType">Crop Type:</label>
        <select id="cropType" required>
          <option value="legume">Legume Crops</option>
          <option value="vegetables">Vegetables</option>
         <option value="grasses">Grasses</option>
         <!-- Add more options as needed -->
        </select>
        <label for="fertilizerUse">Fertilizer Used (kg per hectare):</label>
        <input type="number" id="fertilizerUse" required>
        <label for="waterConsumption">Water Consumed (liters per hectare):</label>
        <input type="number" id="waterConsumption" required>
        <input type="button" value="Generate Report" onclick="generateReport()">
      </form>
    </div>
    <div id="reportOutput"></div>
    <script>
      function generateReport() {
        const hectares = parseFloat(document.getElementById('hectares').value);
        const soilAcidity = parseFloat(document.getElementById('soilAcidity').value);
        const cropType = document.getElementById('cropType').value;
        const fertilizerUse = parseFloat(document.getElementById('fertilizerUse').value);
        const waterConsumption = parseFloat(document.getElementById('waterConsumption').value);
        const potentialCarbonStorage = hectares * 1.45;
        const potentialYieldIncrease = hectares * 0.02;
        const reportOutput = `

                                <div id="reportOutput">
                                    <strong>Potential Carbon Storage:</strong> ${potentialCarbonStorage.toFixed(2)} tons CO2e
                                    <br>
                                        <strong>Potential Yield Increase:</strong> ${potentialYieldIncrease.toFixed(2)} tons

                                    </div>
        `;
        document.getElementById('reportOutput').innerHTML = reportOutput;
      }
    </script>
  </body>
```

## Appendix 4: Potential customer segments

| Industry | Biochar production | Biochar feedstock | Government | Carbon offset | Farming | Gardening tools |
|---|---|---|---|---|---|---|
| End User | 1)R&D employees<br>2)Sales force | 1)Sustainability officers<br>2)Sales force | Policy makers | 1)Engineers<br>2)Sales force | 1)Crop farmers<br>2)Livestock farmers | Marketing employees |
| Application | 1)Product monitoring, product refinement<br>2)Education, sales process | 1)Education, value chain impact measurement<br>2)Education, sales process | Education, impact monitoring, policy making, resource allocation decisions | 1)Impact measurement<br>2)Education, sales process | 1)Buying decision, impact monitoring<br>2)Buying decision, impact monitoring | Buying decision, education, product marketing |
| Benefits | 1)Product insights+, resource need-<br>2)Product insights+, sales+ | 1)Source product insights+, ESG compliance+<br>2)Source product insights+, sales+ | Product insights+ impact quantification+, sustainability goals alignment+, efficient resource allocation+ | 1)Measurement precision+, ESG compliance+<br>2)Product insights+, revenues+ | 1)Productivity+, sustainability+ revenues+<br>2)Productivity+, sustainability+, revenues+ | Product insights+, brand image+ sales+ |

| Industry | Building materials | Aquaculture farming | Wastewater treatment | Academia | Land restructuring | Environmental organisations |
|---|---|---|---|---|---|---|
| End User | 1)R&D employees<br>2)Sales force | 1)Fish farmers<br>2)Seafood farmers | R&D employees | Researchers | Engineers | 1)Policy makers<br>2)Marketing employees |
| Application | 1)Buying decision, product development, product monitoring<br>2)Education, sales process | 1)Buying decision, impact monitoring<br>2)Buying decision, impact monitoring | Buying decision, product development, product monitoring, impact monitoring | Hypotheses testing, impact monitoring | Buying decision, impact monitoring | 1)Education, policy making, impact monitoring<br>2)Education, marketing campaigns |
| Benefits | 1)Sustainability+, product quality+<br>2)Product insights+, brand image+, revenues+ | 1)Productivity+, sustainability+<br>2)Productivity+, sustainability+ | Product insights+, productivity+, sustainability+, costs- | Insights+, credibility+ | Efficiency+, sustainability+ | 1)Product insights+, efficiency+, sustainability goals alignment+<br>2)Product insights+, awareness raising+ |

## Appendix 5: Biochar production by regions/countries - cumulative biochar production capacity in Europe end of 2022




* Screenshot from (EBI, 2023)

**Appendix 6: Persona Profiling**

While our persona profile was derived from conducted interviews, it should be emphasized that certain elements are based on informed assumptions.

