BUSINESS PLAN AND LIFE CYCLE ANALYSIS OF A SOLAR CHARGING INTEGRATED PARASOL FOR MICRO CHARGING OF HAND HELD ELECTRONIC DEVICES

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Thesis to obtain the Master of Science Degree in

Energy engineering and Management

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October 2014

Acknowledgements

I would like to thank, initially, my colleague and co-founder of G-RooT Mr. Danish Rehman for his loyalty during this beautiful and sometimes stormy journey. His temper is admirable and unique. More specifically, I would like to thank Mr. Rehman for his contribution in performing the Computational Fluid Dynamics and structural analysis of our first product G-SOLution and his inspiration in writing part of the business plan. Many thanks to Mrs. Elena Bou, KIC Innovation Director, and Dr. Enrique Velo, general coordinator of RenE program, who from the begging appreciated our idea and our passion and did their best to help us overcome all the initial bureaucratic obstacles. My professor Dr. Tiago Domingos for his contribution to this thesis and of course his open-mindedness in understanding the uniqueness of our project compared to a conventional technical thesis. I cannot also forget the personnel of the Business Incubator in Barcelona for their advices and especially Mr. Nacho Gallardo who was assigned to be our business mentor. Last but not least, I would like to thank my family; without them I would not be where I am.

"you wish the journey to be long,
full of adventure, full of experiences…"
Ithaca, J.P. Cavafy

Abstract

In February 2014 my team and I got inducted in the Business Incubator Iberia in Barcelona. Before that, the submission and approval of our business idea had taken place KIC - Innoenergy community welcomed us and a new scheme on internship and thesis implementation had just started. KIC – Innoenergy, a branch organisation of EIT, is an innovation centre related with different forms of energy and sustainability. The main objective of the European Institute of Innovation and Technology is to bridge the gap between the academic world and the market. The mechanism employed is the creation of start-ups through a platform where academic technical and managerial education is engaged with investors and real world solutions. Four years after the creation of the master's program RenE, we were the first master students who got incubated in order to fulfil their dreams and enhance the bond between technical knowledge and managerial education, which is the slogan of KIC. The aim of the present master's thesis is to initiate, contribute and accelerate the G-RooT start up.

G-RooT is a start-up created by myself and co-founder Danish Rehman in order to integrate photovoltaics into daily life objects, raise awareness about solar energy by engaging opinion leaders and create a world where there is energy available for charging hand held devices where there are areas of products exposed to the sun. G-RooT's first product is G-SOLution, a solar charging parasol targeting the market of luxury hotels. The present master's thesis is divided into two sections: section I where the business plan is written according to the regulations and the formal template used by EIT Incubators across the European Union and section II where an initial Life Cycle Analysis of the product has been performed.

Section II aims to confirm the concept of green - forming G-SOL, which is interpreted by the author as producing objects that not only do not have carbon footprint but on the contrary saving the carbon footprint of the relevant regular ones. .Therefore, the environmental impacts of G-SOL were examined in terms of sixteen impact categories with main focus to Global Warming Potential. This was achieved by performing an LCA study using the SimaPro software and ILCD 2011 Midpoint impact method. Further, different PV technologies were investigated and a sensitivity analysis was also performed in terms of waste treatment and disposal.

The carbon footprint of G-SOL is -128 kg of CO_2 – eq., which is equivalent with 13 UK's households CO_2 daily emissions. and our solution cause the most negative effect in the impact categories Mineral, Fossil and Renewable Resource Depletion followed by Ozone Depletion while the least to acidification. Aluminium is the material that contributes the most to the environmental load with 894 kg of CO_2-eq followed by the woven cotton fabric with 53.8 and the multi-Si module with 52.6 kg of CO_2-eq. Different cases-scenarios' results vary between -274 kg of CO_2 - eq. to 764 kg of CO_2 - eq., where negative value means that the product has a net effect of reducing greenhouse gas emissions.

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1 Opportunity Analysis

1.1 The Need or Problem Definition

1.1.1 Outdoor Charging

Smartphones and devices have become an integral part of our daily lives and with increasing communication services offered by companies, our reliance on these devices will further increase many folds. By the end of 2013 BI Intelligence, Business Insider paid research service, predicted to have 1.78 billion smart phones and tablets around the globe [1]. Assuming an average energy consumption of 5Wh (iPhone), these devices require 3.25 TWh electricity every year, enough to electrify 0.8 million average European households. According to Moomaw et. al [2] CO_2 emissions associated with natural gas are 469g per kWh of energy produced which reflects annual emissions of $1.5x10^3$ tons of CO_2 for charging these devices. Increased use of personal electronic devices certainly has a global impact on environment that can be reduced by charging using clean resources such as solar power.

To have a feedback from smartphone users we employed an online survey to understand their daily dependence on smartphones and associated battery discharging problem. The survey consisted of 20 qualitative questions and response from 112 users was recorded. Online survey and associated results can be found at web address as mentioned in reference [3]. Gender distribution amongst participants from 26 different countries was 67% men and 33% women. 95% of the participants had earned a graduate degree or more. 92% of the users surveyed had faced the problem of running out of juice while out and 13% mentioned to encounter this problem every other day. 44% of the participants expressed their dependence on smartphones as their daily essential need while 39% mentioned the use just for practical purposes. When asked about the reaction of users to charge their devices using clean sources of energy, 85% mentioned that they will feel good for their contribution to the environment and 78% agreed to recommend it to their friends through social media. Another research conducted in USA, UK, Germany and UAE showed that 71% of the people using mobile phones would prefer longer lasting batteries [5]. Users are demanding more than the capabilities of technology mainly because their cell phones are an essential part of their life and secondly because they are not aware of the limits their mobiles have. Nomophobia is the fear of being out mobile phone contact. The term, an abbreviation for "no-mobile-phone phobia", was coined during a 2010 study by the UK Post Office who commissioned YouGov, a UK-based research organization to look at anxieties suffered by mobile phone users. The study found that nearly 53% of mobile phone users in Britain tend to be anxious when they "lose their mobile phone, run out of battery or credit, or have no network coverage". The study found that about 58% of men and 47% of women suffer from the phobia, and an additional 9% feel stressed when their mobile phones are off. Fifty-five per cent of those surveyed cited keeping in touch with friends or family as the main reason that they got anxious when they could not use their mobile phones. The study compared stress levels induced by the average case of nomophobia to be on-pair with those of "wedding day jitters" and trips to the dentists. Ten per cent of those questioned said they needed to be contactable at all times because of work [6].

In conclusion, a strong need for enabling longlast outdoor usage of electronic devices such as smart phones, tablets and notebooks without running out of juice exists which can be served by providing charging platforms outdoors.

1.1.2 Eco Marketing

Our business focuses on serving the above mentioned need in an environmental friendly way that is to use product integrated solar power to generate electricity. Therefore, we plan to address the need of sustainability of our potential clients. Eco-marketing, or green marketing, is a trend in business where companies create an image of themselves as an environmentally friendly organization in order to gain favour with environmentally conscious customers. Companies mainly engage in eco-marketing by deploying more environmental friendly techniques (or less environmental harmful), i.e. the way they make business or by employing environmental friendly practices for third parties, i.e. provide sustainability to others (plant trees, provide renewable energy to developing countries, etc.). Their initiative for 'greening' is basically stemming from the customer demand, both for SMEs as well as bigger companies, ranging up to international corporations. Some people claim that this is part of their CSR (Corporate Social Responsibility) in favour of the environment and the societies while others believe that this is just 'green-washing'. One way or another, it is true fact that enterprises include more and more the term sustainability into their marketing campaigns in order to reach the more and more environmental conscious clients. It is what we like to call as green differentiation.

Designing a sunshade that covers the basic need of shade with integrated solar power to generate enough electricity to charge hand held devices of end users may address the markets presented in Figure 1

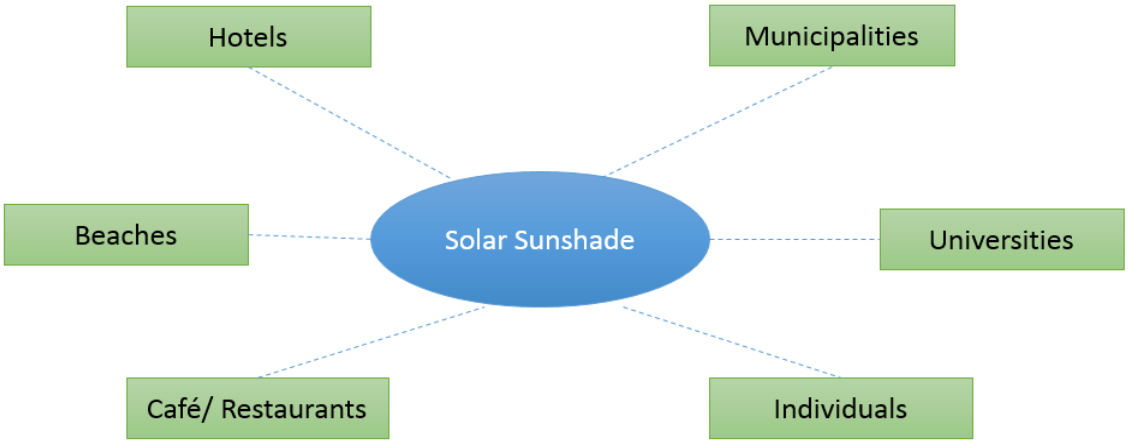


Fig. 1: Potential Markets for Solar Sunshade

Our market is all those businesses and places where sunshade (being a basic need) is already employed and having solar charging will increase the comfort of their clients, in the case of businesses, or themselves, in the case of individuals in their villas.

1.2 Need of each Market Segment

1.2.1 Beaches

The need for this market segment is:

1. Sun shading
2. Off grid electricity generation for:
    a. Charging the EPOS (Electronic Point of Sale) devices when they run out of battery
    b. Making a green party
    c. To have electricity in cases where there is no restaurant in the back of the beach
3. Green differentiation in order to gain a competitive advantage against their competitors which are just next to them
4. Lighting in order to light up the beach at night and to avoid unexpected events.
5. Electricity independence from close by café/restaurants as most of current beaches rely on nearby café/restaurants for their electric needs
6. Comfort to their client (fans which will offer more pleasant time under the hot sun)

1.2.2 Open air businesses (cafes, restaurants)

1. Sun shading
2. Lightning (these places need lightning since they usually use public space and they extend wires from their main building creating an ugly image)
3. Green differentiation in order to gain a competitive advantage against their competitors which are just next to them
4. Comfort to clients by giving them the possibility to charge their devices
5. Additional income by feeding the electricity produced by PVs to the grid

1.2.3 Universities and Municipalities

1. Sun shading
2. Awareness in the people about environment i.e. educating society
3. Presenting a green image of the municipality or university

1.2.4 Hotels

1. Sun shading
2. Sustainability in terms of harmonized integration of renewable energy
3. Green differentiation in order to gain a competitive advantage against their competitors
4. Comfort to their clients by giving the possibility to charge electronic devices

1.2.5 Individuals

1. Sun shading at the pools of villas
2. Green differentiation
3. Opinion leader and leading from the front showing a deep environmental concern

1.3 Evidence of the Need

If we look closely at the potential market segments, they can be grouped in three categories where one is small and medium enterprises (SMEs), which include hotels, cafeterias and beaches. Another would be open air public spaces as in case of municipalities and universities. And the third one is the individual customers. In this section we present detailed analysis of needs that each category has and that can serve as the basis of sales and growth of company.

1.3.1 SMEs (Hotels, Beaches and Cafeteria)

The sustainability trend is recorded for Small and Medium Enterprises. Europe barometer conducted a survey questioning entrepreneurs from all the EU 28 member states on sustainability [7]. 67% of the SMEs replied that saving energy is the primary action they are employing to become more resource efficient. The most interesting fact, though, is that the 16% of SMEs in EU28 are using predominantly renewable energy. Note that the higher percentage is observed in the companies who employ 50-250 employs followed by those with number of employees between 10-49. Hotels rely on this category. And the positive message is that the trend is increasing over the next two years. Specifically, the overall percentage is increasing from 16% to 20% and in services from 17% to 20%.

Further, it is observed that 19% of SMEs in Spain are using predominantly renewable energy sources and 11% in Greece. Spain has the highest percentage in between all the countries in the column "many actions employed to become more resource efficient". In the question "action your company will implement in the upcoming two years", again it is observed an increasing trend.

The question asked about the reasons why the companies are undertaking such actions. First preference as expected for a reasonable answer is the cost savings. It is more interesting, though, the fact that the second preference of SMEs is the environment and its protection.

Finally, the main drivers for which companies offer green products or services are with the following sequence, the demand from the customers, company's core values, company's image and company's competitive advantage.

To conclude 93% of SMEs are taking at least one action to be more resource efficient and eight out of ten SMEs are planning additional resource efficiency actions in the next two years. And the main driver for the companies to offer green products is the demand from the customers

1.3.2 Individuals

People are becoming more concerned about their consumption, its associated impact on environment and are therefore looking to solutions that are healthier and have zero or less impact on the surroundings. One segment of these consumers are those who truly believe in sustainability and are promoters of the fact that for a sustainable future, less consumption is the way out. On the other hand another big segment of the consumers (potentially 2.5 Billion according to [8]) don't want to reduce their consumption and yet claim to feel guilt about impact of their consumption. Looking at the market trends of recent years one can figure out that consumers with their consumption are concerned about themselves, society and environment. In 2016, the global organic food market is forecast to have a value of $102.5 billion, an increase of 52.6% since 2011 [10].

Social responsibility is another important factor in consumers' agendas who are therefore interested in buying the alternative products from brands that show better and transparent social responsibility. Increased consumption with an associated direct help to poor or deserved help us feel better about our spending. Who Gives a Crap is a new startup based in Australia, which gives 50% of its profit by selling these toilet papers to help building toilets in developing world. Brand reached its target of USD 50,000 in just 50 hours at a crowdfunding website Indiegogo in August 2012 showing a keen interest of consumers. Another example of a success is TOMS, a trendy shoe retailer which works on a model called "One for One" according to which every pair of shoe sold, they provide a pair to a needy child in developing world. Last but not the least dimension of guilt is environmental impact of consumption which has resulted in a boost for Eco friendly services and products. Sustainability is new mantra for contemporary design of products ranging from indoor personal devices to outdoor furniture. High end outdoor furniture market accounted for 1.8 Billion Euros worldwide in 2013 and macro trend of this market as pointed out by Bain & Co. [11] is sustainability and LED lightning.

The need our product addresses is therefore sustainability and lightning with integrated aesthetics in product design. Affluent customers having a backyard and/or swimming pool require not only sunshade to protect from UV rays of sunlight but also exclusivity covered by sustainability of offered product. To

Living Clean and Green

With time passing and increased awareness, consumers are becoming more conscious about their consumption. Sustainability demands consuming the apt amount and saving the rest for future generations. This notion makes certain pleasures of life as a social burden. But there is a way out by consuming as much as one wants by eating organic food and using clean energy and that too by helping others fulfilling social responsibility.

We address our customer's need of clean energy consumption by integrating solar technology to outdoor furniture. According to Bain & Co. [11], high end outdoor furniture accounted for 1.8 Billion Euros in 2013 with a strong macro trend of sustainability for the future.

cover a dire need of social responsibility of consumers we plan to introduce a similar business model of "One for One" where every purchase will be associated with a solar lightning solution in developing world through already active social entrepreneurs in those communities. Our company therefore sells more of sustainability and less of electricity to these individual customers.

1.4 PESTEL Analysis

A PESTEL analysis is a framework or a tool used from marketers to analyse and monitor the macro-environmental (external marketing environment) factors that have an impact on an organisation. The PESTEL context surrounding a product which generates renewable electricity and is used as an object of everyday use in households and SMEs needs to be viewed in two dimension: the national and the supranational. This means that some elements of the political, legal, monetary and environmental context derive directly from a European level, since the related policies of Europe are a matter of co-decision. The clear tendency of EU to move towards sustainability creates a prosperous environment for our company, which lays upon the renewable energy generation and the environmental friendly materials. Further, people are more and more getting adapted to eco friendliness and it is becoming-if not have already become-a prerequisite of their choice when it comes to purchase new products.

1.4.1 Political

1.4.1.1 European Energy Policies

The past years the European Union has put forward a series of long-term strategies to foster the sustainability of the European Union both in terms of energy production but as well in the industrial production. The 2020 energy framework is already in actions and most of the EU countries are currently succeeding in their targets, which as result has foster the market of PV panels and reducing their cost up to 50% [12]. The energy framework is currently negotiated which most probably will set a binding target of reducing CO_2 emissions of 40% and set a pan European binding target of use of renewable energies of 27%. Furthermore, the European Parliament is currently negotiating the creation of an European industrial strategy which will have as focus the fostering of EU industries and SMEs on green products, which the EU still has a competitive advantage due to its know-how.

1.4.1.2 Transatlantic Agreement on Trade TTIP

A trade agreement is currently under negotiation with the US, for the free trade agreement between the US and the EU. Although negotiations are not yet finalized, the agreement schemes include the reduction of trade barriers and customs costs for the exports of EU manufactured goods in the US.

The impact of such agreement to a photovoltaic power station - shade, will be the increase of the target group, since it will be easier to export the product to the US market. Additionally since the EU is increasingly interested in creating a leading positioning in green products, such export effort will be backed by the EU branding of green products.

1.4.1.3 Situation of early markets (Greece and Spain)

The current political situation in Greece and Spain is under high pressure due to increased unemployment

(28%-Greece, 26%-Spain) and public debt (160%-Greece, 86%-Spain). The economic situation of both states, makes the economic environment unstable, although unstable within the EU means that economic and labour laws may change within the coming years. However in terms of economic risk for a new company with low labour intensity, the risk is much lower.

Furthermore, Greece aims to become a solar energy exporter and Spain is one of the countries with the best positioning on RES, in the EU. These two facts generate trends within the two states that create a very positive market climate for companies offering innovating green products.

1.4.2 Economical

European Union faced a deep financial crisis in recent past, which caused increased unemployment, inflation and negative GDP growth for most of the member states. However Europe's economic recovery began in the second quarter of 2013, is expected to continue spreading across countries and gaining strength. For successful operation of our company we investigate Greece, Spain and Bulgaria for their current tax system in Table 1 below.

Table 1: Tax rates in countries of interest

Country	Corporate Tax (%)	VAT (%)	Implicit tax rate on Labour (%) as of 2011 from Eurostat
Greece	26	23	30.9
Spain	30	21	33.2
Bulgaria	10	20	24.6

1.4.3 Social

A growing trend on world basis is the increased focus on the global heating issue and the negative effect CO2 emission has on the earth is now common knowledge and the threat is taken more serious than ever. An example of this is the Noble Piece Price Award given to Al Gore and his associates for their effort towards climate change. Further a research conducted in favor of the European Commission shows that 80% of Europeans are concerned about the environmental impact of the products they purchase and 77% prefer to buy environmental friendly products [13].

1.4.4 Technological

We intend to use technology, which is simple and proven. Photovoltaic (PV) cells and modules convert a fraction of sunlight energy into direct current. Various PV technologies are available ranging from organic cells having cell efficiency only 11% to crystalline silicon cells of more than 23%. We plan to choose the best efficiency cells or module available in the market for product development or the colour glass PV technology (encapsulation) and exploit a bigger exposed to the sun area (from the cap of the sunshade).

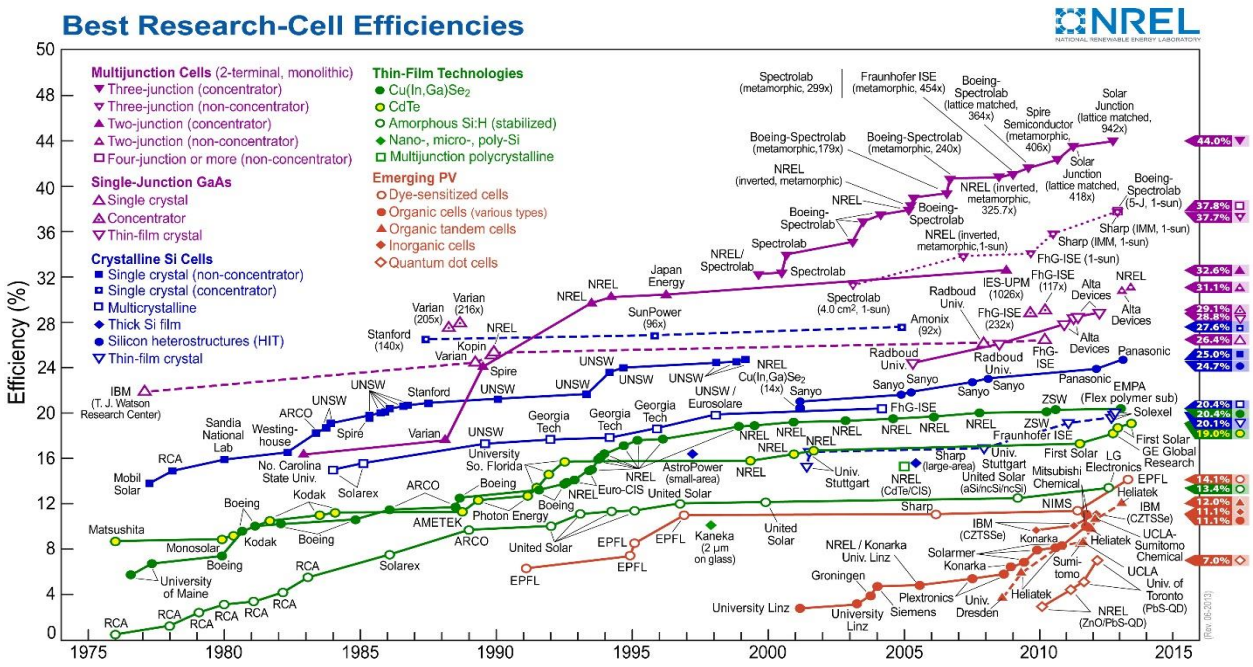


Fig. 2: Best solar cell efficiencies in different PV technology [47]

Current from PV cells will then be used to charge on board battery. Electricity required from battery can will be extracted using USB ports which requires regulation of voltage and current to output requirement according to electric loads.

1.4.5 Legal

An important aspect is the general regulation for photovoltaic technologies installations; for instance, which are the preconditions to connect the PV unit to the grid. This depends on each country member of the EU, however the prerequisites are more or less the same across European Union. The directive about PV installations in households or small enterprises, require that the PV installations have to be stable and not movable. Further, the installation of a PV park, which wants to sell the energy to the grid provider has to be away from the sea according to the Greek regulation [14]. This contributes to a strategic decision of developing a product that offers sustainability with small electrical generation rather than savings by utilizing higher area for PV and feeding energy into the grid.

