Ergonomic Adjustable Furniture

Author(s):

1. Astrid Prończuk
2. Clément Jacques F. Mertz-Revol
3. Jan Lennard Hinzpeter
4. Julie Smeets
5. Mario Konstanty Kochan Chmielik

Together with the coaches and EPS team.

Acknowledgement

Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
CAGR	Compound Annual Growth Rate
FSC	Forest Stewardship Council
PEFC	Programme for the Endorsement of Forest Certification Schemes
MDF	Medium Density Fiberboard
SWOT	Strengths, Weaknesses, Opportunities, Threats
IoT	Internet of Things

Abbreviation	Description
PDCA	Plan-Do-Check-Act
WCED	World Commission on Environment and Development
WBCSD	World Business Council for Sustainable Development
VOC	Volatile Organic Compounds
LED	Light Emitting Diode
LCA	Life cycle analysis
USB	Universal Serial Bus
HPL	High pressure laminate
LPL	Low pressure laminate

1. Introduction

1.1 Presentation

We are a team consisting of five students, from five different countries. Each of us studies in a different field of engineering and other sciences. This project in the Erasmus Project Semester will be a great experience to expand our knowledge and experiences for the future. The knowledge and experience we have from all our different studies will help us throughout the project we are going to carry on. The complete project is going to be in English. Because English is not our native language, this will also be a great opportunity to expand our English language. In Table 1 below, the members of the team are introduced with their field of studies.

Table 1: Team

Name	Studies	Location
Astrid	Forensic science	The Netherlands, Enschede
Jan	Mechanical engineering	Germany, Kiel
Mario	Computer science	Spain, Barcelona
Julie	Product development	Belgium, Antwerp
Clément	General engineering	France, Tarbes

1.2 Motivation

We all came to Porto with the intention to carry out an innovative project. We all wanted a multi-disciplinary project, with mechanics, IT and others fields to explore. During the semester some lessons are proposed, such as management, marketing, communication. We will attend because it will be interesting and helpful for our project. Our main aim is to create a prototype of the project, to have something physical at the end fo the semester. The second goal is to have each team member contribute to the project, by bringing his/her competences, participate fully within the team and to be

respectful to eachothers work. Each teammember wrote his/her motivation that can be read in Table 2 below.

Table 2: Individual motivation

Name	Motivation
Mario	My main motivation for doing the EPS was working with international people. I knew, from the experiencie of my colleagues, that once you start doing the EPS you start meeting new people from different countries and work with them. Also, I think that this experience will help me in my future as a first contact working with people in english. I chose Porto because the city had a great reviews on internet and the portuguese culture is in a way similar to the spanish one.
Jan	Embarking on a European Project Semester that involves interactive work in a team and an interdisciplinary approach is an exciting opportunity to develop my skills and knowledge. By working with people from different backgrounds, I will have the chance to learn from their perspectives and experiences, which can help me expand my horizons and become more open-minded. Due to my very close start of work and finishing my Masters, it is a great opporunity to work for a longer periode on a specific subject in an international context. I have previosly struggeled a bit to follow meetings in english and express myself porperly. I think this will change after this semester.
Astrid	Working on one project with people who have different nationalities and diffent studies was my main motivation to take part in the Erasmus Project Semester. Personally I was really curious about the differences in cultures within the projectgroup and with that the different manners of working within a group. I was looking forward to having a geat time in a new country, meeting new people and work together on a great project where could expand my knowledge and experiences that I could take with me in the future.
Julie	From school we could choose between a regular erasmus and an EPS project, my preference immediately went to an EPS project because of the opportunity the project gives to work with international students from all different backgrounds. Porto was therefore ideal with the EPS project and all the other opportunities the city has to offer such as the beautiful weather, the city and the beach and so much more.
Clément	My choice to go to Porto was motivated by the fact of doing two mobilities during my studies. This is the only way in my school to do it, going in EPS and then in ERASMUS without doing an internship in a foreign country. Furthermore, a good friend of mine advised me to do so, as he did, because of the opportunity to meet new people and work on an interesting topic. It will be one more argument to add on my resume as I wish to have an international career in a few years.

1.3 Problem

As the population continuously increases **[Our World Data, 2022] [The World Bank, 2021]**, living spaces are becoming smaller, more expensive, and more challenging to utilize efficiently. According to the United Nations, “by 2050, around 68 % of the world's population is projected to live in urban areas, which will further increase the demand for efficient living spaces” **[United Nations, 2018]**. This poses a significant challenge for individuals who need to optimize their living spaces, especially when it comes to incorporating functional furniture into their homes **[Lucy Pickford, 2021]**. A specific challenge that arises is finding a way to make the most out of small kitchens and workspaces, which often need to serve multiple purposes.

One potential solution to this problem is to design and produce convertible furniture that can be used

for multiple purposes. For instance, a desk could be designed to fold down and transform into a kitchen island, or a kitchen island could be designed to fold up and transform into a desk. By creating furniture that can serve multiple purposes, individuals can maximize the use of their living spaces and make their homes more efficient.

However, there are additional challenges that need to be addressed in creating convertible furniture that incorporates smart features to adjust to different user needs. For instance, the furniture needs to be sturdy and reliable enough to withstand frequent use and movement, and also include features such as height adjustment for those with specific needs. Additionally, incorporating smart technology into the furniture's design, such as voice-activated commands or automatic adjustments, can further enhance its efficiency and versatility.

Overall, the challenge of making the most out of small living spaces can be addressed through innovative furniture design that incorporates functionality, efficiency, and smart technology. By finding ways to create multi-purpose furniture that is both practical and aesthetically pleasing, individuals can create living spaces that are comfortable, functional, and efficient while also catering to their specific needs.

1.4 Objectives

The objective is to help people that are living in small accommodations such as apartments. To do this, the team came up with a piece of furniture that allows you to cook, to eat and to work. Nobody wants to work on cooking plates but not everybody has enough space to have both a small kitchen and a workingdesk. This multi-functional piece of furniture is designed to cater to the needs of individuals who live in livingspaces with limited space. With this innovative piece of furniture, the person can enjoy the luxury of cooking, eating, and working, all from the same piece of furniture. The furniture is designed to be compact yet spacious, allowing you to prepare meals, dine and work comfortably. Say goodbye to the hassle of juggling between a cramped kitchen and a tiny desk - this all-in-one solution is perfect for those who value functionality and practicality.

1.5 Requirements

The requirements defined below have been made from the point of view of the consumer. The objective is to try to provide a solution to these requirements. These requirements are varied, from the user experience to the solution to everyday needs.

- As a client I want to have a small kitchenet so I can have more living space in my apartment.
- As a client I want a multiuse piece of furniture so I have multiple furnitures in only one place.
- As a client I want a comfortable place where I can study or work whenever I want.
- As a client I want the possibility to invite multiple people to my house socialize around a table.
- As a client I want to have furniture with good quality, that is safe to cook, is resistent to water, and easy to clean.
- As a client I want to have adjustable furniture, so I can work in a sitting position as well as in a standing position.
- As a client I want to have some storage space to store my stuff.
- As a client I want to have good lighting while I am cooking and working.

For all these requirements, the team will try to provide a solution, as well as comply with the quality standards that are considered important.

1.6 Functional Tests

The main objective of our project is to build a prototype with as much mechanical parts as possible, to make the best idealization of the product.

To ensure that this idealization is done the best way possible, functional tests will be done on the prototype. These test will be done for the digital prototype and the physical one. The team will among other test the test weight support and the usability of the product. The test are listed below and will be described further in the project development chapter of this report.

- Digital design prototype test: Test of how is desinged of our product, if it is fulfill all the directives.
- Real quality prototype test: Test if the product fulfills all the directives of quality.
- Weight test: Test the maximum weight that can be supported onto the furniture.
- Functionality test: Test if the furniture can be easily transformed in the kitchen, working desk and extandible table.
- Safety test: Test if the product can not cause any harm and satisfies the safety regulations.

With these test, the team will confirm if the prototype of the product can be produced as a real product, fulfilling all the directives and standards defined by the different organizations around the world. The most important test is the safety test, as it will indicate if our product is viable to be used in a safe way by the future consumers.

1.7 Project Planning

When it comes to project planning, it is important to choose a methodology that best suits the needs of the project. The team decided to use a combination of Scrum and Kanban methodologies.

Scrum is an agile framework that emphasizes teamwork, communication, and rapid iteration. It involves breaking down a project into smaller, more manageable tasks called sprints, which typically last between one and four weeks. At the end of each sprint, the team conducts a review to assess their progress and adjust their approach for the next sprint.

Kanban, on the other hand, is a lean methodology that focuses on visualizing work and limiting work in progress. It involves using a Kanban board, which is a visual representation of the work that needs to be done, the work that is currently in progress, and the work that has been completed. This allows the team to quickly identify bottlenecks and prioritize tasks based on their importance.

By combining these two methodologies, the team will be able to create a project planning that is flexible, adaptable, and focused on continuous improvement. Scrum will be used for planning and executing our sprints, while Kanban will help visualize the work and manage the workflow effectively. Together, these methodologies provide the team with a powerful framework for delivering high-quality work in a timely and efficient manner.

In the Figure 1 an example is shown of the team's kanban.

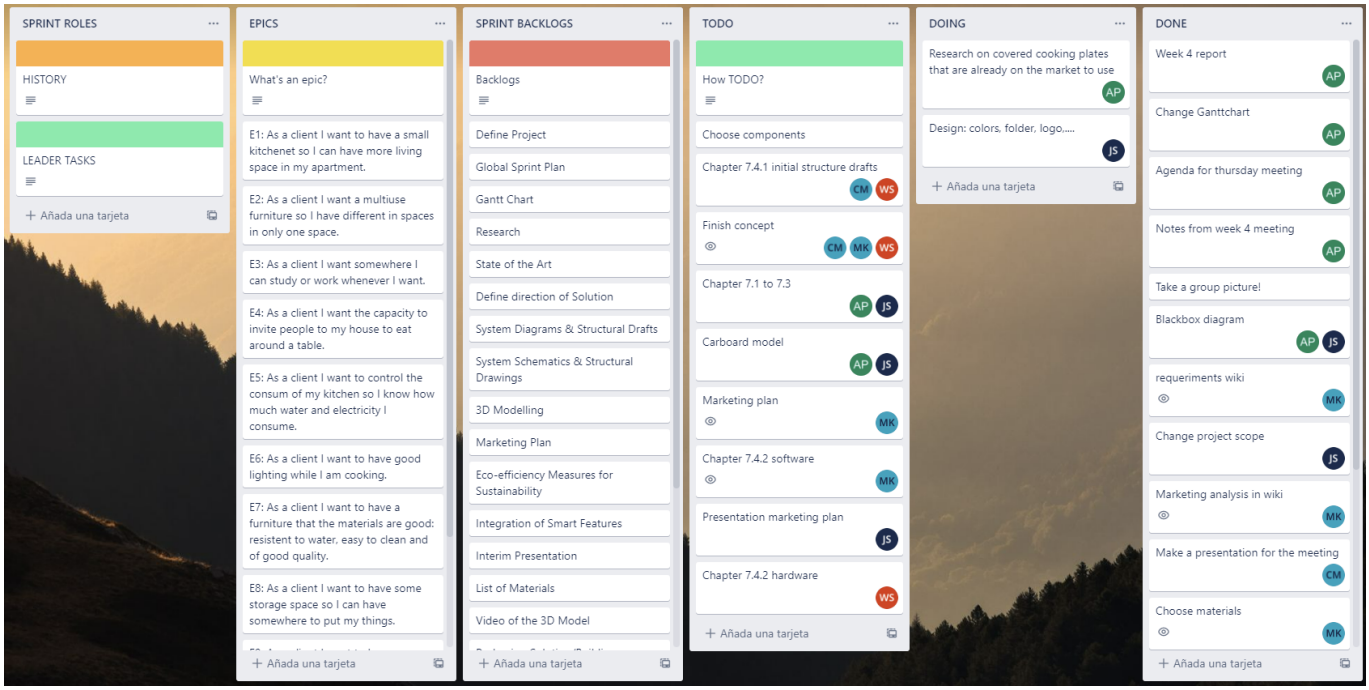


Figure 1: Screenshot of kanban in trello.com

1.8 Report Structure

This report will follow a structured format that is designed to provide a comprehensive overview of our project:

1. Introduction: The team provides a brief overview of the project and its objectives.
2. State of the art: Review the current state of research and technology related to our project.
3. Project managment: This is an outline of the strategies and methods that are used to ensure the success of the project.
4. Marketing plan: The details of the target audience, marketing strategies, and promotional tactics.
5. Eco-efficiency measures for sustainability: This covers the team's approach to minimizing waste, reducing energy consumption, and using sustainable materials.
6. Ethical and deontological concerns: An overview of the important ethical principles and how the team will ensure that the project adheres to these principles.
7. Project development: A detailed description about the process of the project, highlighting key milestones and challenges.
8. Conclusion: This is a summarizing of the findings and outlines of the project, and recommendations for future work.

A summary of the report structure can be seen in Table 3.

Table 3: Report structure

Number	Task	Description
1	Introduction	An introduction to our project and the main points.
2	State of the Art	Analysis of the environment, actual products and similar.

Number	Task	Description
3	Project Management	How the team is going to manage the hour of works and objectives for each sprint.
4	Marketing Plan	Market analysis, SWOT analysis, strategies for positioning our brand.
5	Eco-efficiency Measures for Sustainability	How the project can be ecofriendly and sustainable.
6	Ethical and Deontological Concerns	Directives and ethics that need to be followed as an engineer.
7	Project Development	General evolution of the project.
8	Conclusions	Team's conclusions and future work that can be developed.

2. State of the Art

2.1 Introduction

The group at first selected the topic “Smartification of everyday object”. These topic aims to smartify different objects that we use everyday as for example: eletronic elements, tools, objects, etc.

Smartification can be defined as the creation of *“smart products are based on digitized (or cyber-physical) products, which consist of physical, intelligent and connected components and are capable of a digital upgrading through internet-based services”* **[Günther Schuh, Violett Zeller, Jan Hicking, Anne Bernardy, 2019]**.

Once the group knew what the goal was, the project needed a basis of a technological knowledge as programming, electronic, design, human necessities and mechanical.

At first the members started with a brainstorm. In the brainstorm each member talked about their different ideas and thoughts. At the end, a top three of products was made. This top was made by picking types of products that were most interesting for the topic of the project and products where each member could contribute in a different way.

In the paragraphs below, the three ideas will be discussed.

2.2 Adjustable furniture

In recent years, the importance of ergonomics in the workplace has become increasingly apparent. One solution to promote healthy posture and reduce the risks of sedentary behaviour is the use of adjustable furniture. Adjustable furniture is designed to accommodate the individual needs of users by allowing them to easily adjust the height, angle, or position of the furniture.

One example of state-of-the-art adjustable furniture is the Altwork Station, which is designed to allow users to work in a variety of positions, including lying down, standing, or sitting. The Altwork Station's

unique design provides users with a range of adjustable features, including adjustable monitor heights, keyboard and mouse placement, and seat recline **[Altwork, 2023]**.

Another example of adjustable furniture is the Herman Miller Aeron Chair, which has been recognized as a design classic due to its innovative ergonomic design. The chair is designed to support the body in a natural posture, with adjustable features such as lumbar support, tilt, and armrests **[Herman Miller Inc., 2023]**.

The Steelcase Gesture Chair is another example of adjustable furniture that has received recognition for its innovative design. The chair is designed to accommodate a range of postures and movements, with features such as 360-degree arm rotation, adjustable seat depth, and backrest height adjustment **[Steelcase Inc., 2023]**.

In addition to chairs, adjustable desks are also becoming increasingly popular in modern workspaces. The Varidesk ProDesk 60 Electric is a sit-stand desk that allows users to easily switch between sitting and standing positions. The desk can be adjusted to a range of heights, and its sturdy frame can support up to 250 pounds **[Varidesk LLC., 2023]**.

The Uplift Desk is another popular adjustable desk that is designed to promote healthy posture and movement. The desk can be easily adjusted to different heights, and it includes features such as programmable memory settings, a spacious work surface, and an adjustable keyboard tray (UpliftDesk, 2021).

Other examples of innovative adjustable furniture include the Ergotron WorkFit-TL, the Humanscale Float Table, the Fully Jarvis Bamboo Standing Desk, the Steelcase Flex Collection, and the Haworth Fern Chair. Each of these products is designed with the goal of promoting healthy posture and reducing the risks of sedentary behaviour in the workplace.

In conclusion, adjustable furniture is becoming increasingly popular in modern workspaces due to its ability to promote healthy posture and movement. The state-of-the-art in adjustable furniture includes a range of innovative designs, including chairs, desks, and modular systems, that can easily be adjusted to accommodate the individual needs of users. By incorporating adjustable features into the workplace, employers can promote a healthy and productive work environment.

2.3 Smart furniture

Smart furniture is an emerging field that combines traditional furniture design with advanced technologies such as sensors, microcontrollers, and actuators. It is designed to be more responsive, interactive, and adaptive to the needs of its users. In the following an overview of the state-of-the-art in smart furniture, highlighting the most innovative and cutting-edge designs in the field.

One of the most inspiring furniture on the market is the Sobro Smart Coffee Table, which includes features such as built-in Bluetooth speakers, a touch control panel, a charging port, and a refrigerated drawer. The coffee table's advanced features are designed to enhance the user's entertainment and productivity experience **[StoreBound LLC., 2023]**.

Another example of smart furniture is the Ori Robotic Furniture System, which is designed to transform small spaces into dynamic and functional living areas. The furniture system includes features such as motorized cabinets, a retractable bed, and a hidden workspace. The Ori system is controlled through a mobile app, which allows users to adjust the furniture configuration according to

their needs **[Ori Design Studio, 2023]** .

The Kelvin Home Coffee Roaster is another example of smart furniture that combines advanced technology with traditional furniture design. The coffee roaster includes features such as a touchscreen interface, temperature sensors, and a smoke suppression system. The coffee roaster's advanced features allow users to roast their own coffee beans with precision and ease **[Ikawa Ltd., 2023]**.

In addition to home furniture, smart office furniture is also becoming increasingly popular in modern workspaces. The Herman Miller Live OS system is a smart furniture system that includes features such as height-adjustable desks, smart chairs, and a mobile app that tracks the user's activity and provides personalized recommendations for optimal ergonomic posture. Some of this features is presented in the other chapters of the state of the art **[Herman Miller Inc., 2023]**.

All in all, smart furniture is an emerging field that is transforming traditional furniture design by incorporating advanced technologies such as sensors, microcontrollers, and actuators. The state-of-the-art in smart furniture includes a range of innovative designs, including coffee tables, robotic furniture systems, and smart office furniture. By incorporating smart furniture into the home or workplace, users can enhance their productivity, entertainment, and overall lifestyle experience.

2.4 Ergonomic furniture

Ergonomic furniture is designed to provide users with maximum comfort, support, and efficiency while minimizing the risk of injury and strain. This type of furniture is becoming increasingly popular in modern workplaces and homes, as people become more aware of the importance of maintaining good posture and reducing the risk of musculoskeletal disorders.

The first example of ergonomic furniture is the Steelcase Gesture Chair, which is designed to adapt to a wide range of postures and movements. The chair includes features such as 360-degree swivel, adjustable seat depth, and a flexible backrest that mimics the natural movement of the spine. The Steelcase Gesture Chair is also designed to provide support for the arms and shoulders, reducing the risk of strain and injury **[Steelcase Inc., 2023]**.

Secondly is the Humanscale Float Table, this design promotes movement and reduce the risk of static posture. The table includes features such as a counterbalance mechanism that makes it easy to adjust the height of the table, as well as a built-in cable management system that keeps wires and cords organized and out of the way. The Humanscale Float Table is also designed to be environmentally friendly, using sustainable materials and production methods **[Humanscale, 2023]**.

In addition the Varidesk Pro Plus is another example of ergonomic furniture that has become increasingly popular in modern workplaces. Its height-adjustable Feature allows users to switch between sitting and standing positions throughout the day. The desk is designed to be easy to use, with a simple lever that allows users to adjust the height of the desk to their preferred position. The Varidesk Pro Plus is also designed to be durable and long-lasting, with a sturdy construction that can support up to 35 pounds **[Varidesk LLC, 2023]**. In addition to chairs and desks, ergonomic furniture also includes accessories such as footrests, keyboard trays, and monitor stands.

In conclusion, ergonomic furniture is an essential part of modern workplaces and homes, designed to provide users with maximum comfort, support, and efficiency while minimizing the risk of injury and strain. The state-of-the-art in ergonomic furniture includes a range of innovative designs, including

chairs, desks, and accessories. By incorporating ergonomic furniture into the home or workplace, users can promote good posture, reduce the risk of musculoskeletal disorders, and improve their overall health and wellbeing.

2.5 Conclusion

Based on the state-on-the-art above, the team chose to focus making an adjustable kitchen with different features from the researched types of the already existing types of furniture. With this research, the team picked features from the different existing types of furniture to implement in the new product. The features are listed below:

1. Adjustable furniture: From the already existing adjustable furniture, the new product will have an innovative design with desks and modular systems that can be adjusted to the users needs.
2. Smart furniture: The features from the already existing smart furniture are going to be incorporation of advanced technologies with sensors and controllers.
3. Ergonomic furniture: Ergonomic feature that will be implemented into the product will be adjustability of the furniture to maximize comfort, support and efficiency while minimizing the risk of injury.

Although this topic is already being addressed by others, the idea of a new envisaged product differs from existing ideas. As discusses before, the team will design a product that targets people who live in small spaces, as it will help to optimize the space available. Also, this project fits great in the team, as every member of the team can contribute in different ways to this project.

3. Project Management

3.1 Scope

The scope of a project refers to the boundaries or limits of a project, defining what will be or wont be included in the projects deliverables. The scope contains the goals, task and recources required to achieve a desired outcome.

A project scope refers to the specific details of a project, including the goals, deliverables and requirements of the project. It outlines the specific deliverables that needs to be produce which will help the team to successful complete the project. The project scope is an important part of project management, as it provides a framework for planning, executing and controlling the project. An properly defining project scope helps to ensure that all stakeholders have a clear understanding of what is expected of the project and minimizes the risk of misunderstandings or miscommunication during the execution of the project. The project scope is defined in a work breakdown structure (WBS), which can be found in Figure 2. The WBS is a tool to give an overall overview of the project scope.

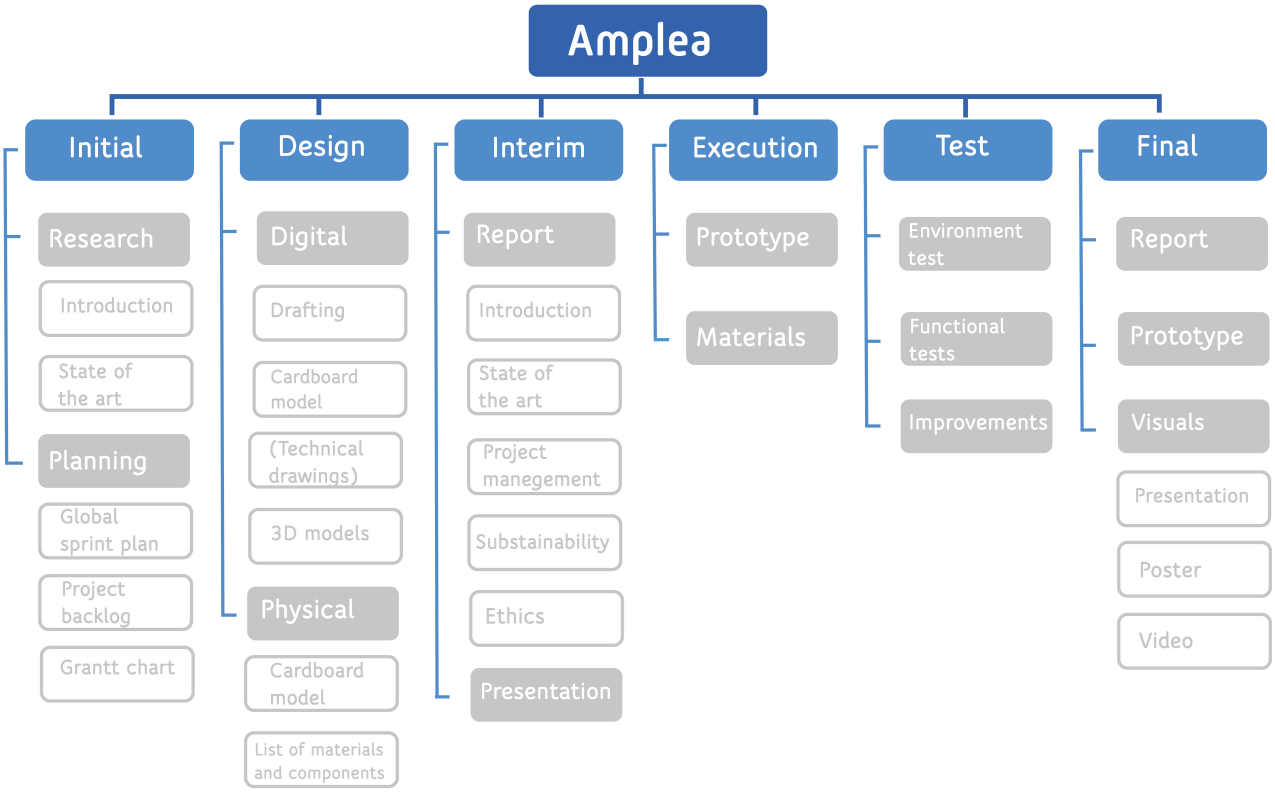


Figure 2: Project scope

3.2 Time

Below, there is the list of the milestones all the teams had to follow. Almost every weeks, a file needed to be upload.

