
# Project Report SustAInability

Team ContainerGrid 1

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# Introduction

In today's world, sustainability has become a paramount concern, prompting institutions and organizations across the globe to seek innovative solutions to environmental challenges. Universities play a crucial role, fostering collaborative projects that address sustainability issues. The sustAInability initiative, a joint effort by LMU, TUM, and Hochschule München, exemplifies this commitment. Through this program, students from different academic backgrounds come together to tackle environmental problems, working closely with industry partners to develop solutions.(“MUC.DAI, sustainability, Artificial Intelligence, Nachhaltigkeit - Hochschule München,” 2024) This year's focus for the sustAInability program is waste management.

The team, consisting of four interdisciplinary students with design and IT, Engineering and Management backgrounds, participated in the sustAInability program and was tasked with a challenge posed by Container Grid, a Munich-based startup. Container Grid focuses on optimizing logistics for waste management and recycling processes. (“Unser Impact - ContainerGrid,” 2023)

The specific issue they presented was the difficulty large corporations face in sourcing locally available recycled materials from waste or end-of-life products. This challenge is significant as companies like to enhance their sustainability practices by incorporating more recycled materials into their production processes, thus reducing environmental impact and aligning with increasing regulatory pressures and consumer demands for sustainability.

# Desk Research

In the initial phase of our research, we focused on the recycling cycle to identify the involved actors and understand the dynamics of the material flow. Our goal was to uncover the obstacles large corporations face when sourcing recycled raw materials and the challenges associated with collecting these materials.

We mapped out the entire process, starting from the collection points at recycling centers and waste collection sites, through the various stages of sorting and processing, and finally to the companies that use recycled materials to create new products. These products eventually reach consumers and, at the end of their life cycle, return to recycling centers.

One particularly surprising discovery was that valuable raw materials, when present in small quantities, are often incinerated rather than recycled. This is due to the economic and logistical challenges of processing small volumes, making it more cost-effective for facilities to burn them instead.(AWM, 2024)

Having established a foundational understanding of the recycling cycle, our next step was to gather more detailed data, particularly focusing on the incineration of recyclable materials and the recycling cycle of end-of-life solar panels. (Woods, 2023)

We chose to focus on solar panels because the first wave of end-of-life panels is approaching.(“End-of-life management Solar Photovoltaic Panels,” 2016) Consequently, the Fraunhofer Institute has been successfully researching the recovery of silicon from end-of-life solar panels.(“PERC-Solarzellen aus 100 Prozent recyceltem Silizium - Fraunhofer ISE,” 2022) However, the quantities that individual recycling centers could currently recover are not yet profitable, leading to the incineration of silicon along with other valuable raw materials.

# Solution

The following part will explain the problem statement and the strategy used to create the solution. A design thinking framework was used to propose a solution to the problem. It involved breaking down the big problem into small, manageable problems. Followed by proposing solutions to small problems and bundling them into a one-stop solution.

## Problem Definition

Supply chains in modern times have become very complex and uncertain. Due to the VUCA challenges existing in the market, streamlining the supply chains has become the biggest challenge for firms. Furthermore, legislative regulations for integrating recycled materials in the supply chain to achieve a circular economy pose an additional challenge for procuring and supplying firms. Additionally, incineration instead of recycling makes it difficult to achieve a circular economy. One such problem was introduced by the startup ContainerGrid.

The problem addresses the challenge of inconsistent supply and demand between city waste collection centers and procuring firms. Evidently, through market research, a gap in the supply chain phase was cited. Procuring firms face difficulty procuring sufficient quantities of recycled materials due to their inconsistent availability and lack of a transparent platform between the procurer and the supplier. At the same time, the suppliers have very little information regarding the demand of the procuring firms. The sale of recycled materials available only in small quantities is not profitable, and a strategy is required to make it profitable.

## Mission Statement

The main aim is to streamline the phase mentioned above of the supply chain through the implementation of AI, which could involve predictive analytics for demand forecasting and process optimisation techniques. These technologies and strategies are expected to significantly improve the efficiency and profitability of the supply chain.