**Name:** Dr. Martin Becker (alias)
**Age:** 45
**Title:** Product manager
**Company:** GreenChar Solutions
**Industry:** Biochar Production
**Education:** PhD in Environmental Chemistry
**Location:** Germany
**Family:** Married with two children
**Income:** Medium-high level
**Personality Traits:** Analytical, environmentally-conscious, problem-solver, forward-thinker.
**Background Story:**
Dr. Martin Becker is an experienced environmental chemist who has turned his expertise toward the production of biochar. With over 20 years in the field, he has witnessed the rise of sustainability as a core consumer value and has dedicated his career to finding solutions that balance economic viability with environmental responsibility. As product manager of GreenChar Solutions, a pioneering biochar company, he is at the forefront of developing innovative applications for biochar that extend beyond agriculture into industries, such as construction and water treatment.
His behavior is characterized by the following aspects:

- Seeks out the latest research and technological innovations in biochar.
- Actively participates in industry conferences and policy discussions.
- Advocates for industry collaboration to address market and regulatory challenges.

**Goals:**

- Develop new, marketable applications for biochar to expand its use.
- Establish GreenChar as a market leader in the biochar industry.
- Navigate and influence regulatory landscapes to favor biochar production and use.

**Needs:**

- Marketing strategies that highlight the quality of biochar over cheaper, less environmentally friendly options.

- Innovative thinking to change traditional practices and industry standards - educate the market and demonstrate biochar's benefits.
- Clear legal definitions for biochar production processes.
- Reliable data on biochar's environmental impact to improve market perception.

**Pains:**

- The difficulty of proving biochar’s worth in a price-sensitive market.
- Economic challenges due to underinvestment and high broker commissions.
- Seasonal demand fluctuations and a lack of year-round sales consistency.
- Regulatory barriers.

**Purchasing Criteria in prioritized order:**

1. **Ability to Increase Awareness:** Our product must demonstrate the capability to significantly raise awareness of biochar benefits among target audiences, which could lead to a wider adoption and market expansion.
2. **Quality of Impact Assessment:** Our product should provide accurate, credible, and easy-to-understand impact assessments for biochar's environmental benefits, influencing buyers and industry stakeholders' decision-making.
3. **Marketplace Visibility:** The platform must offer high visibility for GreenChar Solutions' products, providing an effective online presence that can compete with other marketing channels.
4. **Cost-Benefit Ratio:** The costs associated with listing products must be outweighed by the potential for increased sales and market reach.
5. **User Experience and Engagement:** The platform must provide an excellent user experience for both biochar producers and potential customers, encouraging engagement and repeat visits.