1.4.6 Summary

PESTEL analysis provides us with an understanding of the political, economic, social, technological, environmental and legal framework under which our company operates. The political context of any business plan in Europe can only start and end on the EU level, it is essential of course to take into consideration the national level for some aspect of the analysis, but since the implementation of the Lisbon treaty, it is clear that long term trends and political decision on the vision of development are decided on an EU level. Therefore, we have seen that there is a clear decision for the EU energy sources and industrial policies to move toward sustainability and clean energies. Most important for our case is the idea of industrial renaissance of the EU and the trend of the EU to invest on SME's for creating innovating products for exports, which will be sustainable energy friendly and useful. Further, the

financial crisis hit European Union creates both opportunities and threats. Opportunities like the low salaries of the employees and the lower operational costs in general and threats like the lower purchasing power of the consumers. In the same framework, the tendency of countries to decrease the corporate taxes and provide benefits for businesses in order to attract industries and to flourish entrepreneurship, is also in our favour.

European citizens are getting more and more aware of the term sustainability and they are seeking for eco-friendly products. Many companies have detect this new demand - need and they tend to satisfy their customers' desires. Moreover, 'being green' gives a competitive advantage to the enterprises they implement sustainable and environmental friendly techniques.

1.5 Industry Analysis

1.5.1 Established Rivals

Out of all available clean energy resources, solar energy has proven possibility of integration in everyday products. The advent of this Product Integrated Photovoltaic (PIPV) domain can be traced back to 1980 when the small solar powered pocket calculator was introduced in the market. Scaling up the concept and integrating solar technology in outdoor products having plenty of sunshine throughout the year, therefore offers another way to sustainable future. Our market research has shown that new start-ups and products for sustainable shading have been launched in recent years and market is still developing. Start-ups are USA and Canada based whereas some already established companies from China are producing a practical sunshade with possibility of charging electronic devices. Strawberry Energy is only Serbian company in European continent, which offers threat of adapting quickly and entering the market with similar products. The Key Value Proposition by these companies is mobile charging unit and therefore they offer leasing to events, conferences and open spaces along with the option of buying the solution. Solbrella is the most recent entrant in the market and their target market is quite similar with ours. Our strategy will be to differentiate from them by offering sustainability in product design rather than a mobile charging unit.

A table with all the competitors and their products is following.

Company	Location	Product image	Price (Euro)	Business Model
SolGreen	Arizona, US		10782	Smart Table that has two solar panels attached on the top of the table to power six AC plugins available for charging personal devices and lightning in the hours of sun absence. Company has launched product in summer last year and targeted schools, parks, hotels and resorts, cafes and universities. They had successfully done the business with Arizona State University as first clients. Company was founded in 2009 and work as B2B methodology

Green SunRising	Ontario, Canada		3100	Green Sunrising is focusing on supplying clean energy. Currently they develop products related with clean solar energy and solar thermal clean energy. They developed solar bench product, which supplies clean energy to its visitors. It has 204W solar power and 180Ah battery according to GreenSunRising CEO from personal correspondence
Solbrella	Turkey		350	Solbrella is the last entrant in the market with a product attached to existing umbrellas. It has two USB ports and they are targeting hotels, beaches and yachts. In May 2014, the product enter the greek market as well with the name i-brella.
EnerFusion	Michigan, US		7200	Vision of company established in 2006 is providing consumers with easy and green off grid electricity for their electronic gadgets whenever they need if they are outside home or office. Almost all of the installations that have been done so far are in universities across America Solar PowerDok is a product which is equipped by off the shelf solar panels, 45W X 3 and a 100W on the top of sunshade, giving a total of 235W of maximum installed power. Battery can support a laptop for 28 hours [15] which translates into 1.4kWh of battery bank assuming an average use of 50W by notebook [16]. 2 USB and 4 AC outlets have been provided for charging purposes and table contains benches around as well for sitting
Strawberry Energy	Belgerade Serbia		25000	Strawberry Energy is a young Serbian startup established in 2011 after winning the student Entrepreneurship award at "Sustainable Energy week 2011 at Brussels. They designed the first public solar charger in the world in the form of Strawberry Tree. Company has successfully installed 9 Strawberry Solar Tree units in Serbia. December last year, they made an agreement with 3fficientTM

			7000	for distribution in America. Solar tree is capable of 62,000x10minutes charge for cell phones. It has 530W of monocrystalline modules installed with a battery reserve of 4.7kWh. Dimensions for solar module platform is 3.3mX3.3m with a total weight of charging station to be 1700kg. Strawberry Mini comes with 85W solar panel and 1.5kWh of battery bank making it 85kg in mass. Company is still expanding with a few installations in Serbia only [19]
SolDesign Lab	California	 Solar Pump at Stanford University	3900- 5400	Founded by Dallas Swinson & Beth Ferguson in 2009, SolDesign lab is based in California, United states. They provide eye-catching solar installations and designs. Lab does not work as a product portfolio rather as design consultancy firm [20] as told by Ms. Ferguson in an interview to New York Times in 2012. Market focus of the SolDesign lab is university campuses mainly along with outdoor spaces and parkings [21] .
CarrierClass	Pennsylvania		unknown	CarrierClass Green Infrastructure is a company which became operational in 2011 and gives services for solar installation in buildings and houses as main business. In late November 2013, company launched outdoor charging station named as ConnecTable and since then have been covered by various online media and press. Technical specifications are not given and there are no updates on any installation as of now. On January 07, 2014 an online article mentioned about the concept and encouraged readers to look up for it if in need [22]
Himin PV	China		unknown	Himin PV is a Chinese solar manufacturing company and is being operational since 1995. They specialize in solar panel manufacturing along with PIPV. Their portfolio contains mono and poly crystalline PV panels, solar power plants design and operation, solar street lightning solution, solar charger for outdoor activities, solar powered fountains, and last but not the least our competitive product solar patio umbrella.

OutdoorPro	America		115-195	Outdoor pro is a company, which deals with only outdoor umbrellas. Their motto is "It's time to rethink Umbrella". Their designs are regular as of others but also include some variants with small solar panels and LED lightning in the dark hours. Furthermore they only provide online shopping within US and special delivery to international customers if any. Polyester fabric is used for shade material and spokes are made from either carbon fiber, aluminum or steel. Also they can offer different shapes of umbrellas including circular, square etc.
HS & BrookStone	United States		500	Recently this item has been removed from H&S website and is no longer available and on Brookstone, user reviews have revealed that product is not up to the mark and does not charge anything. HS is an American based shopping store, which offers products from toys, electronics to big sport cars. They are committed to supply international customers unique and unexpected since 1881. Business model is that individual designers partnership with the company and HS presents it under its own brand name. They also have B2B contracts for new products.

1.5.1.1 Summary and Comparison

All the competitors can be segmentized according to the installed power and associated price. Hammacher Schlemer (HS) offers only 1W and requires 12 sunshine hours to fully charge the battery that will give almost 2 charges to the iPhone 4S. Powerbarr (PB) offers 40W requiring 4 sunshine hours to fully charge the accompanied battery that will then enable to have approximately 27 iPhone 4S charges. These two can be classified as small electronic device charging category. Next group encompasses Green SunRising (GSR), EnerFusion (EF) and SolGreen (SG). These shades can be utilized to charge devices, computers and partially e bikes. Solar tree from Strawberry Energy (SE) comes with 530W and storage capacity when fully charged provides almost load of a complete household.

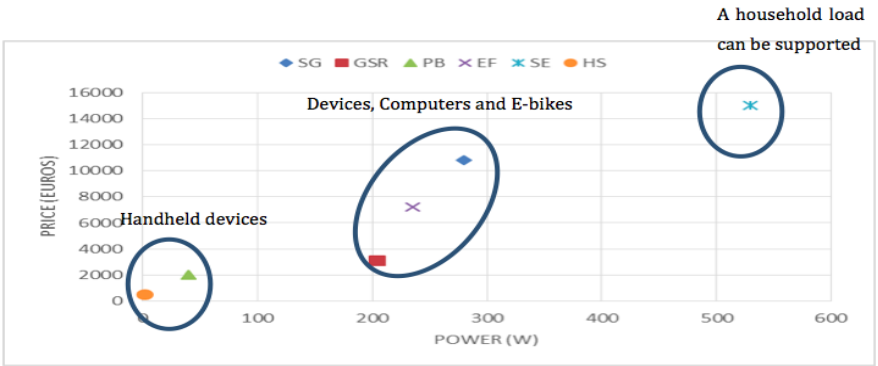


Fig. 3: Competitors power and price analysis

Design Strategy

Current competitors are addressing universities and municipalities. Our strategy would be to design a solar integrated sunshade for other market segments, which have not been exploited yet. A strong hold of conventional sunshade market is observed in those markets and aim will be to design with better or at least similar aesthetic (as conventional) giving an easy penetration to these markets along with enough solar power to charge electronic devices.

One important thing to notice is that almost all the competitors working with solar integrated sunshades are based in US and Canada whereas only Strawberry Energy whose main business is solar chargers works and plans to cover the European market. It is a young start-up that has started 4 years ago and has managed to install their solar tree in 9 Serbian cities. They have also managed to reach the American market through 3efficient (retailer and distributor), although they have not managed any sales in the US yet.

Our market segments can be categorized according to the interest of green technology as shown in Fig. 4 where big motivation for universities and municipalities is bringing awareness to the society by green practices. Café and restaurants are motivated to adopt green practices because of energy efficiency and savings offered. Whereas hotels, beaches and individuals would aim for luxury and differentiation based on high design aesthetics.

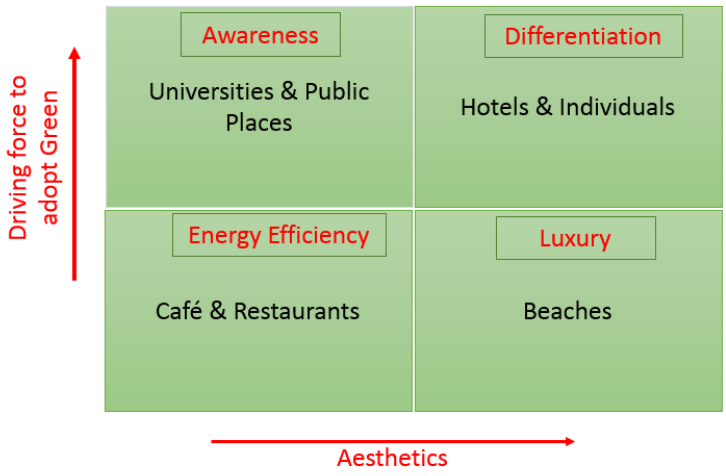


Fig. 4: Market segmentation based on Green interest

Having a deep look at installations made by above mentioned competitors it has been found out that almost all the businesses are aiming for universities and public spaces where aesthetic requirement is small and relatively large revenues associated with green practices are being earned. Our strategy would

be to design a solar integrated sunshade for other market segments, which have not been exploited yet. A strong hold of conventional sunshade market is observed in those markets and aim will be to design with better or at least similar aesthetic (as conventional) giving an easy penetration to these markets along with enough solar power to charge electronic devices.

Solar Chargers

Giving a possibility for some top-up juice for electronic gadgets, small solar chargers also act as a substitute product. It has been observed that almost all renowned businesses in this sector stem from America and Canada with their warehouses in major European countries. Market research shows that having an independent and quick extra charge outdoor is well established need with numerous players involved for providing solution. Almost all such devices are targeting individual end consumers. Open crowd funding platforms has successfully hosted more than 10 projects with more than 1 Million USD funding raised by approximately 4.5 thousand direct consumers showing a great interest of public in charging green.

1.5.2 Substitute Products

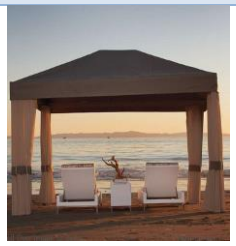
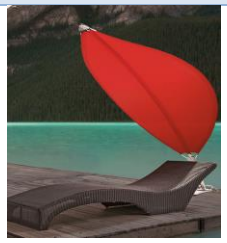
The need for having a sunshade especially in summer is established since long and therefore has a developed market with broad range of players. Therefore our product needs to compete with conventional sunshade companies which may offer easy, aesthetic and cheaper solution to the customer. As day by day contemporary personal electronic gadgets are becoming more power hungry, people are attracted to small scale solar charging solutions for camping and outdoor use. One of the basic need addressed by our offering is electricity for charging gadgets and therefore outdoor solar chargers act also as a substitute product. Many companies around the globe are producing such devices where a small solar panel and various charging outlets for different devices are integrated in the product. Below we will present some of the leading and successful companies producing such devices. There are numerous companies and individuals making individual solar chargers and selling online at ebay, Alibaba etc. but customer reviews and quality are not upto the mark

Company	Location	Picture	Comment
PowerBarr	Totonto, Canada		A crowd sourced funded company in January 2014 launched a modular solar charging point which they refer as PowerBarr. It consists of 40W solar panel and 3 nicely designed platforms for electronic devices charging through 6 USB ports. They started their campaign in a Totonto coffee shop where they displayed it for the first time and raised some development fund which was then followed by a successful Kickstarter campaign. They offer these charging stations to conferences, meeting places and malls to supply with free charge to end consumer. They follow a leasing business model where company charges on daily basis to the businesses (or customers) for this sustainable charging station. They follow footsteps of DanTeb enterprise and RechargeMe which are also Canada based startups for leasing charging stations (not solar) for conferences and events. Device has storage of 160Wh, calculated from given 6 mobile charge every day for 6 days backup assuming iPhone has battery of 5.6Wh (1.4Wh and 3.7V).
Solio	Sant Franscisco, USA		Company was established a decade ago in Sans Francisco California with a mission of making solar battery solutions that can fit into customer's pockets. They offer 4 basic products as shown in out of which is solar personal lightning. In 2010 they have successfully started a solar as service business model in rural Kenya where people get worry free solar energy from a local entrepreneur on weekly subscription fee. Observation of portfolio shows relatively cheap prices, which range from USD 20 to 100 which is quite affordable in the developing world. The business follows the model of online sales with some retailers in America and the company is therefore dealing with customers directly.
Voltaic Systems	NY city, USA		Voltaic Systems makes products that harvest their own energy for electronic devices anywhere. Company is based in New York City, America and maintains sales through their online stores in NYC and Netherlands. Their portfolio includes solar charging panels embedded in bags, backpacks, external battery packs and combined kits for autonomous solar charging. Closely related product in their portfolio is solar charger kit which is solar panel and external battery and required wirings for connections. This system can be put into backpacks and costs around 300-400 USD and can have 18W of solar panels along with 72Wh of battery storage with USB and other charging outlets. Company targets end customers by offering online shopping.
Goal Zero	United States		Established in 2009 with the slogan power anything anywhere. Goal Zero deals with production of external battery packs and associated portable solar chargers for powering these batteries up. Company has operations in Europe, Middle East, Asia and US. External battery solutions are compact and durable and solar panels are also made portable. Goal Zero was ranked 9th by 2013 Inc. magazine with three years sales growth of 16,981%.

Brunton	United States		Brunton deals with outdoor travelling experiences and requirements of customers to enjoy their outdoor activities. Started in 1894 with a pocket precision compass for travelling, Brunton has developed portfolio including products for power, lightning and navigation. They make rolling solar sheets that can be easily rolled and stored in bags. One of their solar powered product is Solaris which is folding fabric with integrated solar panels of 4, 12, 26 and 52 Watts for a price range of 260 to 1380 USD. Company is based in America but has several retailers in Europe as well. Company attracts end customers through online shopping platform.
SOLN1			SOLN1 is the complete system that encompasses a 10-20Ah battery, inverter and USB outlets at the back of standard solar panel assembly. Project was first demonstrated by laserhacker forum where he provided tutorial and parts to manufacture. People followed up and now there are three to four places where these soln1 are manufactured by local entrepreneurs currently focused in US. Europeans entrepreneurs are also in discussion with idea creator and are soon expected to start manufacturing. A unit with 20W panel costs 400USD. They are currently running and managing all the campaign and sales through online shopping model. Similar concept has been launched as a new startup by California based entrepreneur Juan Moncada at Kickstarter. Project got successfully funded and reached its 50,000 USD goal in February 2014. Although many complaints from the first batch clients can be seen on kickstarter project page which shows the room for improvement.

Conventional Parasols

The need of shading and protection fr.om the sun is one of the basic in humans' lives. The sun radiation can cause plethora of disorders with most significant the skin cancer. However, besides the practical use a sunshade has, there is increased interest by the clients for the aesthetics as well. Designers are employed to create unique outdoor furniture that can be sold even more than 8000 Euros. Conventional umbrellas are considered as substitute products, therefore a brief presentation of different options is as follows.

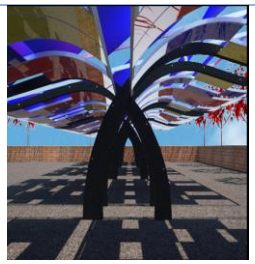
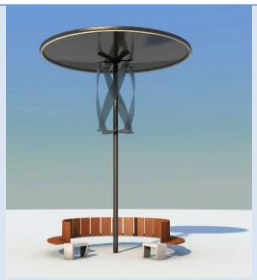
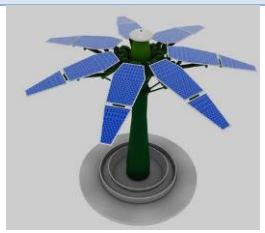
Company	Location	Picture	Comments
Coolaro and Gale Pacific	Australia, America		• Offer patio umbrellas and fabric based shade sails • 90% reduction in UV rays from sun • Value proposition is protection in outdoor living environment from the harmful effects of UV rays and other adverse weather conditions • Customization for colors and specific designs • Online availability • Price ranges from $200 to $900 depending on the design
Got Shade	USA		• They don't offer pre made products rather provide services for customized designs for their customers • They don't make regular umbrellas but sail shades • Variety of products and clients • Optimum UV protection 90-98% • Stylish designs
Shadow Spec	Australia New Zeland		• Unique features and Stylish Umbrellas • 360 rotation • Attractive and appealing • Works only for Australia and New Zeland
Front Gate	United States		• Another American company that hosts variety of products from indoor to outdoor by different manufacturers • They have pavilions that range from **2700 Euros to 8480Euros**
Tucci	United States		• US based and has central offices in Europe, Middle East and North America. • European office is in Netherlands • Umbrellas, Shading Sculptures and sail shades • Very Elegant designs • Big Marketing Campaigns • A proven name
Umbrosa	Belgium		• A renowned European company from Belgium • Elegant and attractive designs • Innovative leaf design • Attractive website

Frankford			• Durable umbrellas • Cantilevered offset and center pole umbrellas • Expensive • 5 umbrella design are available from hayneedle.com ranging from 3000 to 4000 Euros • 16 ft Umbrella on the left costs 4339 Euros
KETTAL	Spain		• Durable umbrellas • Designers products • The most competitive product since it is used in Mykonos island hotels • 1605 Euros per each based on interview conducted in Mykonos hotels' owners

1.5.3 New Entrants

Analysing established rivals gives an insight that there are very few players dealing in this domain and that too with minimum value propositions.. Being an emerging and interesting market, there are though many new and exciting concepts available out of which some are working towards business development. The following table is presenting all the products that are still in the concept phase.

Company	Location	Picture	Comments
Solaris	Portugal		• Dr. Jose Vicente from University of Lisboa • Similar Value proposition as of ours
Loef	Netherlands		• A solar powered parasol • Developed in Netherlands in 2011, parasol that follows the sun using sun sensors and has small panels at the corners of parasol • It is not in production • Prototype existed but could not find any information about the production or availability in the market.
Sunbed	Italy		• Still a design from Francesco Sorrentino • personal sunbed powered with solar energy • Incorporates concept of a small refrigerator • And a 220V plug in

Wing car parking	Great Britain		• Inspired by wing design and designed by Mike Genna • More close to green park • Shade but for parks • A nice concept for design
ECO3	Germany		• Designed by the student Daniel Otterbein • USB ports • Small wind turbine
Strea by FERUM designer			• Collects rain water • Solar panel top • Lightning • Aim for beaches and street or community lightning • Gold Medal winner at Tehmoma 2011
Solbrilla	USA		• Designer Marco
Solar Palm	Jamaica		• Designer Martin • Modular Design • Public Space Charging point • Foldable

1.6 Market Research and Customer Discovery

1.6.1 Hotels

An important reason for targeting hotels as one of key market segment is trend of sustainability and green certification from EU and other renowned institutions. Many studies have been conducted on the environmental performance and its relation to financial performance of hotels. Alvarez Gil conclude that there is strong engagement between financial outcome and environmental practices for the Spanish hotels. The more environmental friendly the hotel is, bigger the targeted market and higher the income [25]. The latter fact has been acknowledged by many private organizations around the globe as well as the European Union itself. For this reason many certification programs exist based upon the hotels'

sustainability. Some examples are the green hotelier award, green globe and green key to name a few which were awarded to more than 2400 establishments in Europe (136 Greek hotels only for the green key). EU has established its own certification system recently, called EU eco label (green flower) and it is one out of 50 green certifications that exist for tourism. We will analyze the hotels from two chosen countries of Greece and Spain. One of the important segments is big hotels that have swimming pool or a lot of open air space.

Fig. 5: A view of a Luxury Hotel in Greece

It was impossible to identify hotels that have big enough open air spaces but the information for hotels with pools was reachable. In Greece, the hotels' chamber is the responsible organization for collecting information on hotels characteristics, like the ranking of hotels according to the method of stars as well as the different facilities that hotels provide. Economy of Greece is based on tourism which contributes to 16.2% of the GDP or in other words 36.2 billion euros stemmed from tourism in 2012 [23]. The total number of hotels in Greece is 9177 according to statistics of 2011 [24] and 3658 out of these provide swimming pool facilities. More detailed analysis is presented in the table below.

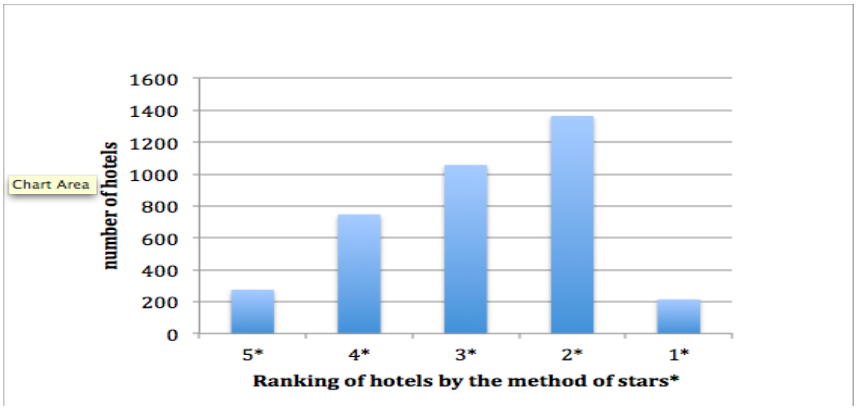


Fig. 6: Classification of Hotels in Greece

In the figure above, it is observed that 275 hotels are 5 (five) stars and 747 are 4 (four) stars which in total sums to 1022 hotels. ***We consider these 1022 as our potential market in Greece and we exclude the lower category hotels from our customer target.***

In order to quantify the number of hotels with pool in Spain, firstly we found out the total number of hotels and their qualification based on the stars system. The number of existing hotels in Spain was pretty similar to the one found for Greece. Further, both countries are Mediterranean and for both of them tourism is a crucial source for the national income. We calculate the percentage of hotels with pool exist in Greece based on the total number of hotels and we multiply this percentage with the total number of hotels in Spain.