- 2023-02-26 Choose a project proposal and send your choice via email to epsatisep@gmail.com
- 2023-03-08 Define the Project Backlog (what must be done and key deliverables - every member should preferably participate in every task), Global Sprint Plan, Initial Sprint Plan (which tasks should be included, who does what) and Release Gantt Chart of the project and insert them on the wiki (planning)
- 2023-03-15 Upload the “black box” System Diagrams & Structural Drafts to the wiki
- 2023-03-22 Upload the List of Components and Materials (what & quantity) to the wiki
- 2023-03-29 Upload the detailed System Schematics & Structural Drawings to the wiki and do the cardboard scale model of the structure
- 2023-04-16 Upload the Interim Report and Presentation to the wiki. The report must contain the the following chapters: Introduction, Project Management, State of the Art, Marketing Plan, Eco-efficiency Measures for Sustainability, Ethical and Deontological Concerns, Proposed Solution and Bibliography. In particular, the Project Management chapter includes the updated project progress register, the sprint report for completed sprints (tasks that were included, statuses, assignees, allocations) and the updated release Gantt chart
- 2023-04-20 Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks
- 2023-04-26 Upload the final List of Materials (local providers & price, including VAT and transportation), and 3D model video to the wiki

- 2023-05-07 Upload refined Interim Report (based on Teacher & Supervisor Feedback)
- 2023-05-24 Upload packaging solution to Deliverables and Report
- 2023-06-31 Upload the results of the Functional Tests to the wiki
- 2023-06-18 Upload the Final Report, Presentation, Video, Paper, Poster and Manual
- 2023-06-22 Final Presentation, Individual Discussion and Assessment (reserve the whole day)
- 2023-06-27:

1. Update the wiki, report, paper with all suggested corrections
2. Place in the files section of the MS Teams channel of your team a folder with the refined deliverables (source + PDF) together with all code and drawings produced
3. Hand in to the EPS coordinator a printed copy of the refined report and poster

- 2023-06-29:

1. Hand in the prototype and user manual to the client
2. Receive the EPS@ISEP certificate
3. Bring typical food from your country

The Gantt chart allows to see how the team organize itself, and the tasks will be detailed better later.

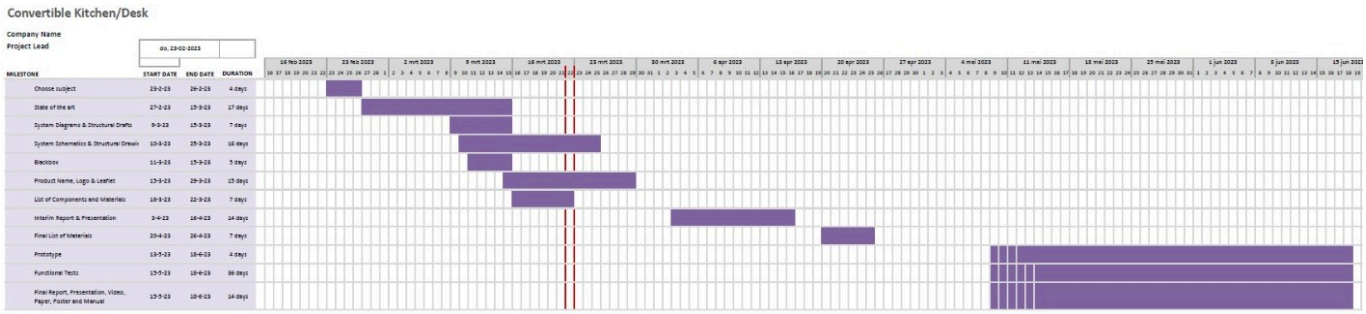


Figure 3: Release Gantt chart

ganttchart.pdf

3.3 Cost

Document the planned vs. effective costs of your project.

Regarding the cost of the project, it is difficult to estimate it. The project last for 5 months with 5 members are participating in the team. As the country of the university is Portugal, the wage of the team member is estimated at 1 500 euros per month. Multiple by 5 (people), for 5 months, the final human ressource cost would have been 37 500 euros. The team also uses a workingroom that is dedicated to all the projectgroups. This place will not be taken into consideration, but there will be usage of electricity for lightning and electronic devices.

The budget for the project is 100 euros. This budget includes all of the components for the physical prototype.

3.4 Quality

The term “quality” is inherently subjective and can be understood through the ISO definition, which emphasizes the features and characteristics of a product or service that contribute to its ability to fulfill stated or implied needs. In simpler terms, a product is deemed to have good quality when it meets the requirements specified by the client. In the context of analytical work, quality can be defined as the delivery of reliable information within agreed-upon timelines, conditions, and costs, with necessary aftercare. The “agreed conditions” should include specifications related to precision and accuracy of data. However, in many cases, the reliability of data is not questioned, and specifications may be omitted, especially when laboratories follow established methods and procedures with inherent default specifications. Additionally, not all future uses of data and reports can be anticipated, making it challenging to provide precise specifications for required precision and accuracy. As a result, laboratories often have discretion in determining and documenting the aspect of quality.

To manage a project with a good quality the work needs to be efficient, and the requirements specification should be respected. Either the timelines and the technics specifications asking by the client have to be taken in account. The efficient work is directly linked to the timelines even if sometimes others elements as the arrival of the raw material, or subcontractor work, can affect the delivery-date. The studies before the product launch define the project and production budget and the cost of the final product.

3.5 People

Effective task delegation is a key aspect of project management that can significantly impact the overall success of a project. Here are some important considerations for task delegation:

1. Clarity of Responsibilities: Clearly defining and communicating the responsibilities and assignments of team members is crucial to ensure that everyone understands their roles and what is expected of them. This includes specifying the scope, timeline, and deliverables of each task, as well as any dependencies or constraints.
2. Capability and Interest of Team Members: Assigning tasks based on the capabilities and interests of team members can lead to optimal performance. It is important to assess the skills, expertise, and preferences of team members and assign tasks that align with their strengths. This can increase motivation, engagement, and productivity, resulting in better outcomes.
3. Collaboration and Synergy: Encouraging collaborative efforts among team members can foster innovation, creativity, and problem-solving. Complex tasks can often be accomplished more effectively through teamwork, where team members can leverage their diverse skills and perspectives to achieve the best results. Facilitating communication, coordination, and knowledge sharing among team members can enhance collaboration and synergy.
4. Monitoring and Support: Once tasks are delegated, it is important to monitor progress and provide support as needed. Regular check-ins, progress updates, and feedback sessions can help ensure that tasks are on track and any obstacles or challenges are addressed in a timely manner. Providing necessary resources, tools, and training can also support team members in completing their tasks effectively.
5. Flexibility and Adaptability: Project dynamics may change over time, and it is important to be flexible and adaptable in task delegation. Adjustments may be needed based on changing priorities, resource availability, or unforeseen circumstances. Being open to reassigning tasks or redistributing workload can help maintain efficiency and effectiveness in project management.
6. By ensuring clarity of responsibilities, leveraging team members' capabilities and interests, fostering collaboration, and providing monitoring and support, effective task delegation can

contribute to seamless project management and enhance project outcomes. It promotes efficient resource utilization, reduces duplication of efforts, and maximizes team performance, leading to successful project completion.

The detailed of the roles are will be discussed in chapter 3.10 of this report, and will be classified by sprint. As it was already explained, the team is composed of 5 students, Jan, Julie, Mario, Astrid and Clément. The whole team decided there will not be a team leader but only a task leader. The teachers and coaches will shadow the project and will advise the team with thoughts they have.

3.6 Communications

At start of the semester the team created a WhatsApp group to be able to communicate, share ideas and thoughts, and to schedule meetings. The meetings were mostly at ISEP (80%), for some meetings we met at a team members accommodation (15%) and a few times we organized an online meeting on MS Teams (5%).

Figure 4: Diagram of our meeting location

To share our files, the programs: MS Teams, Trello and Miro were used to organize the work and ideas. These programs and websites are dedicated to workshare. Below, a communication matrix is shown, explaining how the communication is within the team.

Table 4: Communication Matrix

What	Why	When	To Whom	How
Brainstorming	To share the idea	Every time we needed to	To the team	Face to face meeting, vote on WhatsApp
Agenda	To prepare the weekly meeting	On Tuesday or Wednesday	To the team	Reuniting what has been done during the week
Meeting with the supervisors	To present them where we are	On Thursday morning	To the supervisors	Slideshow presentation
Interim presentation	To have a big appointment	20/04/2023	To everyone	Slideshow presentation
Deliverable	To validate the deadlines	Every time we needed to	To the supervisors	Updating the wiki

What	Why	When	To Whom	How
Final presentation	To conclude our project	22/06/2023	To everyone	Slideshow presentation

3.7 Risk

Risk management is a systematic process used to identify, assess, prioritize, and mitigate risks that may affect the achievement of project or organizational objectives. The risk management process typically involves the following steps:

1. Risk Identification: This step involves identifying potential risks that may arise during the project or organizational activities. This can be done through techniques such as brainstorming, checklists, SWOT analysis, and expert opinions.
2. Risk Evaluation: Once risks are identified, they need to be evaluated to understand their potential impact and likelihood of occurrence. This can be done by assessing the severity of consequences, the probability of occurrence, and the ability to detect and respond to the risks.
3. Risk Handling: After evaluating risks, the next step is to develop appropriate strategies to handle them. This may involve risk mitigation, risk transfer, risk acceptance, or risk avoidance strategies, depending on the nature of the risks and the organization's risk appetite.
4. Risk Monitoring and Control: Once risks are identified and strategies are implemented, it is important to monitor and control them throughout the project or organizational activities. This may involve tracking risks, updating risk registers, analyzing risk trends, and implementing risk response actions.
5. Collaboration with Risk Owners: The project professional works closely with the risk owners, who are responsible for managing specific risks, to ensure that risks are clearly identified, analyzed, and managed effectively. Risk owners are typically individuals or teams who have the knowledge and expertise to manage the risks.

The overall goal of risk management is to minimize the impact of risks on the project or organization by proactively identifying and addressing them. By following a systematic risk management process, project professionals can enhance the chances of project success and minimize the negative consequences of risks.

Table 5: Risk analysis

Risk	Probability (1 to 10)	Detection	Impact (1 to 10)	Consequences	How to prevent
Nobody is able to do a task	3	Impossibility to go on	7	Impossibility to go further on the project, need to think again, go back to find a solution	Identify the tasks previously and if it is not doable, find an other way
Need to exceed the budget	8	Need of component	4	Impossibility to continue on the prototype	Find the cheapest components that correspond to the technical expectations and create a list for the team of what is needed to be order

Risk	Probability (1 to 10)	Detection	Impact (1 to 10)	Consequences	How to prevent
Impossibility to have sustainable product	5	Price of the component to high or for technical issues	2	Impossibility to respect the first requirement, the motivation to be respectful of the environment	The aim was to produce something sustainable but the main objective is to have an ergonomic and usable furniture
Public not interested in the product	2	Impossibility to sell it	10	Lose a lot money and time	The market analysis need to be review during the entire project
A user break the product during the guaranteed	3		between 1 and 8	If it is in less than 2% of the case, separate issue. If it is not, important issues in the product	Be really careful during the 3D model test and the final test of the product
New company	4	Information or when their product is launch	6	New competition	Try to inform regularly
Long sickness or absence	2	The person inform the rest of the team	4	Share his/her work and try to do what the team can, possibility to not be able to do all the work	Nothing obvious, take care of ourselves
Don't have enough time to finish the prototype	7	When the final presentation will be closed	3	Not being advanced enough to satisfy the supervisors	Try to be the most efficient the team can, especially concerning the 3D model

Thanks to this table we can identify the most high chances risk the team can deal with. Hopefully there is no high chance risk with big impact at the end. That is reassuring but it is important to be careful at every decision taken to evaluate the risk and consequences of a bad choice.

3.8 Procurement

As it is written earlier, the budget is tight: 100 euros. The final product will probably cost thousands of euros, but the idea is to have a product intended for small accommodation. The aim is therefore to have the lowest final price while having interesting quality. To do that, it is necessary to limit as much as possible the cost of transportation because of pollution. Our main market being located in Asia, the factory will be implemented there. The factory will manufacture the cupboards, the desk, and the table panels. The materials of those furniture’s parts are coming from KML, which is a Wilsonart Company. Wilsonart is a global manufacturer and distributor of High Pressure Laminates and other engineered composite materials, used in furniture, with an manufacturing site in Shanghai, China. The electronic components typically originate from this geographical region, resulting in relatively short travel distances. The features, such as the tap, the cooking plates, the sink, the plugs will be provided by Leroy Merlin and Ikea, two huge chain shops implemented all over the world. The rails system will

be designed and created by the team and manufactured by a partner in the eastern asian region. Amplea will make a call for tenders and choose which one is the most interesting concerning again, the price, the quality, the timings and a sustainable and eco-friendly production. Finally the elevation system is developed by a company implemented in South Korea and in Japan.

3.9 Stakeholders Management

In the table below, there are the stakeholders and some information about their roles. It is important to identify everything to prepare the contact with each of them.

Table 6: List of stakeholders and their roles

Group of people	**Role**	**Influence**	**Contact with the team**	**Expectations**
Suppliers	Provide the components and the raw material	Moderate	During the whole contracts	Written in the contracts
Buildings owners	Buy a quantity of product and implement it to their accommodations	Moderate	When the trade is made or when there is a disfonctionnement	To not having issues or disfonctionnement
Daily users	Using the product. The majority will be renting from the buildings owners	High	None expect review and feedback	Having a functional furniture
Governments	Verify that we are not selling something not conform	Low	Rarely, when there is a problem	Our product respects their laws

3.10 Project Plan

Define your optimal sprint duration and plan your sprints until project end using Global Sprint Plan Table 7.

Table 7: Global Sprint Plan

Sprint	**Start**	**Finish**	**Status**
1	23/2/2023	01/3/2023	Finished
2	02/3/2023	08/3/2023	Finished
3	09/3/2023	15/3/2023	Finished
4	16/3/2023	22/3/2023	Finished
5	23/3/2023	29/3/2023	In progress
6	30/3/2023	02/4/2023	
7	15/4/2023	19/4/2023	
8	20/4/2023	26/4/2023	
9	27/4/2023	03/5/2023	
10	04/5/2023	10/5/2023	
11	11/5/2023	17/5/2023	
12	18/5/2023	24/5/2023	

Sprint	Start	Finish	Status
13	25/5/2023	31/5/2023	
14	01/6/2023	07/6/2023	
15	08/6/2023	14/6/2023	
16	15/6/2023	21/6/2023	
17	22/6/2023	28/6/2023	
18	29/6/2023		

Build your project backlog, including all relevant tasks/deliverables, using Project Backlog Table 8. Prioritize all backlog items (PBI), keeping higher priority items at the top, and lower priority at the bottom.

Table 8: Project Backlog

PBI	Title	Status
A	Define Project	Done
B	Global Sprint Plan	Done
C	Gantt Chart	Done
D	Research	Done
E	State of the Art	Done
F	Define direction of Solution	Done
G	System Diagrams & Structural Drafts	Done
H	System Schematics & Structural Drawings	To do
I	3D Modelling	To do
J	Marketing Plan	To do
K	Eco-efficiency Measures for Sustainability	To do
L	Integration of Smart Features	To do
M	Interim Presentation	To do
N	List of Materials	To do
O	Video of the 3D Model	To do
P	Packaging Solution/Building Plan	To do
Q	Functional Test	To do
R	Final Report	To do
S	Presentation	To do
T	Paper	To do
U	Poster	To do
V	Upload	To do

Plan each sprint at its beginning (Sprint Planning session) using the Sprint Plan Table 9.

Table 9: Sprint 1

Sprint	Task	Duration (d)	Responsible	Involved
1	A	7	All	All

Table 10: Sprint 2

Sprint	Task	Duration (d)	Responsible	Involved
2	A	7	All	All
2	B	7	JH	JS,C,A,M,JH
2	C	7	JH	JS,C,A,M,JH
2	D	7	JS,C,A,M,JH	JS,C,A,M,JH

Table 11: Sprint 3

Sprint	Task	Duration (d)	Responsible	Involved
3	D	7	All	All
3	E	7	JS	JS,C
3	F	7	A	A,M,JH
3	G	7	M	JS,C,A,M,JH

Review each sprint at its end and update each item status on the Progress Register Table 12.

Table 12: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
1	A	All	All	Done
1,2	B	JH	JS,C,A,M,JH	Done
2	C	JH	JS,C,A,M,JH	Done
2,3	D	JS,C,A,M,JH	JS,C,A,M,JH	In progress
3	E	JS	JS,C	In progress
3	F	A	A,M,JH	In progress
3	G	M	JS,C,A,M,JH	In progress

Identify key project deliverables (when they will be started and completed) and build a release Gantt chart. See Figure 4 for inspiration.

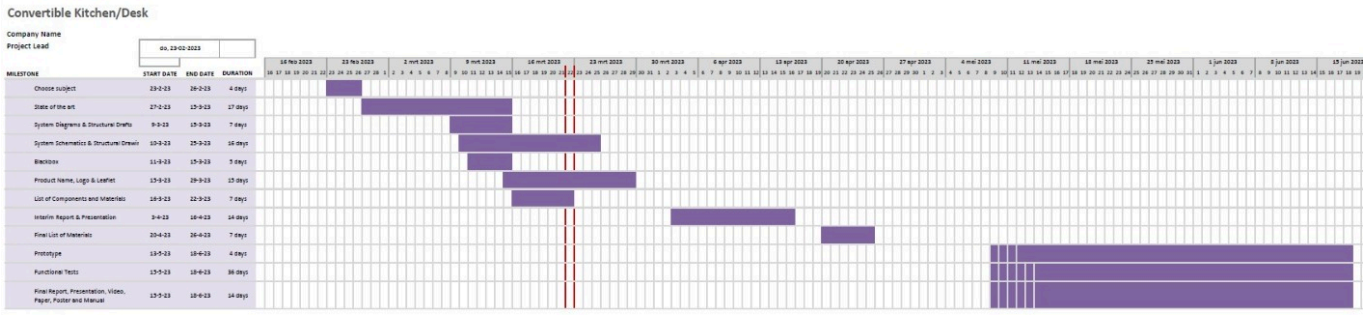


Figure 5: Release Gantt chart

ganttchart.pdf

3.11 Sprint Outcomes

Since the first week of the project, the team have defined an product backlog as saw in the wiki. Also, the team defined that the sprints would take only 1 week, everytime that there was a meeting with the coaches. There are cases that some of the sprint would take longer than 1 week, they will take 2 weeks instead. The main reason are the holidays that are planned in the school schedule, so there wasn't any meeting with the coches during 14 days.

At the end for each sprint, the team meet up and talked about the planning of the project. The main things that were discussed after the srpints were: if someone needed help with some task, if all tasks were done, if there was some invconvenience and what are the next tasks to do.

Since the agile method class we took it in the Sprint 7 and the teacher showed how to do the sprint reviews during that sprint, there will may errors in the next tables as the team didn't wrote down what were talked in the reviews.

Also, the hours may don't be the same for the differents sprints, as the begging the team was doing all together the tasks as: research, looking in the competition, looking for similar products, etc.

After some weeks working together can see that the hours starts to stabilize. This is done because after the sprint 4 each member of the team starts working on independent tasks and also because there are some tasks from before sprints to do. The hours of classes are presented but not counted is the velocity calculation.

Table 13: Sprint 1 16/02-22/02. Velocity: 6h.

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Choose topic	All	1h	X		The team after selected 3 topics to work at it
Brainstorming	All	5h	X		After having the toopic choosen, the team thought about different ideas to do implement

Table 14: Sprint 2 23/02-01/03. Velocity: 20h.

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Define the project ideas together with design thinking	All	10h	X		Definen project with the design thinking
State of the art	Jan, Mario, Clement	4h	X		Done, but after the meeting with the coaches we need to redo
Research	All	5h	X		Looked for products simila to the ideas that we presented.
Motivation	All	1h	X		Do the beggining points of the introduction chapter

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Classes	All	21h	X		

Table 15: Sprint 3 02/03-08/03. Velocity: 23h.

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
First sketches	Astrid, Clement, Mario	10h	X		First sketches of the furniture and which features would have
Select the final project	All	1h	X		Selected the main project and change the topic
Brand and logo	Julie	3h	X		
Blackbox	Clément	2h	X		
References in the wiki	Mario	2h	X		Know how to work with references and add them in the wiki
Research in the cooking plates	Astrid	1h	X		Check what cooking plates are in the web
Change the state of the art	Julie, Jan	4h	X		Redo state of the art
Classes	All	18h	X		

Table 16: Sprint 4 09/03-15/03. Velocity: 19h.

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Project Scope with elevat pitch	Julie	3h	X		
Do project managment	Jan	3h		X	Need to define risk, etc.
Start 3D model ideas	Clément, Jan	10h	X		Done two different versions
Finish introduction	Mario	2h	X		
Week report	Astrid	1h	X		
Classes	All	11h	X		

Table 17: Sprint 5 16/03-22/03. Velocity: 33h.

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Choose a model	All	2h	X		One of the two versions selected.
Design the structure of the furniture	Jan	8h	X		

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Design the rail system and table system	Clément	8h	X		
Leaflet	Julie	3h		X	First version done, but need the final photos of the design to finish the leaflet
Choose mateirals	Mario	6h	X		Materials compared and uploaded to wiki
Define user cases	Mario	2h	X		
Change gantt chart	Astrid	2h	X		
Make presentation for the meeting	Clément	1h	X		
Change project scope	Julie	1h	X		
Classes	All	19h	X		

Table 18: Sprint 6 23/03-29/03. Velocity: 34h

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Hardware selection	Jan	2h	X		
Define direction of solutions	All	1h	X		
Hardware components talk with teacher	Astrid, Mario, Jan	1h	X		
Start final design, extensible table	Clément	5h	X		
Start final desing, elevate desk	Jan	5h	X		
Chapter marketing plan	Mario	6h		X	only did 4.2
Define which materials to use	Mario	4h	X		
Presentation marketing	Julie	2h	X		
Cardboard model	Astrid, Julie	4h	X		
Blackbox diagram	Astrid, Julie	1h	X		Do it more beautiful
Classes	All	13h	X		

Table 19: Sprint 7 30/03-12/04. Velocity: 33h

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Finish marketing plan	Mario	3h	X		All chapter market finished
Details schematics	Jan	3h		X	Must be done in the next sprint
Do user case for software	Mario	2h	X		

Product Backlog Item	Assignee	Planned Effort	Completed	Not completed	Notes
Do software structure for the project	Mario	2h	X		Presented two different versions (bluetooth and cloud service)
Redo blackbox diagram	Mario	1h	X		Coaches told us to do some changes
Improve elevation system	Jan	5h	X		
Improve extension system	Clément	5h	X		
Choose components to implement	Clément	3h	X		
Check errors for the wiki	Astrid	2h	X		
Define elevation sysmte to use	Jan	3h	X		
Redesign logo and design photos for the wiki	Julie	4h		X	Will need to some extra photos for the wiki in the next sprint
Classes	All	9h	X		

3.12 Sprint Evaluations

As mentioned in the last point, the team didn't wrote down all the retros after each sprint until the sprint 7. For that reason, may there retros that are described in this chapter aren't full, as are the feelings that each member had for that sprint and what they remember for them.