## Concept

To propose a solution to the given problem, a design thinking methodology was applied. The problem was divided into multiple manageable small problems. Thereafter, various brainstorming techniques created solutions to the small, manageable problems. In the end, a holistic solution was proposed.

The concept of the solution can be divided into two parts:
1) Predictive Analysis through machine learning algorithms to ensure guaranteed supply.
2) Process optimization and streamlining to increase transparency and reliability in the supply chain phase.

Using the ERP Data available from the city waste collection centers, a machine learning model will be trained to accurately predict the availability of different kinds of recycled materials in a given quantity and at a given time in the future. This considers multiple factors on which the availability of the materials depends. Applying this machine-learning model will increase the collection centers' reliability in providing raw materials at a given time and quantity.

A software implementation decision-making model was proposed to increase the reliability and transparency of the supply chain phase. Applying a combination of AHP and TOPSIS methods would help rate the suppliers based on various factors important to the procurers and help them choose the suppliers that suit their demands the best. Additionally, bundling was proposed to increase the economic viability of recycled products available in small quantities. Bundling involves providing a single platform to multiple suppliers of recycled materials only available in small quantities. Thereby making the sales of such materials profitable by achieving economies of scale.

A software platform combined with the above solutions would help the firms achieve a smooth and transparent process of supplying and procuring recycled materials. It will ensure the availability and sales of important recycled materials.

## Tech Stack

The following paragraph outlines the technology stack chosen for our prediction and matching algorithms. First of all, the prediction of the future waste amounts of each stakeholder in the supply chain is achieved by using the forecasting model Facebook Prophet. The model is pre-trained, open-source, easy-to-use, and scalable. While custom models offer more flexibility, using a pre-trained model and fine-tuning it on a specific dataset saves resources, is environmentally more friendly, and highly accurate. To ensure maximum accuracy, there will be one fine-tuned model per stakeholder based on the neutral dataroom, which is already available through Containergrid’s software.

The dataset includes various features crucial for accurate predictions and efficient matching. Key features include:

- Historical Waste Data: Time-series data of waste amounts and burned waste amounts generated by each stakeholder.
- Geographic Locations: Latitude and longitude coordinates for calculating distances between stakeholders.
- Material Types: Categories of waste materials (e.g., lithium, plastic, metals).
- Material Quality: The grade or quality level of the recycled materials, which can affect the suitability for different requests.
- Capacity: The maximum amount of material each recycler can process.
- Pricing: Cost per unit of recycled material offered by each recycler.

- Operational Constraints: Specific operational limitations or preferences of each stakeholder.

These features are stored in a relational database like PostgreSQL, which not only supports structured data but also handles location data through its PostGIS extension, making it ideal for initial filter queries.

As for the matching algorithms, after a corporation has sent a request, there are two significant steps happening. Firstly, there is an initial filtering via SQL queries considering the predictions for the material quantities, the distance constraints, and the prices of the materials. This step leverages the PostgreSQL database to quickly filter out unsuitable suppliers based on predefined criteria.

Following the initial filtering, an optimization model, based on linear programming, is run to find the minimal cost solution while also considering the distances between stakeholders. For this, we use Google OR-Tools, which is well-suited for formulating and solving such optimization problems efficiently. This ensures that the selected suppliers not only meet the demand at the lowest cost but also minimize the environmental impact through reduced transportation distances.

Subsequently, as the delivery date approaches, the algorithm is re-run to verify the actual amounts and re-optimize the selection of suppliers if necessary. This step ensures that any changes in the available quantities or other dynamic factors are taken into account. Finally, using graph algorithms, the system creates short and efficient logistic routes. These algorithms, such as Dijkstra's or A*, help in determining the shortest path for delivery, further optimizing logistics and reducing CO2 emissions.

By integrating these advanced technologies and leveraging detailed data features, our system ensures efficient, cost-effective, and environmentally friendly waste management across the entire supply chain.