Table 2: Classification of Hotels in Greece and Spain

Ranking	Hotels in Greece		% of hotels with pool	Hotels in Spain	
	Total	With Pool		Total	With Pool
5*	361	275	76	275	209
4*	1305	747	57	2248	1286
3*	2359	1057	44	3013	1350
2*	4227	1365	32	2194	708
1*	1485	214	14	1413	203
TOTAL	9177	3658	40	9143	3644

Therefore, we ended up with 209 hotels of 5* (five stars) and 1287 hotels of 4* (four stars) which in total are 1496 hotels. ***These 1496 hotels are considered as our potential market in Spain.***

1.6.2 Beaches

It would have been important at this point to briefly explain what do we mean by beaches and how do they operate. Greece is a country with 227 inhabited islands and a huge coastal line and therefore plenty of beaches. The municipalities of each island rent the use of the beaches to potential entrepreneurs in order to install sun shades (umbrellas) in a part of the beach they bid. However, one beach can have more than one entrepreneurs who install sun shades.

Fig. 7: A view of an organized beach in Mykonos

In Mykonos for instance, a small island of 85.5 km^2, there are 20 organized (where entrepreneurs install shades/umbrellas) beaches and a mean value of installed sun shades of 300 per beach [24]. In Rhodes there are 41 organized beaches and in Crete this number is 151. Assuming an average value of 300 umbrellas per beach (on a conservative side) translates into **63600 sunshades from only 3 islands**. As it can be understood, these permits are given by municipalities and the exact information on how many umbrellas are allowed per beach cannot be reached for every island or for the sea areas of the mainland. However, there are 54 inhabited islands in Greece with plenty of beaches

Besides the islands there are many beaches along the 14800 km coastal line of Greece. And by only looking at the best ten of the beaches of Athens, number of sunshades installed is found out to be **3675** units. Breakdown of sunshades installed for these beaches is as follows: Astir Vouliagmenis with 400, South Coast Voulas with 375, Aulaki with 500, Yabannaki with 300, Grand Beach with 300, Eden Beach with 450, Karavi with 400, Astir Glufadas with 400 and Akti Vouliagmenis with 250. Note that all these sunshades have two sunbeds each and the calculation of umbrellas came from the capacity of sunbeds [26].

1.6.3 Cafeterias and Restaurants

According to EU statistics on entrepreneurship, in 2011 the SMEs (small and medium enterprises) in Greece were 727883 [27]. Another research conducted by ENDEAVOR shows that in 2012 the new businesses started up in Athens were 42437 and 10003 out of these were restaurants or cafeterias, i.e. 23.62% out of all SMEs in Athens [28].

Table 3: Quantification of SMEs in Greece

	Number of enterprises		
	Greece		EU27
	Number	Share %	Share %
Very small	703648	96.6	92.2
Small	21586	3	6.5
Small-medium	2649	0.4	1.1
SMEs	**727883**	**99.9**	**99.8**

It is worth mentioning that in 2009, 850 new permits for coffee shops, restaurants and snack bars were given to the new businessmen in Athens.. In 2013 this number increased to 1201 by the end of October 2013. According to the deputy mayor of Athens such an increase has been possible due to reduction of usage fee for public open air spaces like pedestrian roads, piazzas etc. Finally, she mentioned that these fee reductions will be continued in 2014 as well to further local entrepreneurship.

Therefore, we assume that similar proportion of cafeterias and restaurants (23.62%) throughout Greece . Such an assumption will be considered conservative due to the fact that there is lack of innovative ideas for SMEs in the countryside compared with the capital, Athens and thus the percentage of cafeterias and restaurants will be higher than Athens. However, by employing the same percentage we led to 171,937 cafeterias and restaurants all over Greece***. Assuming that only 20% of these cafeterias and restaurants employ outdoor sitting space makes a potential market of roughly 34.5 thousand SMEs***.

The number of SMEs in Europe (specifically in EU 27) was calculated by Eurostat as 20,335,839. Out of this, 1.7 million were in the food and accommodation sector. ***If only 20% of these use open air spaces for their operations, a number of 340 thousand SMEs could be our potential market.***

1.6.4 Individuals

Following green principles and going green mantra is becoming dominant in today's environmentally aware consumers. A survey conducted by GlobeScan [29] questioned over 6000 participants around the globe (Germany, UK, USA, China, Brazil and India) about their preferences and choices for green consumption. Consumption included diet, energy, transportation and housing.

- 65% respondents voted for green products
- In emerging economies i.e. Brazil, China and India, 60% of people are willing to pay more than usual substitute available in the market compared to 22% in Germany, England and United States
- When questioned about the willingness of buying a green product and factors to choose
    - 75% showed strong interest if the product was equivalent or better in performance
    - 70% approved that they will opt for green product if it did not cost more and in developed world this is 78%

- 64% showed willingness to buy a green product, if company claims about sustainability are more believable (Credibility or Transparency)
- Decisive factors to purchase for consumer are quality (49%), value for the money (62%) and price (64%) in developed countries
- Customer segmentation shows that on a sustainability spectrum 14% are strong advocates followed by 37% style and status seeking Aspirationals and 34 % Practicals. (Our market 37% Aspirationals and some percentage of practicals)

A group of random individuals would reflect the common traits of its society trends and values. There is a big segment in sustainable market that seek materialism (70% loved shopping) yet projecting social and environmental values. Such a group does not want to reduce their consumption (spending) and also desired to have less impact on the environment considering sustainability values. "***Consumers are now hungry for a new kind of consumption, one that will allow them to continue to enjoy consumption, yet not worry (or at least worry less) about its negative impact***"[31]. So there is a need of **guilt free consumption**.

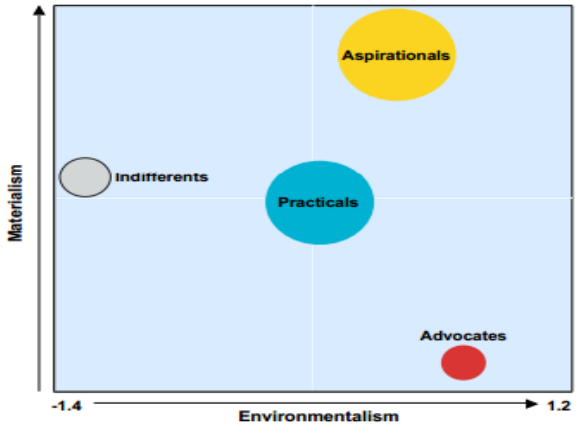


Fig. 8: Sustainable consumer segmentation. Source: GlobeScan report 2013 [8]

Making an environment friendly product is not sufficient for consumers. They want practical benefits, sustainability and tribal benefits i.e. rewards that make them feel connected with others in the same community sharing same values. Therefore product needs to serve physical as well as emotional expectations. Another important trait to be emphasized is the need of this aspirational group is to connect and it asks for a platform or community where they can socialize views of sustainable product, review it for benefit of others, emotional alleviation by doing good and sharing it with community.

As a continuation of this study, in October 2013, Company has published new stats covering 21 international markets and discovered 2.5 billion potential ***aspirational*** customers 36.4% of global consumers, defined by their love of shopping (78%) and desire of responsible consumption (92%).

In October 2013, Bain and Company published their "2013 Luxury Goods Worldwide Market Study" which estimated personal luxury market sales to be reached at 217 billion Euros by the end of 2013 as compared to 212 billion Euros in 2012 showing a ***conservative*** increase of 2% with 80% probability. They also predict a ***hopeful*** scenario with 20% probability to reach up to 218 billion Euros with 3% increase from 2012 [11].

The big Luxury market consists of cars, yachts, wines and spirits, hotels, food. Persona; luxury goods and design products. This big market is expected to grow to 800 billion Euros by 2013 with an overall increase of 6% compared 2012. Our product lies within sub market of Design Furniture which accounts for 19 billion Euros taking a humble 2.375% of overall pie of luxury market. Looking closely at the high end furniture and design market that accounts for 18 billion Euros in 2012, macro trend shows an increase in lightning and outdoor spending of affluent. Both sub components combined account for annual sales of roughly 4.5 billion Euros. Aforementioned report highlights the macro trend of this sector to be ***go green*** along with affordable price. More sustainable materials and LED lightning solutions are the future.

New luxury of current times and foreseeable future is going ***green*** which will enable our company to position itself distinctively in the market with not only fine quality but integrated sustainability of products.

2 Business Model Definition

2.1 Business Model Canvas

Instructions for reading the business model canvas

Each market segment refers to the same colour bullet points in the rest of the table as well as the colours of the previous market segments, i.e. restaurants and cafeterias have the blue colour bullet points as well as the black ones, beaches have the green colour bullet points (same colour) as well as the black and the blue (all the previous ones). The first costumer segment is hotels and subsequently all bullet points written in black refer to all the market segments. If a bullet point is excluded for the market segment, then it is in between parenthesis with the same colour as the segment.

<table>
<tr><th>KEY PARTNERS</th><th>KEY ACTIVITIES</th><th>VALUE PROPOSITION</th><th>COSTUMER RELATIONSHIPS</th><th>COSTUMER SEGMENTS</th></tr>
<tr>
<td rowspan="2">-BULGARIAN FURNITURE MANUFACTURING
-PCB MANUFACTURING
-DESIGNER
-SOLAR PANELS
-LOCAL MAINTENANCE PARTNERS
-TRANSPORTATION
-TWO START UPS FROM KIC
-SOFTWARE DEVELOPER</td>
<td>(((-ELEGANT DESIGN)))
-MANUFACTURING, ASSEMBLY
-MARKETING, CATALOGUES
-SUPPLIERS CONTACT
-TRANSPORTATION
(-VISITS TO JOB FAIRS)
(-DEMONSTRATION TO STUDENT UNION)</td>
<td rowspan="2">WE OFFER GREEN DIFFERENTIATION TO OUR CUSTOMERS AND INCREASED SATISFACTION TO THEIR CUSTOMERS. SITTING UNDER THE SUN BECOMES MORE PLAYFUL THAN EVER BY EXPLORING THE SOLAR POWER.
- GREEN DIFFERENTIATION
(((- CSR)))
- CUSTOMER/STUDENTS SATISFACTION
-SUSTAINABILITY
-MODERNAZATION
-SHADE
-LIGHTNING
((-COSTUMIZATION))
(-GREEN AWARENESS)</td>
<td>- THE MONTHLY REDUCTIONS OF CO^2
- POST SALES SERVICE
(-NEWSLETTER)
(-AWARENESS OF NEW TECHNOLOGIES)
((-LOCAL OFFICE))
-COMMUNITY SHARING EXPERIENCE</td>
<td rowspan="2">HOTELS
RESTAURANTS
CAFETERIAS
BEACHES
UNIVERSITIES
INDIVIDUALS</td>
</tr>
<tr>
<td>KEY RESOURCES
-R.E. KNOWLEDGE/TEAM
-CONTACT WITH THE FIRST MARKET
(-CONTACTS WITH STUDENTS POLITICAL PARTIES)</td>
<td>CHANNELS
-DIRECT SALESFORCE
((((-HOTEL MANAGEMENT COMPANIES))))
(-FURNITURE OUTLETS)
-INTERNET
((-MUNICIPALITY))
(-STUDENTS UNION)</td>
</tr>
<tr><th colspan="3">COST STRUCTURE</th><th colspan="2">REVENUE STREAMS</th></tr>
<tr><td colspan="3">-RAW MATERIALS
-SALARIES
-COMISSIONS OF PARTNERS
-MARKETING/CATALOGUE
-MANUFACTURING
-TRANSPORTATION</td><td colspan="2">-SALES
-POST SALES SERVICES (ONLINE SHOP)
-ONLINE COMMUNITY ADDS</td></tr>
</table>

2.1.1 Value proposition

We are offering green differentiation to our customers and increased satisfaction to their clients during their relaxing or working time outdoors. Being under the sun becomes more playful and comfortable than ever. Environmental techniques or measures usually taken by luxury hotels are decreasing the comfort they offer to their customers while our offer increase their customers' satisfaction and at the same time gives them the green differentiation they are seeking of. We define green differentiation as the combination of sustainability and quality. Dual or multifunctional products, such as our solar charging shades, which are used for sun protection and harvesting of sun power simultaneously. The rapid growing technological development has set our mobile phones, tablets or laptops as integral part of our lives, depriving us many times of the outdoor environment because we need electricity. We transform, or greenform- as we like to call it- lifeless outdoor furniture to alive and elegant objects which interact with the users by providing them free, clean and limitless energy. Our customers can work or play with their hand held electronic devices while out and away from grid tied sockets without caring of running out of juice. Nature employ its tools; the sun and gives solution to our modern problems, we, on the other hand, need to show the way.

2.1.2 Customer Segments

The identified customer groups are presented in the

Table 4 Customer segments

Customer segments	Comment
Luxury hotels	Sustainable outdoor furniture encompasses various market segments. Luxury hotels nowadays are becoming responsive to their contribution to environment degradation and therefore are actively looking for sustainable solutions. However, they are often struggling due to client's complaints for decreasing their comfort. Leading hotel chains have already shifted to energy efficiency, paper and plastic recycling.
Restaurants	Moreover restaurants are continuously looking to increase their customers' satisfaction in every possible respect, be it service or sitting space, owners want to meet customers' expectations. Living in an era where gadgets and smartphones are part and parcel of consumers life, sustainable outdoor furniture with solar charging covers exactly this need and that too in an aesthetically appealing and environment friendly way.
Organised beaches	Another attractive potential market segment is organized beaches with sunshades. Their basic need is sunshade and sustainability might not be a big concern. A multi-functional sunshade that keeps alive electronic devices of end customers without any messy wires is certainly an essential to this market. Universities and municipalities are continuously working to educate the society all over the world. Knowing the revealing facts of global warming, academia and local regulatory authorities are interested more than ever to show the way in green technology and practices to inhabitants of society. A keen interest in sustainability makes these markets attractive to be investigated.
Universities and municipalities	Universities and municipalities are continuously working to educate the society all over the world. Knowing the revealing facts of global warming, academia and local regulatory authorities are interested more than ever to show the way in green technology and practices to inhabitants of society. A keen interest in sustainability makes these markets attractive to be investigated.
Individual customers	individual green consumers who prefer to live healthy lifestyle and are concerned about their individual carbon footprint. Besides that, they love comfort and they can afford solutions, which will make them feel different. These green consumers would play the role of opinion leaders to embed sustainability in individual lives.

2.1.3 Customer relationships

Customer relationships are an important aspect for the viability of our company. We want our clients to be satisfied and pleased of our offer. Therefore, in Table 5 we present the different techniques we are planning to implement.

Table 5 Customer relationship techniques

Technique	Comment
Newsletter	, We maintain excellent relationship with our clients even after they have purchased our products. For us they are more than clients, we are sharing the same values; protection of the environment and comfort. For this reason, we send them newsletters informing them about the new technological development in the field of renewable energy
CO_2 savings report	We believe that our clients are special and we need to provide them all the necessary information; moreover awareness is our basic goal. Further, we send them e-mails with the monthly reduction of CO_2 emissions, which can use as a marketing tool to gain a competitive advantage for their enterprise or publish it in the social media as their environmental contribution. For the latter, there will be a web community for our clients, where they can claim their carbon dioxide emissions, compare it with the other users and share it in order to aware also people that are not users and subsequently our customers
Room information-card brochure	We want to offer to our hotel clients a comprehensive sustainability solution and not just a product. Therefore, besides the others, we believe that a card, which will be located inside each room is crucial. This brochure will state the existence of solar charging shades in the hotel and will exhort the customers to charge their devices there. By doing so, they will also get the feeling of contributing to the sustainable policy of the hotel, the hotel will better advertise its green measure and for our company is an additional way of advertisement.
Post sales service	Furthermore, we provide them with service and spare parts in case of failure. We have technicians as partners who have been trained by us in order to fix easily any possible problem. In addition we maintain a solving problem Internet forum where we educate local technicians to become our partners.
Local Office	Last but not least, we maintain an office and a call line, which can be used from our clients for more direct communication. Our clients are of high priority in our business and we want to be accessible through many means of communication.

2.1.4 Channels

The way a company reaches its clients is a key of success and the Table 6 presents these channels

Table 6 Potential channels of reaching customers

Channel	Comment
Internet	First of all, we maintain our Internet page where it can be accessible from everyone. Internet is a fast growing domain and it cannot be neglected in any case. This is actually, the easiest way to make our business known to public. However, we do not stay only in this and more techniques are employed in order to assure that we will reach the right people.
Furniture outlets	Cooperation with selected furniture stores where our products will be exposed either physically or through catalogues is crucial; moreover, the traditional way of buying furniture is through these places.
Direct Sales	Our direct sales force will contact enterprises and promote our offer. The door to door is an old fashioned technique necessary, though, for the beginning at least of our venture.
Opinion	Another way of making our offer suitable and attractive is engaging opinion leaders; our personal contacts are

Leaders	useful at this point. We present them our product and we offer them to experience it. Our reward we expect to be a statement who will affect the purchasing decision of our potential clients. Do not forget that 2.5 billion customers are aspirational and their preferences are driven by opinion leaders and trends
Hotel Management companies	For the hotels, we will approach hotel management companies. These enterprises are promoting a variety of different products to their clients with a small commission on the sales. This channel is quite promising since it gives us the possibility to target a wider market really fast.
Municipalities and student unions	For the market segments of the beaches and the universities we will use the municipalities and the students unions respectively. The Greek municipalities are issuing the licenses for renting the beaches to entrepreneurs and place sun umbrellas and the students' unions because they have the power to demand as well as to purchase.

2.1.5 Key Partners

Key partners are the most important- as the name indicates- players to make the business model work. They are presented in the table below.

Table 7 Key partners

Key partners	**Comment**
Senior designer	To reach into high end luxury market design of the product plays a crucial role, therefore we actively seek a senior product designer who will be able to innovative creative outdoor furniture designs. Such a designer would be helpful to train a junior designer who is in cofounding team for future years of operation
Manufacturing facility	We work with a small furniture manufacturing facility in Bulgaria which has been in operation since 5 years supplying furniture to various EU customers according to design provided by customers.
Solar technology supplier	Solar module supplier is another essential partner that we would be interested in for a successful design. Various technologies are available in the market including thin film modules, polycrystalline modules and coloured solar glass with associated pros and cons. Final use of any of these technologies would be depending on the market focus and customer interest during the detailed design stage.
Hotel management companies	These are companies, which manage hotels with similar characteristics, for instance small luxury hotels. Their advantage is the number of hotels they are under their management since they can achieve better prices for the goods a hotel needs. Having so many hotels at their consultancy disposal, it would be of great advantage to pair up with such external companies in order to reach to the hotel industry.
Hotel green certification companies	Hospitality industry is essentially a very big market interested in ecological solutions to reduce their carbon footprints. Therefore this industry actively seeks help from external energy efficiency management companies which guide the hotel management team for efficient practices as well as new technologies in sustainability domain. Further, they issue green certificates using a system point and this is what we want to take advantage of. Collaborating with such a company we will be able to match the purchase of our product with the acquisition of green points in order to reach a higher green certification level.
Transportation Company	Shipping and packaging of final product requires to partner up with a transportation/ shipping company so that orders can be met without any delay and availability of the products can be made to reach wider segment of market.
KIC Innoenergy Incubation Centre	To develop and refine the business idea as well as business model, mentorship from KIC Innoenergy incubation centre, Iberia will serve as one of key partners. It will also help us finding venture capitalists and seed money to start the business with low ramp up times.

2.1.6 Key Activities

Key activities is a term used for the most important activities for our start up are presented below:

Table 8 Key activities

Key activity	Comment
Product design	Product design is one crucial step for the success. With the help of a senior designer we seek to come up with sleek products to meet the luxury market segments
Advanced Electronics	Next key activity is to design an advanced electronics to be integrated in the product for reliable performance over the product lifecycle. Solar charging circuit is one basic electronics entity and PCB manufacturing with required features will follow afterwards.
Manufacturing and assembly	To realize the design, product manufacturing and assembly is next important activity to be performed for which we partner with furniture manufacturing facility in Bulgaria.
Life Cycle Analysis Considerations	Our commitment is to design products from lifecycle perspective and therefore finding sustainable raw material supplier (wood or aluminium or recyclable fiberglass) will be essential activity to be performed. Also contact with companies to recycle photovoltaic cells and electronic circuitry has to be done in order to meet the goal of a sustainable product.
Digital Media Designer	To reach to the customers, marketing catalogues would be imperative and therefore will require digital art designing from our cofounding designer.
Marketing Activities	Personal meetings with potential customers, participating in exhibitions and product demonstrations will also be imperative key activities to be performed.

2.1.7 Key Resources

The term is used to subscribe the resources that are necessary to create value to the customer. They are considered an asset to the company, which are necessary to sustain and support the business.

Table 9 Key resources

Key resources	Comment
Senior designer	First and foremost key resource required is a senior designer to achieve aesthetically appealing products for luxury customers.
Technology knowledge	Combining this design with solar knowledge of the team would help to integrate electronic circuitry and solar photovoltaic cells in products.
Contacts with the first market	One important resource is the contacts to the first market where we have met most of potential clients. The hotel industry is the main source of money generation in Greek islands and being from Mykonos, which is top touristic destination, gives us a competitive advantage. Further, good contacts with the governing political party in Greece and the municipality of Mykonos, since the father of one of our members is the vice-mayor, gives us a good potential for the public spaces (installations in parks, airports, ports, municipalities spaces in general). And in order to reach to the universities, personal contacts with student unions and student political parties will also be utilized.

2.1.8 Cost Structure

This describes the most important monetary consequences while operating under different business models.

Table 10 presents basic costs.

Table 10 Basic Costs

Costs	Comment
Raw material	Eco friendly materials for outdoor furniture together with solar modules will make up the raw material costs required.
Commission to partners	Commission to the partners for sales channel, catalogues, exhibitions, and launch parties would be incurred in marketing costs.
Others	Manufacturing, assembly and transportation will also contribute in cost structure. Salaries for the cofounders and any staff hired will contribute to costs.

2.1.9 Revenue Streams

The way a company makes income from each customer segment is presented in Table 11

Table 11 Revenue streams

Revenue streams	Comment
Direct sales	First and foremost stream would be direct sales of products.
Post Sales	Post sale services for buying batteries or any other associated equipment would be provided through online shop and help centre.
Online marketing of local businesses	Long term goal is to make an online community (might be only individuals) of all the customers to engage and promote their green practices where local businesses sharing same values might be featured and hence this will serve as secondary revenue stream.