Table 20: Sprint 1

Positive	Negative	Start doing	Keep doing	Stop doing
Great group, the team works good, first contact with the group so no problem yet	Nothing	Nothing	Nothing	Nothing

Table 21: Sprint 2

Positive	Negative	Start doing	Keep doing	Stop doing
Working great, any problem	The team still doesn't have a clear idea of what the project will be about	Nothing	Nothing	Nothing

Table 22: Sprint 3

Positive	Negative	Start doing	Keep doing	Stop doing
Communication and work have been done correctly, teambuilding activity was lovely	Nothing	Nothing	Keep great ambient	Nothing

Table 23: Sprint 4

Positive	Negative	Start doing	Keep doing	Stop doing
The team has some good ideas, people are doing their stuff and there is not any problem	The coaches may criticize some stuff that doesn't feel as important	Talking more to each other to try to have more balance work	Nothing	Nothing

Table 24: Sprint 5

Positive	Negative	Start doing	Keep doing	Stop doing
The team discussed about some stuff related to the behavior team without being rude, great experience to about teambuilding	Nothing	try to do better the tasks, try pay attention when someone of the group talks	Balance work and talking more about the problems	Try to no comfort with the basics and try to work all the time at class

Table 25: Sprint 6

Positive	Negative	Start doing	Keep doing	Stop doing
The team talked with the coaches and they give interesting feedback	Bit of stress about the project, but not with the mates	Try to help each other in any case	Still working as we are doing	Nothing

Table 26: Sprint 7

Positive	Negative	Start doing	Keep doing	Stop doing
Vacation, family visits and friends visits, everyone was doing stuff in the vacations	Nothing	Nothing	Nothing	Nothing

- Summary

For now, the team is working good together. After each sprint, the teams meets up and talks about the sprint, how they feel and what is going to be the next tasks. The team didn't suffer any internal problem and every time that someone wanted to say something the others listened. The suggestions from the coaches, the secretary of the team wrote down during the meeting and update it after the meeting, so there is a logbook where is possible to find how went all meeting summarized. In the sprint 5 the team meets up for an activity of team building where they need to score the personal experience of each member in the team. There, the team talked about the best things and worst things in the team.

3.13 Conclusion

In conclusion, project management plays a critical role in the successful completion of projects. It provides a structured approach for planning, organizing, and executing projects, resulting in improved

project outcomes. Effective project management encompasses various elements such as goal identification, resource management, timeline tracking, risk mitigation, and stakeholder communication.

By utilizing project management principles and techniques, the team can optimize resource allocation, manage risks, and ensure that project goals are achieved on time and within budget. Project management also enables teams to effectively collaborate, communicate, and coordinate efforts, leading to increased efficiency and productivity.

It helps in minimizing project risks, preventing delays, and ensuring that projects are completed successfully. It also fosters effective communication with stakeholders, ensuring that expectations are managed, and project progress is transparently communicated.

Now, the team is going to present the marketing plan, which is an essential tool, in combination with project management, to the success of a project.

4. Marketing Plan

4.1 Introduction

A marketing plan serves as a roadmap for a company's marketing efforts, outlining strategies and tactics to reach specific business goals. The team will present a marketing plan for a new product, a smart piece of furniture that can be used as a kitchen, office desk and dining table, with sensors monitoring energy and water consumption, targeted at people who live in small accomodations.

To start with, a market analysis will be conducted to gain a better understanding of the target audience, their needs, preferences, and behavior. This analysis will enable the team to develop strategies that are tailored to meet the specific needs of our target audience. A SWOT analysis will be conducted to identify the product's strengths, weaknesses, opportunities, and threats, which will guide the marketing efforts and help the team to make informed decisions.

After conducting the market and SWOT analysis, the team will identify the strategies and programs that will be implemented to promote the product in the market. These strategies will include identifying the most effective channels to reach the target audience, such as social media platforms, online marketplaces, and targeted advertising. The idea is also to develop programs that will help to engage with the target audience, such as promotions, events, and other marketing activities.

Overall, the aim of this marketing plan is to develop a comprehensive strategy that will enable the team to successfully introduce this new smart piece furniture into the already existing market. By understanding the target audience, identifying the new product's strengths and weaknesses, and developing effective marketing strategies, the team can increase the chances of success and achieve business objectives.

4.2 Market Analysis

4.2.1 Introduction to Market Analysis

The target consumers are individuals who live in small living accomodations, such as camping houses, small apartments, or student studios. The demand for smart furniture is high among people who live in these small accomodations, and our product will provide them with a practical and affordable solution. Our primary market will be in Asia, where the population density is high, and people live in smaller living spaces.

According to recent statistics, over 33 % of the world's population currently lives in urban areas, and this percentage is projected to increase to 60 % by 2030 **[Hannah Ritchie, Max Roser, 2018]**. With such a significant population shift, the demand for smart furniture that fits small living spaces will only increase. For that reason, the idea of the new product fits perfectly for those who live in small living spaces. With the increasing demand for smart furniture that can adapt and optimize space usage, the new product is positioned to be a game-changer in the industry. Mainly, because the benefits of using smaller furniture are clear. It allows individuals to maximize space, which is crucial for those living in small living spaces. Additionally, smaller furniture is more affordable, making it accessible to a wider range of consumers. With the solution of smart, adjustable furniture, consumers can have a kitchen, an office desk and dining table in one piece of furniture, which will not only save space but also money.

4.2.2 Value pitch

For starting with the market analysis, the team developed a value pitch where the main keys of the product can be seen as well as in what way and to what audience the product will be sold to. Like mentioned in the last paragraph, it is clear what the group of consumers (nitch) will be and how the team will sell the product. In Figure 6 below, the details can be found.

Figure 6: Value pitch of the product

4.2.3 Status of the market

The market for smart furniture is still relatively new, but it is expected to grow significantly in the coming years.

When the team talk about Smart furniture we need to talk about Smart home, since Smart Furniture is a part of Smart home market. The market value of Smart Home was 92.48 billion in 2022 and is projected to reach 138.9 billion by 2026. The CAGR is witness up to 10.4 % between the years 2023 to 2026. Inside Smart Home, Smart furniture is expected to growth the highest CAGR one, up to 24.8 % **[MarketsandMarkets, 2021]**.

These can be justified by the increasing popularity of smart homes and the Internet of Things (IoT), more and more people are looking for furniture that can be integrated with their smart devices and provide additional features and convenience as: energy-saving, expansion of smart home products, safety, increasing number of internet users, monitoring, etc. Figure 7 below, shows the quantity of house owners that had implemented different features from the smart homes in their houses, including the topic that we are researching, in the european market.

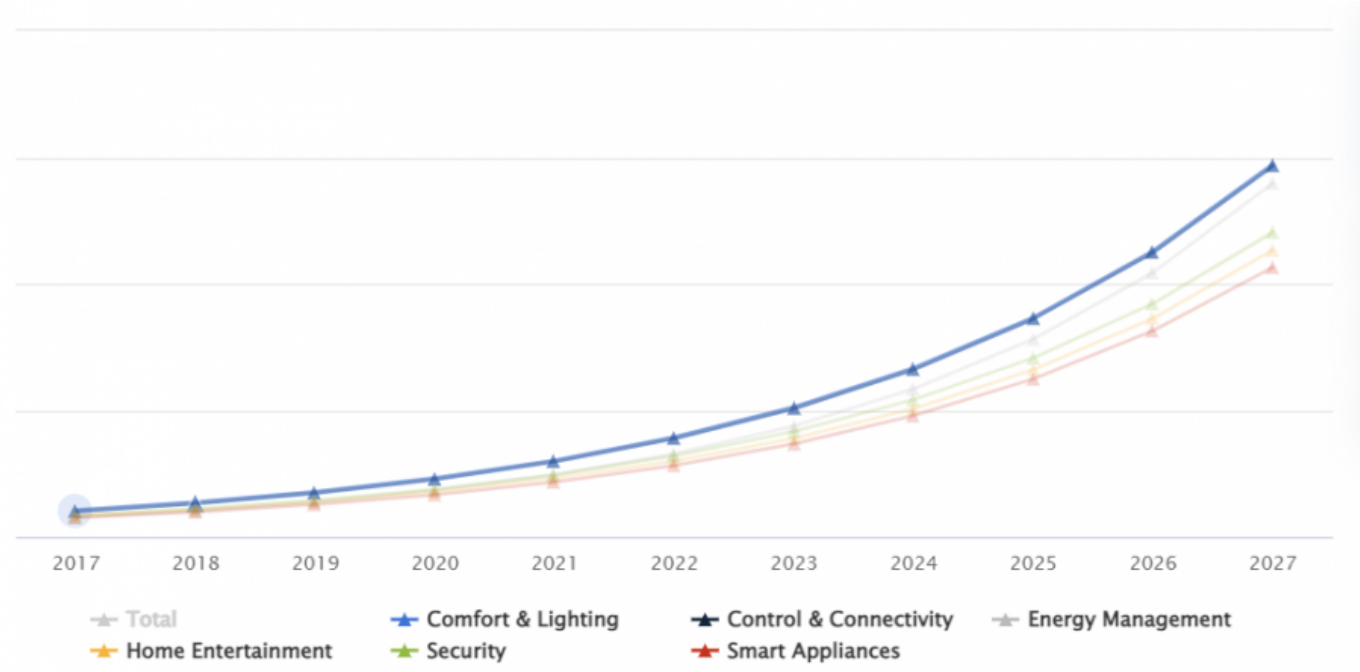


Figure 7: Status of European smart homes and the expected growth.

Having the capacity of operate in every international market, the main consumers will be located at Asia. Is very knew that Asia is suffering an overpopulation that affects direct the living space in the cities. As seen in Figure 6, the rural population in Japan lowers each year in comparison to the urban population **[Statista, 2023]**.

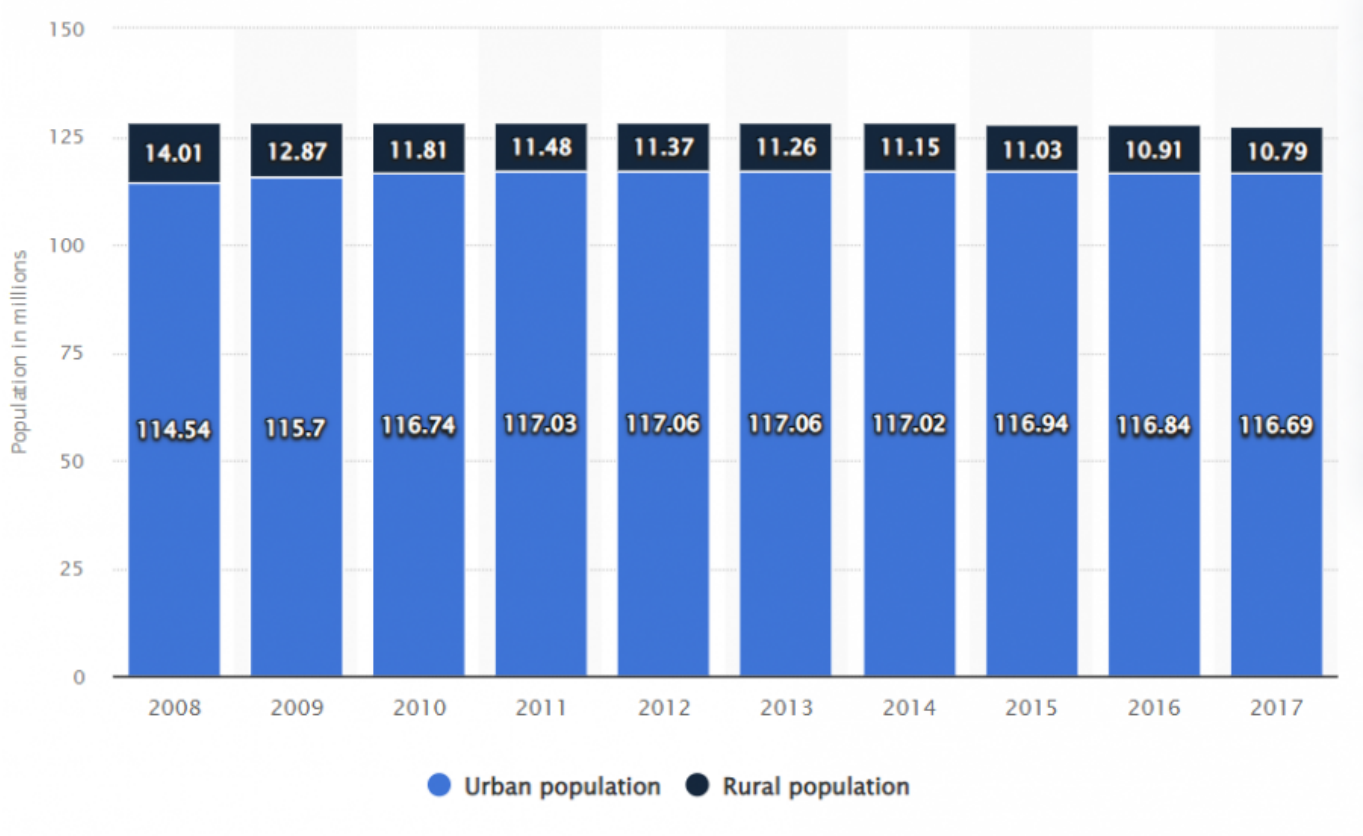


Figure 8: Population in million in urban and rural areas in Japan

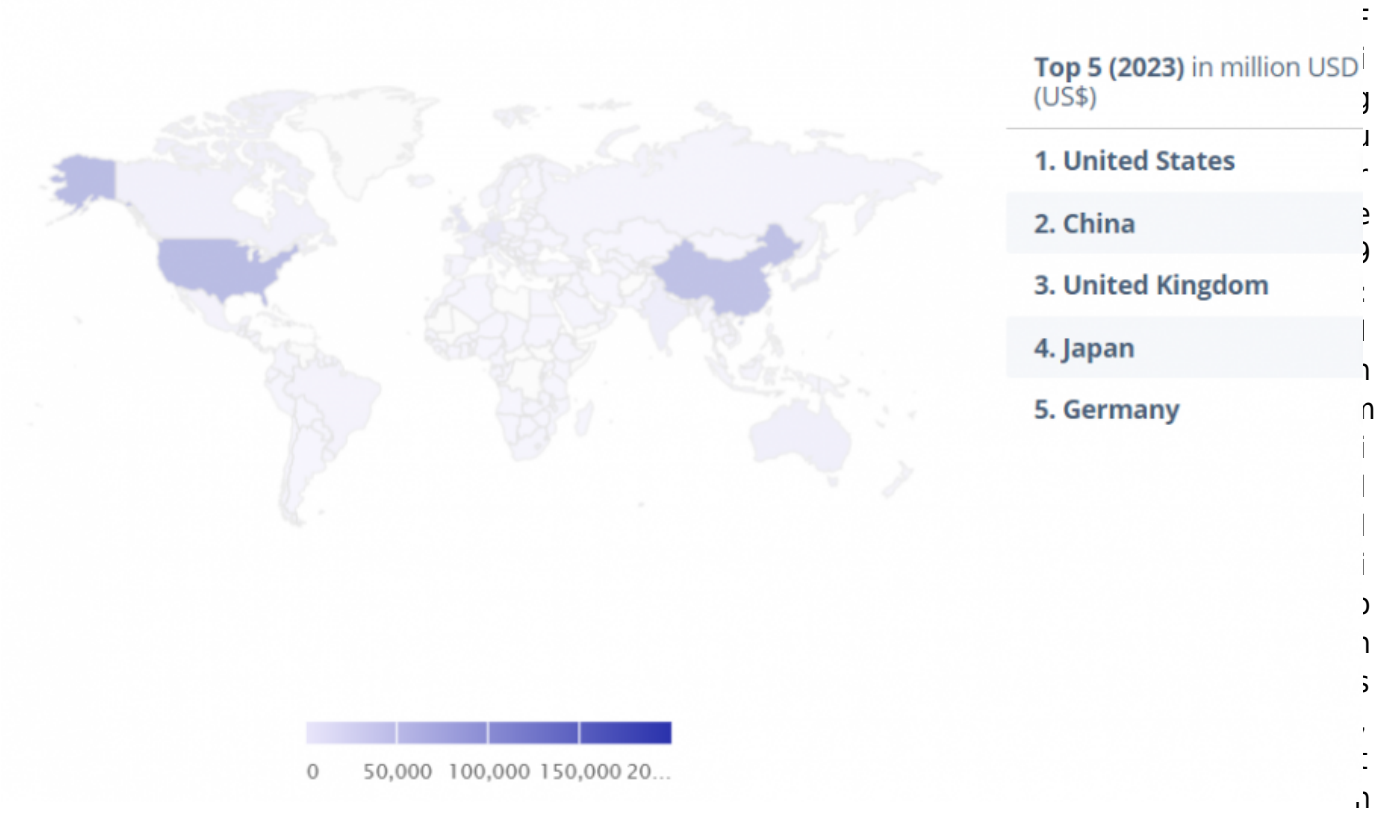
Considering that Japan is less populated in China, can expect to have the same issue in the big Asiatic, where the people is going to use to move to big cities.

Comparing the different markets present, it can be seen that there is one that stands out from the others and that is the Asian market. Largely thanks to its economic and demographic situation, it makes its market one of the most powerful and interesting to integrate the product. We can see different characteristics of different markets in the table below.

Table 27: Comparation of the differents markets

Market	Revenue (2022)	Average revenue	Revenue (2023)	Revenue change (2023)	CAGR	Users (2027)	Market volume (2027)	Market penetration (2027)
Europe	28.58 billion	449.8	35.51 billion	24.2%	12.15%	150.5 million	56.18 billion	17.8%
Asia	46.12 billion	304.5	55.19 billion	19.7%	14.26%	349.2 million	94.70 billion	12.6%
Africa	1551 million	156.9	1812 million	16.6%	11.30%	22.61 million	2718 million	3.8%
America	46.12 billion	483.1	42.89 billion	13.3%	10.63%	140 million	64.24 billion	23.2%
Oceania	46.12 billion	756	3.90 billion	13.9%	9.59%	10.25 million	5.63 billion	31.1%

And more specifically, when you look at which countries in these markets are the most important, in the top 5 are the 2 countries mentioned above. This can be seen in the following Figure:



e revenue value per countries.

For that reason, the team considers that the Asian market is a great one. As it can be seen in this image **[MarketsandMarkets, 2021]**, is expected that the smart home market related to Asia is going to be one of the highest growth in the world.

Figure 10: Asian market expectations growth

4.2.4 Competitors

The competitors is another important point to mention. Since the United States has the technological

node of research and development, it is not surprising that most competing companies are from there. The smart home market and the smart furniture market is usually adapted by famous traditional companies that are responsible for the development of furniture and tools for homes. For that reason, it is not strange to see Ikea investing in the development of this product. Below we have a list of the main competitors of the market, in which some names will not be strange since they are giants of the market.

- Bosch (Germany)
- Sony (Japan)
- Comcast (US)
- Samsung (South Korea)
- SimpliSafe (US)
- SmartHome (US)
- Amazon (US)
- Apple (US)
- Siemens (Germany)
- Canary (US)
- LG (South Korea)

The team did research, looking for similar products in the competence. There are adjustable furniture already made, like for a example a wardrobe that can be converted to a table. But there aren't any products related to kitchen having the possibility of being something more. In any case, the prices are very expensive most of the times. That would be because in the price, the design part (the hardest one) it is the more complicated to develop and for that reason, the price inflates. For the product, we must look at all the expenses that occur when manufacturing it, have in terms of labour and decide together how much would be a reasonable price that would seem fair, the latter decided from a deep analysis of the consumer to know how much he would be willing to pay for our furniture. We must not forget that we try to make the furniture accessible to everyone.

4.2.5 Summary

Table 28: Market report scope

Topic	**Numbers**
Estimated Market size	92.48 billion
Projected Market size	138.9 billion
Growth rate (CAGR)	10.4 % in smart home, 24. 8% in smart furniture
years	2022-2026
Top companies	Sony, LG, Amazon, Apple, Canary, Siemens, Bosch, Steelcase, Ikea
Segments to cover	IoT, smart furniture, smart home, data, security

Having this information, the team can affirm that there is the possibility of placing ourselves in the market, or else, selling the prototype to a giant of the market. The constant growth of this market makes it a gateway to new start-ups and there are investors waiting to gain a foothold in the market.

4.3 SWOT Analysis

The SWOT Analysis can be helpfull to provide different points of views about the strengths, weakness, opportunities and threats that the project has. After brainstorming, we agreed on the following points.

The strengths in the SWOT

Product

- Monitoring: As monitoring of statistics became every time more common in our society, we considered that providing a way of monitoring the consum of water and electricity will benefit the consumers.
- Smartifying: A way of smartifying a kitchen and office desk may be attractive for new investors and new users.
- Useful: This furniture can be a smart way to optimize the space in small places, giving more living space for the users and be useful being two furniture in one.
- Multifunctional: The product contains 3 furniture in one, a kitchen, an office desk and a dining table. This is benificial for small places.

Market

- New on the market: On the current market isn't anything similar to the product.
- Growing market: With the market analysis we saw that it is a developing market and therefore, a gateway for the team's product.
- Wide target group: The target group contains: rent house owners, students, campers, residents of urban areas, etc.This is a big amount of people, so there is a big target group.

The weakness in the SWOT

Product

- Repair: As the furniture implements mechanical movement, informatics and electricty the repair of these parts can be expensive.
- Mixing elements: In the moment of implementing the furniture, the team are working in one element that contains fire, water and electricity. This may be dangerous in case of accident.
- Safety problems: With the last point mentioned, there are also other features that may are dangerous for the user, as the table movement.
- Limited people: The product, being designed to be in small spaces, cannot offer the same utility for a family as for an individual.

Market

- Usage of the product: Having a big range of users don't mean to have a group of consumers with the ability and desire to buy.
- Lack of capital: The manufactiring of the product is expensive and there is not enough capital to provide a real prototype.
- Price of furniture: One of the team's main objectives is provide the cheapest furniture possible for the users. Anyway, analyzing the market and looking products of the competence, it may be difficult to put a cheap price since it is also about making a profit.

The opportunities in the SWOT

Product

- Creating more space
- Making life comfortable

Market

- Urbanization of the people: More year, more people moves to the city. That increase the range of users.

The threats in the SWOT

Product

- May the people won't find interesting the solution provide: People won't be interested in the furniture as they want two different spaces for doing two different things.
- Poor quality: If the team wants to provide a cheap product, one of the best way to do it is getting a low quality materials. Anyway, was decided that team will select the best materials in quality-price.

Market

- Big market: There are a lot fo big companies in the market providing different products. This make a bit harder to introduce the product.
- Main market far away: As wrote in the market analysis, the main market were the furniture is tougth to be sold is far away from team's location. This would make harder to deploy our product in the market.

All these points can be saw in the Figure 11:

Figure 11: SWOT table of the product

4.4 PESTEL Analysis

PESTEL analysis is a framework used to identify and analyze the external factors that can affect an organization or industry. The acronym stands for Political, Economic, Sociocultural, Technological, Environmental, and Legal factors. Each of these categories represents a different aspect of the external environment that can have an impact on the organization or industry. The purpose of PESTEL analysis is to help organizations understand the potential opportunities and threats in their external environment, and to develop strategies to manage them.

Figure 12: Representation of PESTEL analysis

By conducting a PESTEL analysis, the group can gain insight into the broader forces that shape our industry and develop a better understanding of the external factors that are likely to impact our business in the future. PESTEL are the akronims for: Politcal, economical, sociological, technological, environmental and legal factor.

Political factor

These are the factors related to government policies, regulations, political stability, and political institutions that can affect an organization or industry.

- International and governmental regulations that can be led to make different materials and products. When using physical materials, the price of the product can be affected by regulations imposed by governments.
- Related to the previous point, the continuous attempt of governments to motivate the use of sustainable materials is also an important factor to take into account, since at any time they can apply regulations to certain products.
- As jobs modernize and become safer, governments are implementing laws that seek safe, human-friendly workplaces. This means that both local and national governments can motivate companies to look for products that are as ergonomic as possible.

Economical factor

These are the factors related to the overall economic conditions such as inflation, interest rates, exchange rates, economic growth, and business cycle that can impact an organization or industry.

- The growth of inflation has meant that the most basic day-to-day products have risen in price. This means that the end user does not have the same purchasing power as years ago.
- When you buy a piece of furniture, you want it to be durable. To do this, you have to use quality materials that last for as long as it takes. This means that the products to be chosen are usually expensive because they meet these characteristics.
- Related to the above, the team must also look for sustainable products. They are also expensive.

Sociocultural facotrs

These are the factors related to the cultural and social environment such as demographics, lifestyle changes, education, values, and beliefs that can impact an organization or industry.

- People are becoming increasingly aware of climate change and the misuse of materials. That is why they often look for ecofriendly products.
- People live in more urbanized areas, this means a decrease in living space and therefore live in smaller areas. That is why more and more products are generated for small homes.
- Related to the above, people also look for efficiency and modernity in the furniture of their house.

Technological factors

hese are the factors related to the technological advancements and innovation that can impact an organization or industry. This includes things like automation, new products and services, and changes in the way people communicate and work.

