# Summary


**Essence**
In this thesis the design process of Parthian Technology's assignment can be found. This assignment can be described as:
Parthian Technology would like to enter the outdoor furniture market, by developing an innovative outdoor furniture. Since the traditional outdoor furnitures are made out of wood or metal and Parthian Technology is specialized in composites, it is required that this furniture is made out of composite.
Only having an innovative look is not enough, the outdoor furniture must also include electrical functionality and solar panels that provide power to the electrical functionality.
Furthermore, the left side and the right side of the furniture must be the same, a product family must be made and a 1:1 scaled prototype must be built.

**Research**
First a research must be done to find out what the requirements and the possibilities are. To be able to do that the research is divided in ; the target group, market analysis, usage analysis, electrical components, production methods and aesthetic analysis.
The target group has the age 13-64 years and the main stakeholders are ; private persons, the municipality of Enschede and companies and organisations.
The market can be divided into two sectors; direct and indirect competitors. The direct competitors are the companies that design, manufacture and sell solar benches. The indirect competitors are the companies that design, manufacture and sell regular outdoor furniture. The indirect competitors can be subdivided in; furniture for in private areas and furniture for in public areas.
According to the Ansoff matrix, Parthian Technology should choose the market strategy product development. This means that Parthian Technology should invest in developing this new product which fulfills the new or other needs of the end-user to make profit in the long-term.
By using scenarios we can find out which functionalities are valuable to the end-user, these are: wireless charging, Wi-Fi, USB plug-in, a heating system, an electricity plug and lights.
We assumed that the solar panels provide at least 45 Wh, because of this we chose to integrate  USB plug-ins and LED light in the outdoor furniture.
Parthian Technology B.V. is specialised in composites consisting of fibers embedded in a plastic also called fiber reinforced plastics. The production methods that are available at Parthian Technology are; hand lay-up, vacuum infusion and the usage of pre impregnated fibers.
The appearance of the furniture must be attractive to the main stakeholders. The municipality prefers a robust, sustainable, simple looking furniture. Form follows function is suitable for the municipality. Organisations and companies prefer an innovative, futuristic and outstanding looking furniture. Private persons are looking for a comfortable, sustainable and high-tech looking furniture.

**Ideation**
To generate many potential ideas a mind map is made and the approach to diverge and converge is applied. Out of this, five concept are obtained; a bench with a roof, a simple bench, a combination of a bench and a table, a modular furniture and a double curved furniture.

**Concepts**
These five concept are further developed. The advantages and the disadvantages of each design is defined. Then the concept choice must be made, which is based on the factors; producibility, the integration of the electronics, the position of the solar foils, ability to make a product family and its appearance. Finally, it is concluded that the concept simple couch is the best concept. This is mainly because of its producibility, the position of the solar foils and the ability to make a product family out of it.

**Final design**
The concept simple couch has a couple of uncertainties which are; electrical components, the location of the electronics, the armrests and the protection of the solar panels. When this is known, the details must be solved, which are; the dimensions, the strength, the mounting in the ground and the communication to the end-user.
The electrical components that are needed are; four solar panels, an MPPT charge controller, a gel battery, a load centre, a time

switch, a light sensor, one meter LED strip and two USB plug-ins. In the chapter final design an overview can be found on how these components should be connected.
Because of the special form of the sides of the furniture an area for the electronics and the armrests are created.
Protecting the solar panels could be done by placing transparent meshlite and vandalite sheets on top of the solar panels.
Using the anthropometric data of the human we can find the ergonomic dimensions of the furniture. The dimensions which are relevant are; the hip breadth, buttuck-popliteal depth and the elbow height. We can conclude that the hip breadth should be at least 466 mm per seat, the buttock-popliteal depth should be around the 438 mm, the elbow height should also be around the 182 mm and the popliteal height should be maximum 370 mm. Another important dimension is the angle between the seat and the backrest, this should be between 95 and 105 degrees.
To make sure the seat will hold a person of 150 kg a strength calculation is done. Out of this calculation can be concluded that the thickness of the laminate should be at least 18,5 mm.
Furthermore concrete sign bases can be used to mount the furniture into the ground.
By using the special material property of composite light transmittance, a unique looking furniture can be created. This property can also be combined with the LED light, which the furniture must have. This is done by filling an area in the seat with only a semi-transparent matrix, so without glass fiber and a core material. Underneath this semi-transparent beam, the LED lights are placed.
From a distance it should be clear to the end-user that this furniture has a USB charging point, since its innovative look and the solar panels are not clear enough. This can be done by painting logos of a USB charging point on the backrest, so the end-user can recognize this solar bench.
Finally renders of the product family are made to show how the product family should look.

**Prototype**
In this project also a prototype with the scale 1:1 must be build, so this is taken into account in the final design. Prototyping is divided into three parts; shaping process, joining process and the surface treatment.
In consultation with Parthian Technology it is decided that biax glass fiber, epoxy resin (766H) and PMI foam must be used to make the parts.
The shaping process can be subdivided into the shaping of the side parts and the shaping of plates.The side parts are made out of the mould, the plates, which connect the left part to the right part of the furniture are vacuum infused.
After all the parts are made, the parts must be glued together. This is done with the epoxy resin that is used to produce the parts. Only the solar plate is not glued, because the mechanic should be able to reach the electrical components. This plate could be screwed with a torx screw, because this kind is rare to use.
After gluing all the parts together, the holes and the irregularities must be treated, so it get a professional look and feel. This is done by filling the holes with putty and a pore filler and sanding the whole furniture. Eventually, the bench is painted with two layers of Aeolus Aqua 2K Pur Mat Wit. To simulate the light, a waterproof RGB LED strip with 3 AAA batteries is used, so a large battery is not needed. Also one universal USB plug-in is used to show how a phone could be charged.