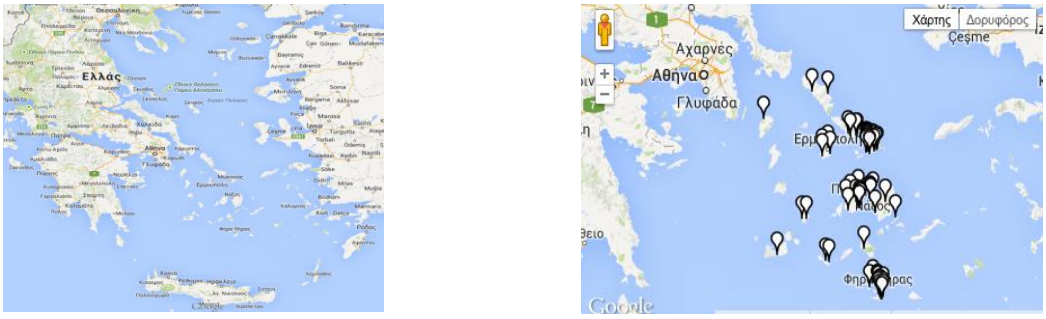
2.2 Beachhead market

Our preference for brand development is to access luxury market. Looking at the available market segments high end hotels and individuals can be served under luxury market segments. Reaching individual luxury customers can get difficult without brand proven name, therefore as a first attempt, our focus will be on the hotel industry. In Greece and Spain only, there are approximately 2,517 four and five star hotels with pool facility as mentioned earlier in market analysis. Further narrowing it down to our starting place Mykonos, Greek Island, there are 13 five star and 51 four star hotels. This island with its heart touching beaches and sceneries, serves around 1.8 million tourists every year and is home to many known luxury brands. Our personal contacts with luxury hotel owners in this Island will help us establishing set of their demanding features of products. On the other hand, a product serving aesthetics and sustainability will suit best to this market segment. Furthermore, it will serve long term purpose of entering into individual luxury market segment by working as a promotional channel to luxurious customers visiting these hotels. Selected Café and Beach bars can also serve as promotional channel to attract individual customers. Another important advantage at our disposal is having access to already existing furniture designing and retailing store belonging to family of one of team members.

2.3 Micro-segmentation

Our aim is to target 64 luxury hotels of Mykonos for the first year of operation. Focus would be to develop a design that can suffice the feature requirement of these clients as all of them share need of sunshades by swimming pools or beach. On average all these hotels have 20-25 sunshades by the pool. This gives us a total addressable market of 1280-1600 sunshades translating into 3.2 Million Euros considering 2000 Euros per sunshade. At this point, it is useful to mention that our assumption is quite conservative according to the interviews conducted to six hotel owners. The majority of them mentioned a minimum of 150 umbrellas with one of them refereeing to around 400 umbrellas all around the hotel property.

At this point there are three crucial parameters. First, many of the hotels located in Mykonos island belong to hotel chains that own hotels to other places too. Second, the majority of hotels in the Greek islands share similar design theme or concept at least for their pool or beach side. Therefore, our initial market is much wider than just Mykonos island. More specifically, 40 five stars hotels and 182 four stars are located in geographical region of Cyclades (where Mykonos belongs to as well) where the architectural and physical environment is the same (small white dwellings, blue see and sky). Third but not least, the hotels in small regions like this area following or better to say copying each other.



(a) (b)

Fig. 9: Geographical region of Cyclades (a), Forty 5- star hotels in this region (b)

2.3.1 Objectives

Out of total addressable market we aim to achieve the business with top reputed 30% of these hotels, which is around 20 hotels in first couple of years of operation.

2.3.2 Strategy

Upon initial contact with some of the potential clients, it has been seen that in Mykonos island they are changing their conventional umbrellas every year before the summer season where one good unit with fabric costs around 1600 Euros. The main reason that makes it imperative to change their umbrella is wearing because of high speed winds which go till 20m/s in Mykonos occasionally. A great interest from these clients have been seen for our product and they were well aware of charging need for their valuable customers. And in fact, one of them had already bought some small solar chargers to be available at the pool side for his clients and rest of them were trying to make up solutions for fulfilling this need. One common thing observed is that all of the hotels follow other competitors even in small environmental decisions to be competitive. Most of them agreed that they will also employ this solution if employed by their competitors. This gives us the opportunity for a rapid expansion of customer acquisition.

Two of the total five star hotels were interviewed and they found great interest for such a product. Whereas 2 of four star hotels even claimed to buy it as soon as it is ready. We will utilize these clients as opinion leaders of the Mykonian market for first year and will then expand to more hotels with a better and refined product. We believe that a year after our first sale, 10 up to 13 five star hotels will employ our solution. We base this assumption to the fact that the hotels are following new things one of them employs.

Table 12: 5 star hotels in Mykonos

5* hotels	comments
Mykonos Grand	3 hotels in Mykonos (2 more 4*)
Tharroe	
Imperial Mykonian	Kapa hotels
Royal Mykonian	Kapa hotels
Kivotos	
Sant John	2 hotels in Mykonos (the other is 4*)
Mykonian Ambassador	Kapa hotels (4 hotels and building one more)
Grecotel Mykonos Blue	28 hotels all over Greece
Mykonos blue Villas	
Cavo Tagoo	
Palladium	
Mykonos Theoxenia	21 hotels in Greece and Cyprus
Santa Marina	

Further, many of these hotels belong to hotel chains, which quite fast and early will introduce us in new markets in other places too. Further, luxury hotels will operate as promotion channels for our individual customers since they host a great number of clients who belong in the upper class society. Already from the second year, we are planning to participate in the pan-Greek exhibition of tourism (EXPO tourism), make our company popular and widen our market potential.

2.3.3 Timeline

Our aim is to launch a minimum viable product (MVP) for our selected 4 clients by summer 2015. The sole purpose of these initially designed MVPs will be to learn and improve any feature list. Before summer 2016, we aim to acquire 8 five star and 8 four star hotels of Mykonos. In the next year we will try to expand in other Greek Islands as well as try to get into individual customers. By the end of the third year, we believe that 32 five star hotels, 20 four star hotels will have employed our solution.

2.4 Market Quantification for Initial Period of Operation

In this section, it can be found the sales forecast in tables. Initially, it is addressed the potential market which has been analysed in previous chapter and then the proportion of the captured market during the years.

Table 13: Number of potential clients in Greece and Spain

Ranking	Hotels in Greece		% of hotels with pool	Hotels in Spain	
	Total	With Pool		Total	With Pool

5*	361	275	76	275	209
4*	1305	747	57	2248	1286

We are planning at the begging to approach the Greek hospitality sector since we have better connections and we better understand this market. We narrow down our target to Greek hotels since this is our initial market. Making a conservative assumption that on average each hotel has around 20 sunshades by its pool, we present in the following table:

Table 14 Hotels and 20 as mean number of sunshades based on the geographical department

	Hotel ranking		Total number of sunshades by the pool [1]		
Geographical area	5*	4*	In 5* hotels	In 4* hotels	In total
Mykonos	13	41	260	820	1080
Cyclades	40	124	800	2480	32803280
Creta	77	165	1540	3300	48404840
N. Aegean islands	6	33	120	660	780780
Dodekanisa	58	135	1160	2700	38603280
Ionion sea	24	83	480	1660	21404340
Peloponisos (sea side)	16	34	320	680	1000
C. Greece (sea side)	17	48	340	960	1300
Thessaly (sea side)	9	23	180	460	640
Macedonia (sea side)	29	48	580	960	1570
Rest (sea side)	5	8	100	160	260
Total	281	701	5620	14020	19670

However, 5 (five) out of 6 (six) of the hotels interviewed claimed that they have more than 200 umbrellas. Therefore, we assume that on average each hotel has 100 umbrellas and we present the previous table including all the hotels (not only the ones with sunshades).

Table 15: Hotels and 100 as mean number of sunshades based on the geographical department

	Hotel ranking		Total number of sunshades [2]		
Geographical area	5*	4*	In 5* hotels	In 4* hotels	In total
Mykonos	13	41	1300	4100	5400
Cyclades	40	124	4000	12400	16400
Creta	77	165	7700	16500	2420024200
N. Aegean islands	6	33	600	3300	39003900
Dodekanisa	58	135	5800	13500	1930019300
Ionion sea	24	83	2400	8300	1070010700
Peloponisos (sea side)	16	34	1600	3400	5000
C. Greece (sea side)	17	48	1700	4800	6100
Thessaly (sea side)	9	23	900	2300	3200
Macedonia (sea side)	29	48	2900	4800	7700

[1] Assuming that each hotel has 20 sunshades

[2] Assuming that each hotel has 100 sunshades

Rest (sea side)	5	8	500	800	1300
Total	281	701	28100	70100	98200

2.5 Sales forecasting

In the first year of operation we believe that our market share will be quite small and for our introduction year to the market we prefer to stay with a small number of clients in order to optimize the product. Next table presents the sales forecasting till 2018 following the sales forecasting scenario (see ANNEX for more details)

Table 16: Conservative Number of Sunshades sales and associated revenues by year

Year	Normal Product			Premium Product			Total Sales (x1000 Euros)
	Mykonos	Cyclades	Rest	Mykonos	Cyclades	Rest	
2015	0	0	0	80	0	0	160
2016	100	0	0	200	0	0	550
2017	180	160	0	40	720	0	2030
2018	0	180	820	0	160	1780	5380

*Assuming price for normal and premium product to be 1500 and 2000 Euros respectively

2.5.1 Sensitivity analysis

The sensitivity analysis is conducted under two frameworks. The first one takes into account that only the by the pool sunshades of a hotel will be replaced (i.e. 20 sunshades per hotel) and the second that all the sunshades a hotel has will be replaced (with 100 to be the average number of sunshades).

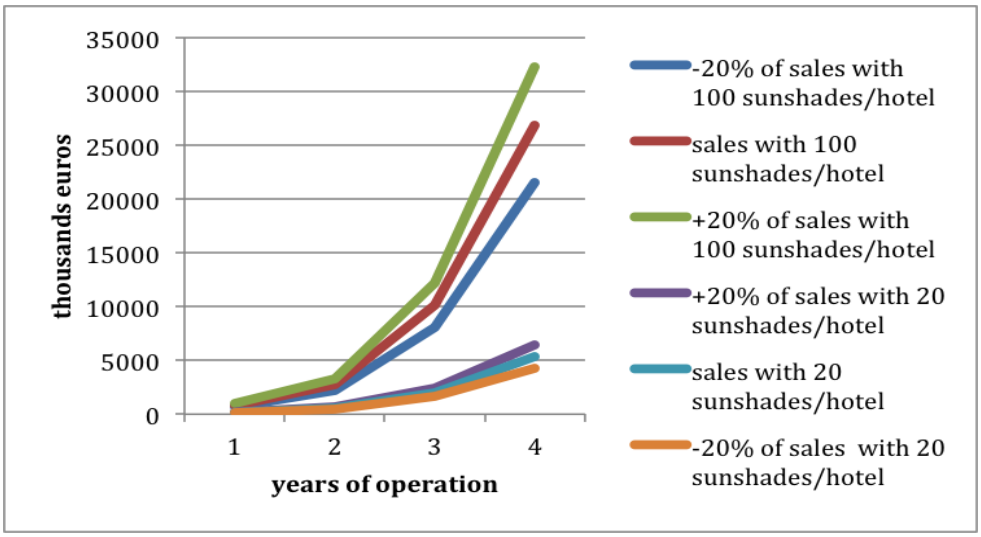


Fig. 10: Sensitivity analysis of sales

3 Marketing Plan (Product, Price, Place and Promotion)

3.1 Product

G-SOLution is a solar powered sunshade designed to produce enough electricity to charge personal gadgets by exploiting the available sun outdoors. It utilizes high performance solar cells to convert sunlight into electricity and stores in a built-in battery.

3.1.1 Technical Features

- High performance 20W solar cells module on the top of sunshade
- Damp proof Sunbrella fabric available in different colours
- 10Amph battery backup for at least 10 iPhone charges
- 5 sunshine hours required to fully charge the battery
- 2 standard USB 2.0 outlets for charging devices
- Positive carbon footprint in the entire life cycle
- Wind resistance in loads of 6 Beaufort

3.1.2 Conceptual Design

A contemporary design is pursued with the covered area of sunshade as 5m^2. Sunshade is 2 m in height with two possible configurations of the solar panel integration. The configuration utilizes multi-Si PV covering surface area of 0.24 m^2 on the top of the sunshade as shown in figure shown below.

(a) (b)

Fig. 11 Physical Specification of G-SOLution, side view

The final rendering results in an aesthetically appealing product that not only improves the green image of our clients but also improves comfort of their customers.

Fig. 12: Rendering of G-SOLution by swimming pool

3.1.3 Post sale service

G-SOLution is designed carefully to have an efficient spare replacement. Batteries and solar module can be replaced easily by local electricians. Spare parts would be available at our online store as well as selected offices in countries of operation.

3.2 Price

G-SOLution requires following activities, materials and associated costs to be manufactured:

Table 17: Cost breakdown for G-SOLution

Component	Price (euros)	Comment
PV glass	94	ONYX solar; Cost reduces to 21euros if conventional solar cells would be used
Battery	60	
Electronics	3	
PCB	2	
Fabric	38	Dickson
Aluminum structure	250	7.2 euros/kg (anodized) plus manufacturer expenses
Metallic base	10	
Dies	3	3,000 euros for two dies (price per unit for 1000 units)
Assembling and packaging	10	Bulgaria (in the house)
TOTAL	432	

3.2.1 Strategy

Adding 70,000 euros for salaries, utilities and marketing purposes (48,000 euros salaries, 4000 utilities and 28,000 marketing) to the 432,000 euros (unit cost multiplied with 1000 units), results to 502,000 euros, i.e. 502 euros per unit. Considering this price, we can offer 50% discount to big orders of hotels and therefore being able to bit the offer our competitors make.

Taking into account the unit costs and the operating ones, we ended up with a **sales price of 1500 Euros per final product**. Please note that one of suppliers in Mykonian hospitality sector is offering a conventional umbrella at 1660Euros/unit.

3.3 Place

3.3.1 Mykonos retailer

As it has been addressed earlier, our initial market is Mykonos island. Our product has to be exposed there and for this reason we chose a local furniture retailer (Scala store) and our company's website simultaneously. This retailer has the best reputation on the island since they have more than 20 years of experience in the field and great brand name. This place perfectly fits with our company's image since they have just started selling solar dehumidifiers and promote a more sustainable - environmental profile.

3.3.2 Channel

Our main market channel is our initial market. To be more specific, it is of great importance that from the beginning of our company's life, our product will be exposed to so many potential clients from so many different countries. Mykonos island is a touristic destination where many good quality hotels are located

and many upper financial level tourists are visiting. This gives us a triple benefit; firstly, there is big competition in between the hotels to satisfy their clients and their needs. Secondly, Mykonos is considered an initiator in the Greek touristic sector since it holds the lion's share, i.e. what is employed there it is copied by others in different places. Thirdly, our products will be exposed to high-class clients who are additional market segment besides the hospitality sector.

3.3.3 *Corporate Message: Sustainability is the new Luxury*

Luxury concept that fascinated people in the past was unique and old. However in the last century, luxury has been confined to spending lavishly without considering social and environmental impacts. In recent years, due to increased and easy access to authentic information, luxury customers are becoming aware of impacts on the environment and society associated with their actions and are adopting sustainable behaviours. This trend is increasing and will dictate the success of businesses in future. Our Eco Luxury offer will address three dimensions as presented in the figure below.

Fig. 13: Corporate Message Flow Diagram

3.3.3.1 Channel: Website

The website will convey our corporate message to the clients and will encourage them to engage in ethical shopping which will help them feeling connected and serving their local society. Main values highlighted in website body for our clients would be:

- Integrating sustainability in client's profile
- Helping people which in case of our first market is a non-profit recycling facility MOIKONOS (http://moikonos.wordpress.com).
- Caring for the environment by producing clean electricity and increased comfort of their customers i.e. providing comfort while caring for environment and others

3.3.4 *Commercial Message: A world where quality is defined by sustainability*

Our commercial message is more focused to the sales and will address hotel owners/ managers. Upon question asked from Ms. Mariola Ana (interviewed for insight into hotel management) who has 15 years of consultation experience to luxury hotels and now she is COO of Eco-Luxury Financial investments, she said luxury customers do not care about the reduction of hotel bills due to energy efficiency rather they

care about environment and philosophy of the hotel. If a hotel claims to be eco-friendly, it has to reflect through all interior, exterior design and everyday routines.

3.3.5 Social Media

We also plan to be on social media such as Twitter, Facebook and LinkedIn where we will feature our clients and their savings to build up the movement and awareness across the world about the product and company.

3.3.6 Launch Gala

Our personal contacts with the local businesses give us an additional advantage in order to make our company successful. Moreover, there is trust in between our potential clients (local hotels) and the members of our enterprise.

As part of the company's public relationships, it is planned to be carried out a gala where we will present the philosophy of our company, the product and inform the guests about all the green aspects of it. Our goal is always to introduce a world where quality and lux is combined with sustainability. The CEO of Hermes (luxury company), celebrities and hotel owners will be invited. They will experience our product and we will ask a comment from them in order to be used for promotional and marketing purposes.

3.3.7 Summary

To summarize, following table mentions our promotional strategy.

Table 18: Promotional Strategy Summary

Frequency	Channel	Audience	Material	Cost (eur/year)
Live all time	Website	Corporate message to potential customers and general public	Product portfolio, shopping cart for spare parts at web platform	10000
Once a month	Email and Direct Sales force	Commercial message to potential customers	E-Brochure and Printed Catalogue	4800 (including transportation to hotels)
Bimonthly	Meet-up Lunch/Dinner	Learning and sharing within the community to all luxury hotel managers/owners	Talks from motivated speakers from hospitality industry experts regarding energy efficiency and sustainability	2000
Everyday	Social Media	General Public	To increase awareness of the company in general public across the world for spreading word of mouth	-
Once a year	Print Media	General Public, Commercial Message	Advertisement in an International Fashion/Furniture Magazine	1500

4 Operations

4.1 Map and process identification

The main manufacturing process and final assembly takes place in furniture artisanship in Bulgaria. There, all the necessary parts are gathered for construction of the final product.

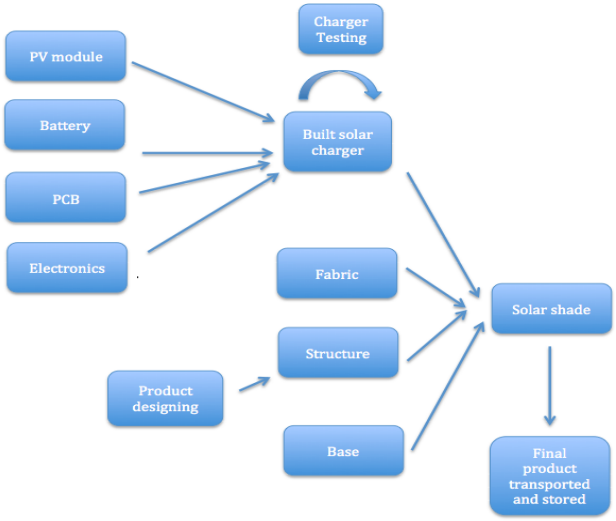


Fig. 14: Process Part Plan

The technological parts, i.e. the PV modules, the batteries, the PCB and the rest of the electronics are gathered in our facility in Bulgaria. There, we built the solar charger box, which then is tested to secure its desired functionality and delivered to the furniture industry for the final assembly. The furniture industry manufactures the body of the sunshade (structure) and the base based on the design, which has been provided by us. The solar shade is ready to be stored and transported in Greece.

4.2 Product development

The product is manufactured in two faces. The first one is the manufacturing of the shade as a furniture and the manufacturing of the solar charger which is taking place in parallel. Both parts are assembled together in the second face in order to create the final product. The designing and the assembling are the processes, which add value to the solar shade. On the other side, another important aspect is the solar charger and its proper function. A potential mistake can drastically decrease the added value of our product since it will just serve as a regular sunshade. Our facility in Bulgaria is consisted from a technician who builds the charger and tests it and a secretary who is responsible for the orders and our communication.

4.3 Subcontracting Suppliers

Our most important partner is the furniture manufacturer as it has been already mentioned. Therefore, a good deal with them is of paramount importance. The fact that we already have contacts with them since the mother of one of our team members (furniture store in Mykonos) is collaborating with them is a key advantage. Further, the plethora of furniture manufacturing facilities in the area is our strong point in the

negotiations. It would have been useful to mention that in order to manufacture a part of the product they make a die. This die is the higher expense and it costs 1500 euros. We will need three of them and then the parts are manufactured pretty fast and in low cost. A first estimation that has been given to us is 90-100 euros for all the structure. Then, the PV supplier and electronics equipment is another important supplier to us. We request delivering time of 5 working days. Finally, we need to transport the products to our clients and we have decided to outsource this operation. Based on Internet prices [32], the cost for 50 units (products) with total weight of 2500kg is 320 euros. However, potential lower price and a 10% reduction in the costs can be achieved through truckbird (start up in international transportation sector) [33].

4.4 Location

Our company's location is in Bulgaria, close to Bansko area. Bulgaria has been chosen due to good know how in furniture construction, low corporate taxes and cheap labour costs. There, we have a small and simply constructed building to be used as warehouse for the row materials and the finished products. It will also take place the building of the charger and the assembly of the final product. The material used for the structure (aluminium) and its characteristics do not require heavy equipment for the assembling rather simple tools.

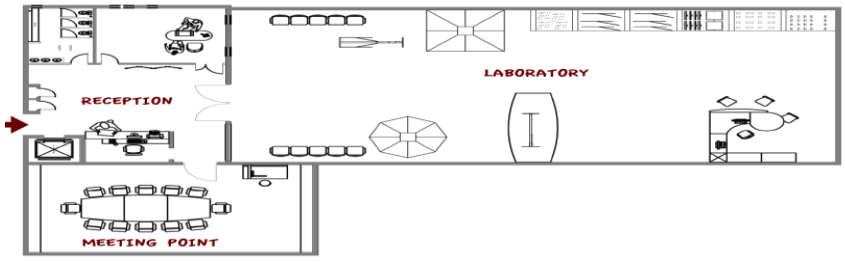


Fig. 15: Top view of our facility in Bulgaria

4.5 Production Capacity

The production of our solar shade is based on production of the aluminium structure and the solar charger. The production of the aluminium structure is based on the capacity of the Bulgarian manufacturer. Working in 100% capacity, the facility is able to produce 20 units a day and subsequently working 70% capacity they can produce 14 units a day. Building up the chargers is a faster process but taking into account the testing and the aluminium cover that it has to be produced from the aluminium manufacturer, it is also limited in 20 units a day in full capacity. We estimate, though, that the charger's production (without the cover) can be 40 units per day. On the other side, the fabric will be in stock and delivery time is between 5-7 days. Finally if all parts are available, our assembling capacity is estimated in 40 units per day including the packaging.

4.6 Delivery time to clients and availability

Delivery time to our customers is an important parameter. During the interviews that we conducted, we realize how crucial is the fast product delivery. The mentioned times were varying between 20 to 45 days while the touristic period for the hotels is 5-6 months with full capacity 1.5-2 months. As it can be

understood, the one month of delivering time for the traditional sunshades is way too much for them and they manage to overcome this problem by purchasing more products than needed (in order to have stock and replace the broken umbrellas).

At this point, it is also worth to mention that the hotels are operating during the summer and more specifically from end of April beginning of May till end of September to begging of October. The season opening and the orders are usually made in April. This subsequently means that March and April will be the highest production for us.