- The modernization of conventional furniture, applying technology such as IoT, is a fact that has been happening for years and is expected to continue evolving drastically in the coming years.
- The generation of the interconnection of the different devices is always well received among the end users.
- Technology is often related to efficiency. That is why, it is also important for the user.

Environmental factors

These are the factors related to the natural environment such as climate change, resource scarcity, and environmental regulations that can impact an organization or industry.

- As mentioned above, climate change is a topic that concerns a large part of the population. That is why it is necessary to offer products that are sustainable and made of recyclable materials.
- In the most developed countries, the use of materials is legislated and therefore controlled. Therefore, you have to choose products that are in the legal scope and are not dangerous for the population.

Legal factors

These are the factors related to the legal environment such as laws, regulations, and legal institutions that can impact an organization or industry. This includes things like intellectual property laws, labor laws, and consumer protection laws.

In this factor, only the guidelines of the European union and the standards for the furniture of the houses should be followed.

4.5 Strategy

4.5.1 Strategic Objectives

For the strategic objectives, the teams is going to use the method called SMART, used to create effective and achievable strategic objectives for a market product. The acronym SMART stands for Specific, Measurable, Achievable, Relevant, and Time-bound. Here's what each letter of the SMART method means:

Figure 13: SMART representation

S - Specific

Objectives should be clearly defined and specific. They should answer the questions of who, what, where, when, and why. In this case, the team want to make a smart adjustable ergonomic furniture that be mainly for the small house We want to make a smart adjustable ergonomic piece of furniture that offers people living in a small space the possibility of having several spaces of the house in the same place, all this, by 2024.

M - Measurable

Objectives should be measurable so that progress can be tracked and evaluated. It should be clear how progress will be measured, and what metrics will be used to track success. The team will go from the definition of the materials, to the creation of the 3D prototype to the creation of a real prototype.

A - Achievable

Objectives should be realistic and achievable. They should be challenging but still within the realm of possibility. Objectives that are too ambitious can be demotivating, while objectives that are too easy may not provide enough motivation. The objectives would be: Learn to work in an international environment, improve our English, make a challenging project with the most sustainable materials and learn to work with other techniques.

R - Relevant

Objectives should be relevant to the overall goals of the business and aligned with the company's mission and vision. They should contribute to the growth and success of the organization. The product

must be eye-catching for people to notice and has to have a style that matches any type of house.

T - Time-bound

Objectives should be time-bound, with a specific deadline or timeframe for completion. This helps to create a sense of urgency and keeps the team focused on achieving the objective. The time-bound is defined below, where the deadline is the product launch.

General objectives of the project

Economical objectives

- Enter an innovative market that is in the growth phase, trying to make a dent in it.
- Create a multi-purpose product that is efficient and sustainable.
- Generate the most profit with a product that is cheap.

Customer objectives

- Help users to have more living space in their home.
- Offer users an intelligent piece of furniture that facilitates the control of the consumption and its use.
- Offer a piece of furniture that gives you the opportunity to be multipurpose.

Technological objectives

- Offer a piece of furniture that controls electricity and water consumption.
- Offer interconnectivity between the furniture and the telephone, which will be the end user.
- Smartify the object so that it does things on its own.

Learning objectives

- Learn to work in an international team with different fields.
- Improve English.
- Learn from different fields and gain more experience.

For fullfilling these objectives, there are deadlines defined for every part of the project.

- Select materials of the furniture before 31th of April.
- The materials must be sustainable and ecofriendly.
- Build a 3D model of the furniture before 31th of May.
- Found sponsors to invest in our project before 15th of Juny.
- The project must follow the standards for furnitures in the kitchen.
- The project must follow the standards of European Union.
- Select the electric parts before of 16th of April.
- Have the schemas of the diferent technologies involucrated before of the 20th of April.
- Finish the final report of the project before 15th of Juny.
- Do a real prototype of the project before 15th of Juny.
- Launch the product in the Asian Market before the the end of 2023.

4.5.2 Segmentation

As we need to define a strategy for the product, we are going to use the STP method that stands for Segmentation, Targeting and Positiong. Each of these elements is crucial in creating an effective marketing strategy. Here is a brief explanation of each component:

Figure 14: STP representation

S - Segmentation: This refers to the process of dividing a larger market into smaller groups, or segments, based on shared characteristics such as demographics, psychographics, or behavior. Segmentation helps marketers understand their customers better and tailor their marketing efforts to the specific needs and preferences of each segment.

T - Targeting: Once the market has been segmented, the next step is to identify the most attractive segments to target. This involves evaluating each segment's size, growth potential, profitability, and fit with the company's offerings and capabilities. Targeting helps marketers prioritize their efforts and allocate resources more effectively.

P - Positioning: This refers to the process of creating a distinct image and reputation for a brand or product in the minds of the target audience. Positioning involves identifying the unique value proposition of the brand or product and communicating it in a way that resonates with the target audience. Effective positioning helps differentiate the brand or product from competitors and build customer loyalty.

Demographics segmentation

The demographic segment can be defined in those people who live in small spaces, who need to make the most of the space available in their home. Also, in this set, people who work from home should be highlighted, needing an office. Most of these people will be population that is between 18 years of life and 50 years of life, with age to work, study and have the ability to live in small spaces.

Geographical segmentation

The geographical segment can be defined in the whole of the population that is in developed countries and lives in urbanized areas. This refers, in general, to the northern part of the planet (North America, Europe and North Asia) along with some countries of the southern hemisphere (Australia, New Zealand, Latin America). As mentioned above, the large part of the world's population is increasingly moving to urbanized areas, therefore it is a growing niche.

behavior segmentation

The end user will be an investor in new technologies who will be interested in smartifying the most basic elements of his house and investing in new concepts that make his life easier. Basically, you will be an enthusiastic person, knowledgeable about new technologies and with investment capacity (therefore, you will have a good job). This person is not afraid to try new products.

4.5.3 Targeting

The target group can be defined as follows:

- People between 18-50 years old
- People with previous knowledge of technologies
- People who love new technologies
- People with a good income and who are willing to spend money on new products
- People who live in small spaces
- People who work and cook at home
- People who seek to reuse spaces
- People looking for a piece of furniture that is adjustable
- People looking for an ergonomic furniture for their health.

With all these characteristics, there is a defined niche in the market segment.

4.5.4 Positioning

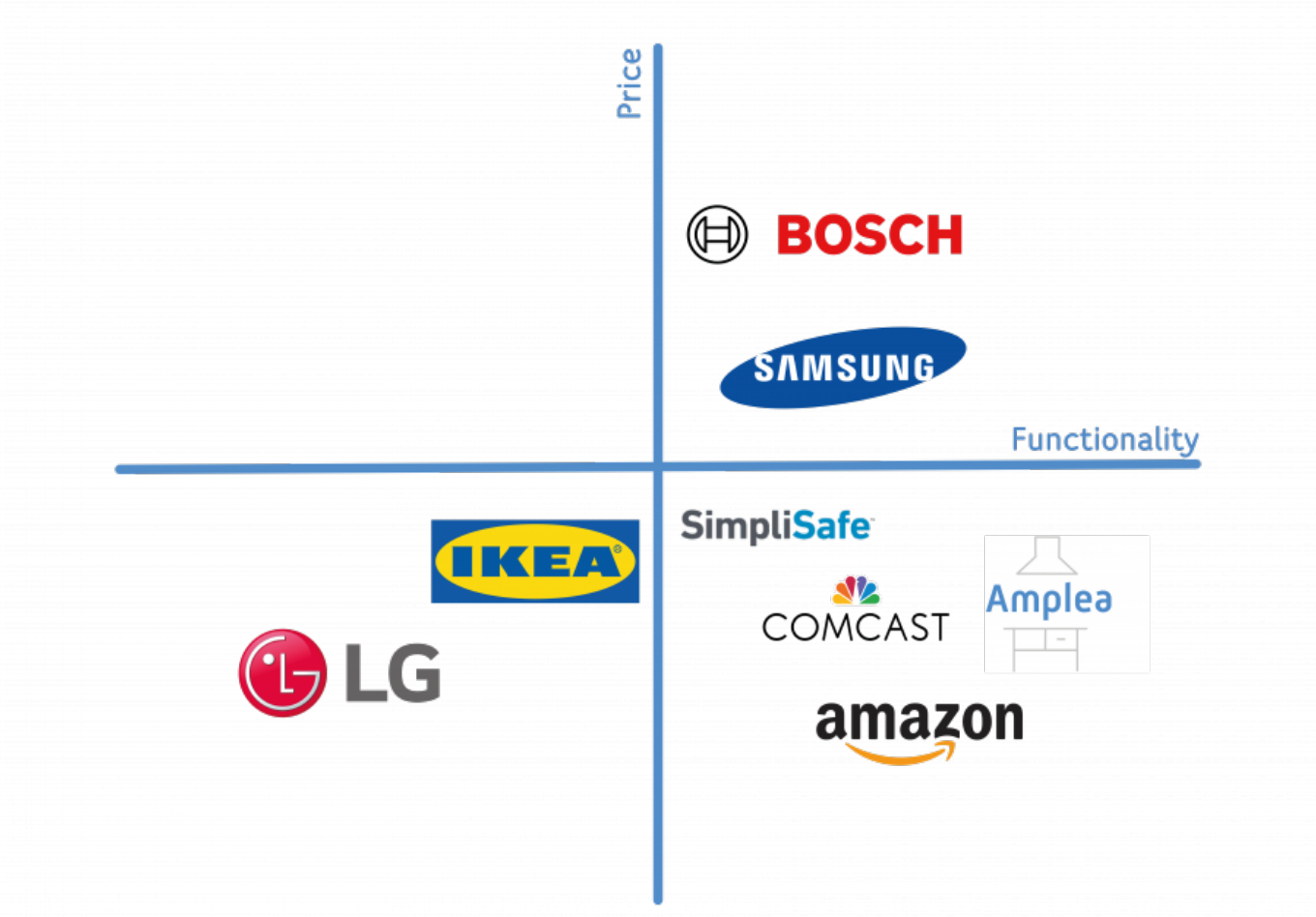


Figure 15: Positioning of our brand compared with the competition

The product is positioned in the sweet spot of the positioning diagram, offering a balance between price and functionality. Is more affordable compared to high-end products on the market, while still offering a great deal of functionality and features. This makes the product an attractive option for customers who want a high-quality product without breaking the bank. Additionally, is more functional than lower-priced options, giving an advantage over competitors who prioritize price over features. This positioning strategy allows to appeal to a wide range of customers and give a competitive advantage in the market.

4.5.5 Marketing-Mix

The marketing mix is a set of tactical tools and strategies that a company uses to promote and sell its products or services in the market. The marketing mix consists of four key elements, often referred to as the “4 Ps”:

Figure 16: Marketing mix representation

Product

This refers to the physical product or service that a company offers. It includes features, design, packaging, branding, and quality. Companies must develop products that meet the needs and preferences of their target customers and differentiate them from their competitors.

Amplea can be defined as an attempt to seek ergonomics and adjustability in the smallest possible space, maritifying the elements that the user is interested in having access and that he cannot. It is an attempt to help people living in more urban areas to have more space for themselves, to have greater control of their expenses and to offer them a safe and effective space.

Price

This refers to the amount of money that a company charges for its products or services. Price is determined by factors such as production costs, competition, and customer demand. Companies must set prices that are competitive and profitable while also providing value to customers.

The price of the product cannot yet be defined since it is not yet in the production phase and has not defined the quantity of materials, nor the labor, etc. But it is clear that you are looking to create an object that has a price accessible to the public and with sustainable materials. In any case, must be clear that we also need a competitive price and that offers benefits that can help cover the expenses generated without fear.

Promotion

This refers to the various methods that a company uses to communicate with its target customers and promote its products or services. Promotion includes advertising, sales promotion, public relations, personal selling, and direct marketing. Companies must create effective promotional strategies that reach their target customers and persuade them to buy their products or services.

For the promotion, modern advertising channels will be used, such as now social networks, since the market niche to which the project focuses is understood to be people connected to each other through the internet. Social engineering will also be used so that advertising is done by word of mouth, thanks to the fact that the advertising that is carried out is dynamic and innovative, producing that people start talking about it.

Place

This refers to the channels and locations that a company uses to distribute its products or services to customers. It includes factors such as distribution channels, logistics, and inventory management. Companies must ensure that their products are available in the right places at the right times to meet customer demand.

Here it must be separated into 2 concepts.

- The first would be that the sale was made online and that the warehouses with the product are close to the main points of sale, in this case, it is expected to be Asia. The warehouses must offer a fast packaging and shipment of our product to the final recipient, together with a reliable parcel service that takes care of customer service if the product arrives badly due to transport.
- The other is based on offering excellent customer service before purchase and after purchase, producing the customer to recommend our product to their friends and family in the same situation.

4.5.6 Brand

The name of the product eventually became Amplea. Ample means enough, or more than enough. This refers that the product that is being offered is sufficient to meet the expectations of our users: multipurpose, takes up little space and is intelligent. And the E and the A at the end of Amplea stands for ergonomic and adjustable.

The logo consist out two parts, as you can see in Figure 17, the name itself and a kitchen/ desk to implicit that is a focus on furniture. The mix from the kitchen and desk means that it is not just one

piece of furniture. The colors are blue and grey. The logo have a peaceful and quite color, grey, and an accent color to implicit stability, peace and trust.

Figure 17: Logo of the the brand, Amplea

4.6 Marketing Programmes

4.6.1 Programmes

As a team, we have decided to leverage social media as a key channel to advertise our product. Recognizing the importance of reaching our target audience where they spend most of their time and social media platforms present an excellent opportunity for the team to do so. In order to make the most of this channel, there is a plan to incorporate social engineering into our advertising strategy. The goal is to spark conversations and generate buzz around our product through innovative and engaging marketing techniques.

To achieve this, there will be a focus on creating content that is not only visually appealing but also thought-provoking and shareable. There is a understanding that social media users are bombarded with a constant stream of information and it takes something truly unique and eye-catching to stand out from the crowd. The content will be designed to pique the interest of our target audience and entice them to engage with the product.

The team also plan to leverage the power of social influencers to help spread the word about the product. By partnering with influencers who align with the brand values and have a strong following, tap into their networks and reach a wider audience. The market team will work closely with these influencers to create content that is authentic and resonates with their followers, further increasing the chances of generating buzz around the product.

In summary, the team believe that social media presents a powerful channel for advertising the product and they are excited to explore innovative ways to make the most of this opportunity. By incorporating social engineering into the advertising strategy, there is a oportunity that can spark conversations and generate buzz around the product, ultimately driving greater awareness and sales.

In a physical way, a leaflet and a poster have been made to be able to advertise the product directly and with physical contact to the closest users. LEAFLET PHOOT POSTER PHOTO

4.6.2 Budget

A marketing budget is a financial plan that outlines the anticipated costs associated with promoting and selling a company's products or services. It includes all the expenses related to various marketing activities such as advertising, public relations, direct marketing, trade shows, and social media marketing. The main objectives of doing the advertising is:

- Generate greater brand recognition to consumers
- Increase revenue
- Attract investors
- Compete with the competition

Table 29: Advertising expenses

Income	**Price**	**Link**
Budget	5000€	
Team money	2500€	
Expenses	**Price**	
Leaflets	33.94€	**[360imprimir Company, 2023]**
Posters	450€	**[letscopy SL, 2023]**
Facebook	700€	**[Facebook Company, 2023]**
Instagram	700€	**[Instagram Company, 2023]**
TikTok	700€	**[iebschool, 2022]**
SnapChat	700€	**[alucare, 2022]**
Youtubue	700€	**[comunicare, 2022]**
Influencers	1000€	
Total	**Price**	
Income	7500€	
Expenses	4983.94€	
Total	2516.06€	

After analyzing and searching for the amount of money needed to be able to place an ad and reach as many viewers as possible on the different social platforms, it has been decided to define the amounts seen in the table above. There are some expenses that are variable: they depend on the number of visits the ad has had or the number of days you want to place it. For this reason, a limit of 700€ is set for the expenses. It can see that there is money left over. This money will be used for future campaigns, as now: physical campaigns, meetings, in-store promotions, etc.

4.6.3 Control

For the control planning, the team is going to use the method PDCA, which stands for Plan-Do-Check-

Act, is a continuous improvement cycle that is widely used in business and other industries to help organizations improve their processes and outcomes. The PDCA cycle is also known as the Deming Cycle or the Shewhart Cycle, named after its originators.

The PDCA cycle consists of four phases:

Plan: In this phase, the organization identifies the problem, sets goals, and develops a plan to address the problem. This involves gathering data, analyzing it, and developing a plan of action to improve the process.

Do: In this phase, the organization implements the plan and carries out the changes that were identified in the planning phase. This may involve training employees, updating processes, or implementing new tools or technologies.

Check: In this phase, the organization evaluates the results of the changes made in the “Do” phase. This involves measuring and analyzing data to determine whether the changes have had the desired effect.

Act: Based on the results of the “Check” phase, the organization takes action to standardize the new process, refine it, or implement additional improvements. This could involve making further changes to the process, training employees on the new process, or documenting the changes.

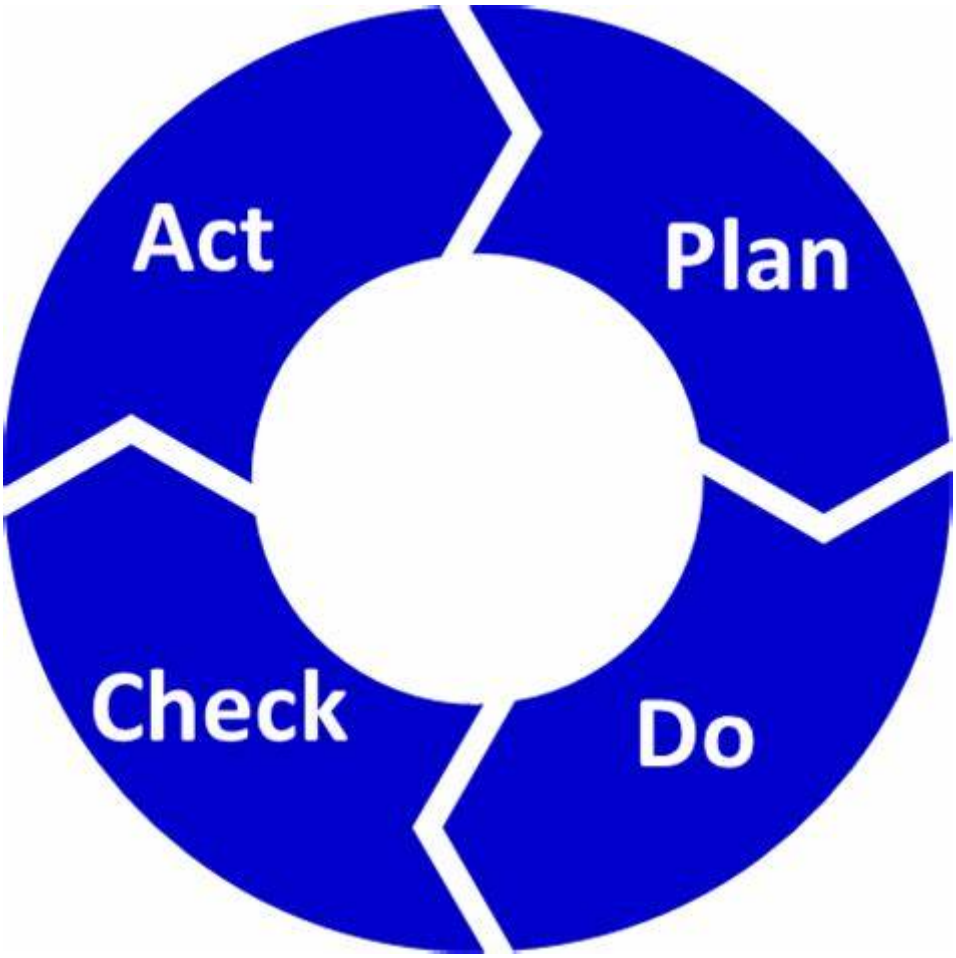


Figure 18: PDCA representation

4.7 Conclusion

In conclusion, after analyzing the market and current trends, it can be stated that our product, the smart adjustable ergonomic furniture, has a great opportunity in the market. It has been observed that there are no similar products on the market, and the focus on functionality and adaptability makes it attractive to a growing end user, which is found in all developed countries. In addition, the product is designed to meet the needs of users living in increasingly populated urban areas, where the demand for products that can provide multiple spaces in one is growing.

The smartification of the object makes it novel and attractive to consumers, which increases the chances of attracting new investors and users willing to try it out. The aim is to focus on the Asian market, as it is one of the fastest growing regions in the world in terms of home smartification and where there is a large population living in urban areas.

In addition, the team is committed to providing our customers with a satisfactory shopping and usage experience. Therefore, it will focus on providing quality customer service and product quality assurance, which allows us to build customer loyalty and ensure customer satisfaction.

In addition to the marketing strategies mentioned above, it is important to highlight that advertising actions will be carried out through modern and popular platforms such as Youtube, Facebook and Instagram, to reach the target audience effectively and with an attractive message. On the other hand, an innovative strategy that will be implemented to generate word-of-mouth advertising is the use of social engineering in advertising campaigns.

Also, the Asian market will be considered as a key area for our marketing strategy, due to the fact that it is one of the fastest growing markets in terms of household smartification, and where the population is increasingly living in urban areas.

In summary, the smart adjustable ergonomic furniture market has a great opportunity for growth, and the project is poised to capitalize on this trend by focusing on innovation, functionality and product quality, as well as delivering a satisfying customer experience.

5. Eco-efficiency Measures for Sustainability

5.1 Introduction

This chapter deals in genaral with the sustainability of the Amplea and our company. First, a deeper look will go into de definitions of sustainable development and eco-efficiency. The way these concepts are implemented will be discussed further on, focusing on the three pillars of sustainbility and the Life Cycle Analysis of the Amplea.

Sustainable development

Our Common Future was published on October 1987 by the United Nations. The report is also known as the Brundtland Report, referring to former Norwegian prime minister Gro Harlem Brundtland. Brundtland was the chair of the World Commission on Environment and Development (WCED). “Our Common Future placed environmental issues firmly on the political agenda; it aimed to discuss the environment and development as one single issue **[28]**.” The report famously defined sustainable development as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs **[University of Alberta, 2018]**.”

Sustainability is more than just environmentalism; “In addition to natural resources, we also need social and economic resources. Embedded in most definitions of sustainability we also find concerns for social equity and economic development **[30]**.” The concept of sustainability is a holistic approach that covers three pillars; the economic, environmental and social. This approach is shown in Figure 37. The three pillars, sometimes better known as people, planet and people, will each be addressed in this chapter. We don’t want sustainability do be yet another part of the job, it should be a guiding influence for the whole project.

Figure 19: Three pillars of sustainability

Eco-efficiency

Eco-efficiency is a key concept for companies to reach a more sustainable development, considering not only the added value aspect of its activities but also the environmental impacts **[Paulo Peças, Uwe Götze, Rita Bravo, Fanny Richter, Inês Ribeiro, 2019]**. Many companies all over the world have adopted this management philosophy. Eco-efficiency is all about doing more with less. The World Business Council for Sustainable Development (WBCSD) first used the term in 1992 in its publication ‘Changing Course.’ It is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution **[Lidija Čuček, Jiří Jaromír Klemeš, Zdravko Kravanja, 2015]**.

The WBCD outlined the following actions, shown in Figure 20 to implement eco-efficiency.

Core Measurements	Eco-efficiency Principles
Optimizing the use of resources	Reduce the material intensity
	Reduce energy intensity
	Enhance recyclability
Reducing environmental impact	Reduce dispersion of toxic substances
	Maximize use of renewable resources
Increasing product or service value	Extend product durability
	Increase service intensity

Figure 20: Eco efficiencys core measurements and principles

5.2 Environmental

In the context of the environmental pillar, the focus will be on designing furniture that is easily repairable, disassemblable, and recyclable. The principle of eco-friendliness dictates that furniture should be designed with easy disassembly in mind to prevent it from ending up in landfills. This approach facilitates repairs, prolongs the product's lifespan, and simplifies the recycling process for end-of-life products. Enhancing recyclability is a crucial goal, as furniture constitutes a significant and growing proportion of landfill waste. Therefore, the Amplea should be designed for easy disassembly, sorting, and recycling at the end of its usable life.

The Amplea will be constructed using two main materials: Aluminium and a hardwood composite with

a honeycomb core. Hardwood was chosen for several reasons, including its non-toxic properties. Consideration was given to using engineered woods such as medium-density fiberboard (MDF), plywood, or chipboard for the Amplea. Engineered woods encompass a range of derivative wood products that are manufactured by binding or fixing strands, particles, fibers, veneers, or boards of wood together with adhesives or other fixation methods to form composite materials **[33]**. Engineered woods offer versatility and numerous design possibilities, and they are also less expensive than solid woods. Plywood, for example, has an excellent strength-to-weight ratio and is a popular choice for furniture due to its durability and strength.