# Appendix 7: List of outreaches – biochar producers

| Stage | Name | Title | Company | Contact | Location |
|---|---|---|---|---|---|
| Had meet... | Sara Fernandes | Replacing Ana | Imflorestal | sara.fernandes@imflorestal.com | Oliveira de Azeméis |
| Posponed | Ana Machado | | Imflorestal | ana.machado@imflorestal.com | Oliveira de Azeméis |
| Contacted | Circle Carbon | | Circle Carbon | info@circlecarbon.com | Spain |
| Had meet... | Dr. Robert Johnson | R&D Manager | Arigna Fuels | robert@arignafuels.ie | Ireland |
| Contacted | carbonauten GmbH | | carbonauten GmbH | info@carbonauten.com | Germany |
| Contacted | F. Ehrich GmbH & Co. | | Ehrich Gruppe | info@ehrich.de | Germany |
| Had meet... | Sarah Hildebrandt | Project Lead | icon carbon// Ehrich Gruppe | s.hildebrandt@icon-carbon.de | Germany |
| Contacted | BASNA d.o.o. | | BASNA d.o.o. | info@basna.net | Serbia |
| Contacted | Carbo-FORCE GmbH | | Carbo-FORCE GmbH | info@carbo-force.de | Germany |
| Had meet... | Harald Fichtl 1 | | LignoCarbon Schweiz AG | harald.fichtl@lignocarbon.ch | Switzerland |
| Contacted | klimafarmer 1 | | klimafarmer GmbH | service@klimafarmer.de | Germany |
| In contact | Florin Milla | | Novocarbo GmbH | f.milla@novocarbo.com | Germany |
| Had meet... | Hans Sanzenbacher | Dipl.-Ing. | *ProE* Bioenergie | hs@proe-bioenergie.de | Germany |
| Contacted | Oxford biochar | | Oxford biochar | office@oxfordbiochar.org | England |
| Contacted | Woodtek Biochar | | Woodtek Biochar | info@woodtekbiochar.com | Wales |
| Contacted | Carbo Culture | | Carbo Culture | hello@carboculture.com | Finnland / UK / USA |
| Contacted | Grassroots Biochar AI | | Grassroots Biochar AB | Info@grassrootsbiochar.se | Sweden |
| In contact | Edvard Hamilton | | BIOKOL | ro@biokol.se | Sweden |
| Contacted | CharLine GmbH | | CharLine GmbH | office@charline.at | Austria |
| Had meet... | Gerlach Dunst | | Sonnenerde GmbH | g.dunst@sonnenerde.at | Austria |
| Contacted | Swiss Biochar 1 | | Swiss Biochar | info@swiss-biochar.com | Switzerland |
| Had meet... | Fabian Link 1 | Produktmanager | Bioenergie Frauenfeld AG | fabian.link@bioenergie-frauenfeld.ch | Switzerland |
| Had meet... | Aaron Saßmannshaus | CEO | bionero | aaron.sassmannshausen@bionero.de | Germany |
| Contacted | Carbex 1 | | Carbex | info@carbex.one | Germany |
| In contact | Horst Wagner | | Innovations Centrum Meißen ( | kundenservice@pflanzenkohle.info | Germany |
| Contacted | CarboVerte GmbHC | | CarboVerte GmbH | info@carboverte.de | Germany |
| Contacted | BioCarbo | | BioCarbo | info@biocarbo.it | Italy |
| Lead | Carbonloop 1 | | Carbonloop | contact form | France |
| Contacted | Carbo Centric | | Carbo Centric | contact form | France |
| Had meet... | Stefan Sziwek 1 | | Biatex GmbH | sz@biatex.de // sz@varem-energie.c | Germany |
| Contacted | Mash Makes | | Mash Makes | contact form | Denmark / India |
| Contacted | Bionika AG | | Bionika AG | office@bionika.ch | Switzerland |
| Contacted | Koen Cardinaels | Plant Manager | TorrCoal | k.cardinaels@torrcoal.nl | Belgium |
| Contacted | Origin Biochar | | Origin Biochar | info@originbiochar.com | Ireland |
| Contacted | Dad's Farm Biochar | | Dad's Farm Biochar | info@dadsfarmbiochar.com | Wales |
| Contacted | DEMIO | | DEMIO | contact form | France |
| In contact | Carine COAT 1 | | Terra Fertilis | c.coat@terrafertilis.com | France |
| Lead | Carbonex 1 | | Carbonex / Groupe SOLER | contact form | France |
| Contacted | Groupe Bordet | | Groupe Bordet | contact@groupebordet.fr | France |
| Contacted | Carbons Finland Oy | | Carbons Finland Oy | info@carbons.fi | Finland |
| Had meet... | Morten Heick 1 | | Stiesdal | mhe@stiesdal.com | Denmark |
| Contacted | Oplandske Bioenergi / | | Oplandske Bioenergi AS | post@obio.no | Norway |
| Had meet... | Eva Stal 4 | Projekt Manager | Nordvästra Skånes Renhållnin | Eva.stal@nsr.se | Sweden |