Below, it is presented a table for the production of 40 units, taking into account the delivering times of the different components.

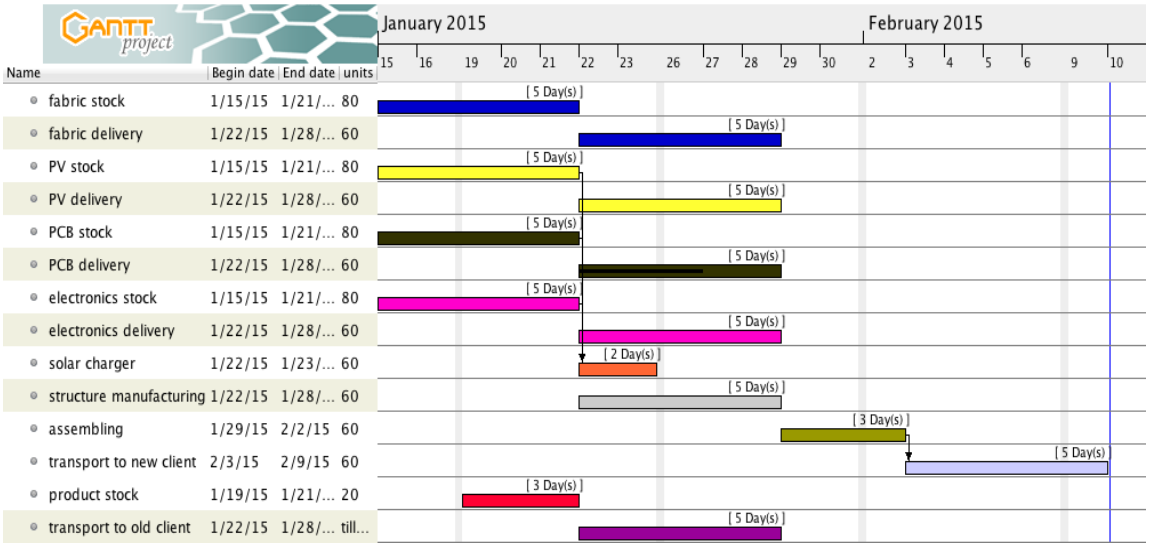


Fig. 16: Gantt Chart for Delivery times

It can be observed that our delivering time has been estimated to 18 days of the placed order (from the 22nd that the order is made to the 10th of February when it is the delivery day).

4.7 Capital and operating expenses

Our capital cost is quite small since we are trying to exploit self-owned properties of the team members. Therefore, the facility in Bulgaria, which will be used as assembling and storage unit, is owned by one of the team members. The same occurs for the offices in Mykonos, which also are owned by another member. However, this does not mean that we will not have capital expenses at all. Initially, an amount of approximately 20,000 euros will be necessary in order to equip these two sites. Two desks, storage selves, two telephones, a PC, Internet connection, packaging machine and basic assembling tools will be required. Besides the tangible assets, an Internet page should also be encountered in the capital costs. We have account 10,000 euros for the designing, coding and releasing of the page in the web.

Our operating expenses are basically the utilities costs, which are quite low as well. We have estimated these expenses as 4,000 euros per year taking into account electricity, Internet and water bills.

4.8 Unit costs

In order to calculate the unit costs we have ask quotes from our potential suppliers for 1000 units of each part. Table 19 presents the costs per unit for our first product.

Table 19: Cost Breakdown for a Unit

Component	Price (euros)	Comment
PV glass	94	ONYX solar
Battery	60	
Electronics	3	
PCB	2	
Fabric	38	Dickson
Aluminum structure	250	7.2 euros/kg (anodized) plus manufacturer expenses
Metallic base	10	
Dies	3	3,000 euros for two dies (price per unit for 1000 units)
Assembling and packaging	10	Bulgaria (in the house)
TOTAL	432	

4.9 Launch plan

A successful company has to take into consideration that unexpected events can happen at any time. For this reason it is crucial to have a good launch plan, meaning not only the 'bing bang' of the launching day but also before and after it.

Initially, we have to give some technical characteristics to our product. For this reason, we will conduct structural analysis and wind load resistance using scientific software for Computational Fluid Dynamics. Secondly, we will conduct life cycle assessment during the development of the product in order to minimize the environmental impact and to select eco-friendly materials, using the scientific software SimaPro. The research would have been completed by the end of the coming August.

Next step is to sign contracts and close deals with our suppliers. We have been already in contact with the majority of them. In parallel, we will implement our marketing strategy (catalogues, launching gala, and advertisement) and we will prepare and manage our facilities in order to be ready (warehouse in Bulgaria, exhibition place in Mykonos). We have already acquire the interest of the first two clients, we are in contact and we are designing for them; therefore we believe that when we will present them the final product, they will give us the first order. We further need one technician who will be responsible for the assembling in house and we will teach him the way he needs to work (do list and tick to secure higher quality and avoid mistakes).

By the end of March 2015 we will be able to deliver our first products in Mykonos island and have deals with local technicians as well or educate the hotel technicians about the use of our product. The next big thing will be our promotional gala and we will have to prepare in the best way in order to show to the opinion leaders from all over the world (since Mykonos attracts global elite) our product and pass our message that 'quality is defined by sustainability'.

5 Organization and human resources

5.1 Team and Job descriptions

Our team consists of four persons: one mechanical engineer and one industrial engineer with master studies in renewable energy, one interior designer and one business manager. Their profiles are presented below:

Table 20: Job Descriptions of Founding Members

Name	Profile	Role in company
Lerios Nikolaos	MA interior and living design and HND in architectural and interior design. Experience in luxury shop design and furnishing.	CMO
Danish Rehman	MSc in Renewable Energy. Experience in Mechanical design and engineering.	CTO
Theofilou Aristidis-Alain	MA in European studies and BA in Business administration and international management.	COO
Panagiotakopoulos Dimitrios	MSc in Renewable energy. Experience in energy management and LCA.	CEO

Please note that we will actively seek for a senior product designer and an electrical engineer during first couple of years of operation. Their personnel cost and salaries have not been specified yet and are not included in this analysis. The duties of each member are not analytically presented in this document in order to save some space but are well defined in the document delivered to KIC-Innoenergy incubator in Barcelona.

5.2 Personnel and total cost

At the begging, we will require also one technician and one secretary who will be placed in our Bulgarian facility. The technician will be responsible for the assembling and the packaging and the secretary will be there to secure our communication with clients and suppliers.

Every one of the team members will share the same salaries, which will be a minimum wage of 750 euros, so in total 3,000 per month or 36,000 and the personnel will acquire 1000 euros per month, which is much higher than the Bulgarian average. Therefore, in total 48,000 euros for the first year will be required for salaries. The second year our salaries will be double whether we are in between 10% deviation from our sales forecasting.

6 Finance

The financial forecasting has been conducted for the first four years of operation. Therefore, the years 2015 till 2018 will be presented in the following tables.

6.1 Table explanation

The values mentioned in the tables are in accordance with all the previous prices mentioned. The three columns: Pro-forma, Increases and Forecast are referring to initial sales forecasting (**Table 16: Conservative Number of Sunshades sales and associated revenues by year**), 20% increase and sales forecasting adding this 20% increase, respectively. Subsequently, with 20% increase have been encountered all the corresponding costs. The raw materials have been calculated taking into account 403 euros per unit. This number is multiplied with the number of shades sold plus the 100 units in stock. For the fixed costs, the launching gala is considered as a crucial marketing event and for this reason 50,000 euros will be invested. Finally, 30,000 euros have been encountered for the other fixed costs and these are one time expenses (20,000 euros for equipment and 10,000 euros for the Internet page).

6.1.1 Year 2015

Table 21 First year finances

	Pro-forma	Increases	Forecast
NET SALES	160000.00	32000.00	192000.00
Raw materials	72540.00	6448.00	78988.00
Transportation	512.00	102.40	614.40
Energy	320.00	64.00	384.00
VARIABLE COSTS	73372.00	6512.00	79884.00
GROSS MARGIN	86628.00	25488.00	112116.00
Labor cost	48000.00	0.00	48000.00
Brochures and catalogue	4800.00	0.00	4800.00
Depreciation	6000.00	121.60	6121.60
External workshops	2000.00	0.00	2000.00
Launching gala	50000.00	0.00	50000.00
Advertisement	1500.00	0.00	1500.00
Other fixed costs	30000.00	0.00	30000.00
TOTAL FIXED COSTS	142300.00	121.60	142421.60
TOTAL OPERATIONAL COSTS	215672.00	6633.60	222305.60
EBIT	-55672.00	25366.40	-30305.60
Non operational income	0.00	0.00	0.00
EBT	-55672.00	25366.40	-30305.60
Taxes on EBT	0.00	2536.64	2536.64
EAT	-55672.00	22829.76	-32842.24

The depreciation has been calculated with the straight-line depreciation method, taking into account our stock. A table is following:

Table 22 Depreciation calculation method

Calculate Straight Line Depreciation	
Purchase price	403.00
Salvage value	103.00
Depreciable value	300.00
Life (in years)	5
Output	
Depreciation expense	60.00

6.1.2 Year 2016

The second year of operation we will already have positive EAT. Consider that launching plan expenses will not occur and on the other hand, we have encounter 10,000 euros in the other fixed costs for participating in the tourism exposition.

Table 23 Second year finances

	Pro-forma	**Increases**	**Forecast**
NET SALES	550000.00	110000.00	660000.00
Raw materials	151125.00	22165.00	173290.00
Transportation	1760.00	352.00	2112.00
Energy	1100.00	220.00	1320.00
VARIABLE COSTS	153985.00	22385.00	176370.00
GROSS MARGIN	396015.00	87615.00	483630.00
Labor cost	84000.00	0.00	84000.00
Brochures and catalogue	4800.00	0.00	4800.00
Depreciation	6000.00	121.60	6121.60
External workshops	2000.00	0.00	2000.00
Advertisement	1500.00	0.00	1500.00
Other fixed costs	10000.00	0.00	10000.00
TOTAL FIXED COSTS	108300.00	121.60	108421.60
TOTAL OPERATIONAL COSTS	262285.00	22506.60	284791.60
EBIT	287715.00	87493.40	375208.40
Non operational income	0.00	0.00	0.00
EBT	287715.00	87493.40	375208.40
Taxes on EBT	28771.50	8749.34	37520.84
EAT	258943.50	78744.06	337687.56

6.1.3 Year 2017

The third year, the EAT increases further to 1,297,619 . During this year we encounter in the section 'other fixed costs' additional 20,000 euros for unexpected costs may occur.

Table 24 Third year finances

	Pro-forma	Increases	Forecast
NET SALES	2030000.00	406000.00	2436000.00
Raw materials	449345.00	81809.00	531154.00
Transportation	6496.00	1299.20	7795.20
Energy	4060.00	812.00	4872.00
VARIABLE COSTS	459901.00	82621.00	542522.00
GROSS MARGIN	1570099.00	323379.00	1893478.00
Labor cost	84000.00	0.00	84000.00
Brochures and catalogue	4800.00	0.00	4800.00
Depreciation	6000.00	121.60	6121.60
External workshops	2000.00	0.00	2000.00
Advertisment	1500.00	0.00	1500.00
Other fixed costs	30000.00	0.00	30000.00
TOTAL FIXED COSTS	128300.00	121.60	128421.60
TOTAL OPERATIONAL COSTS	588201.00	82742.60	670943.60
EBIT	1441799.00	323257.40	1765056.40
Non operational income	0.00	0.00	0.00
EBT	1441799.00	323257.40	1765056.40
Taxes on EBT	144179.90	32325.74	176505.64
EAT	1297619.10	290931.66	1588550.76

6.1.4 Year 2018

Finally it is presented the forth year where it is observed the higher earnings. Note that other fixed costs remained the same as in the previous year (encountering 20,000 euros for unexpected events).

Table 25 Fourth year finances

	Pro-forma	Increases	Forecast
NET SALES	5380000.00	1076000.00	6456000.00
Raw materials	1124370.00	216814.00	1341184.00
Transportation	17216.00	3443.20	20659.20
Energy	10760.00	2152.00	12912.00
VARIABLE COSTS	1152346.00	218966.00	1371312.00
GROSS MARGIN	4227654.00	857034.00	5084688.00
Labor cost	84000.00	0.00	84000.00
Brochures and catalogue	4800.00	0.00	4800.00
Depreciation	6000.00	121.60	6121.60
External workshops	2000.00	0.00	2000.00
Advertisment	1500.00	0.00	1500.00
Other fixed costs	30000.00	0.00	30000.00

TOTAL FIXED COSTS	128300.00	121.60	128421.60
TOTAL OPERATIONAL COSTS	1280646.00	219087.60	1499733.60
EBIT	4099354.00	856912.40	4956266.40
Non operational income	0.00	0.00	0.00
EBT	4099354.00	856912.40	4956266.40
Taxes on EBT	409935.40	85691.24	495626.64
EAT	3689418.60	771221.16	4460639.76

6.2 Conclusion

The financial part conducted in the previous sections is a useful guide for decision-making. Even though, it is not fully comprehensive, in a sense that the hiring of a senior designer, for instance, is not included, it is giving us the overall financial development of our company. The most important, it is guiding us and showing not only the viability of our business but mainly the potential for our financial capabilities, i.e. for example what offer can we make to the senior designer.

SECTION II- Life Cycle Assessment Study

Abstract

In mid February 2014 we got inducted into KIC – Innoenergy incubator Iberia after presenting our business idea. The concept of green-forming daily life objects, like the one proposed, was highly appreciated and we entered in the incubator following the Sidewalk program. Our proposed start up G-RooT is aiming at developing as green as possible products. By the term green, we mean environmental friendly products with the lowest possible carbon footprint.

Our first product G-SOLution is a parasol with integrated solar PV technology for micro-generation of electrical energy for charging hand held devices, targeting luxury hotels. This report aims to examine the environmental impacts of G-SOL in terms of sixteen impact categories with main focus to Global Warming Potential. This was achieved by performing an LCA study using the SimaPro software and ILCD 2011 Midpoint impact method. Further, different PV technologies were investigated and a sensitivity analysis was also performed in terms of waste treatment and disposal.

The carbon footprint of G-SOL is -128 kg of CO_2 – eq. and our solution LCA cause the most negative effect in the impact categories Mineral, Fossil and Renewable Resource Depletion followed by Ozone Depletion while the least to acidification. Aluminium is the material that contributes the most to the environmental load with 894 kg of CO_2-eq followed by the woven cotton fabric with 53.8 and the multi-Si module with 52.6 kg of CO_2-eq. Different cases-scenarios' results vary between -274 kg of CO_2 - eq. to 764 kg of CO_2 - eq., where negative value means that the product has a net effect of reducing greenhouse gas emissions. Green - forming is interpreted by the author as producing objects that not only do not have carbon footprint but on the contrary saving the carbon footprint of the relevant regular ones. .

7 Introduction

7.1 Introduction

During the last years of the 21st century the world has shown a great interest towards sustainability. More research and policy making in favour of renewable energy sources have been made. The so-called developed world is taking actions towards this direction. Especially, European Union has formed many policies with outstanding one the 2020 climate package or commonly known as 20-20-20 targets. This sets targets for 20% reduction in Green House Gas emissions from the 1990 levels, raising the share of EU energy consumption produced from renewable resources to 20% and 20% improvement in the energy efficiency. Further, policies on reducing energy consumption and subsequently the carbon footprint of products have also been taken. EU eco label and eco friendly appliances policies are some of the examples. These targets are basically driven from subsidies and in some countries sustainability still remains a ground of speculation and fast profiting. On the other hand, citizens of the Northern European countries are more familiar and better educated about terms like climate change and the potential effects. It cannot be refused the fact that Europe is in a transition period on this issue.

One of the greatest challenges of our era is to find the appropriate ways to 'implant' environmental thinking into less eco-progressive European societies. Both environmental and financial aspects should be taken into account as well as local financial, cultural and behavioural conditions in order such an effort to succeed.

Our initial aim was to introduce solar energy and its benefits to people that were unconcerned with environmental protection and renewable energies in general.

7.2 Aims/ Research issues and goals

The aims of this study are multifaceted:

- to introduce in the G-RooT start up the Life Cycle Assessment methodology and its advantages;
- to examine the environmental impact of G-RooT's handheld solar charging product during all its life cycle;
- to determine the best choices in terms of LCA that can be made during the design process in order G-RooT to better market its product in the future.

This will be made possible by using the Life Cycle Assessment methodology as it has already been mentioned. The system will be evaluated in terms of environmental impacts based on the ILCD 2011 Midpoint methodology. .The impact categories under research will be the Global Warming Potential, the Ozone Depletion Potential, Human Toxicity (cancer and no cancer effects, Particulate matter, Ionizing radiation Human Health, Ionizing radiation Ecosystem, Photochemical Ozone Formation, Acidification, Terrestrial Eutrophication, Fresh Water Eutrophication., Marine Eutrophication, Fresh Water Eco-toxicity, Land use, Water Resource Depletion and Mineral, Fossil and renewable Resource Depletion. The

GWP will be characterized by the Carbon Dioxide equivalent or CO_2eq and will be the main focus of the study

7.3 System definition

The system is defined by the solar charging parasol and the flow of resources, energy and emissions during its whole life cycle. The life cycle is divided into four stages: raw material extraction and production, manufacturing usage, disposal.

In each stage there are resources or materials and energy entering the sub system as well as emissions exiting each sub system.

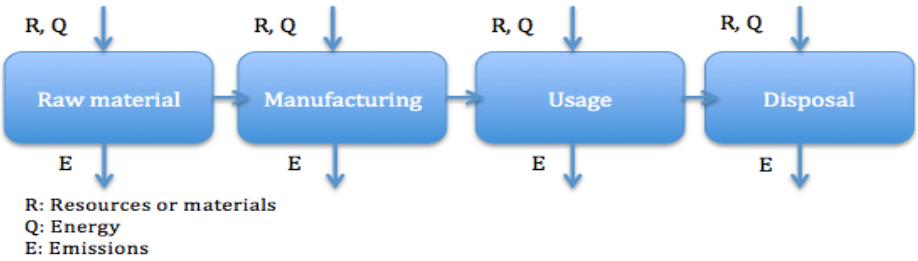


Fig. 17: LCA stages

All these four stages are complex and many different processes are taking place in each. The processes have been identified through previous studies in each field and are better explained in a later stage.

7.4 Background and relevance of the subject

A literature review was conducted based on two frameworks; the first one is the eco design and the second one the LCA of different materials and basically PV technologies. Obviously, the goal of the report is to integrate eco thinking during the designing phase of G-RooT's product. The basic principle of eco-design is increasing eco-efficiency and reducing environmental loads. Literature highlights the importance of taking environmental considerations into account in the early stage of product design and development [34]. Specifically, Kathleen Donnelly et al. from Lucent Technologies describe a product-based environmental management system (PBEMS) where the leading idea is to incorporate sustainable principles during product design phase. In the PBEMS system, business and environmental processes are utilized together in order to integrate product strategy with Life Cycle Assessment (LCA). Another paper [35] from Conrad Luttropp and Lagerstedt have created a generic set of rules/good advice/checklists for the early phase of product development. The paper presents Luttropp's generic set of design rules and how they can be used as a base to make situation-specific guidelines and checklists, e.g. adapted for various design tasks, product types and persons. This set of 'rules' promotes more effective early compromises and specification negotiations.

There is no doubt that considering eco-design during the early stages of the product development is more beneficial than taking it into account after the product manufacturing. However, the vast majority of SMEs are underestimating, and in some cases ignoring, the benefits of eco-branding and subsequently eco-marketing. European Union is making a great effort towards this direction by conducting educative seminars on LCA and entrepreneurship as well as having its own eco-label [36]. The categories that eco-flower (EU eco-label) has formed till now are summarized below:

- Beauty care
- Cleaning up
- Clothing
- Do it yourself
- Electronic equipment
- Coverings
- Furniture
- Gardening
- Household appliances
- Lubricants
- Other household items
- Paper products
- Holiday accommodation

Each of these categories is further subdivided, however SOLution parasol do not stand in any of these. It is truth that the eco-labelling is under development and that there is open to public call for new categories or subcategories proposals.

Besides the EU, there are many private entities or corporations that provide eco-labelling for almost any kind of product, like the carbon neutral company [37]. In any case, though, a LCA is necessitated in order to further proceed. On the other hand, there is a significant number of Life Cycle Assessments made for photovoltaic systems, e.g. by Ftenakis and Kim [39]

The research conducted in this thesis will be focused on researching different PV technologies and their environmental impact as well as techniques and measures that can be implemented in a start up in the general framework of reducing the environmental burden. The goal is to come up with a as much as possible sustainable company and to support its Eco branding.

8 Chapter 2

8.1 Photovoltaic technology

In this chapter different PV technologies, their manufacturing processes, similarities and differences will be presented.

8.1.1 Introduction

Photovoltaics are semiconductors materials that convert the sunlight into direct electricity current. This phenomenon is called photoelectric and takes place in atomic level. More specifically, some materials (semiconductors) exhibit a unique characteristic of absorbing the photons from the sunlight and releasing electrons. These electrons, then, are captured and an electric current is been created.

Edmund Becquerel was the first who noted the photoelectric effect in 1839. Till 70s photovoltaic modules were solely used in the aerospace in order to supply energy satellites and space crafts while in space. Their price start to decline during the oil crisis and nowadays have gained a broad recognition as power sources. During the 21st century, photovoltaic industry boomed basically due to governmental policies and subsidies.

The smallest commercial form of Photovoltaic material is called cell. As it can be observed in Fig. 17, many electrically connected cells create a module and many modules create the well-known PV panel (array).

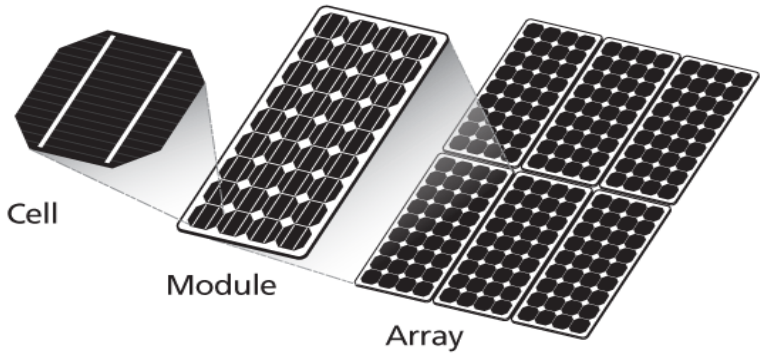


Fig. 18: Photovoltaic array sub components

Many different photovoltaic technologies exist with the most common commercially available to be the silicon based ones, which are subdivided to mono and multi crystalline as well as the thin film ones, such as amorphous-silicon (a-Si), Cadmium Telluride (CdTe) and Copper Indium Diselenide (CIS). For the purpose of this report, the under investigation technologies in the framework of LCA, are presented below.