However, there are concerns regarding the sustainability of engineered woods. Firstly, the production process for manufactured woods consumes a significant amount of energy. Additionally, these materials often contain toxic substances, such as formaldehyde, which is used in the glue compounds during manufacturing. Furthermore, laminates or veneers are typically applied to manufactured woods, and these also require the use of glue. While laminates are affordable, customizable, scratch-resistant, fade-resistant, and easy to clean, they cannot be considered sustainable. Laminates are not as durable as solid hardwoods and have a shorter lifespan. Moreover, laminates cannot be refinished, which further reduces their lifespan, and they are non-recyclable. Bamboo, often promoted as a sustainable material, requires substantial amounts of energy, water, and adhesives to transform it into a desktop material. Additionally, once transformed into a desktop, bamboo is no longer recyclable.

In contrast, solid woods are known for their strength and durability, and they require very little energy during the production process compared to engineered woods. Solid woods do not require adhesives, which makes them less toxic. Furthermore, the combination with a core out of recycled cupboard the structural strength will remain and weight will be reduced. By using biodegradable glues the composite can be recycled a lot easier than chemical glues, which are used for MDF.

Figure 21: Composite with honeycomb core

For the lifting mechanism, aluminium is used. The material is supplied by both primary (around 65%) and recycled (around 35%) metal sources. Aluminium can be recycled using only 5% of the original energy input, without any loss of its inherent properties. For our desk, we'll be purchasing recycled aluminium. "It requires up to 95% less energy to recycle aluminium than to produce primary metal and thereby avoids corresponding emissions, including greenhouse gases **[Recycling World, 2021]**." Reducing the amount of VOC's and keeping our materials clean were the driving factors behind our material choice. The first feature of eco-efficiency mentioned in the introduction, is reducing the amount of material. We need to find a way to use less material for the desk, while still producing a strong, durable product. Moving very heavy furniture is often more expensive than

buying new furniture, especially furniture from fast chains. It is important to think of ways to keep our furniture more light and flexible, also in terms of transport. Our desk, which is illustrated below in 21, is made out of a table top with integrated sink and cooktop, two or one cupboard depending on the configuration the user chooses, a rail system to extend the table and a lifting mechanism. By choosing a solid wood for our desk, our material is quite heavy to start with. By testing our 3D model using simulation software, we can check how thick our material can be too keep it as minimal as possible, while still having a solid and safe construction.

Figure 22: Crank lifting system

The user will have to assemble the Amplea at home, like IKEA does with their products. This way the different wooden planks, out of which the cupboard and desk are made, can be flat-packed. By making the user assembly the Amplea himself, it is assured that the Amplea is easy to disassemble. As previously mentioned, this will result in easier repairs and better recyclability. This also makes our product more efficient in terms of shipping; if the Amplea can be partly disassembled and flat-packed, carriers can fill their trucks to capacity and prevent additional delivery trips and fuel stops. This isn’t the only thing to reduce the energy intensity; looking for more ways to produce our Amplea more efficiently. Multiple ways are possible, like using more energy efficient techniques, recycling wood waste and sawdust, insulation improvement and replacing old machines. There are lights integrated

into the Amplea, which is a LED light. LED lights are known to be more efficient and last longer, as shown in Figure ??.

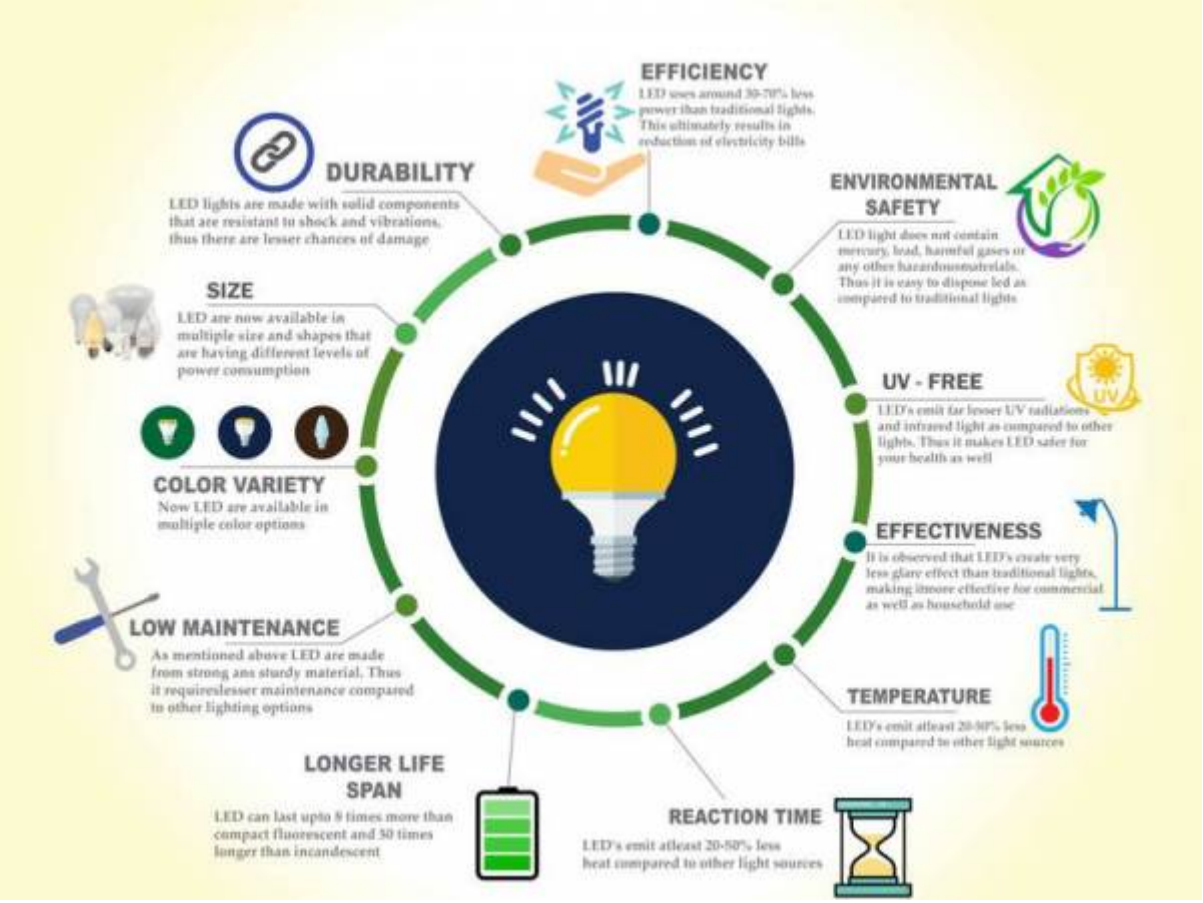


Figure 23: Adevantages LED-Light

As mentioned earlier, it is aimed to reduce the dispersion of toxic materials. Solvent-based lacquers contribute to the pollution in a closed room by emitting volatile organic compounds**[MDC-UM, 2019]**. Examples of these VOCs off-gassed by furniture are flame retardants and formaldehyde. Because of that the decision was made towards natural composites and treat them with natural substances as linseed or tung oil. Those oils are a green alternative to finish wood furniture **[MDC-UM, 2019]**. They contain no solvent in comparison to conventional solvent-based finishes. Because of this no solvent can evaporate into the air which is benefitial for the environment as well as the health of the users. An other positive fact is, that they do not require any chemicals when cleaning. Water resistance is give aswell as those oils are used in boating, outdoor furniture and kitchens for decades.

An other target is maximizing the use of renewable resources. IKEA, for example, has suppliers that turn wood waste from production into a source for renewable energy. On top of being self-sufficient in renewable energy, they are selling the emerging heat for district heating **[IKEA, 2020]**. Using recycable materials like aluminium can help avoiding the purchase of additional resources. Enhancing durability is a crucial objective that should be pursued. Departing from the prevailing fast furniture paradigm, it is imperative to construct furniture with the intention of longevity, rather than disposability. Furniture that is built to last can be easily passed on to others in the event of relocation or changing tastes, while broken items are rendered unviable. Furthermore, even reparable items still entail energy expenditure for repairs, thereby highlighting the need for another eco-efficiency measure, namely service intensity. To this end, the incorporation of repair points in the design of the Amplea to facilitate easy mending of broken components is being contemplated. Additionally, exemplary client service is of paramount importance. Inadequate assistance, such as in cases of

broken or missing items, may prompt users to discard the entire desk rather than attempting to repair it. Given that the desk is assembled by the end-user at home, a comprehensive manual with lucid instructions must be provided to ensure successful assembly.

In the context of wood-based materials, it is imperative to ensure that the wood used is sourced sustainably, in order to avoid contributing to deforestation and its adverse environmental impacts. Certified wood, which has been verified to be harvested in a sustainable manner, is a preferred choice for this purpose. The certification process typically encompasses various aspects, including the assessment of the impact of harvesting on the surrounding environment, such as the preservation of biodiversity, erosion control, and water resource management, as well as considerations for social justice, including the treatment of workers and impact on local/indigenous communities **[Michael Bloch, 2011]**. One of the well-known certification systems for wood is the Forest Stewardship Council (FSC) and the Program for the Endorsement of Forest Certification (PEFC). The FSC defines their certification as a voluntary and market-based tool that promotes responsible forest management worldwide, with certified forest products being verified from the forest of origin through the supply chain. The FSC label indicates that the forest products used are sourced from responsibly harvested and verified sources **[Michael Bloch, 2011]**. The FSC has established 10 principles, as depicted in Figure ??, which serve as guiding principles and form the foundation for all FSC standards.

Figure 24: FSC principles

The Program for the Endorsement of Forest Certification (PEFC) is a global umbrella organization that endorses 30 national forest certification programs. With approximately 800 million acres of land certified, PEFC is recognized as the world's largest forest certification system. In order to gain recognition from PEFC, national systems must undergo a rigorous independent assessment to ensure compliance with PEFC's Sustainability Benchmark. This assessment encompasses various criteria, including stakeholder involvement, forestry requirements, chain-of-custody requirements, and third-party certification and accreditation requirements **[PEFC, 2021]**. However, these national systems have been criticized for their perceived lack of practical implementation of the standards. Despite these criticisms, we choose to work with them as there is limited certainty regarding the validity of such claims, and the potential benefits achieved through these programs outweigh the potential drawbacks.

5.3 Economical

Nowadays, all big brands make pledges to be more sustainable. This often takes a long time to achieve. “Sustainability encourages businesses to frame decisions in terms of environmental, social, and human impact for the long-term, rather than on short-term gains such as next quarter's earnings report **[Mitchell Grant, 2020]**. “It is evident that sustainability embedded in business models and products has the potential to enhance economic growth, return on assets, return on equity, internal rate on return and lead to superior stock market performance **[Martin V Bennetzen, 2020]**.” On short term however, companies that commit to the sustainable development of resources may have more modest results in the next term. This makes the whole economical pillar a somtimes a bit difficult. It is of great value to consider sustainability at the beginning of the design phase. This will result in long-term solutions and minimize the need of resources such as material, energy, water. “If a project is well planned and sustainable criteria are implemented in its early approach, the possibility to reduce negative impacts is greater and the cost of criteria implementation is greatly reduced **[J. Lu, H. Cui, Luís Bragança, Susana M. Vieira, Joana B. Andrade, 2014]**”. This is illustrated in Figure ##REF:flabel29##.

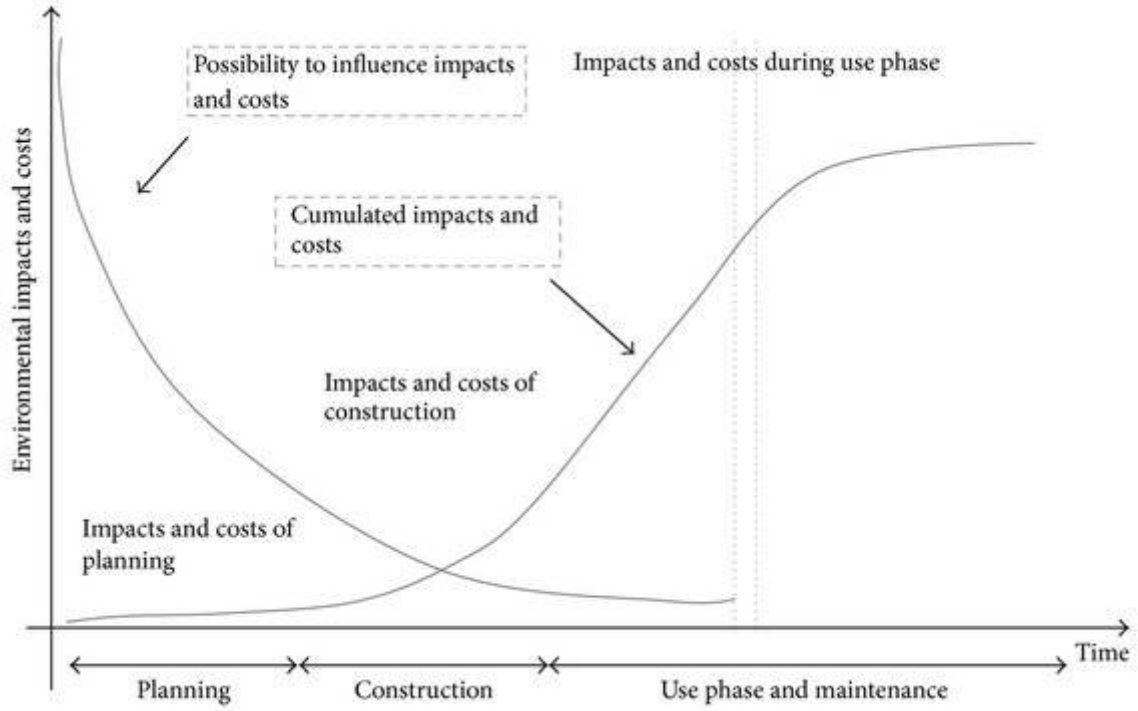


Figure 25: Influence of design decisions on life cicle impacts and costs

“Instead of trying to “force fit” sustainable principles into an existing and often unreceptive manufacturing system, it may be useful to approach the subject from the opposite direction, and consider how functional objects might be designed and manufactured to be compatible with principles of sustainable development **[Stuart Walker, 2006]**“. We should adopt a different mind-set about costs and focus on increasing the efficiency of the system as a whole. By implementing eco-efficiency measures, we can reduce our ecological impact. Eco-efficiency is all about doing more with less. This translates into an increase in resource productivity, which in turn can create a competitive advantage. Listed down below in table 14 are the seven principles of eco-efficiency outlined by the WBCD, supplemented by our applications of these principles.

Table 30: Eco-Efficiency Principles

Number	Principle	Application
1	Reduction in the material intensity of goods or services	-Stuctual tests of the 3D model help to identify weak/strong spots of the material, reducing or increasing material ; using as much as necessary and little as possible material
2	Reduction in the energy intensity of goods or services	-By designing the Amplea easy to disassemble, it can be packed in a flat way, which gives the carriers the opportunity to fill their containers to capacity and prevent additional delivery trips -Use of LED lighting
3	Reduced dispersion of toxic materials	- Use of natural substances for the wood treatment (Water-based lacquers are a green alternative for finishing wood furniture
4	Improve recycability	- Desingning the Amplea for self assembly, an easy disassemle is assured, this leads to possible repairs, recycle and longer life time - Using natural glues for composites makes it easier to recycle in retreat
5	Maximum use of renewable resources	- Using certified materials to assure the origin and a sustainable source - maximizing the use of renewable resources; e.g. turn wood waste from the production process into a source for new materials or renewable energy by using the excess heat (district heating)
6	Greater durability of products	- Desingning the Amplea to last for a lifetime (maybe a bit more expensive)
7	Increase service intensity of goods and services	- Manual/Video with very clear instructions - Good client service

5.4 Social

Socially sustainable action consists of identifying and managing the impact of companies on people, both positive and negative. The quality of a company's relationships and engagement with its stakeholders is critical. Companies directly or indirectly affect the fate of employees, value chain workers, customers, and local communities, and it is important to proactively manage impacts **[45]**. Social sustainability begins with the recognition that we can influence ora impact many people. It is important for us to have the support and buy-in of our employees, stakeholders, and the community in which we operate, both locally and globally. We strive to be an inclusive company that strives for equality. In addition, social responsibility is profitable in the long term. It can open new markets, be a source of innovation, attract business partners and employees. However, a lack of social sustainability efforts can hurt business and growth. Consider the Bangladesh factory collapse and its horrific aftermath, followed by justifiable outrage. “While it is the primary responsibility of governments to protect, respect, fulfill and progressively implement human rights, companies can and should do their part. At a minimum, we expect companies to conduct due diligence to prevent human rights abuses

and address any adverse human rights impacts associated with their activities **[46]**."

As a company, we can implement social action at the level of our employees and at the global level. With regard to employees, it is about treating everyone fairly and equally. Good and safe working conditions should always be guaranteed, as well as a fair income. Better maternity and paternity benefits, high-quality safety measures, flexible working hours, learning opportunities, etc. can help our employees identify more strongly with the company. In addition to respecting and applying human rights, we aim to promote and support gender equality and diversity in the workplace. The latter is crucial for a successful company, especially in terms of employee engagement. This means ensuring cultural diversity, gender diversity, religious diversity, and different levels of education and perspectives. Each employee can contribute his or her own perspective and background, which leads to increased creativity and innovation **[Cristian Grossmann, 2021]**. We should take steps to ensure that this diversity is embraced system-wide, from recruitment through promotion to career development, is promoted. This can be done, for example, through diversity awareness training, implementing equal opportunity policies, and creating an inclusive work environment.

On a global level, we can implement social action through responsible supply chain management practices. This means ensuring that our suppliers and partner companies also comply with social and environmental standards. This can be done through audits, reviews, certifications or partnerships with organizations that promote social and environmental sustainability. We should ensure that there is no forced labor, child labor, discrimination or other human rights abuses in our supply chain.

We can also promote social sustainability locally in the communities in which we operate. This can be done through partnerships with non-profit organizations, fundraising, volunteering or other initiatives that help improve the lives of local people and contribute to social development.

It is important to emphasize that social sustainability should not be viewed as an isolated measure, but as an integral part of a comprehensive sustainability strategy that also takes into account environmental and economic aspects. A holistic approach to sustainability that takes equal account of social, environmental and economic aspects is crucial to achieving long-term positive impacts.

Overall, social action is an important aspect of social sustainability, where companies take responsibility to identify, manage and improve the impact of their activities on people. There is a need to promote a culture of social action in companies and implement measures at different levels to contribute to a more inclusive, equitable and sustainable society.

5.5 Life Cycle Analysis

"Life cycle analysis (LCA) has been defined by the EPA as a way to 'evaluate the environmental effects associated with any given industrial activity from the initial gathering of raw materials from the earth until the point at which all residuals are returned to the earth' or 'cradle-to-grave' **[Salah M. El Haggar, 2005]**." We can use this tool to quantify and qualify the impact of our desk all across its life cycle. As mentioned before, an LCA begins at the cradle stage with the raw materials. It then goes through all of the manufacturing steps and follows the product during his whole lifetime up untill the grave stage. This can be defined as the moment of disposal and/or recycling.The study applies to the full life cycle of a product and is illustrated in Fig. ##REF:flabel6## **[Stephen Gent, Michael Twedt, Christina Gerometta, Evan Almberg, 2017]**.

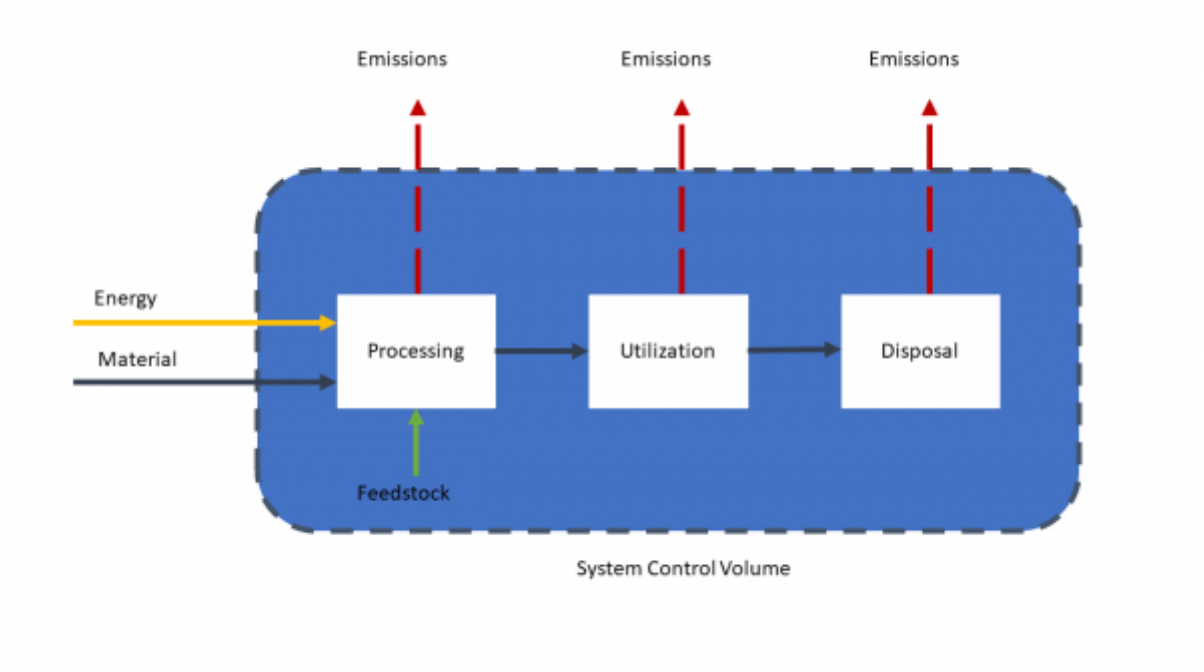


Figure 26: Life cycle of a product

In this chapter, we will attempt to follow the structure of a real life cycle analysis (LCA) by starting with our goal definition and delineation.

Goal definition and scoping

Amplea is a convertible desk/kitchen for small places. It will allow the user to customize the Amplea according to their needs in every situation. It can be a normal work desk which can be used in different positions like sitting or standing, aswell as kitchen to prepare your meals and can be extended to a larger table to meet with your family and friends for different activities. Therefore the user can decide which position allows him to concentrate the most while working or giving him/her enough space for a certain activity. The focus are people who live in relatively small spaces and need to transform their home by keeping enough space to move. In terms of sustainability, the Amplea should be easy to disassemble, repair and recycle. Focusing on reducing the amount of volatile organic compounds (VOCs) that can be released from the furniture is an other aspect we want to implement. In addition, making our product more eco-efficient throughout its life cycle by considering energy consumption, transportation, etc. will be challenging but is a key thing throughout the process making the Amplea

Inventory analysis and impact assessment

Consumption of energy, water, materials, and environmental releases (e.g. air emissions, solid waste disposal, wastewater discharges) should be identified and quantified in the inventory analysis. The impact assessment should include estimation of the potential human and environmental impacts of everything identified in the inventory analysis. Since we do not have the expertise, time, and/or knowledge to calculate this, we will instead go through the various steps during developing our Amplea. The different steps are procurement, treatment, production, assembly, and transportation; each step will be discussed in terms of sustainability.

1. Procurement

We use aluminum for the lifting mechanism and solid wood composite with a cardboard honeycomb core for the Amplea. Aluminum can be recycled with only 5% of the original energy input without losing its inherent properties. By purchasing recycled aluminum, we are benefiting current and future

generations by conserving energy and other natural resources. Since we will be working with wood, it is important to know that the wood is sustainably sourced. Avoiding that the wood which is used contributing to the problems associated with deforestation is a goal to tackle. We will look for Forest Stewardship Council (FSC) and/or Program for the Endorsement of Forest Certification (PEFC) certification, two of the most well-known certification systems. “A product that uses certified wood used, helps to reduce pressure on forests and promote the sustainability of the timber industry.”

2. Treatment:

With regard to the treatment of materials, environmentally friendly methods are used to treat the aluminum and process the wood. In this regard, care is taken to use processes with a low environmental impact and to avoid the use of chemicals or processes that are harmful to the environment.

3. Production:

Energy-efficient methods and machinery are used in the production of the Amplea to minimize energy consumption. Care is also taken to minimize waste and use recyclable materials to reduce environmental impact. The use of renewable energy such as solar power or wind energy can also help reduce environmental impact.

4. Assembly:

The assembly of the Amplea is designed to be simple and efficient to avoid wasting unnecessary time and energy. Care is also taken to ensure that assembly methods are environmentally friendly and that no harmful chemicals or materials are used.