| Contacted | Envigas | | Envigas | info@envigas.com | Sweden |
| Contacted | Bussme Energy AB | | Bussme Energy AB | contact form | Sweden |

| | | | | | |
|---|---|---|---|---|---|
| Had meet... | Claes-Göran Henrikss | Senior Consultant | Skånefrö AB | cgh@skanefro.se | Sweden |
| Contacted | Siotuu 2 | | Siotuu | info@siotuu.com | Austria |
| Contacted | Energy Ocean GmbH | | Energy Ocean GmbH | info@energyocean.ch | Switzerland |
| Contacted | Reto o. Franziska Gro | | Grossenbacher Grüngut | info@grossenbacher-gruengut.ch | Switzerland |
| Contacted | INEGA AG | | INEGA AG | admin@inega.swiss | Switzerland |
| In contact | Sandi Martin 1 | CEO & Founder | Amanta Green | amatagreenconsulting@gmail.com | Spain |
| Contacted | Josiah Hunt | CEO | Pacific Biochar | https://www.linkedin.com/in/josiah-hu | US |
| Contacted | Adrian Würsch | | Verora GmbH | mail@verora.ch | Switzerland |
| Contacted | Christopher Carstens | CTO | Carbo Culture | https://www.linkedin.com/in/christopl | Finnland / UK / USA |
| Had meet... | Bryan M. Eagle III | CEO | Glanris | https://www.linkedin.com/in/bryanme | US |
| Contacted | Wakefield | | Wakefield | Contact form | US |
| Contacted | Peter Burgess | | Rainbow Bee Eater | https://www.rainbowbeeeater.com.au | Australia |
| Contacted | Sampo Tukiainen | Founder and Ex-CEO | Carbofex | https://www.linkedin.com/in/sampo-t | Finland |
| Contacted | Pyreg | | Pyreg | contact form | Germany |
| + New | | | | | |

COUNT 59

## Appendix 8: Annual revenue reasoning

| BIOCHAR MARKET | | |
|---|---|---|
| **Metric** | **Number** | **Details** |
| Expected Number of Biochar Production Plants | 180 | end 2023 |
| Expected Biochar Producers Germany | 58 | end 2023, production capacity proxy |
| Expected Biochar Producers Austria/Switzerland | 32 | end 2023, production capacity proxy |
| Expected Biochar Producers Nordics | 45 | end 2023, production capacity proxy |
| Expected Biochar Producers Others | 45 | end 2023, production capacity proxy |
| Growth Rate in Biochar Production Plants | 25,35% | |
| Expected Production Capacity | 90000 | tons end 2023 |
| Expected Production Capacity Germany | 28800 | tons end 2023 |
| Expected Production Capacity Austria/Switzerland | 16200 | tons end 2023 |
| Expected Production Capacity Nordics | 22500 | tons end 2023 |
| Expected Production Capacity Others | 22500 | tons end 2023 |
| Expected Actual Production | 50000 | tons end 2023 |
| New Installation Productivity Factor | 30% | of Uptime |
| Long-term Productivity Factor | 80% | of Uptime |
| Biochar 1m3 = | 0,35 | tons |
| Biochar 1t = | 2,86 | m3 |
| Biochar Price Germany | € 800 | per ton |
| Biochar Price Austria/Switzerland | € 800 | per ton |
| Biochar Price Nordics | € 800 | per ton |
| Biochar Price Others | € 800 | per ton |
| Expected Sales Germany | =(Old!B44/B4)*B16*B10*B19+((B4-Old!B44)/B4)*B15*B10*B19 | |

Combined annual revenue = expected sales in Germany of €15,232,000.

**Appendix 9: Fieldwork notes – Carbon Bridge external validation**

**Appendix 9.1: Interview with Ibero Massa Florestal**

| | |
|---|---|
| **Interviewee's name** | Ibero Massa Florestal |
| **Organization** | Sara Fernandes and Paulo Correia |
| **Interview Date** | 23th of November at 11 am |
| **Location** | Onsite |
| **Length** | 2 hours |
| **Interview history** | 4th interview |

**1. In general, how did the interview go?**

The on-site meeting gave us a deep understanding of the complex processes in the industry. By observing the machines in action, we gained insight into the extensive investments and challenges Imflorestal faces, from procurement and maintenance to production optimization. This first-hand experience gave us a tangible understanding of the intricacies of the industry and enriched our view of the inner workings of the biochar market and the key pain points encountered by those in the industry.