8.1.2 Multi Crystalline Silicon/ Mono Crystalline Silicon

The most widely known or in other words mainstream PV technology is the Crystalline Silicon, which hold 85-90% of global market share [38]. Crystalline Silicon is subdivided to Mono and Multi Crystalline based on the cell manufacturing. These two types of semiconductors, as it has been mentioned earlier the

cell is nothing more than a semiconductor, differ in the composition. Mono Crystalline Silicon is more efficient and also more expensive while Multi Crystalline is more used in the solar industry.

The manufacturing process involves: raw material acquisition, ingot growing or brick casting, slicing, doping, wiring, coating and assembling.

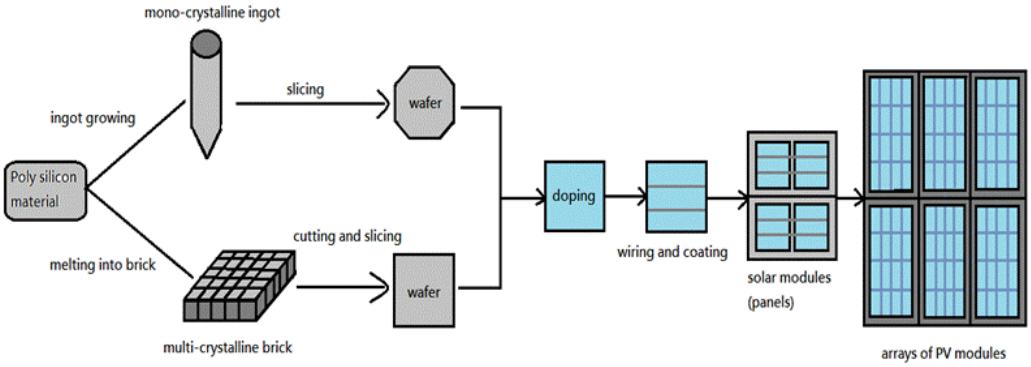


Fig. 19: Split process for mono and multi crystalline PV modules

8.1.2.1 Raw material: silicon

The basic material of the cells is stemming from quartz sand, which is mostly made up of silica. Silica, at the first place, goes through a carbothermic reduction process in order to become metallurgical grade silicon. The MG-Si then goes through better refining and casting scratch process to become poly-silicon. More specifically, the MG-Silicon is further purified to 'electronic grade' silicon or 'solar grade' silicon. The purification step involves the Siemens or modified Siemens process [39]. In the Siemens process, a reactor chamber with trichlorosilane ($SiHCl_3$) and hydrogen (H_2) gases is heated to 1100-1200 ^oC for growing the silicon rods. In the modified Siemens process, silane (SiH_4) and hydrogen gases are heated up to around 800 ^oC, which results in less energy consumption.

8.1.2.2 Ingot growing or brick casting

The poly-silicon material created is now split up to two different production processes in order to produce Crystalline Silicon. The poly-silicon is used for ingot growing either through the Czochralski (CZ) or the Float Zone (FZ) for the mono-crystalline silicon production [40] and for the multi-crystalline, poly-silicon is melted and then cast into bricks.

8.1.2.3 Slicing

A visible difference between the two Silicon materials (mono-Si and multi-Si) is the shape of the cell. This is a result of the slicing process. The mono-Si ingot is sliced into wafers and since it grows in a cylindrical shape, their wafers are not perfect squares. Being cut into squares, it would have been the optimum from the area filling perspective, i.e. more square shaped cells than circular ones can fit in the rectangular area of a PV module. On the other hand, the multi-Si brick is first diced into bars and then sliced into wafers.

8.1.2.4 Doping

This is the most important process to take advantage of the photoelectric phenomenon. A semiconductor is formed by diffusing n-type or p-type onto the top surface of the silicon wafer to form the p-n junction. As p-type dopant is usually used Boron and as n-type phosphorous [40].

8.1.2.5 Wiring

The cells then are wired together to form a circuit and to allow us exploit the electrical current generated in the p-n junction.

8.1.2.6 Coating

Different materials coating is applied in the front (basically) as well as in the back of the solar module in order to protect the cells and increase the efficiency. For instance, a glass with low reflectivity and high absorptivity is employed in order to increase the amount of photons that will reach the p-n junction and subsequently will generate electricity.

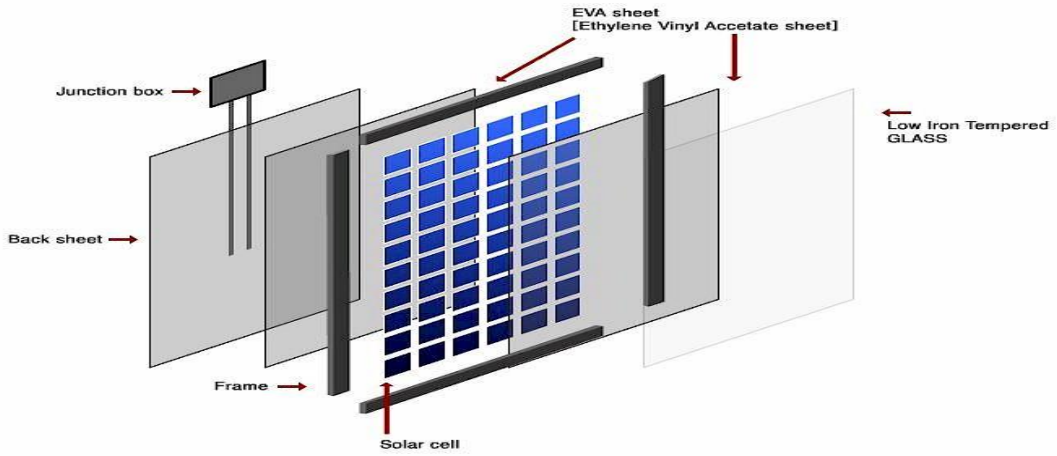


Fig. 20: Solar module assembly

8.1.2.7 Assembly

In the assembly, modules, which consist from cells, are assembled together to form the solar panel. As it can be observed in Fig. 20 the coating, encapsulants, front glass and junction box are the main parts of the final assembly.

8.1.2.8 LCA studies on mono and multi crystalline made PV panels

Many studies on photovoltaic modules in terms of Life Cycle Assessment have been conducted by researchers all over the world. Their results differ quite a lot and in some cases the differences are in the range of 300-400%. More specifically, for multi-crystalline silicon the required energy ranges from 2400 – 7600 MJ/m^2 of PV panel and for mono-crystalline in the range of 5300 – 16500 MJ/m^2 of PV panel [69]. The differences were mainly allocated to the assumptions each researcher made and to allocation rules he employed. Dr. Alsema in his report [68] for 14% efficiency module in Southern European conditions, he mentions that the energy requirements for multi – crystalline panel is 4200 MJ/m^2 and for mono 5700 MJ/m^2. The energy payback time for multi - crystalline has been calculated 2.5 years and the emissions 46

g of CO_2 – eq./kWh while for mono - crystalline the values are 3.1 years and 63 g of CO_2 – eq./kWh respectively.

8.1.3 Thin Film

Thin film is an alternative technology that uses less or no silicon in the manufacturing process. Main thin film PV technologies are the amorphous-silicon (a-Si), the Cadmium Telluride CdTe and the Copper Indium Diselenide CIS. As their name indicates, they are constructed by the deposition of thin layers onto a low cost back side coating such as glass, stainless steel or plastic. A conducting layer is formed on the front electrical contact and a metal layer is formed on the back electrical contact of the cell [38].

8.1.3.1 Cadmium Telluride (CdTe) as raw material

This material is manufactured from purified Cadmium and Telluride, which are by-products of smelting prime metals; more commonly Copper, Zinc and Lead [42]**.** Around 80% of Cadmium is generated as a by-product of smelting Zinc ores. A more detailed diagram is shown below.

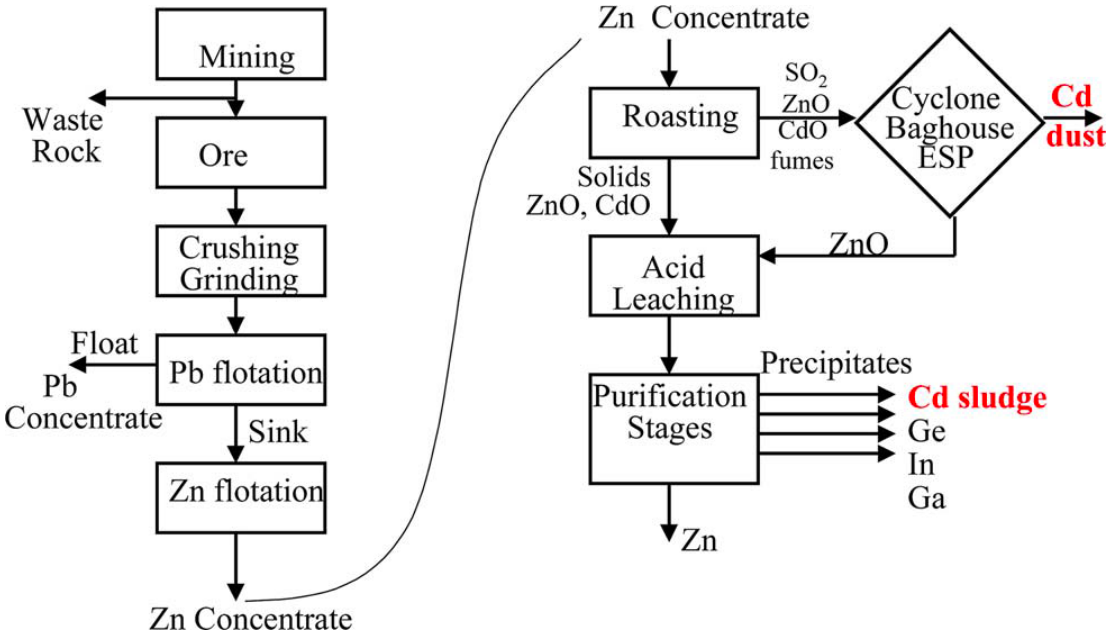


Fig. 21: Process flow diagram of Zn mining till Cd dust and sludge production

As it can be observed in Fig. 21, the feed material for producing cadmium consists of residues from the electrolytic production of zinc, and of fume and dust, collected in baghouses from emissions during pyrometallurgical processing [43].

In the photovoltaic industry, it is used high purity Cd and Te (five to six 9s). CdTe is taken in the form of powder and through proprietary methods becomes the material used as semiconductor in the photovoltaic module [44].

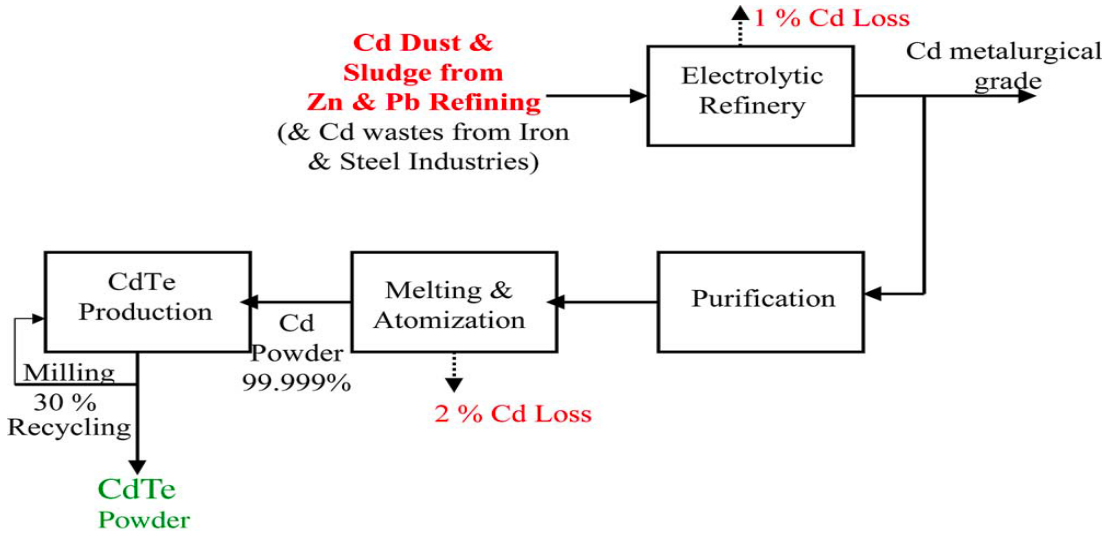


Fig. 22: Production of CdTe powder

8.1.3.2 CdTe photovoltaic manufacturing

Two are the basic methods of producing CdTe/CdS thin films, the electro-deposition of CdTe combined with chemical surface deposition of CdS and the high rate vapor transport of the two compounds [42]. In electro-deposition , a CdTe thin film is deposited on a substrate of an electrolytic system using an aqueous solution of cadmium sulfate ($CdSO_4$) or cadmium chloride ($CdCL_2$) and tellurium dioxide (TeO_2). The above mentioned process is followed by a chemical bath deposition of CdS. Both processes are very efficient due to the massive amount of recycling residues.

On the other hand, in the vapor transport deposition, CdS and CdTe are deposit from the compounds in powder form after vaporization. These processes are also very efficient and cadmium is used very effectively and without losses (less than 1% is stated by Fthenakis in 2008).

8.1.3.3 Amorphous Silicon (a-Si)

Amorphous Silicon is the most common thin film technology. It is the non crystalline form of silicon and it is consisted of cells with a single sequence of p-i-n layers. The a-Si type of photovoltaic is manufactured in six steps as illustrated in the Fig. 23 below:

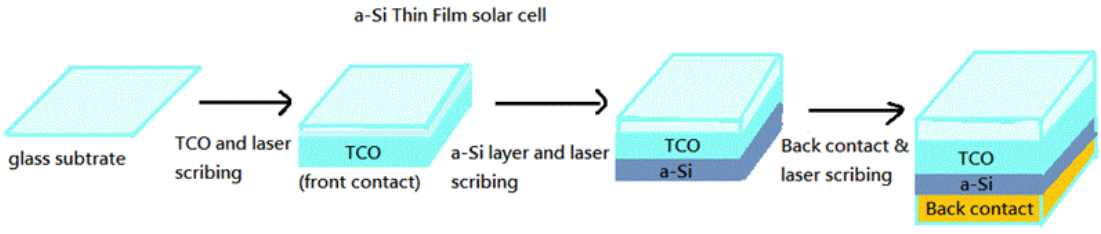


Fig. 23: a-Si cell manufacturing

Initially, the glass substrate is coated with a Transparent Conductive Oxide (TCO) layer on the top of the thin film layer of a-Si. Amorphous Silicon can be deposited to stainless steel or plastic substrates besides glass. The technique is called PECVD (Plasma Enhanced Chemical Vapor Deposition) and a mixture of silane (SiH_4) and hydrogen (H_2) is heated up to 150-500 ^oC depending on the substrate material [45]. The resulting layers contain hydrogen that has semiconductor properties and can be doped [46]. A laser

scribing is following in order to deposit the photovoltaic layer. It is useful at this point to mention that of interest in the photovoltaic applications is the absorption coefficient (alfa) in relation with the photon energy (and photon wavelength). The Fig. 24 shows this relationship for different thin film materials.

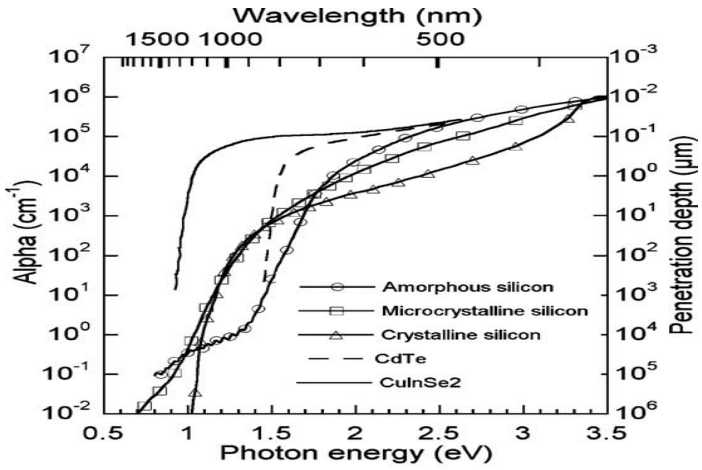


Fig. 24: Absorption coefficient and photon energy of various thin film PV materials [47]

It can be noted that a-Si has relatively low absorption coefficient, which leads to light trapping schemes in order to absorb a sufficient part of the incoming solar spectrum. In the crystalline silicon based materials a way of achieving higher photon energy absorption is increasing the depth of the conductive material. In the thin (as the name indicates, film of around 150-300nm thin) film this is achieved through diffusion (that is why the scribing is taking place) and p-i-n diodes where the photo-generation takes place in the I layer and transport and collection are drift assisted.

After the deposition of the a-Si, one more laser scribing is taking place and another conductive material is placed on the back side. The conductive materials can be glass, polymers or metals.

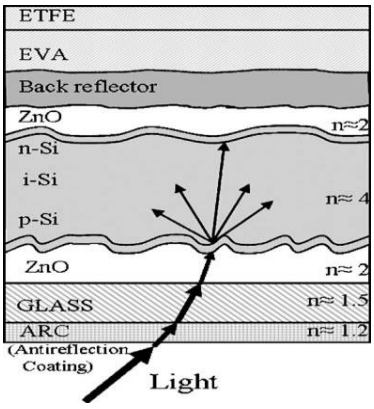


Fig. 25: Light scattering due to scribing in thin film a-Si deposited in glass substrate [47]

In the Fig. 25 as TCO is used ZnO, which will ensure with the Al or Ag back reflector efficient light trapping within the solar cell.

8.1.3.4 LCA studies on thin film PV panels

Less LCA studies have been conducted in thin film technologies. Meijer et al. mentions in the life cycle study he conducted that the energy requirement from the raw material extraction till the production of the a-Si panel is ranging between 710 – 1980 MJ/m^2. On the other hand for Cd-Te the respective energy is 993 MJ/m^2 if no vacuum electro – deposition of 1.5 μm absorber layer in conjunction with chemical bath deposition of 0.2 μm window layer CdS is employed. On the other hand, if 5 μm thick absorber layer and 1.7 μm thick of window layer by thermal evaporation is employed then the energy is 1188 MJ/m^2.

8.2 Aluminium

8.2.1 Primary aluminium production

Primary aluminium production is achieved through two different processes. The first one is the alumina or aluminium oxide (Al_2O_3), i.e. the Bayer chemical process and the aluminium conversion by electrolysis. As it can be understood, alumina is the intermediate material. Aluminium is stemming from Bauxite, which is consisted of aluminium hydroxide compounds and a variety of impurities. In the Bayer process the aluminium oxide is leached from the other substances at high temperatures in autoclaves. Next step is the cleaning of the so called red mud. Cooling is following in a soda solution and then drying and heating again at around 1100 ^oC. The final product (alumina) is usually coming in the form of a grained white powder.

The aluminium transformation is achieved through the Hall-Heroult process in electrolysis plants or primary smelters. Alumina is reduced in a fluorinated bath of cryolite under high intensity electrical current. Carbon cathodes form the bottom of the cells while carbon anodes are held at the top. At this point, it is worth mentioning that electricity consumption during the electrolysis step constitutes the major part in aluminium primary production. Last step is the transportation to the cast house where aluminium is alloyed, cleaned of oxides and gases and casted into ingots.

8.2.2 Secondary aluminium production

Secondary production refers to the production of ingots from aluminium scrap. The recycling of aluminium can be done without any losses of quality (however the alloys alter the material quality) and requires much less energy than primary aluminium production.

For further processing of aluminium (both primary and secondary) semi-fabricates leaving the cast house one can distinguish between sheet production, foil production and extrusion. In our case we are interested in the extrusion processes where aluminium profiles are formed by pushing a hot cylindrical billet or log of aluminium through a shaped die.

8.2.3 Aluminium

8.2.3.1 CO_2 emissions

Carbon dioxide direct emissions occur during the leaching and the calcination process at the first stage. Further, direct emissions occur during the electrolysis process due to the carbon anode consumption as well as PFC emissions resulting from anode effects. In the pre-baking process of anodes, about 50% of

direct CO2 emissions result from fuel used for the baking process and the other half from process emissions due to the combustion of pitch volatiles from the anode and packing coke. The production of semi-finished and foundry products as well as the hot rolling, cold rolling and extrusion processes lead to direct CO2 emission from the fuel used in these installations [56].

According to the EAA (European Aluminium Association) [57], production data for the different aluminium production steps is presented below:

Table 26: CO2 emissions data for Aluminium

Activity	Range of direct emissions (kg CO_2/t of product)
Alumina refining	400-830
Anode production	320-575
Primary smelting	1500-2550
Primary casting	70-200
Secondary remelting	150-350
Secondary refining	250-390
Rolling operations	20-235
Extrusion operations	50-170

The Fraunhofer institute has estimated energy consumption for the different aluminium processes (Table 20). The numbers have been derived from the production volume and the specific electricity consumption in the EU27 [41].

Table 27: Electricity consumption from the aluminium production chain in 2007 for the EU27

Activity	Production volume (Mt)	Range of specific power consumption (kWh/t product)	Approximate power consumption (GWh)
Alumina refining	6.8	225-260	1649
Prebake anode production	2.3	120-190	357
Primary smelting	3.054	14000-16000	45352
Primary casting	3.658	50-200	685
Secondary remelting	4.9	120-340	1127
Secondary refining	2.7	?	?
Rolling operations	4.8	70-900	2740
Extrusion operations	3.3	300-1200	2475
Total			**54385**

8.3 Solar charger

8.3.1 Introduction

Technological development and the improvement of the people's living standards have set hand held electronic devices as part of people's lives. The higher the people's financial status, the more devices they acquire; such as last generation mobile phones, smart tablets, cameras and music players. Besides the practical convenience these devices are offering, people have psychological connection with them as well. Atchley and Worden conclude that mobile phones are in some cases even more important in our lives than money [48]. Therefore, the need for charging is arising and especially in places or in moments where there is no grid electricity. A sustainable way to overcome this barrier and to offer more comfort is solar charging.

A simple solar charger for micro-generation of electricity to charge hand held devices through USB requires 4 basic components: photovoltaic module, battery, Printed Circuit Board (PCB), cabling and USB port.

8.3.2 PCB

PCB is an electronic circuitry printed on cardboard which is mainly made from glass fibre and phenol. The support that just described in addition with the components' housing (plastic and ceramics) account for 73 weight-% of the PCBs. Furthermore, a multitude of elements is present in varying concentrations. Metals account for about 27 weight-% of the PCB. Typical concentrations in PCBs are Fe 10%, Al 5%, Cu 5%, Pb 1%, Ni 1%, Sn 2%, Zn 1%, Mn 1%, Br 1%, and traces of many other hazardous and/or precious metals (Ag, Au, Pt, Pd) [49].

The components that are necessary for our solar charger Minimum Viable Product (MVP) are:

- two resistors of 49.7 KΩ and ¼ W;
- one resistor of 43 KΩ and ¼ W and one of 74.9 KΩ and ¼ W;

- one IC model LM2574 from Texas Instruments Ltd. which is functioning as step down voltage regulator to 0.5A;
- one diode 11DQ06;
- one inductor of 330 μH;
- one capacitor of 220 μF and one of 22 μF;
- USB port.