5. Transportation:

Transporting the Amplea from the manufacturing facility to the consumer can contribute significantly to environmental impact, especially over long distances. Opportunities are being thought to optimize transport, for example by using local production sites or sustainable transport methods such as rail or shipping, to reduce the carbon footprint.

In summary, the life cycle analysis of the convertible kitchen/desk, the Amplea, will look to use environmentally friendly materials, minimize environmentally harmful processes, use energy efficient production methods, optimize assembly and transportation, and consider certifications for sustainable wood sourcing. These measures are designed to ensure that the product is as sustainable as possible throughout its lifetime and has as little negative impact on the environment as possible.

5.6 Conclusion

The principle of sustainability should serve as a guiding influence throughout the entire project. The Amplea will be developed with a constant consideration of the four pillars of sustainability, environmental, social, and economic aspects. Efforts will be made to minimize the environmental impact, while also being aware of the potential impact on stakeholders, including the local and global community. Support for the community and employees will be prioritized. The environmental impact of the Amplea is influenced by the careful selection of materials and production processes. The primary objective is to optimize the product's lifespan and minimize the environmental impact through the use of recycled materials while retaining their original properties. The choice of a solid

wood shell is motivated by its durability and the potential for treatment with natural substances such as oil. Additionally, the utilization of recycled cardboard for the core material serves to reduce the overall weight of the product and facilitates easy adhesion to the shell due to the presence of fibers. Economically, efficient choices will be made to benefit not only the environment but also the company and its employees. Introducing a product that combines two significant pieces of furniture for a residential space can result in reduced resource consumption, while also offering cost savings to customers compared to purchasing two separate furniture items for their home. Addressing sustainability at the design stage can help reduce negative impacts and implementation costs. The Amplea will be designed with ease of disassembly, repair, and recycling in mind, to prolong its lifespan and avoid premature disposal. Ensuring robustness of the Amplea will contribute to avoiding waste at the end of its lifecycle.

6. Ethical and Deontological Concerns

6.1 Introduction

Deontology is a part of ethics that focuses on the moral duties and obligations individuals have toward each other. It is a normative ethical theory that holds that some actions are inherently wrong or right, regardless of their consequences, according to a clear set of rules. Deontologist believe that there are some ethical principles, such as respect for each other, the duty to tell the truth, are universally applicable and must be followed by everyone, regardless of the circumstances.

Ethics, in general, is the study of moral principles and values concern human behavior and decision making. Ethics is based in one’s character and not specific rules like deontology. It tries to determine what is right or wrong, good or bad and just or unjust in all different aspects of human life. Ethical theories provide frameworks for analyzing and evaluating moral issues and dilemmas, and offer guidance for individuals and societies to make ethical decisions and ethical choices.

To make the project ethical and deontologist correct we looked from all different angels, which make to following section. First of al engineering ethics, where the focus is on engineering duties. Then, sales and marketing ethics, where is tried to set clear boundaries to ensure that the activities remain within a designated and acceptable range. At the end there is also an focus on environmental ethics which is related to the sustainability section and finally liability.

6.2 Engineering Ethics

Ethics and engineering are unseparated of each other. Engineers are expected to exhibit the highest standards of honesty and integrity. This field of study has a big and direct impact on the quality of life for all people. Engineers are expected to be honesty, impartiality, fairness and equity, and must be dedicated to the public safety, welfare and safety. Engineering Ethics - Introduction **[unknown, unknown]** The deontology rules for engineering can vary from one country to another and some countries don’t have a written code of ethics. Amplea is focused the most on the Asian market but is made to use over the whole world. According to (national society of professional engineers, 2019), engineers should follow fundamental cannons, practice rules, and personal obligations:

Fundamental cannons:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

Rules of practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act for each employer or client as faithful agents or trustees.
5. Engineers shall issue public statements only in an objective and truthful manner.
6. Engineers shall act for each employer or client as faithful agents or trustees.
7. Engineers shall avoid deceptive acts.

Professional Obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
2. Engineers shall at all times strive to serve the public interest.
3. Engineers shall avoid all conduct or practice that deceives the public.
4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
5. Engineers shall not be influenced in their professional duties by conflicting interests.
6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.
7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
8. Engineers in private practice shall not review the work of another engineer for
9. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
10. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

By all the rules show that the engineering has a significant world on the world and the people, that’s why its very important to ensure that their contribution to the world is beneficial and ethical. Engineers should follow the fundamental cannons, practice rules and personal obligation to make sure that they ensure the safety and integrity of the highest standards.

6.3 Sales and Marketing Ethics

Sales ethics as well as marketing ethics are essential to have a responsible business. They involve in honesty, transparency and fair manner, with the best interest of the costumers in mind. Ethical sales practices are important to build a genuine relationship with customers. Therefore, the team will work with some bullet points to enhance ethical sales and marketing. Emphasizing these principles will build a positive reputation, promote customer loyalty, and contribute to long-term business success. For the sales and marketing of Amplea, the focus will be put on the following:

Share clear and truthful information: It is important to highlight the features of the offered product and how the customer will be benefitted with is. While doing this, it as important to avoid making unrealistic promises. This can lead to disappointment and loss of trust for the customer.

Foster trust and credibility with the customer: To ensure a mutually beneficial experience for both the customer and the company, it is important to prioritize trust-building within sales interaction. The goal is to let customers feel heard and valued.

Be accountable: When a problem with the product arises, the responsibility for the fault should be taken quickly and truthfully. The company has to offer a solution to fix the problem for the customer.

Fairness: Fairness within the business signifies to commit to fair prices, good wages, and sustainable development **[Lestraundra Alfred, 2019]**.

6.4 Environmental Ethics

Environmental ethics is a philosophical and interdisciplinary field that studies the moral relationship of human beings to the natural environment. It examines the sustainability, moral responsibility and the value of nature, as well as the consideration of how our ethical beliefs and actions impact the environment and future generations **[52]**.

The environmental contamination and degradation of natural resources issues are worsening, so it is important for companies to take immediate action to save the environment. Businesses that follow environmental ethics culture are proven to be more valuable within the industry. Fulfilling environmental responsibilities will also put pressure on other firms that are not willing to undertake environmental responsibilities. Due to these reasons, it is important for the team to take into consideration the effects that the product will have on the environment, whether this is direct or indirect **[53]**.

In order to provide a environmentally friendly product, the team will focus on making the ecological footprint as small as possible. The first goal is to make the product as environmentally friendly as possible, by sustainable practices throughout the entire value chain, from sourcing materials to manufacturing, packaging, and distribution. By implementing sensors to control the use of electricity and water by the user, the product will also give an insight into the ecological footprint of the user. This part has been detailed addresses in the previous chapter.

6.5 Liability

In the marketing chapter the market of the company was explained. The team will be focussing on the Asian market. Therefore the liability for the furniture companies in Asia will be discussed. In Asia, furniture companies are restrained to several key principles when it comes to liability. The principles for this liability vary depending on the specific country or region. However, there are some general principles that are commonly in many Asian countries. To ensure the liability of Amplea, the team will work by the general principles that will be listed here below:

1. Consent with safety regulations: Companies are expected to comply with safety regulations and standards to ensure that their products are safe for consumers. This may include safe materials and proper manufacturing processes. Also conducting quality and control checks.
2. Product liability: Furniture companies can be held liable for any defects in their products that may cause harm to consumers. Defects can be design defect, manufacturing defects, or inadequate warnings or instructions.
3. Consumer protection: The consumers must be provided with accurate product information. This includes proper usage instructions and warnings.
4. Environmental sustainability and ethical practices: Companies are being held accountable for their environmental impact and ethical practices, such as responsible sourcing of materials, proper waste disposal, and adhere to laws and human rights. By complying with the laws and regulations, the company will have to registrate the business, the taxation, and the import/export requirements.
5. After-sales support: The company must provide services for handling product complaints, addressing product recalls, and providing refunds or replacements for defective products.

6.6 Conclusion

Based on this ethical and deontological analysis, the team chose to focus on making sure the manufacturing process will be as responsible as possible. Amplea will be made with the most sustainable materials possible, but still ensure a safe product that complies with the safety regulations. The team will work with suppliers who are transparent with their products and their origins. Furthermore, the engineers will follow the fundamental cannons, practice rules, and personal obligations as listed above. To build a trustable and strong company, the company will be build on honesty, transparency and fair manner, with the best interest of the costumers in mind.

In the following chapter, the project development will be discussed, while all it is components will be explained.

7. Project Development

7.1 Introduction

The following chapter will describe the ongoing process of the development of AmpleSEAF. The process is devided into multiple topics that will each be adressed. The ideation and the concept of

AmpleSEAF will be explained. Furthermore the design as well as the packaging will be discussed by explaining the material selection and 3D models. Also the Smart System of AmpleSEAF will be made clear while adressing the hardware and the software using a Blackbox. In the last section everything about the system and the system design will be explained. This will be done by explaining the components that will be used, how they are connected and in the end the prototype with the tests that are done as well as the results from those tests.

7.2 Ideation

The team started the project with a different subject named 'Smartification of everyday objects'. While the brainstorming was in process, the team ended up with the idea to smartify a kitchen into multipurpose furniture. This is when the subject was changed to 'Smart Ergonomic Adjustable Furniture'.

For the ideation of the furniture, the idea was to make a multipurpose type of furniture for small houses. The team kept in mind that since the Covid epidemic, working from home became a normal thing. This was the reason the final idea was to make a small kitchen that could be converted into a working desk. Eventually, to enhance the kitchen into a more social space, the idea of the conversion to a dining table was made. From there on, the different types of our furniture were discussed.

7.3 Concept

7.3.1 Logo

The name of the product eventually became Amplea. Ample means enough, or more than enough. This refers that the product that is being offered is sufficient to meet the expectations of our users: multipurpose, takes up little space and is intelligent. And the E and the A at the end of Amplea stands for ergonomic and adjustable.

The logo consist out two parts, as you can see in Figure …, the name itself and a kitchen/ desk to implicit that we focus on furniture. The mix from the kitchen and desk means that it is not just one piece of furniture. The colors are blue and grey. We wanted a peaceful and quite color, grey, and an accent color to implicit stability, peace and trust.

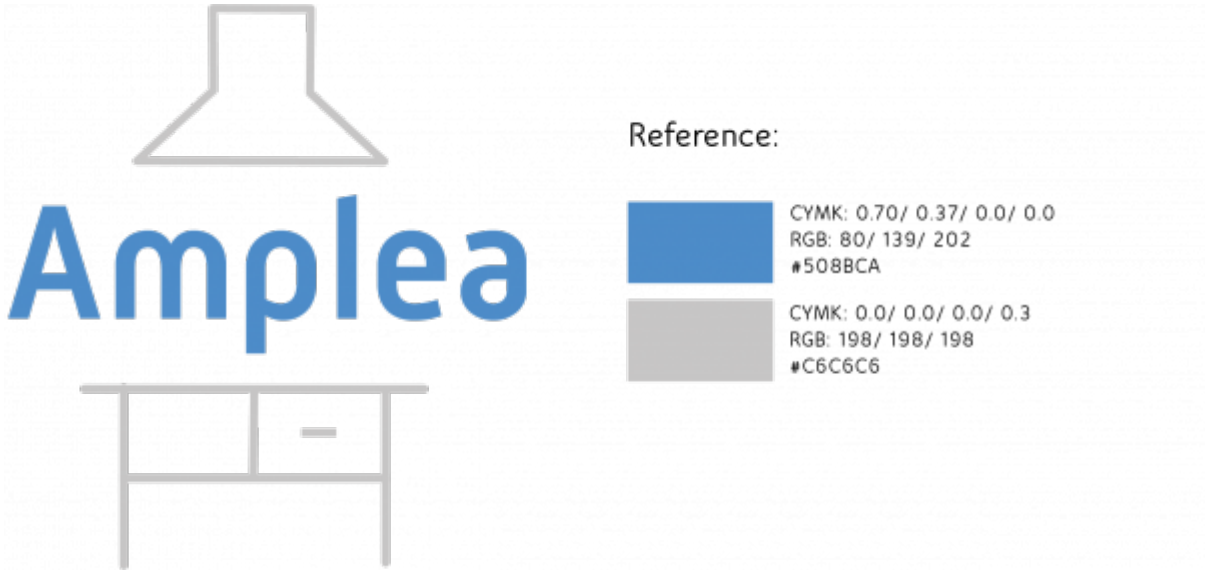


Figure 27: Amplea Logo

7.3.2 Concept

The initial phase of the project involved brainstorming design ideas, considering both technological and financial factors. Three options were identified: a manual system or an automated system, or a combination of the two. After some consideration, it was decided to proceed with a design that combined manual and automated elements. Two different designs were created: the first involved using a cupboard door as a table as seen in the following images

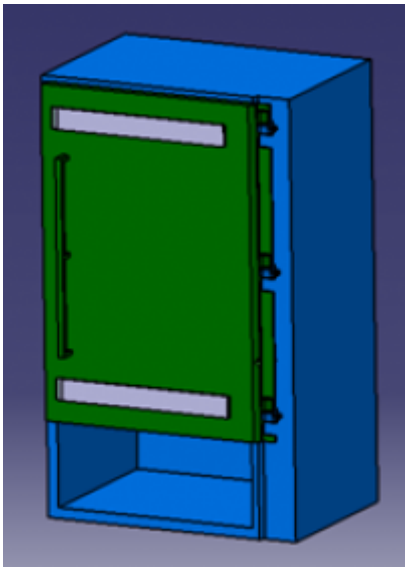


Figure 28: Idea 1:Image of the cupboard closed

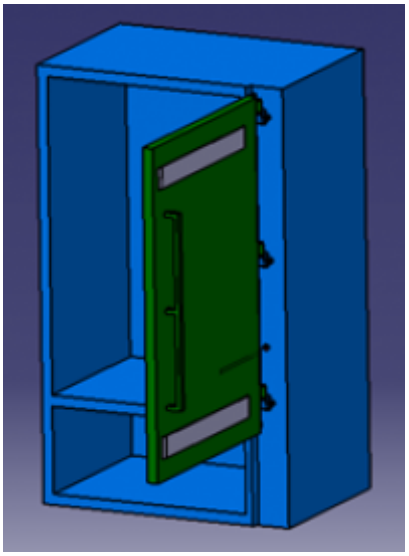


Figure 29: Idea 1:Image of the cupboard opened

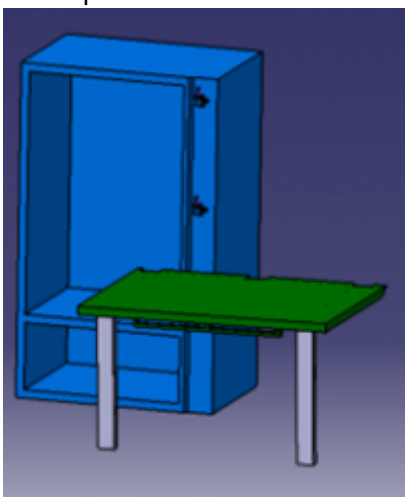


Figure 30: Idea 1:Image of the table extended

The second design contains a support system from underneath the work desk using rails, which are used to support the extended table top. This idea is shown in the following images.

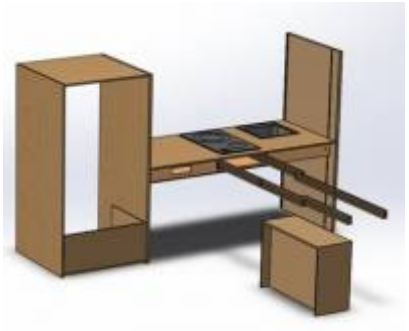


Figure 31: Idea 2:Image of the extension of the rails

The initial concept presented a higher degree of creativity and originality, but requires a greater complexity in user manipulation. In addition, upon installation, the design posed difficulties for users in accessing the cooking plate without causing discomfort to their backs. As a result, the team ultimately opted for the second design, which is simpler to use and allows a convenient access to the cooking plate, even when the table is extended. Notably, the second design also permits the table to be elevated, a feature that was not possible with the first design.

7.4 Design

7.4.1 Structure

Add and explain thoroughly the:

(*i*) initial structural drafts;

Even if the team chose the second type of solution, several modifications were made to improve the ergonomics and technology of the solution. Initially, the table was meant to be placed next to the work desk, but this would have obstructed access to the sink and cooking plates. Additionally, the stools were originally intended to be integrated into a cupboard, but this would have taken up too much space. Finally, the team had originally planned for the height of both the work desk and the table to be adjustable at any time, but making the legs of the table automatically adjustable would have been prohibitively expensive. To solve this problem, a sensor was integrated into the design that would prevent the raising and lowering of the table if it was extended. This would allow users to adjust the height of the table when it was placed under the work desk, while also keeping costs manageable. On the cooking desk, two normal plugs and two USB plugs are available. The main idea is to be able to charge phones with the USB plugs and to charge a computer, to use a coffee machine or any cooking robot, there are the normal ones. On the cooking desk, there are two standard electrical plugs and two USB ports. The purpose of the USB ports is to charge mobile phones, while the standard plugs can be used to power a computer, coffee machine, or other cooking appliances. The desk can be elevated only when the table is not extended. This is achieved through a microcontroller that analyzes data from a magnetic sensor. The user can then control the elevation of the desk using a lever, allowing for a height range of 70cm to 130cm, suitable for standing or sitting work. Additionally, the desk is designed for efficient use of space. The cooking plate can be concealed by closing a small hatch. Storage options include two large cupboards on each side of the desk or only a single cupboard to save space. There is also storage space available under the cooking desk, which can be utilized according to the customer's needs. The light will be able to adjust themselves thanks to a sensor. It is also possible to adjust it by yourself. The consumption of water and electricity will be tracked by the system all the time and the user is able to see it on their individual app.

The process of designing and building furniture involves several critical steps, and material selection stands out as a vital aspect. The tables presented below provide a comprehensive overview of the materials that are considered as potential options.

General wood

Table 31: Materials from wood

Material	Description	Pros	Cons
Solid wood (birch, maple, oak, pine)	Solid wood refers to timber that is obtained by milling trees directly. The unique features of each type of solid wood, such as grain pattern, color, and texture, distinguish it from other types.	-Strong -Durable -Natural (not synthetic) -Good ability to receive nails and screws -Uses very little energy during the production process -Does not warp as easily as many engineered woods -No fillers or adhesives are used -Easy to repair -Recyclable	-Heavy weight -Expensive -Susceptible to stains
Engineered Wood (MDF, plywood, particle board)	Manufactured wood is composed of wood fibers that are held together with adhesives.	-Versatile -Durable -Results in smooth surfaces -Flexible -Uses wood waste -Lightweight	-Likely to expand or warp -Has to be finished with laminates or veneer -Uses a tremendous amount of energy as well as potentially toxic materials (since formaldehyde often forms part of the glue compounds used during the manufacturing process)
Laminate	Constructed by pressing together layers of heavy-duty paper with a compound known as melamine, which hardens into a resin (creates a solid veneer, which can then be covered in a thin decorative layer). There is a difference between HPL and LPL: the latter tends to cost less because it is less expensive to manufacture.	-Durable -Affordable -Incredibly customizable -Resistant to scratch and fade -Easy to clean -Flame retardant -Some types have antibacterial properties	-Not as strong as solid hardwoods -Non-recyclable -Shorter lifespan than solid woods -Toxic -Susceptible to water damage -Shows stains and fingerprints -Lack of natural feel -Cannot be refinished
Bamboo	A very fast growing grass. The material is strong but flexible, which is a rare combination.	-Strong -Durable More scratch-resistant than most hardwoods -Resistant to swelling and moisture -Some types are antibacterial -Lightweight and easy to move	-Immense amounts of energy, water and adhesives are required to re-form bamboo into a wood desktop -Not recyclable

Material	Description	Pros	Cons
Composite with core-material (honeycomb)	Comination of a solid wood outer layer and a honeycomb core; light weight by high stiffness and durability	-Resource conservation -Reduced waste -Energy-efficient manufacturing -Low VOC emissions -Durability and longevity -Versatility	-Young technic -delamination -Higher production costs

Engineer wood

Inside the engineer woods, the following 4 different types could be options for the build of the Amplea:

Table 32: Table comparition of the engineer wood

Material	Description	Pros	Cons
Chipboard	It is build up from rest of wood together with resin It has rough surface	Very cheap, it has different types: for fire, water, resistent, sustainable	The glue is it dangerous for the health, if it suffers any cut, may it would be starting damage from there, is not good against humidity (it gets bigger), the surface is rough, so I can be uncomfortable to use it
Plywood	Made by different types of woods, it is a combine of different plates of woods glued between them	Different types of wood It is not expensive, but no the cheapest, resistent, it is smooth surface, easy to work with it, it can use outside as it has features against humidity, has a lot of capacity of KG	Most of features depends of the wood used.
MDF	Made from subproducts of wood with resin Not the same as chipboard	Resistent against humidity and fire Strong, smooth surface, it is not used to expand or incur	It is not recomendable to work as they have issues when you are putting screws, the dust left by working with its dangerous (or may if it is cut by accident), can absorve too much water and damaged itself The weight if it is not correctly shared in the surface may can produce problems.
OSB	Made of little parts of wood that stick together with clay and pressure	Resistent to fire and water Resistant against fungus, have high capacity for weight, can be work easily, it does not have any bad point, isolation against sound and temperature, sustainable	Surface is rought, have not too much capacity to resist humidity, it weights more that others solutions.

By comparing those materials two materials as hardwood honeycomb composite and medium-density fiberboard were suitable to our products needs. In conclusion, hardwood honeycomb composite offers several advantages over medium-density fiberboard (MDF) in terms of sustainability, resource conservation, lightweight and strength, durability and stability, versatility, aesthetics, and customizability. Hardwood honeycomb composite is often considered more environmentally friendly due to its efficient use of wood resources and potential incorporation of recycled materials. It is also lighter in weight while still maintaining good structural strength, making it suitable for various applications where weight reduction is important. Additionally, hardwood honeycomb composite is designed to be durable, stable, and moisture-resistant, making it a reliable choice for long-term use. Its versatility in design and application options, as well as its customizability in terms of specifications, provide flexibility for various uses. Furthermore, its natural wood grain and high-quality appearance offer aesthetic benefits. Overall, hardwood honeycomb composite is a viable alternative to MDF for those who prioritize sustainability, efficiency, performance, versatility, and aesthetics in their material choice.

Metals

To connect the door of the wardrobe, hinges will be required. A minimum of three hinges will be needed for a wardrobe that is approximately 2 meters in height. For prototype B, which consists of two wardrobes, a total of six hinges will be needed. Various materials can be used for the hinges, such as:

- Metal: The most typical metals for the furniture are: steel, zinc, bronze, aluminium and brass.
- Plastic
- Stainless steel

Table 33: Table comparition of metals

Material	Pros	Cons
Steel	Cost-effective compared to stainless steel, strong and durable, easy to work with and manufacture, suitable for indoor use	Prone to rusting and corrision if exponed to humidity, requires regular maintenance, not suitable for outdoor, may not be very resitant over the pass of time
Aluminium	Non-corrosive, Easily machined and cast, light, durable, non-magnetic, recyclable. Cheapest Material	Can be easily dented or scratched also compared with steel, so the steel is a little bit stronger material
Zinc	Corrision-resistant (can be used in kitchen), durable and long-lasting, can be easily work, Ligthweigth and easy to install	Not strong as other materials, may not hold up heavy weigth, can become brittle over time and break under stress, not suitable for high-temperature environments (near stoven or ovens), not safe for heavy doors
Bronze	Highly durable and long-lasting, resistant to corrosion and rust, easily polished to maintain the appearance, secure hold for heavy doors	More expensive than steel or zinc, heavy and may require additional support if the door is large, may require periodic maintenance to prevenent tranishing, may not suitable for high-temperature environments (near oven or stove)
Brass	Highly durable and long-lasting, resistant to corrosion and rust, easily polished to maintain the appearance, secure hold for heavy doors, suitable for high-temperature environments	More expensive than the others materials, may required support for large doors, periodic maintenace, more prone to wear and tear compared with stainless steel

Material	Pros	Cons
Plastic	Ligthweight and easy to install, resistant to corrosion and rust, affordable and widely available, can be easily modified, suitable for use in a kitchen or bathroom, do not used to make noises	Less durable and long-lasting, can break when used for heavy weigth, may no provide a strong hold for heavy doors, can be difficult to repair.
Stainless steel	Highly resistant to rust and corrision, low maintenace, suitalbe for outdoor and indoor, durable and long-lasting	More expensive than normal steel, harder to work with, may not suitable for every type of door or cabinets

In the selection of hinges, there are various types that can be utilized. Some examples of hinges that can be considered include:

- Book hinges: Book hinges are a type of hinge that are commonly used for wardrobe doors. They are characterized by their ability to allow the door to swing open a full 270 degrees, which allows for maximum access to the contents of the wardrobe.
- Bowl hinges: Bowl hinges are a type of concealed hinge that are commonly used for wardrobe doors. They are characterized by their ability to be completely concealed within the door and the cabinet, which provides a clean and seamless look.