**2. In brief, what were the main findings for each theme discussed in the interview?**

- **Product Diversification**: The introduction of various products, such as Microbiochar for animal nutrition and upcoming Nutrichar, indicates a strategy to diversify and expand the customer base.
- **Customer Spectrum**: A wide customer base including large farmers, wine producers, rice companies, small farmers, and private individuals, reflects diverse market penetration.
- **Municipal Opportunities**: Targeting municipalities to address water conservation issues with biochar, showcasing the company's innovative marketing approach.
- **Impact Measurement**: A need for a tool to measure biochar's impact accurately was identified, as current figures are based on assumptions.
- **Competitive Challenges**: New competitors for biomass and the increased cost of materials present significant challenges, alongside the issue of cost distribution to end consumers.
- **Regulatory Push**: Biochar's role as a carbon sink within European environmental projects highlighted its ecological significance. Also emphasizing on the importance of regulations promoting biochar, with the current market in Portugal valued at 8 million euros.
- **Seasonal Demand**: Biochar sales experience high seasonality, with peaks during May and June, affecting stock management.
- **Platform Feedback**: Positive reception of our platform paired with constructive feedback on the impact assessment tool, showcasing potential for collaboration.

**3. Were there any themes or questions which were not answered /not asked / avoided by participant? Why?**

There were no answers avoided by the participants.

**4. What themes were discussed in the most depth?**

The discussion explored the strategic market positioning of Imflorestal's diverse biochar products. They are broadening their reach by developing innovative products like

Microbiochar for animal nutrition, an alternative to antibiotics, and preparing to launch Nutrichar. Yet as of know they have been surviving on the revenue generated from their product, Carvão Zero, which they sell mostly to restaurants. The customer base is varied, encompassing large-scale agricultural operations like Nutrifarms, prominent wine producers such as Sogrape, rice companies, and small-scale farmers. Private individuals, often purchasing 10-liter sacks, indicate the retail potential. Imflorestal's market strategy also targets municipalities with strategies to alleviate water expenses by using biochar in urban gardens, which could significantly reduce water consumption. However, they noted the need for a precise tool to quantify biochar's impact, as current estimates are not 100% reliable.

**5. What were the most significant or interesting discussions within the interview?**

Significant discussions centered on Imflorestal's customized pyrolysis containers tailored to their production needs, enabling the daily output of 50 to 70 tonnes of high-quality biochar with over 90% carbon content. The intensive process requires 2 to 2.5 tonnes of wood to produce approximately 450 kg of biochar over 10 to 12 hours. Challenges in securing biomass due to new competitors and the seasonal nature of biochar demand were also highlighted, alongside the company's positive response to our platform and potential partnership opportunities.

The detailed production insights from Imflorestal were crucial, as understanding the operational scale and economics of biochar production directly informs our assessment of a facility's capacity and potential market reach. This knowledge is significant in gauging their willingness to invest in a platform like ours, helping us estimate a value proposition that aligns with their production economics and sales potential.

**6. What were the least significant or interesting discussions within the interview?**

The exact design specifics of their pyrolysis containers were less critical for the platform's scope.

7. **Any improvement needed on the script or fieldwork strategy?**

To enhance our research approach, future fieldwork should incorporate a more targeted investigation into the economics. This includes delving into production costs, sales volumes, and the operational efficiencies of different producers. A better understanding of these economic factors will inform our platform's value proposition and pricing strategy to meet the needs of biochar facilities.

**8. Final thoughts / comments?**

Imflorestal's interest in a partnership and the positive feedback on the platform were encouraging, highlighting the importance of accurate impact assessment tools.


Carbon Bridge team in Avenal with Sara Fernandes and Paulo Correia

Pyrolysis containers

Testing laboratory