Figures 26 presents the circuitry of the IC regulator and the bridge, which is necessary for charging Apple devices. At this point, it is useful to mention that this bridge was designed through reverse engineering from a regular Apple charger.

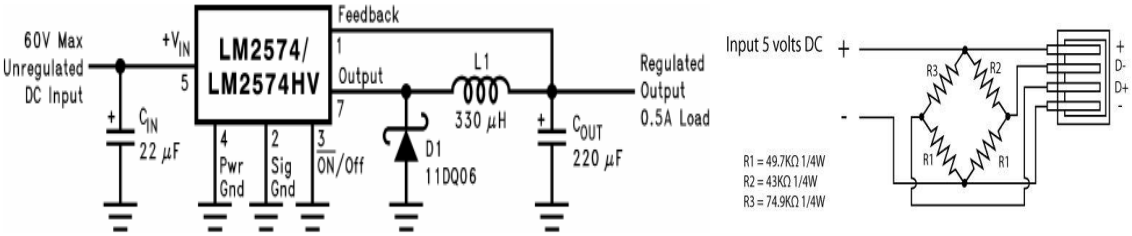


Fig. 26: Electric circuitry for the voltage regulator (left) and for the apple bridge (right)

9 LCA theory

9.1 Terminology/Definition

Life Cycle Assessment is a tool for assessing the environmental impacts of a product or a product system or even a service over its entire life cycle. The phases of a product's life cycle are: the raw material extraction, the manufacturing, the distribution, the use, the maintenance and the end of life treatment, recycling and/or final disposal [51]. The emissions and resources connected with each of them are accounted and therefore such an approach is called cradle to grave. The more holistic the approach, the better is the picture of the environmental burdens related with product.

9.2 LCA concept

During the last half century, it has been noticed an increased awareness of environmental issues in society, which has led to a growing market for environmental friendly products, according to Rydh et al. [50]. Companies tried to reduce their emissions and minimize the residues reaching the waste streams and soon it was realized that a more comprehensive perspective of the production chain was necessary in order to achieve significant improvements. In 1950s the first life cycle assessment studies were made and in 1990s the International Standardization Organization started working on a standardised methodology for Life Cycle Assessments. This initiative set a standard framework for LCA studies, enabling comparisons between different types of processes and different products. However, the results of LCA

studies of the same product can vary based on the boundaries of the system and on how the product's system has been defined.

9.3 LCA stages

According to ISO 14040 (2006a) an LCA study has to be conducted in four different as well as interconnected main steps: Goal and scope definition, Inventory analysis, Impact assessment, Interpretation.

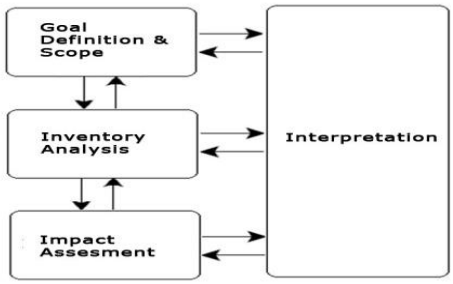


Fig. 27: Life Cycle Assessment stages

9.4 Goal and Scope definition

As it has already been stated before an LCA models a product, service or system life cycle. It is important to be realized that a model is not the reality and some complexities will be excluded and some simplifications will be made. Inevitably, the complicated reality will be distorted in some way. Therefore, the first and most important while conducting an LCA, is a good and clearly defined goal and scope of the study. The consistency of your study is basically depended on the goal and scope choices, which are presented below [52]:

- The reason for executing the LCA
- A definition of the product, its life cycle and the function it fulfils
- A description of the system boundaries
- Data, assumptions and limitations
- The requirements regarding the LCIA procedure and the subsequent interpretation to be used
- The intended audience and the way the results will be communicated

More specifically, the goal states the purpose of making a Life Cycle Analysis and who will be interested of reading such an analysis, i.e. for who is useful. Or in other words, the goal of an LCA states the intended application, the reason for carrying out the study and the intended audience [51]. On the other hand, the scope describes methodological choices and involves making several decisions. The product system has to be described inside the defined system boundaries, i.e. which processes will be included and how detailed the processes will be analyzed. Subsequently, the collection of data and its quality will be affected. It is worth to mention, that there is no wrongly carried out LCA as far as all the limitations and assumptions have been clearly stated. For instance, omitting to mention that a process, which has significant environmental impact- has been excluded from the study, will cause remarkable alteration of the final result.

9.5 Functional unit

One important methodological choice is the functional unit, i.e. the comparison basis. The functional unit should describe what kind of function or service the product system delivers, defines what is being studied and quantifies the service delivered by the product system. Furthermore, it is a reference for the inputs and outputs of the system to be related [53]. The functional unit should be measurable and it is the comparison indicator for different product systems.

9.6 System boundaries

The system boundaries are the limitations of the system or in other words the line that specifies what is on the one side and is included in the analysis and what is on the other and is excluded. To be more understandable, a truck (a capital good for our x product system) is needed during the transportation of the raw materials to the factory and this truck has its own life cycle related with emissions and raw materials. Whether the LCA of the truck will be included or not in the environmental burden of our x product, will be defined by the system boundaries. In any case, this has to be clearly mentioned in order to avoid confusion.

9.7 Inventory Analysis

The inventory in an LCA is the relevant data on inputs, outputs and emissions needed for each process and during every stage of the product system. This information can be collected through previous studies on LCA, databases and the production site itself. Data gathering is the most time consuming process of a life cycle assessment and the most difficult. Difficulties in the data gathering can alter the goal and scope of the study that is the reason why there is great interconnection in between these two phases. Clearly mentioning where the data is stemming from and what it is being included, increases the credibility of the report. Two groups of data are usually found in literature: the foreground and the background. The first is more accurate since it is stemming usually from the production site and subsequently is more detailed while the latter is related with secondary processes, for instance transportation of the raw materials to the site, where less accuracy is needed, i.e. generic data of the databases is adequate.

Dealing with enterprises for the data collection becomes sometimes time consuming or even impossible. Many companies do not want to share their information usually either because it is a competitive advantage or due to confidentiality issues. Even though some data may be public available, still some data often need to be collected for the particular case of the study [54]. If obtaining data from the production site is impossible, data from databases and literature should be used instead. However, it has to be kept in mind that the results may differ from the 100% real case scenario.

9.8 Impact Assessment

As the word indicates this phase refers to the assessment of the impacts caused by the product system during its lifetime. According to ISO 14040 and 14044, there are obligatory elements, which have to be included in the study and optional elements, as represented in Table 28.

Table 28: Steps to perform impact assessment

Elements	Obligatory	Optional
Classification	x	
Characterization	x	
Normalization		x
Ranking		x
Grouping		x
Weighting		x

9.8.1 Classification

Elementary flows, or in other words emissions or extractions to and from the environment, are related with the inventory of the product's life cycle (or Life Cycle Inventory). These elementary flows have to be classified according to the environmental burdens (problems or impact category, for instance climate change or ozone depletion) they cause [53]. As it can be easily understood not all the elementary flows contribute to the same impact category and each entry of the LCI may contribute in more than one impact category; that is the reason why classification is necessary.

9.8.2 Characterization

Characterization is a process of calculating the environmental impacts of a class based on category indicator results. In other words, LCI results are converted into impact potentials within the different impact categories (classes) [55]. Each type of substance inside the same class contributes differently to the impact potential of an impact category. In order to be able to sum all these different contributions, it is necessary to have a characterization factor to be multiplied with. This characterization factor measures the potential of a substance relative to a reference substance. For instance, for the impact category climate change the reference substance is kg of CO_2-eq and all the other substances that also contribute to the climate change have to be converted to kg of CO_2-eq before they sum up.

9.8.3 Normalization

After the characterization all the LCI inside an impact category have been converted to common unit and can be compared. But what about the results from the different impact categories? To clarify this issue an example it is used. For instance, the result from the impact category *climate change* is x kg CO_2-eq and from the *ozone layer depletion* is x kg CFC11-eq. Subsequently these two results cannot be compared since the units are different. This comparison becomes possible through the normalization, where units incompatibility problem is solved. Moreover, normalization shows how intense or weak is a result inside an impact category, based on a reference value comparison. For our example, an appropriate normalization value should be the average CO_2 and CFC11 emissions of a European per year. Dividing each impact category with the relevant emissions of a European, a normalized result would have been obtained.

9.8.4 Grouping

Grouping is dividing the results from the characterization step into different groups in order to create an overview of the environmental impact. Emissions are sorted on a nominal basis (global vs local or input vs output) or ranked by a priority hierarchy [55]. It is worth to mention that this is based on value choices.

9.8.5 Weighting

Weighting is a process where weighting scores are assigned to each impact category in order to be summed all together and present an aggregated total score (environmental impact) for all the product system. However, there is no clear methodology on how to determine the weighting scores and the score is not scientifically based. ISO, for instance does not allow weighting, although it is often used to make the results more understandable to the public.

9.9 Interpretation of the results

An LCA study concludes with the interpretation of the results from the impact assessment step. In other words, it is investigated how the different emissions or processes contribute to the environmental burden of the product system. Further, the interpretation should highlight the most environmental intense processes and find alternatives on how to reduce these impacts. However, as every LCA is not the reality and some are even far from it, a sensitivity analysis should be conducted on assumptions or obtained data based for instance on technological development or other parameters (like uncertainty).

Uncertainty can be distinguished in three main types according to Koedkoop (2013):

1. Variation in the data
2. Correctness of the model (representativeness)
3. Incompleteness of the model

10 LCA study of G-SOLution

10.1 Goal and Scope

The primary goal of this study is to assess the environmental life cycle impacts of the proposed product G-SOL. Sixteen impact categories will be investigated with main focus to the GWP since the climate change is of paramount importance environmental issue. Furthermore, it is investigated the possibility of producing carbon neutral or near to neutral product. One of our main goals as a start up is to create carbon neutral or even positive environmental contributing products of daily life; as we like to call it green-form existing daily use objects into power sources.

The secondary objective is to perform a sensitivity analysis. By doing so, we will identify what are the main contributors to the environmental burden as well as how sensitive is our model to changes in a range of parameters' values of the model and to changes in the structure of the model, i.e. t will be a focus on parameters and their values sensitivity. A series of simulations will be performed by varying parameters in a base case scenario to investigate how the changes affect the environmental performance

of the proposed product. Five years of G-SOL use has been defined as the functional unit of the product system.

Finally, different end of life scenarios will be under research in order to evaluate the environmental performance and to come up with techniques to reduce the final carbon footprint. Both the results from the LCA and the sensitivity analysis will contribute to identify environmental issues and possible options on how these can be improved.

10.2 System definition and description

This life cycle assessment is covering the product's emissions of Green House Gases, measured in Global Warming Potential, during its whole life cycle. The system is analyzed from cradle to grave, i.e. from the 'birth' of the raw materials – or in other words the raw material extraction – till its 'death' – the final disposal or recycling. As it has been already mentioned we are interested to know initially whether our product can potentially be carbon neutral during its life cycle and secondary how big its total impact on the environment can be. Therefore, we tried to include as much as possible components in its life cycle. For this reason, we have identified the five most important components, leaving aside some like for instance screws. These are presented below:

1. Aluminium pole
2. Photovoltaic (PV) module
3. Battery
4. Printed Circuitry Board (PCB)
5. Textile

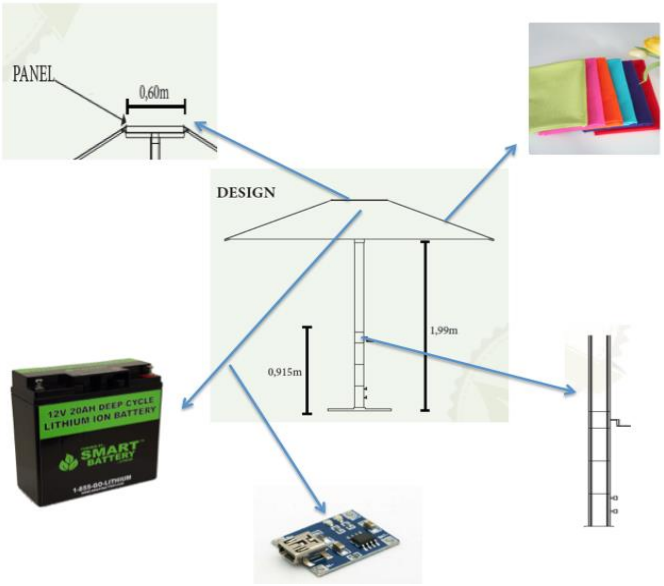


Fig. 28: Illustration of system components

The system can be seen as a sum of different components of which it consists of. The aluminium pole has been designed to be two meters tall. More specifically, it is a tube with 1cm thickness. On the top of the parasol, there is the solar panel, which occupies an area of 0.2484 m^2. The rest of the cap consists of woven cotton textile. The battery is a lithium ion battery with weight of 1.7 kg. Furthermore, there is a PCB with weight of approximately 40 grams.

The usage stage of the system can be seen as a stage where electricity is generated from the solar module. All the electricity generated can be used for charging hand held devices. This energy is seen as replacing energy from the grid since the devices would have been charged aliquo modo.

10.3 Assumptions and limitations

The initial and basic limitation is that the product under research is not a manufactured product. This by itself is setting some limitations in the degree of the analysis. In other words, there is lack of information about the manufacturing details. However, the main components, i.e. the materials used are well defined as well as the potential suppliers. In other words, transportation from the manufacturers of the different components has been taken into account. For the materials used in the production of the G-SOLution, LCA data from the ecoinvent3 library as well as the ELCD and the Swiss input output libraries have been used. Modifications have been made in some cases in order better to match the data of the proposed components, as for instance in the case of the PV module efficiency.

The usage phase is another stage where assumptions have been made, since the product has not been tested in real conditions. In the base case scenario, it has been assumed that the product will be used for 5 years and during this time no component will be replaced due to malfunctioning. We consider 5 years even though the life expectancy of all the sub components is higher due to the fact that luxury hotels usually renovate their decoration every five years.

10.3.1 Geographical

The system has been placed in Mykonos island and the transportation from our assembling facility till there has been taken into account. Besides that, solar irradiation and energy yield has been calculated on real data. About the suppliers and their geographical placement is presented below:

- Aluminium: Alumil with industrial facility in Kilkis, Greece
- PV module
    - Multi Si: Silcio solar technologies, Patra, Greece
    - Mono Si: MunchenSolar, Germany
    - Amorphous Si: Global Solar, Shenzen China
- Battery: Smart Battery, Florida, United States
- PCB: Locally manufactured in Bulgaria
- Textiles: Sunbrella, mother company Dickson, France

For the avoided product 'electricity production from the grid', which is the electricity that would have been consumed in order to charge the devices charged from our product, background data from the ecoinvent3 library has been used. Specifically, the electricity mix of Greece has been used since the product has been placed in Greece.

10.3.2 Time

All the components of our parasol have quite high life expectancy. The data provided from the manufacturers is presented:

- Aluminium: 10 years warranty from Alumil [58]
- PV modules: 20-25 years life expectancy [61]
- Battery: 5,000 cycles or around 10 years [60]
- PCB: It has been assumed 5 years. There is no end of life for the PCB however the sub components of it like resistors or IC may break down during its usage.
- Fabric: 10 years warranty from Sunbrella [59]

10.4 Solar irradiation and energy yield

For the examined system, it has been assumed that all the solar energy produced throughout the year by the solar charger will charge the hand held devices of the users. In reality, some energy may be lost because of no demand for charging and/or a fully charged battery. However sizing and usage optimizing is another scientific topic, out of the scope of this report.

Solar calculations should be performed in order to find out the real solar energy yield. In the majority of the LCAs reports and papers generic values for solar irradiance, solar radiation and insolation have been used. Ftenakis et al [63] and Alsema et al [62] are using Southern European average insolation data with value 1700 KWh/m^2/yr, performance ratio of 0.8 and lifetime of the PV modules of 30 years. These values can be characterized quite optimistic; satisfactory though for the purposes of an LCA of PV paper. Furthermore, the calculation procedure is quite vague and it is not clear whether losses (for instance temperature losses) have been taken into account.

In our case, the solar calculations are precise and they are based on real data measured for the year 2012 [65].

Table 29: Climatic Data for Mykonos Island in Greece, 2012

Mykonos island, Greece		
Month	Tenv [ºC]	Hdm(0)[wh/m2.day]
1	9	2270
2	9.9	3040
3	12	4600
4	14.2	6000
5	16.8	7300
6	20.5	8260
7	23.1	8190
8	23.2	7390
9	21.2	5850
10	17.8	4100
11	12.8	2760
12	9.4	2320

Insolation Hdm(0) was multiplied by the days of each month and divided by the sun hours of each month in order to be converted to irradiance G (Wh/m2.day). The irradiance G was used thereafter to calculate the effect of power losses due to the cell temperature increase.

$$T_c = T_a + \frac{G * (NOCT - 20)}{800} \quad (1)$$

where Tc the cell temperature and Ta is the ambient temperature given. At this point, it would have been useful to mention that a more accurate result would have been made if the mean values of temperatures per month were encountering only the daytime and not all the day. This, though, can be ignored and the final result may deviate in the range of 0.1-.5%

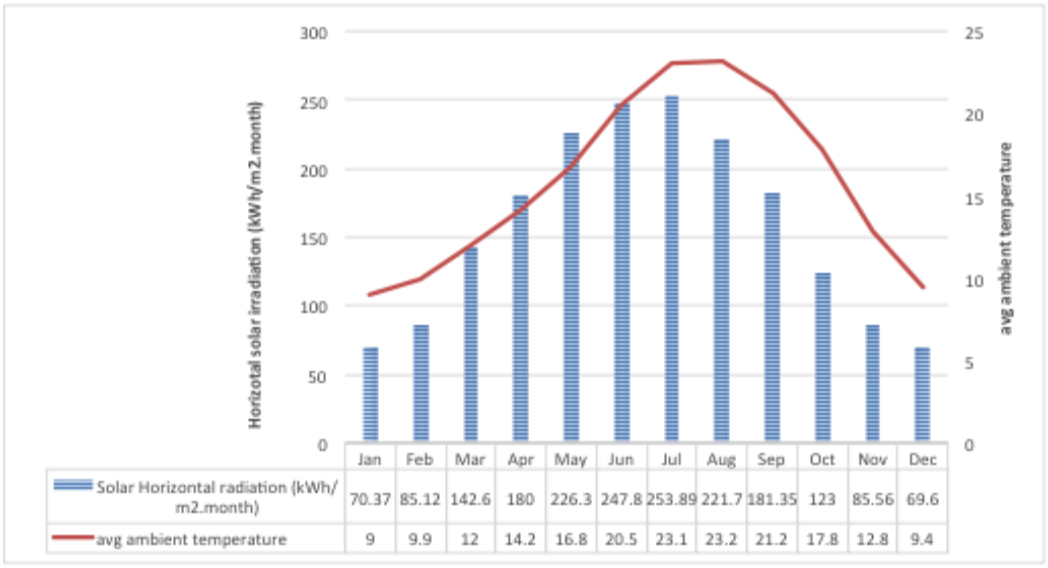


Fig. 29: Horizontal Solar Insolation and average ambient temperature for Mykonos Island

The temperature defined by STC, i.e. 25 ºC was deducted from the cell temperature and for each degree was encountered 0.42% (this value is changing based on the PV manufacturer specifications and subsequently on the PV technology; however it is used as fixed value for all our panels) reduction in the power of the module tested under STC (Standard Test Conditions). The new maximum power obtained was multiplied by the sun hours per month to compute the final energy output.

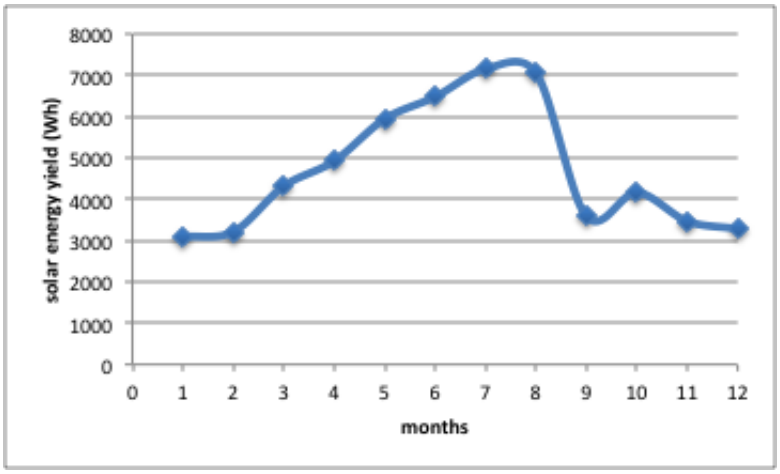


Fig. 30: Energy yield from multi-Si module in Mykonos

The total energy yield from our 20W nominal power solar module during a whole year is estimated at 56.6591 kWh. For simplicity reasons it will be from now on used the value of 56kWh. The calculations have been made using excel and analytically, the results can be found in the annex.

10.5 Impact assessment method

The method that has been chosen to perform the impact assessment is ILCD 2011 Midpoint. This method was released by the Joint Research Centre of the European Commission in 2012. The ILCD 2011 Midpoint method supports 16 impact categories. We present them below as they have been documented in the ILCD guidance document "Recommendations for Life Cycle Impact Assessment in the European context – based on existing environmental and impact assessment models and factors"; however for the purpose of G-RooT's LCA basically the climate change impact category is investigated:

1. Climate change: Global Warming Potential calculating the radiative forcing over a time horizon of 100 years (based on IPCC 2007)
2. Ozone depletion: Ozone Depletion Potential calculating the destructive effects on the stratospheric ozone layer over 100 years (based on the World Meteorological Organization 1999)
3. Human toxicity, cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kg). (based on the USEtox).
4. Human toxicity, non-cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kg). (based on the USEtox).
5. Particulate matter: Quantification of the impact of premature death or disability that particulates/respiratory inorganics have on the population, in comparison to PM2.5. It includes

the assessment of primary (PM10 and PM2.5) and secondary PM (incl. creation of secondary PM due to SOx, NOx and NH3 emissions) and CO. (based on Rabl and Spadaro 2004).