In the selection of bowl hinges, there are various types:

- Straight hinge: One of the most common. Has an aperture of 110º.

- Angled hinge: It is the one that allows the door not to cover the side of the entire module, and also has a 110° opening. It is one of the most used types of door hinges.

- Super-layered hinge: It is used to attach the door of the furniture with the furniture itself, so that it can be opened and closed. Its opening is also 110°.

- 180° opening: They are used for overlapping doors in small furniture. They have a 180° aperture, as the name suggests.

- Invisible hinge: As its name indicates, it is not seen, as it is hidden. It has a 180° aperture. There are two types: cylindrical (for folding tables and kitchen furniture) and normal.

Table 34: Table comparition of hinges

Hinges	Pros	Cons
Book hinges	Maximum acces to the contents of the wardrobe, often used with a soft-closing mechanism for smooth and quiet closing, can be adjustbale, can be used on heavy or large wardrobe doors	more expensive than other types of hinges, may need additional space to accommodate the swing angle, may not suitable for small wardrobes, complex installation
Bowl hinges	Completely concealed, provide clean and seamless look, can be adjust to fit properly, used to come with a soft-closing mechanism, can be use in a different variety of door, can be used inset and overlay doors	Exepensive, it may requires specialized tools for installation, adjustments are difficult to do once it is installed, not suitable for heavy or large doors

Hinges	Pros	Cons
Invisible hinge	Completly hidden, can be adjustbale to ensure fitting, soft-closing mechanism, can be used on a variety of doors, can be used inset and overlay doors	Expensive, may require tools for installation, there are not adjustments after installing, may not suitable for heavy or large doors

Lifting mechanism For adjusting the table to the most egonomic positions for the user, a lifting mechanism is needed. The system should be useable in an easy and efficient way, that the user feels flexible and comfortable to use the desk for different activities. This kitchen/desk should range between .... and .... The range of height refers to the researched average height of the population and will be adjusted on the market we want to enter with our product. Because of the mechanical mechanism the height can be adjusted to every height within the range. The following table illustrates the comparison between different lifting mechanisms which are avaible on the market.

Table 35: Lifting mechanisms

Product	Pros and Cons	Price (€)	Picture
Crank mechanism	(+)Durable (+)Wide lifting range (manual or electrical) (+)Comes with a handle/button (-)Expensive (-) Heavy	83 for manual, 170 for electronic	
Lift-up table mechanism	(+)Quick to lift up (-)Less durable (-)Expensive	167	
Automatic Sliding Mechanism	(+)Automated mechanism (+)Can be done handmade (+)Space saving (-)Complex structure (-)Expensive (-)Does not lift heavy weights	Unavailable	
Scissor lifting mechanism	(+)Durable (+)Can lift heavy weights (+)Space saving (-)Slow lifting process	Unavailable	

Provisional material list Given that the measurements of the furniture have been determined, the team can now proceed with selecting the approximate sizes of the materials and determining the necessary quantities. Having conducted prior research on the available material options, a provisional list will be compiled, specifying the distances and measurements of each material to be used, along with their intended purpose. It should be noted that this list is subject to revision as the project progresses, and adjustments may be made to the distances or quantities as needed.

Version A

Table 36: Provisional list of woods elements for version A

Identifier	Name	Measurements (cm)	Quantity	Material	Price €/m3 (Aprox)	Price
WS	Wardrobe side	70x200x5	3	Solid wood mapler	To be defined	To be defined
WUD	Wardrobe up and down	50x70x5	2	Solid wood mapler	To be defined	To be defined
WD	Wardrobe door	50x200x5	1	Solid wood mapler	To be defined	To be defined
WB	Wardrobe back	50x200x3	1	MDF	To be defined	To be defined
TU	Table up	150x70x1.5	1	Plywood birch	To be defined	To be defined
TD	Table down	150x70x1.5	1	Plywood birch	To be defined	To be defined
TB	Table back	150x70x4	1	Plywood birch	To be defined	To be defined
TFL	Table front	75x70x4	2	Plywood birch	To be defined	To be defined
AT	Auxiliar tables	75x50x2	3	Plywood birch	To be defined	To be defined

NOTE: The problem with the hinge is that we don't know yet which one we are going to use. For that reason, it is not defined.

Table 37: Provisional list of metalic elements for version A

Identifier	Name	Measurements (cm)	Quantity	Material	Price	
SH	Hinge	NA	3	NA	To be defined	To be defined

Version B

Table 38: Provisional list of woods elements for version B

Identifier	Name	Measurements (cm)	Quantity	Material	Price €/m3 (Aprox)	Price
WS	Wardrobe side	70x200x5	4	Solid wood mapler	To be defined	To be defined
WUD	Wardrobe up and down	50x70x5	4	Solid wood mapler	To be defined	To be defined
WD	Wardrobe door	50x200x5	2	Solid wood mapler	To be defined	To be defined
WB	Wardrobe back	50x200x3	2	MDF	To be defined	To be defined
TU	Table up	150x70x1.5	1	Plywood birch	To be defined	To be defined

Identifier	Name	Measurements (cm)	Quantity	Material	Price €/m3 (Aprox)	Price
TD	Table down	150x70x1.5	1	Plywood birch	To be defined	To be defined
TB	Table back	150x70x4	1	Plywood birch	To be defined	To be defined
TFL	Table front	75x70x4	2	Plywood birch	To be defined	To be defined
AT	Auxiliar tables	75x50x2	3	Plywood birch	To be defined	To be defined

NOTE: The problem with the hinge is that we don't know yet which one we are going to use. For that reason, it is not defined.

Table 39: Provisional list of metalic elements for version B

Identifier	Name	Measurements (cm)	Quantity	Material	Price	
SH	Hinge	NA	6	NA	To be defined	To be defined

Fix parts

The final product will require the procurement of items that are readily available in the market. The table below presents a comparison of features, including both affordable and premium options, for each item.

Table 40: List of components

Element	Price (€)	Store	Link
Sink	42	Ikea	https://www.ikea.com/fr/fr/p/fyndig-evier-integre-1-bac-acier-inoxydable-s59158003/
Hinge x2	5,45	Leroy Merlin	https://www.leroymerlin.fr/produits/quincaillerie/quincaillerie-du-meuble/charniere-fiche-et-paumelle/charniere-de-porte-charniere-de-meuble/charniere-invisible/lot-de-2-charnieres-pour-facade-de-cuisine-ouverture-105-sans-amortisseur-80129466.html?src=cat&query=charni%C3%A8re
Tap	25,99	Ikea	https://www.ikea.com/fr/fr/p/lagan-mitigeur-chrome-10085027/
Tap	89.90	Leroy Merlin	https://www.leroymerlin.fr/produits/cuisine/evier-et-robinet-de-cuisine/robinet-de-cuisine/swiss-aqua-technologies-mitigeur-evier-a-bras-pivotant-2-jets-chrome-bsd284-84283760.html?src=clk
Cooking plates	109,95	Leroy Merlin	https://www.leroymerlin.fr/produits/table-de-cuisson-a-induction-avec-2zones-3000w-controle-tactile-auto-minuterie-87655035.html?src=clk
Cooking plates	240	Leroy Merlin	https://www.leroymerlin.fr/produits/cuisine/gros-electromenager/plaque-de-cuisson/plaque-induction/plaque-a-induction-2-foyers-cata-isb-3102-bk-noir-82929378.html?src=clk
Plugs	Unknow (around 30)	Leroy Merlin	https://www.leroymerlin.fr/produits/electricite-domotique/interrupteur-et-prise/nos-gammes-interrupteurs-et-prises/legrand-dooxie/prise-legrand-dooxie/prise-chargeur-usb-et-2-prises-dooxie-legrand-blanc-83626797.html
Electric and water cable	Unknow		

The price for these features will be between 300 and 600 euros. A possibility could be to give the customer the decision between different models to target their own price category.

(*iii*) detailed drawings;

(*iv*) 3D model with load and stress analysis;

(*v*) colour palette.

7.4.2 Smart System

Hardware

The smart system requires several hardware components to enable the tracking of water and energy consumption, as well as adaptive light management, and provide the necessary information for the software to handle and operate effectively. The processors and sensors used in the system are presented in the following tables, and decisions regarding their selection are made based on their characteristics.

Table 41: List of Microprocessor Development Boards (overview)

Name	Wireless Connection	Main Characteristics	Dimensions	Price [€]	Photo	Link
Arduiono Nano 33 IoT	Wi-Fi, Bluetooth	USB connector: Mircro USB/ Pins (Built-in LED, Pin: 13, Digital I/O Pins: 14, Analog input pins: 8, PWM pins: 5, External interrupts: All digital pins)/ Communication (UART: RX/TX; 12C: A4(SDA), A5 (SCL); SPI: D11 (COPI), D12)/ POWER (I/O Voltage: 3.3V; Input Voltage (Norminal): 5-18 V; DC Current per I/O Pin: 7 mA)/ Clock speed (Processor: SAMC21G18A, 8 MHz)/ Memory(SAMC21G18A: 256 kB SRAM, 1 MB flash)	18 mm x 45 mm; 5 g	12.99		
Raspberry Pi pico RP2040 + Adafruit AirLift-ESP32 Wi-Fi Co-Processor	Wi-Fi	Dual-core Arm Cortex-M0+ processor, flexible clock running up to 133 MHz/ 264 kB on-chip SRAM/ 2 MB on-board QSPI Flash/ 26 multifunction GPIO pins, including 3 analogue inputs/ 2 × UART, 2 × SPI controllers, 2 × I2C controllers, 16 × PWM channels/ 1 × USB 1.1 controller and PHY, with host and device support/ 8 × Programmable I/O (PIO) state machines for custom peripheral support/ Supported input power 1.8–5.5 V DC/ Operating temperature -20 °C to +85 °C/ Castellated module allows soldering direct to carrier boards/ Drag-and-drop programming using mass storage over USB/ Low-power sleep and dormant modes/ Accurate on-chip clock/ Temperature sensor: Accelerated integer and floating-point libraries on-chip	21 mm x 51 mm	12.99		

Name	Wireless Connection	Main Characteristics	Dimensions	Price [€]	Photo	Link
Wemos D1 R32 C/ESP32	Wi-Fi, Bluetooth	ESP32-WROOM-32 in Arduino UNO form factor Working Voltage: 3.3 V DC Input Voltage: 5-12 V DC Wi-Fi: 802.11 b/g/n/e/i (802.11n up to 150 Mbps) Bluetooth: v4.2 BR/EDR and BLE specification RAM: 520KB Flash Memory: 32Mb (4M bytes) Power consumption: Max current: 250mA Sleep current: 0.15mA Active without WiFi current: 20 mA Operating Temperature: -40 °C > +85 °C	68.5 x 53.7 mm	11.90		

In terms of cost consideration and function to connect via WiFi, which is required for the app, the Wemos D1 R32 C/EPS32 board was chosen.

Table 42: Water Flow Sensor

Name	Characteristics	Price [€]	Photo
Water Flow Hall Sensor	Interface size: 4 points (G1/2), Working voltage range: DC5□18V, Inner diameter/outer diameter: inner diameter water inlet 15.4, water outlet 13.5mm/ outer diameter 20.5mm, Thread length: 9.3mm, Water pressure resistance: ≤1.75MPa, Output pulse high level: >DC4.7V (input voltage DC 5V), Output pulse duty cycle: 50%±10%, Insulation resistance: >100MΩ, Flow range: (at 1□25L\MIN) ±3%, Pulse frequency: (Hz)=[11*Q]±5%(Q–Flow L/min)	9.08	

Table 43: Magnetic Switch

Name	Characteristics	Price [€]	Photo
Magnetic Reed Switch SPST	Contact: Normally Open (Normally Closed when activated by magnet), Range: 13-18mm, Switching capacity: 10W, Body dimensions: 29 x 18.8 x 6.9 mm, Lead connection, 2-component sensors, Switched current: 500mA, Maximum switched voltage: 110V, IP rating: IP68	3.63	

Table 44: Light/Brightness Sensor

Name	Characteristics	Price [€]	Photo
Light sensor BH1750 I2C	Measuring range: 0 to 65535 lux, Accuracy: ±1%, Sampling rate: up to 120 measurements per second, Power supply: 3-5V DC, Current consumption: typically 20-60 mA, dimensions: 28.5 mm x 13.5 mm x 2.8 mm, Weight: approx. 2 g	2.90	

Blackbox

In the initial proposal of the blackbox, the aim was to automate the various processes related to furniture. This included plans to implement a digital screen that would enable direct interaction between the user and the furniture, as well as automation of the height adjustment feature for the work table. Another crucial aspect was the control of kitchen plates and the extractor. However, it should be noted that these ideas were generated during brainstorming sessions and were not thoroughly assessed for factors such as power requirements or the need for additional motors to enable automation, as is currently being considered for the automatic lifting of the table.

Old blackbox diagram:

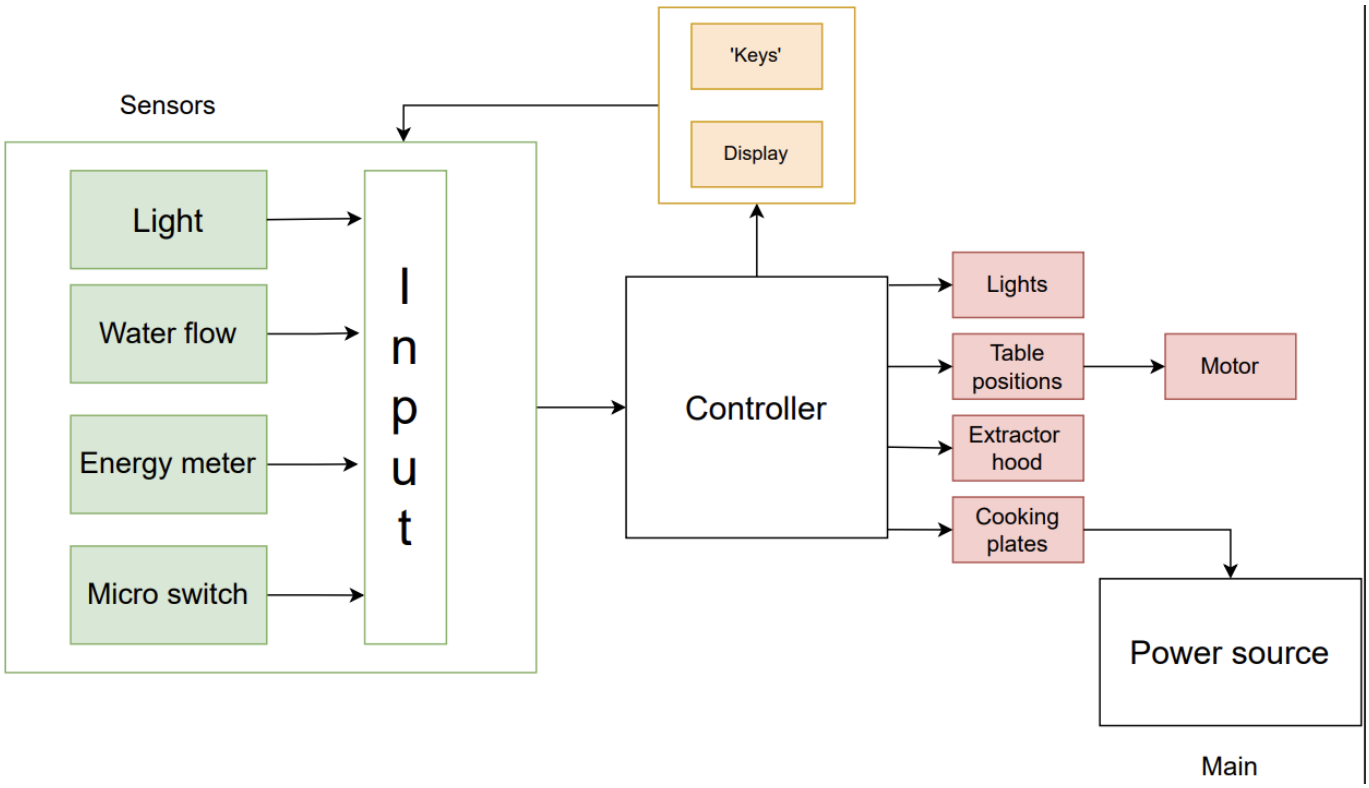


Figure 32: First version of the blackbox

When we started with the design we realized that there were some features that were difficult to implement. That is why, after being embodied our idea we saw that the blackbox we had did not adapt to the ideas that were being realized. In the new blackbox, we've removed features to add more rundimentary but simpler solutions. Some of these features are:

- Replacement of the digital panel with a Webapp application.
- Elimination of the control of the kitchen plates and the extractor through the app.
- Elimination of the automation of the elevation of the table.

New blackbox diagram:

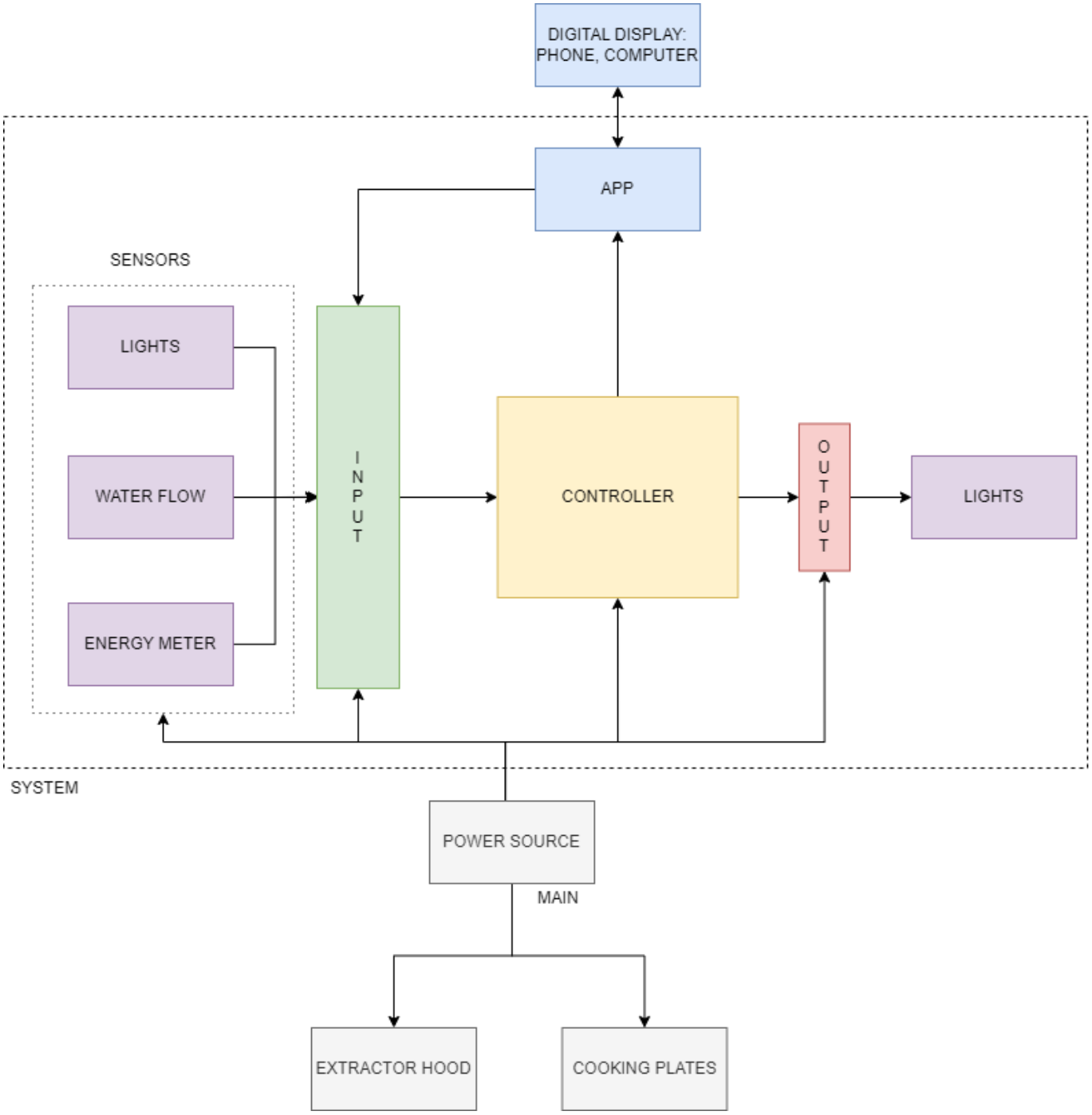


Figure 33: Second version of the blackbox

(*ii*) hardware component selection (use tables to compare the different options for each component;

(*iii*) detailed schematics; (*iv*) power budget.

7.4.2.1 User cases

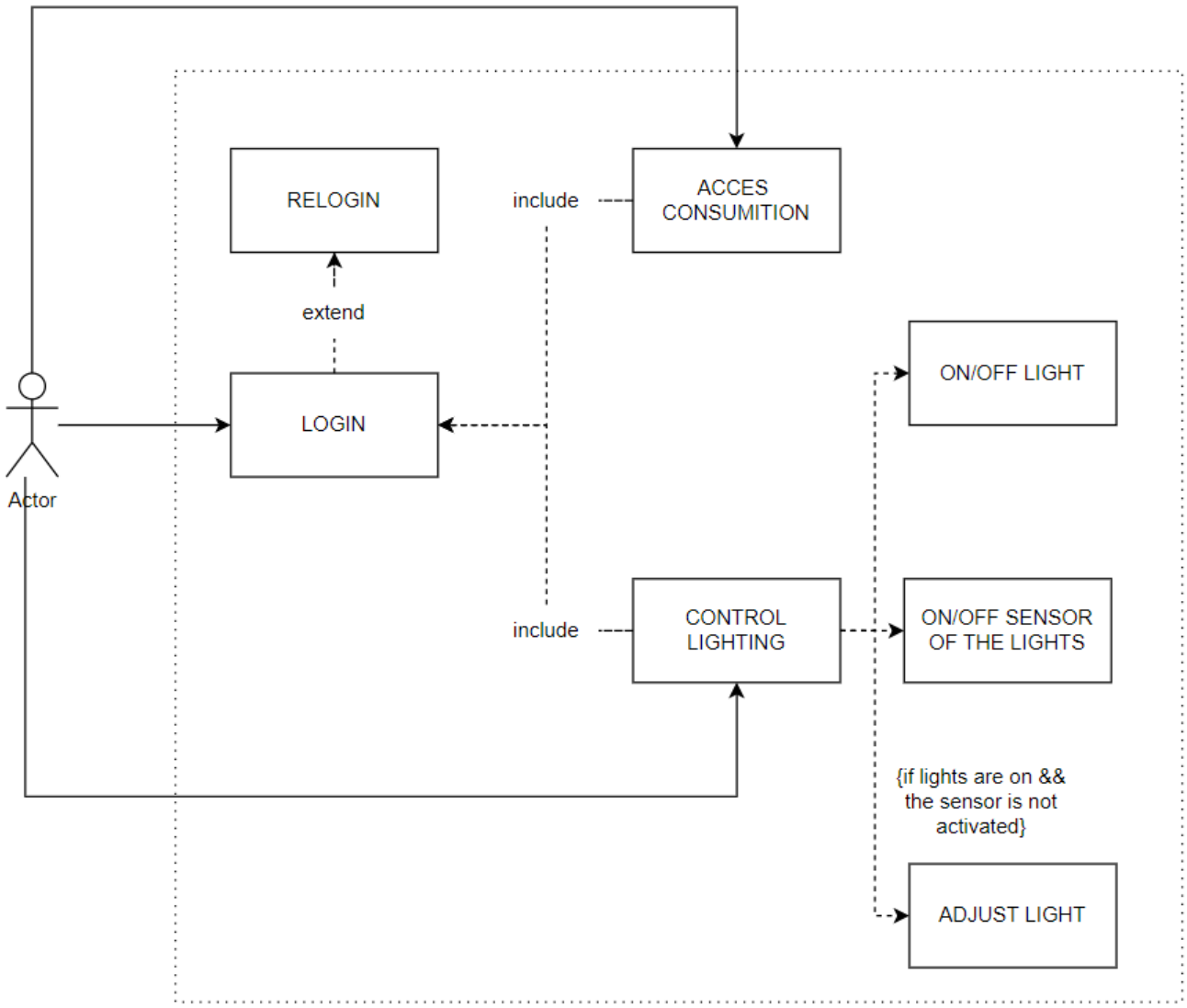


Figure 34: User case of the system

1. User case

Topics	**Definition**
Description	This user case is when the user want to check the electricity and water consumition. Before checking the consumition, must have a connection realized with the furniture
Actors	User
Trigger	The user wants to check how much water and electricity did consume
Preconditions	None
Postconditions	None
Normal flow	Step 1: The user needs to do a connection between the app and the furniture. Alternative flow (step 1a): There went something wrong, so the user can try to connect again or call IT support. Step 2: Have acces to the data of his furniture and can check how much consumed.