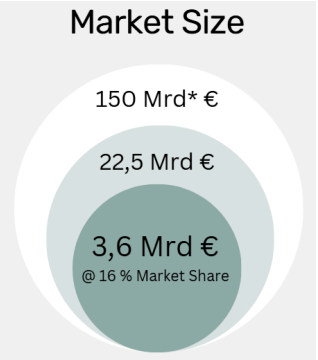
# Business Model

The proposed business model is an innovative extension of ContainerGrid's current operations, aimed at exploring new market opportunities and diversifying revenue streams. Developed using the business model canva, this model focuses on developing a modern, integrated platform that serves both recyclers and manufacturers, enhancing the value proposition for all stakeholders involved.

## Value Proposition

The business model offers a dual value proposition. For recyclers, the platform will increase revenue by enabling the recycling of previously non-profitable waste streams through efficient bundling. This approach allows recyclers to process more materials in a cost-effective and sustainable manner. For manufacturers and suppliers, the platform provides supply guarantees for certified recycled materials, ensuring a steady and reliable supply chain. This helps manufacturers meet their sustainability goals while securing raw materials at competitive prices.

## Market Size




The initial rollout of the marketplace will focus on Germany, which presents significant growth potential. By 2030, the total recycling and waste market in Germany is estimated to reach approximately €150 billion (*Statusbericht der deutschen Kreislaufwirtschaft*, 2024), assuming an 18% recycling share (Limberger et al., 2021). The goal is to capture 15% of this total addressable market by addressing the currently unmet demand, which constitutes around 15% of the market in Germany (Fredershausen et al., 2022) resulting in €22,5 billion. With a conservative market penetration assumption of 16%, the serviceable obtainable market translates at €3,6 billion to a substantial market segment, supported by ContainerGrid's existing market values.

## Revenue Model

The revenue model is designed to be both robust and flexible, ensuring steady income and scalability. It includes a monthly subscription fee for access to the platform, variable commissions based on the type of contracts facilitated through the marketplace, and fees based on the accuracy of supply guarantees, with premiums increasing as the booking period extends. Accurate predictions allow for charging a premium for the certainty provided. By attracting more paying customers to the platform through the above mentioned value proposition, this model drives revenue growth while enhancing customer satisfaction.

## Risk management

Effective risk management is crucial for the success of this business model. Several strategies are employed to minimize risks. The advanced prediction model minimizes errors and associated costs, with continuous tuning and machine learning improvements ensuring increasingly accurate forecasts over time. By optimizing the supply chain and bundling materials, it is possible to mitigate supply fluctuations and ensure consistent material availability. Additionally, balancing reinsurance costs with prediction premiums provides a safety net against unforeseen supply chain disruptions, ensuring safe and profitable operations.

By leveraging these strategies, this business model minimizes risks and creates a reliable, efficient, and profitable system that enhances ContainerGrid's market presence and value proposition.

# Conclusion

In conclusion, the sustAInability seminar highlights a strong commitment to tackling significant environmental challenges through innovative and collaborative efforts. Despite initial uncertainties and limited support, the interdisciplinary team effectively navigated the complexities of the waste management issue presented by Container Grid. The small team size increased individual workload but also enabled smoother communication and collaboration.

The project emphasized the importance of early clarity in project scope and sufficient initial support. The proposed solution, which uses AI-driven predictive analytics and process optimization, offers a comprehensive approach to improving the efficiency and profitability of recycling processes. Given the broad scope of the topic though, more careful validation of the concept scope would have been necessary to ensure the feasibility of developing an early stage prototype.

The design thinking methodology helped in breaking down the complex problem into manageable parts, leading to the development of a solid solution framework. The use of advanced technologies like machine learning models, optimization algorithms, and integrated software platforms showcases the potential for innovative solutions to sustainability challenges.

Overall, the project was a success, providing valuable insights and demonstrating significant potential for environmental impact. The teamwork, productive discussions, and enjoyable collaboration contributed to the project's success. The seminar not only offers developing practical solutions for waste management but also sets a precedent for future projects aimed at promoting sustainability through interdisciplinary collaboration and technological innovation.

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