2. User case:

Topics	Definition
Description	This user case is when the user wants to manage the lights on the furniture. Can have turn them on and off and adjust the lights of the furniture always that the sensor of the lights is not activated.
Actors	User
Trigger	The user wants to manipulate the lights.
Preconditions	None
Postconditions	None
Normal flow	Step 1: The user needs to do a connection between the app and the furniture. Alternative flow (step 1a): There went something wrong, so the user can try to connect again or call IT support. Step 2: User can control the light. Can turn on or off the lights, sensors of the light and adjust the light under the previous defined conditions.

7.4.2.2 Platforms and software selections

The connection of the interface is possible in 2 different ways. One of them and the most common in the user choice, is the via WiFi. As WiFi it is very reliable, the most important and dangerous risk of doing using this environment is the safety issue. For implementing this system, a webservice or protocol can be defined to send data. The main difference between these protocols and the webservices, is that the webservice is not used to send data that is need to be instantaneal and when the protocols are used it is because the data, that is requested, must be transfered instantanly. For the protocols, the use of MQTT is the best option as it is one of the most populars at the moment and the team has experiencie working with it. INSERT TABLE COMPARING SOFTWARE TECHNOLOGIES

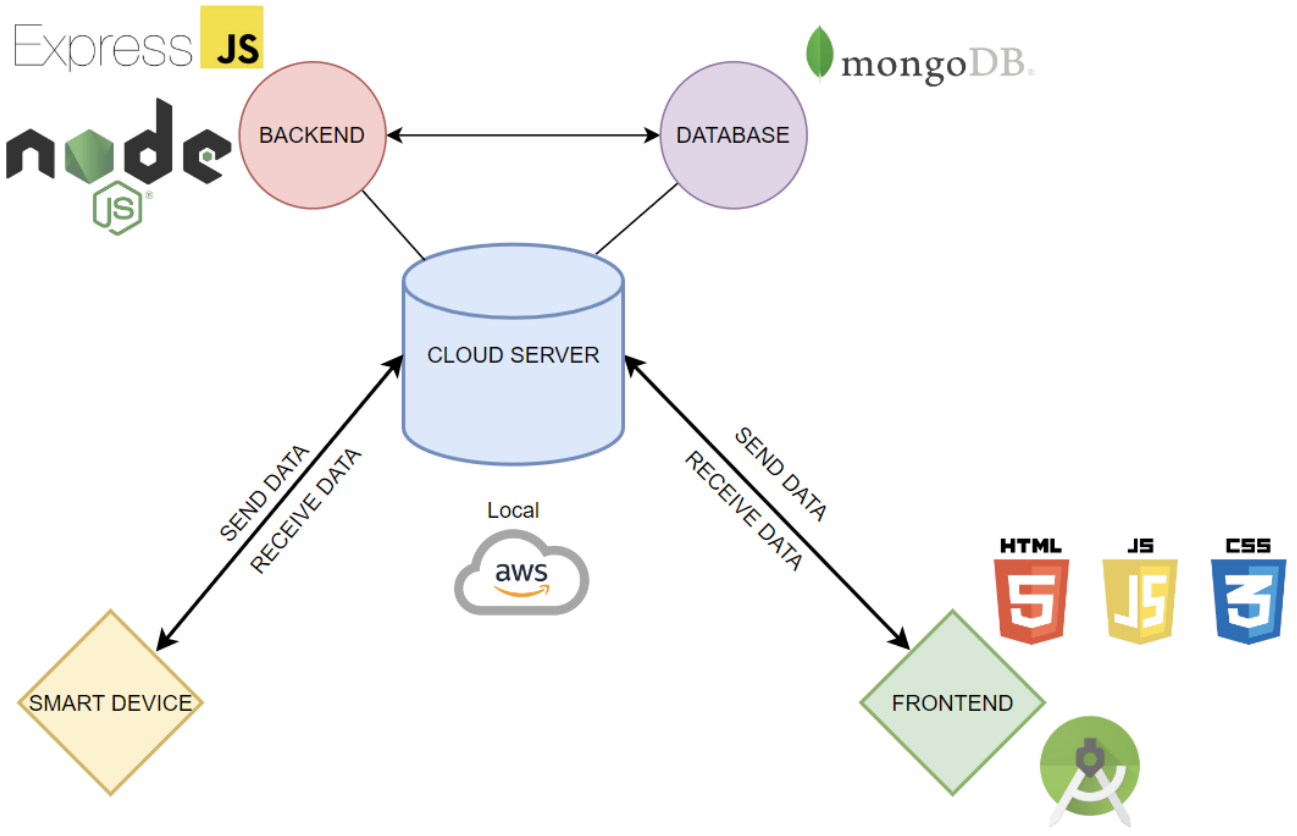


Figure 35: Webservice system

As said before, there is another way of connecting the furniture with the app, with bluetooth. With the bluetooth connection we don't need to have an intermediary (cloud server) that process the data the controller sends, because it will be processed in the application. As the data that we are going to manage is not very big, can be managed in the controller or the aplication. In any case, this data won't be possible be saved as it will start occupying a lot of space in both devices. For that reason, the app or controller should have some type of script that will clean up the thrash memory every space of time.

INSERT TABLE COMPARING SOFTWARE TECHNOLOGIES

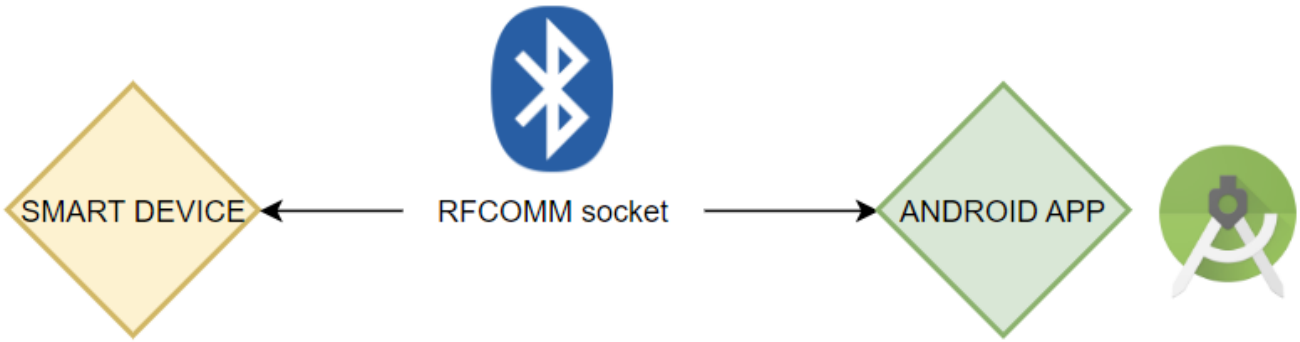


Figure 36: Bluetooth system

After team's meeting with the coaches we decided to use of a webservice over a Bluetooth socket for controlling an electronic device. This decision is based on several factors, including better space control, faster communication, greater control over the infrastructure, and a more user-friendly experience.

A webservice offers better space control as it can be accessed from anywhere with an internet connection. In contrast, Bluetooth has limited range and requires a direct line of sight between the devices. Additionally, a webservice provides faster communication with a much higher data transfer rate than Bluetooth, allowing for real-time control without noticeable delays.

Furthermore, a webservice provides greater control over the infrastructure. It can handle a large number of users and devices without compromising performance and can be scaled up or down easily to adapt to changing needs. Finally, a webservice offers a more user-friendly experience as it allows users to control the electronic device through a web interface accessible from any device with an internet connection.

In conclusion, after careful consideration, we believe that a webservice is the superior choice for controlling an electronic device. It offers better space control, faster communication, greater control over the infrastructure, and a more user-friendly experience. We are confident that implementing a webservice will result in a more efficient and satisfactory user experience.

The class diagram that we have created defines the key elements that we will be working with and outlines how they are connected. At present, the diagram includes a generalization known as consumition. This generalization is then used to represent two specific elements: water and electricity. These generalization has two main attributes: consum and date. Consum will indicate how much kWh or liter has consumed the user during a gap of time to be defined and the date will indicate

when was generated the data. In addition to this, the class diagram also includes another class named “light”, which has three attributes: power, status and automatic. Power will indicate how mucho power we are going to provide to the ligths in the furniture, status will indicate if it is on or off and automatic if it is working via sensor or we defined the power usage.

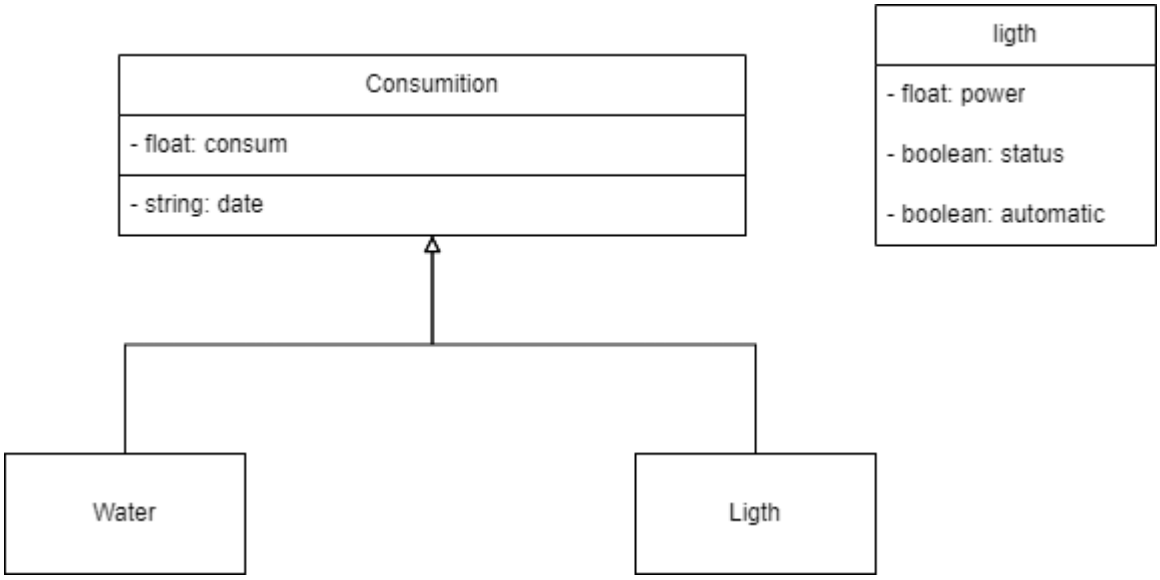


Figure 37: Class diagram of the system

By defining the key elements and their relationships through this class diagram, we can gain a better understanding of how our system will work and how different components will interact with each other. This will help us to identify potential issues or areas where improvements can be made, ensuring that we create a robust and effective system that meets the needs of our users.

7.4.2.3 Component Diagram

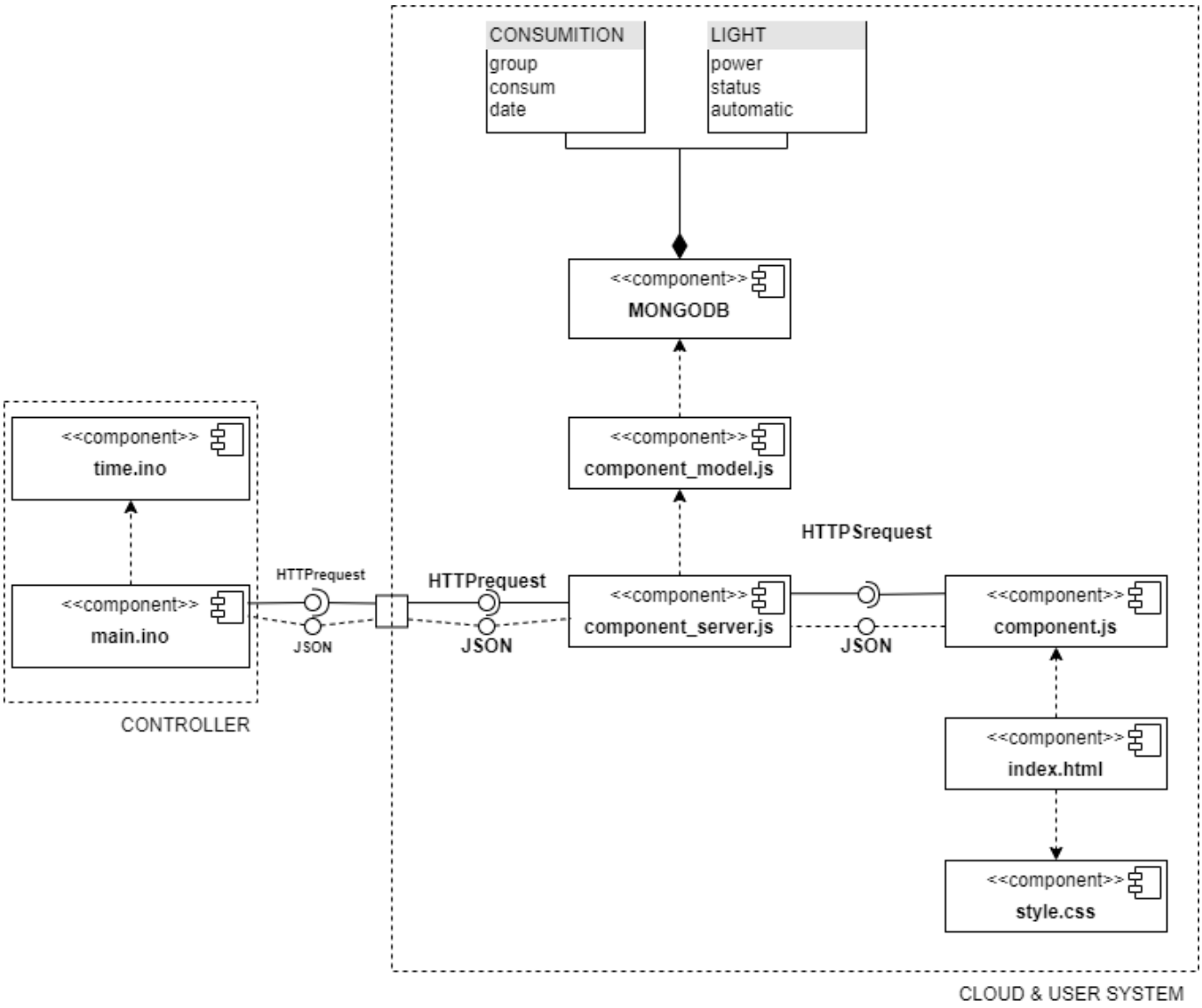


Figure 38: Componentdiagram of the system

The component diagram consists of two systems: the controller and the cloud and user. The user component is composed of three files, named index.html, component.js, and style.css, which together form the app. On the other hand, the cloud component consists of a mongodb database and two backend files written in JavaScript that will be the responsible to comunicate and update the mongodb database. For doing that, the app comunicates with the cloud with HTTPSrequest to comunicate with the backend.

The controller component is composed of two .ino files, with one file handling time functions while the other file handles the main.ino. The main.ino file, in turn, sends and request HTTP requests to get the JSON data from mongodb.

The component diagram provides a visual representation of the interactions between the different components of the system. It shows how the various components are connected and how they work together to provide the required functionality. The diagram helps in understanding the overall architecture of the system and how different components interact with each other.

7.4.3 Packaging

Present and explain the: (*i*) initial packaging drafts; (*ii*) detailed drawings; (*iii*) 3D model with load and stress analysis, if applicable.

7.5 Prototype

Refer main changes in relation to the designed solution.

7.5.1 Structure

Detail and explain any changes made in relation to the designed solution, including structural downscaling, different materials, parts, etc.

7.5.2 Hardware

Detail and explain any change made in relation to the designed solution. In case there are changes regarding the hardware, present the detailed schematics of the prototype.

7.5.3 Software

Detail and explain any changes made in relation to the designed solution, including different software components, tools, platforms, etc.

The code developed for the prototype (smart device and apps) is described here using code flowcharts.

7.5.4 Tests & Results

Hardware tests

Perform the hardware tests specified in **1.6 Functional Tests**. These results are usually presented in the form of tables with two columns: Functionality and Test Result (Pass/Fail).

Software tests

Software tests comprise: (i) functional tests regarding the identified use cases / user stories; (ii)

performance tests regarding exchanged data volume, load and runtime (these tests are usually repeated 10 times to determine the average and standard deviation results); (iii) usability tests according to the System Usability Scale.

7.6 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

8. Conclusions

8.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

8.2 Future Development

Provide here your recommendations for future work.

Bibliography

Will be added automatically by citing, in the body of the report, entries specified in BibTeX format and stored in the https://www.eps2023-wiki1.dee.isep.ipp.pt/doku.php?id=refnotes:bib file

PS - *If you have doubts on how to make citations, create captions, insert formulas, etc. visit this page with examples and select "Show pagesource" to see the source code.*

[Our World Data, 2022] Our World Data, 2022. *Population growth during all the human history.* [Accessed in February 2023].
[The World Bank, 2021] The World Bank, 2021. *Population growth the last 70 years.* [Accessed in February 2023].
[United Nations, 2018] United Nations, 2018. Welcome to the United Nations. *United Nations Website*.
[Lucy Pickford, 2021] Lucy Pickford, 2021. Tiny living space in Japan: How to make the most of a small home. *Go! Go! Nihon*.
[Günther Schuh, Violett Zeller, Jan Hicking, Anne Bernardy, 2019] Günther Schuh, Violett Zeller, Jan Hicking, Anne Bernardy, 2019. Introducing a methodology for smartification of products in manufacturing industry. *Procedia CIRP*, 81, pp.228-233, ISSN 2212-8271.
[Altwork, 2023] Altwork, 2023. The Altwork Station: A Revolutionary Desk and Chair System for

Professionals. *Altwork*, [Accessed in March 2023].
[Herman Miller Inc., 2023] Herman Miller Inc., 2023. The Herman Miller Aeron Chair: A Design Classic. *Office Chairs - Herman Miller*, [Accessed in March 2023].
[Steelcase Inc., 2023], **[Steelcase Inc., 2023]** Steelcase Inc., 2023. The Steelcase Gesture Chair: A Highly-Adjustable Office Chair for Ultimate Comfort. *Steelcase*, [Accessed in March 2023].
[Varidesk LLC., 2023] Varidesk LLC., 2023. The Varidesk ProDesk 60 Electric: A Sit-Stand Desk That Adapts to Your Needs. *Varidesk*, [Accessed in March 2023].
[StoreBound LLC., 2023] StoreBound LLC., 2023. The Sobro Smart Coffee Table: A Centerpiece for the Modern Living Room. *Sobro*, [Accessed in March 2023].
[Ori Design Studio, 2023] Ori Design Studio, 2023. Ori Expandable Apartments. *Ori Living*, [Accessed in March 2023].
[Ikawa Ltd., 2023] Ikawa Ltd., 2023. Kelvin Home Coffee Roaster. *Ikawa*, [Accessed in March 2023].
[Herman Miller Inc., 2023] Herman Miller Inc., 2023. Live OS: A Smart Furniture System for the Modern Workplace. *Herman Miller*, [Accessed in March 2023].
[Humanscale, 2023] Humanscale, 2023. Float Table. *Humanscale*, [Accessed in March 2023].
[Varidesk LLC, 2023] Varidesk LLC, 2023. Pro Plus 36. *Varidesk*, [Accessed in March 2023].
[Hannah Ritchie, Max Roser, 2018] Hannah Ritchie, Max Roser, 2018. Urbanization. *Our World in Data*, [Accessed in March 2023].
[MarketsandMarkets, 2021], **[MarketsandMarkets, 2021]** MarketsandMarkets, 2021. Smart Home Market - Global Forecast to 2026. *MarketsandMarkets*, [Accessed in March 2023].
[Statista, 2023] Statista, 2023. Japan: Urban and rural population. *Statista*, [Accessed in March 2023].
[360imprimir Company, 2023] 360imprimir Company, 2023. Leaflet. *360imprimir*.
[letscopy SL, 2023] letscopy SL, 2023. Posters prices. *letscopy*.
[Facebook Company, 2023] Facebook Company, 2023. Facebook business. *Facebook*.
[Instagram Company, 2023] Instagram Company, 2023. Instagram business. *Instagram*.
[iebschool, 2022] iebschool, 2022. Guia completa sobre como anunciarse en tiktok. *iebschool*.
[alucare, 2022] alucare, 2022. Cuanto cuesta anunciarse en snapchat. *alucare*.
[comunicare, 2022] comunicare, 2022. Cuanto cuesta poner anuncios en YouTube. *comunicare*.
[28], **[33]** Wikipedia. *Engineerd wood.* [Accessed in April 2023].
[University of Alberta, 2018] University of Alberta, 2018. *What is sustainability?.*
[Paulo Peças, Uwe Götze, Rita Bravo, Fanny Richter, Inês Ribeiro, 2019] Paulo Peças, Uwe Götze, Rita Bravo, Fanny Richter, Inês Ribeiro, 2019. Chapter 1 - Methodology for Selection and Application of Eco-Efficiency Indicators Fostering Decision-Making and Communication at Product Level—The Case of Molds for Injection Molding. *Advanced Applications in Manufacturing Enginering*, Woodhead Publishing, pp.1-52, ISBN 978-0-08-102414-0.
[Lidija Čuček, Jiří Jaromír Klemeš, Zdravko Kravanja, 2015] Lidija Čuček, Jiří Jaromír Klemeš, Zdravko Kravanja, 2015. Chapter 5 - Overview of environmental footprints. *Assessing and Measuring Environmental Impact and Sustainability*, Oxford: Butterworth-Heinemann, pp.131-193, ISBN 978-0-12-799968-5.
[Recycling World, 2021] Recycling World, 2021. *Aluminium for future generations.* [Accessed in June 2023].
[MDC-UM, 2019], **[MDC-UM, 2019]** MDC-UM, 2019. *Sustainable Furniture in Modern World.* [Accessed in April 2023].
[IKEA, 2020] IKEA, 2020. *Climate footprint from production.* [Accessed in April 2023].
[Michael Bloch, 2011], **[Michael Bloch, 2011]** Michael Bloch, 2011. *An introduction to wood certifications.* [Accessed in May 2023].
[PEFC, 2021] PEFC, 2021. *What is PEFC.* [Accessed in May 2023].
[Mitchell Grant, 2020] Mitchell Grant, 2020. *Sustainability.* [Accessed in April 2023].
[Martin V Bennetzen, 2020] Martin V Bennetzen, 2020. *The Positive Impact of Sustainability on Business, Financial Performance and Resiliency.* [Accessed in April 2023].

[J. Lu, H. Cui, Luís Bragança, Susana M. Vieira, Joana B. Andrade, 2014] J. Lu, H. Cui, Luís Bragança, Susana M. Vieira, Joana B. Andrade, 2014. Early Stage Design Decisions: The Way to Achieve Sustainable Buildings at Lower Costs. *The Scientific World Journal*, 2014, Hindawi Publishing Corporation, pp.365364, ISSN 2356-6140.
[Stuart Walker, 2006] Stuart Walker, 2006. *Sustainable by Design: Explorations in Theory and Practice..* Earthscan / James and James Science Publishers, London, ISBN 978-1844073535.
[Cristian Grossmann, 2021] Cristian Grossmann, 2021. *Promote Workplace Diversity Through Employee Engagement.* [Accessed in May 2023].
[Salah M. El Haggar, 2005] Salah M. El Haggar, 2005. CHAPTER 13 - Rural and Developing Country Solutions. *Environmental Solutions*, Burlington: Academic Press, pp.313-400, ISBN 978-0-12-088441-4.
[Stephen Gent, Michael Twedt, Christina Gerometta, Evan Almberg, 2017] Stephen Gent, Michael Twedt, Christina Gerometta, Evan Almberg, 2017. Chapter Eight - Environmental Considerations of Torrefaction. *Theoretical and Applied Aspects of Biomass Torrefaction*, Butterworth-Heinemann, pp.185-202, ISBN 978-0-12-809483-9.
[unknown, unknown] unknown, unknown. Engineering Ethics - Introduction. *Tutorialspoint*, [Accessed in March 2023].
[Lestraundra Alfred, 2019] Lestraundra Alfred, 2019. 8 Ethical Behaviors to Live and Sell by in Sales. *blog.hubspot*, [Accessed in March 2023].
[52] sep-ethics-environmental