6. Ionizing radiation HH (human health): Quantification of the impact of ionizing radiation on the population, in comparison to Uranium 235. (based on Frischknecht et al. 2000).
7. Ionizing radiation E (ecosystems): Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a radionucleide emitted (PAF m3 year/kg). Fate of radionucleide based on USEtox consensus model (multimedia model). Relevant for freshwater ecosystems. (based on Garnier-Laplace et al. 2008).
8. Photochemical ozone formation: Expression of the potential contribution to photochemical ozone formation. Only for Europe. It includes spatial differentiation. (based on van Zelm et al. 2008).
9. Acidification: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area in terrestrial and main freshwater ecosystems, to which acidifying substances deposit. European-country dependent. (based on Seppälä et al. 2006 and Posch et al. 2008).
10. Terrestrial eutrophication: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area, to which eutrophying substances deposit. European-country dependent. (based on Seppälä et al. 2006 and Posch et al. 2008).
11. Freshwater eutrophication: Expression of the degree to which the emitted nutrients reaches the freshwater end compartment (phosphorus considered as limiting factor in freshwater). European validity. Averaged characterization factors from country dependent characterization factors. (based on ReCiPe version 1.05).
12. Marine eutrophication: Expression of the degree to which the emitted nutrients reaches the marine end compartment (nitrogen considered as limiting factor in marine water). European validity. Averaged characterization factors from country dependent characterization factors. (based on ReCiPe version 1.05).
13. Freshwater ecotoxicity: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m3 year/kg). (based on USEtox).
14. Land use: Soil Organic Matter (SOM) based on changes in SOM, measured in (kg C/m2/a). Biodiversity impacts not covered by the data set. (based on Mila i Canals et al. 2007).
15. Water resource depletion: Freshwater scarcity: Scarcity-adjusted amount of water used. (based on Swiss Ecoscarcity 2006).
16. Mineral, fossil & renewable resource depletion: Scarcity of mineral resource with the scarcity calculated as 'Reserve base'. It refers to identified resources that meets specified minimum physical and chemical criteria related to current mining practice. The reserve base may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. (based on van Oers et al. 2002) [66].

11 Results and Discussion

11.1 LCA Results

11.1.1 System network

The system under analysis, i.e. the life cycle of our product named G-SOL is presented below. Figure, 31 which follows, represents partially the whole system. A cut off percentage of 0.7% has been applied and only the top part of the network is shown. The cut-off percentage indicates that processes that contribute less than 0.7% are not shown. A more detailed network can be found in the ANNEX.

It is useful to first briefly explain the network presented in Fig. **31**. As can be seen there are different boxes with different colours. The green colours represent materials, the olive oil colour energy usage, the blue assemblies, the yellow life cycle and the pink waste treatment. Further, next to each box there is a thermometer, which represents the environmental contribution to climate change. The thermometer is red when it is a negative effect and green when it is positive. Climate change is measured in kg of CO_2 – equivalent.

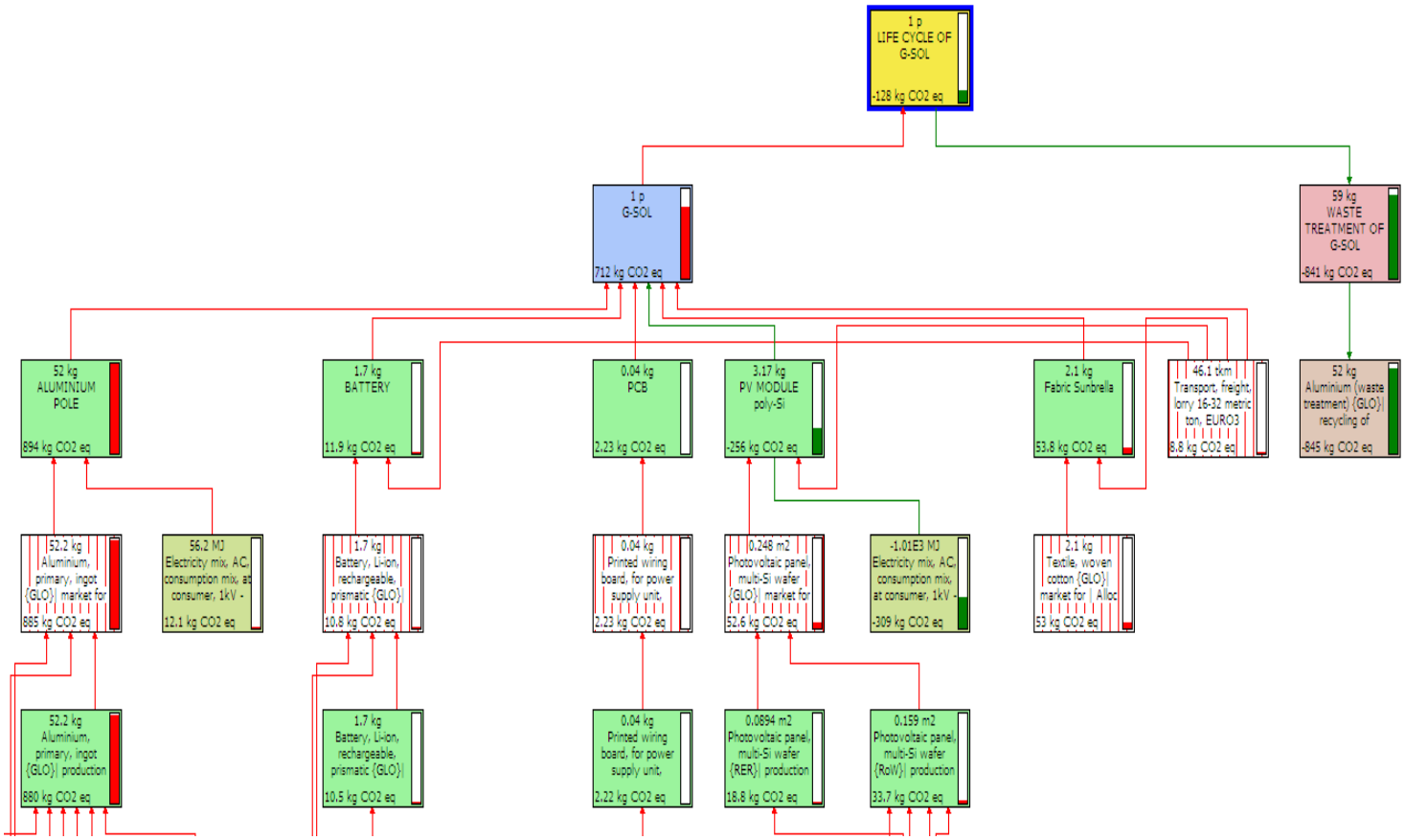


Fig. 31: Base case system network

In the life cycle of G-SOL are included the raw material extraction, the manufacturing of the materials used for building up the product, the use phase and the disposal scenario. For the raw material extraction and the manufacturing of the materials used in the product, generic data from the libraries of SimaPro has been used. For the manufacturing of the aluminium pole literature data has been used [56]. Transportation from the industrial facilities of the suppliers have been considered and calculated based on approximately the real distances [67]. Furthermore, transportation from our facility till Mykonos island has also been taken into account. For the use phase we have considered 5 years of usage. For this time period we calculated the solar energy yield in the previous chapter. The same amount of energy, produced though from the grid, was set as an avoided product during the use phase. By doing so, the positive environmental effect of using PV modules could be directly represented in the network. Finally, for the waste scenario the components of the parasol are disposed as follows:

- The aluminium pole is recycled;
- The battery is treated under hydrometallurgical treatment for batteries;
- Textiles and the PV module are sent to MSW, considering average landfill values for Greece, Spain, Portugal:
- The PCB is treated as scrap printed wiring boards with shredding and separation.

11.1.2 Network results

As can be observed the highest contribution to climate change is from the production of the aluminium pole, specifically 894 kg of CO_2-eq. It is followed by the woven cotton fabric with 53.8 kg of CO_2-eq., the battery and last can be found the PCB. On the other hand, the PV module has a positive contribution of 256 kg of CO_2-eq. since it has been accounted that the amount of energy which produces, which would have otherwise been generated from the grid. More specifically, from the production of the multi – Si PV panel there is negative contribution of 52.6 kg of CO_2-eq. and from the avoided energy generation from the grid a positive contribution of 309 kg of CO_2-eq.,.

Besides the materials and processes that G-SOL consists of, the assembly is completed with the transportation. It can be observed that the transportation by freight trucks has 8.8 kg of CO_2-eq emissions while the transportation by ships is not essentially contributing to the final carbon footprint. Last but not least, the biggest positive contribution stems from the waste treatment and especially from the aluminium recycling, which indicates the importance of recycling in the case of using aluminium as the basic production material.

11.1.3 Characterization results

The ILCD method Midpoint V1.03 for characterization is used and a discrete representation of the waste treatment and the rest of the G-SOL life cycle is presented in Figure 33.

Fig. 32: Characterization

As can be observed the G-SOL life cycle dominates ten out of sixteen impact categories while the waste treatment contributes negatively only to the category mineral, fossil and renewable resource depletion. The biggest improvement in terms of environmental burden is achieved in the categories climate change, acidification, particulate matter and photochemical ozone formation. To conclude, it is of paramount importance the proper waste treatment of the product.

11.1.4 Characterization results per group of processes

A quite useful and interesting representation of results is per group of processes. Four different phases were defined: use, transportation, waste, and top. The avoided energy from the grid was defined as use phase and in the transportation we solely included the transportation from and to our facility in Bulgaria. In other words, only the transportation which is directly linked with our operations was accounted for. Finally, "top" groups all the other processes.

Fig. 33 presents the results per group. It can be seen that the role of transportation is not significant. Its contribution is limited in 5-6 categories while in the category climate change it is even indiscernible. On the other hand, the use phase positively influence the environmental load, in particular the categories acidification, particulate matter and climate change.

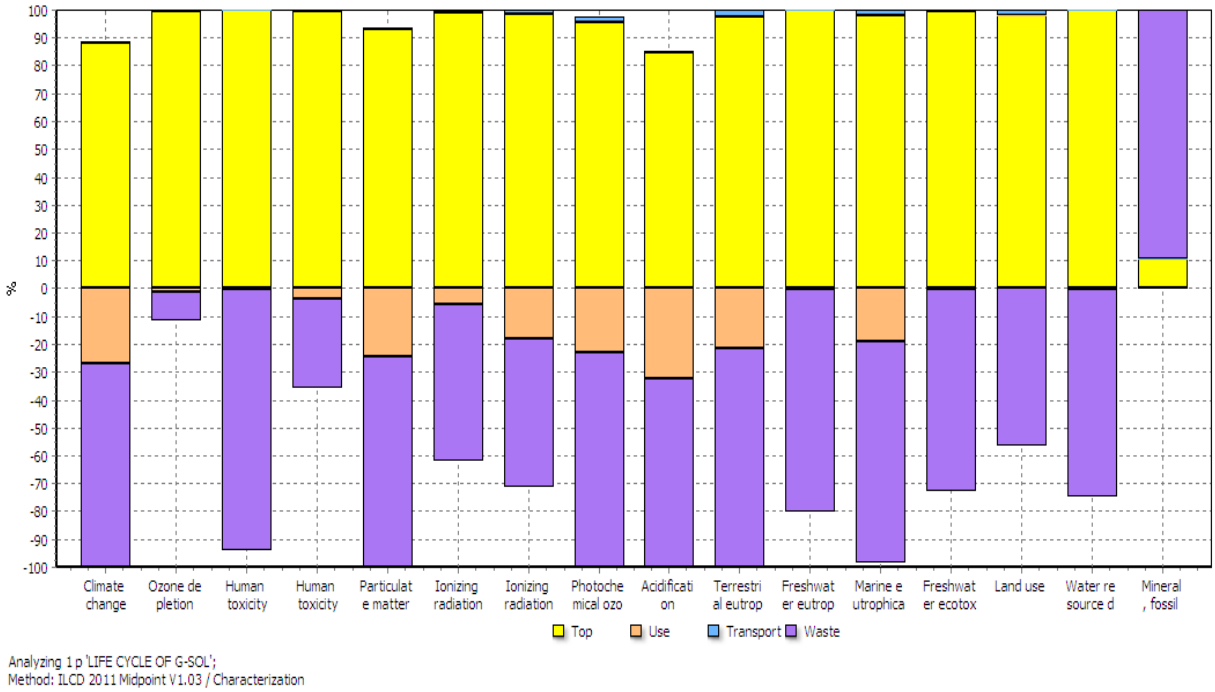


Fig. 33: Results analysis per group of processes

11.2 Comparative analysis

In this section the three different PV module technologies are examined: poly-crystalline silicon (which is the base case scenario), mono-crystalline and amorphous silicon.

11.2.1 System parameters

Using different modules sequence that some parameters are changing. These are presented in the following table:

Table 30: System parameters based on the photovoltaic technology

PV technology	Supplier	Location (for transportation calculations)	PV module area (m^2)	PV module weight (kg)	Fabric weight (kg)
poly-Si	Silcio Solar technologies	Patra, Greece	0.2484	3.17	2.1
mono-Si	Munchen Solar	Munich, Germany	0.19	2.47	2.12
a-Si	Global Solar	Shenzhen, China	0.4138	1.44	2.05

The table above indicates that by changing solar module, other parameters are also changing. This is a result of different solar module efficiencies, which is translated into change in the module area. Subsequently, it changes the area that the fabric occupies on the cap of our parasol. It has to be stated that besides the weight of the photovoltaic and the fabric, it is also altered the final weight of the product. These changes even though they have been taken into account are small in the range of one to two kilos.

11.2.2 Results

We took into account the parameters' alterations described previously and we followed the same procedure as in the base case scenario in order to create assemblies and life cycles into SimaPro. By doing so, we ended up with Figure 35

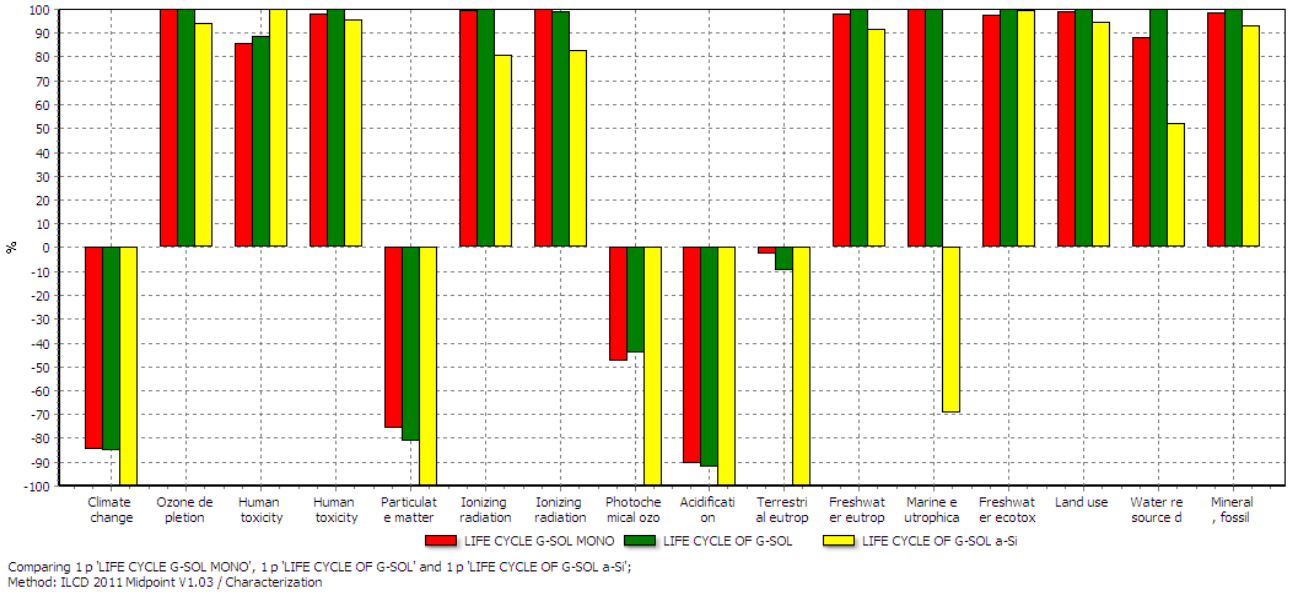


Fig. 34: Comparative LCA analysis based on different PV technologies

It can be observed, initially, that the scenario, which uses amorphous silicon as the PV technology results in a better performance in terms of life cycle assessment. More specifically, in the category climate change, which is our main concern, there is around 16% less environmental burden. In six out of sixteen categories, the technology a-Si is positively contributing to the environment. In climate change, particulate matter, photochemical ozone formation, acidification and terrestrial eutrophication all the three technologies have positive contribution while in marine eutrophication two out of three, i.e. mono-crystalline and poly-crystalline have negative environmental influence. Last, only in two categories – human toxicity and fresh water eco-toxicity – has higher environmental load compared to the other two.

Finally, it is presented a table where the carbon footprint of the product and the product life cycle is illustrated based on the tree different modules

Table 31: Carbon footprint of G-SOL

Carbon Footprint	Multi-Si	Mono-Si	a-Si
G-SOL life cycle	-128 kg of CO_2-eq.	-128 kg of CO_2-eq.	-151 kg of CO_2-eq.
G-SOL (life cycle without end of life scenario)	712 kg of CO_2-eq.	713 kg of CO_2-eq.	691 kg of CO_2-eq.

The difference in terms of carbon footprint in between the product having as its solar module supplier Silcio Solar in Greece (multi-crystalline Si) or Munchen Solar in Germany (mono crystalline Si) is negligible. However, the Global Solar PV module illustrate a much better performance basically due to the

use of amorphous silicon as PV material. The transportation from China, where the company is located, does not seem to affect essentially the positive result.

11.3 Waste treatment scenarios

In this chapter two different waste treatment scenarios will be presented and analyzed in terms of life cycle assessment.

11.3.1 Scenario case 4: MSW disposal of G-SOL

The base case scenario has been developed on the assumption that the aluminium pole will be recycled. What if , though, the product owner simply dispose all the components of the product into a landfill? In this scenario, we analyze the potential impacts of such an action. This is quite possible to happen due to lack of awareness or maybe incentives. In the vast majority of the cases, people prefer ease and convenience instead of putting additional effort. Therefore, it is important to observe the results of such a common action.

The figure below presents the top processes and assemblies of that scenario network. A cut off rule of 2.1% has been applied.

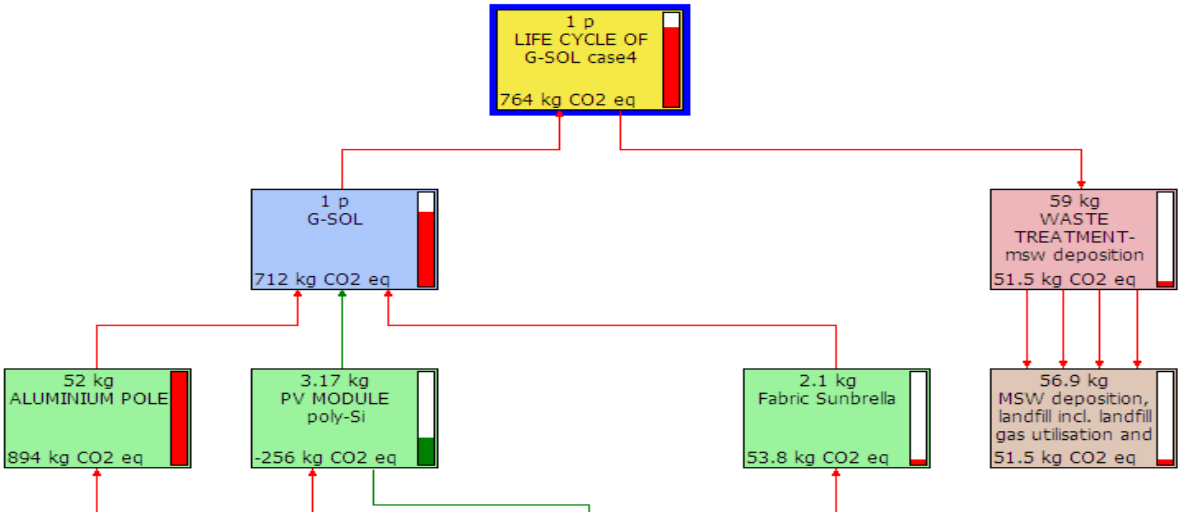


Fig. 35: Case 4: MSW deposition of G-SOL

As it can be seen, the life cycle of such a scenario results in 764 kg of CO_2-eq.. More specifically, the assembly G-SOL contributes with 712 kg of CO_2-eq. and the waste treatment with 59 kg of CO_2-eq. The assembly of our product has been kept the same as in the base case scenario. The difference in the final result is stemming from the disposal of it. It is clear the importance of a proper end of life treatment in order to minimize the final carbon footprint. Analytically, results of the different impact categories are following:

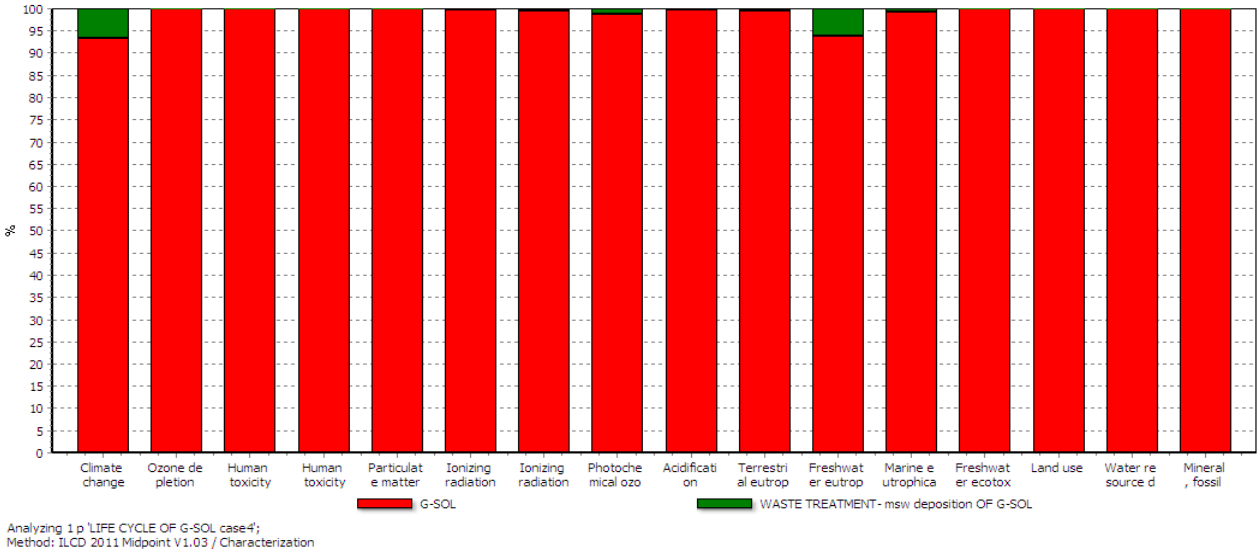


Fig. 36: Impact assessment for different categories for the case scenario 4

The dominance of the G-SOL assembly impacts is obvious in the previous Fig. 36. Further, the waste treatment that in the base case scenario had a positive contribution, now it turns negative. Even though, it just adds around 12% in the climate change category and approximately the same proportion in the fresh water eutrophication, it is enhancing the negative effect.

11.3.2 Scenario case 5: Solar charger for developing country

In this chapter a reusing scenario of the solar charger has been set (for the functional unit: five years of operation). In detail, it was decided to investigate the possibility of sending the solar charger part of our product to Pakistan through a local donation organization. In many developing countries there is absence of grid electricity or there are electricity shortages. On the other hand, mobiles are becoming, if not yet be, an essential part of people's lives in these countries (for instance paying bills or microloans through their phones). By providing these people with our solar charger, we spread awareness in these areas, providing solution to their problem, helping ourselves reduce our carbon footprint and motivating our clients to contribute for a better world.

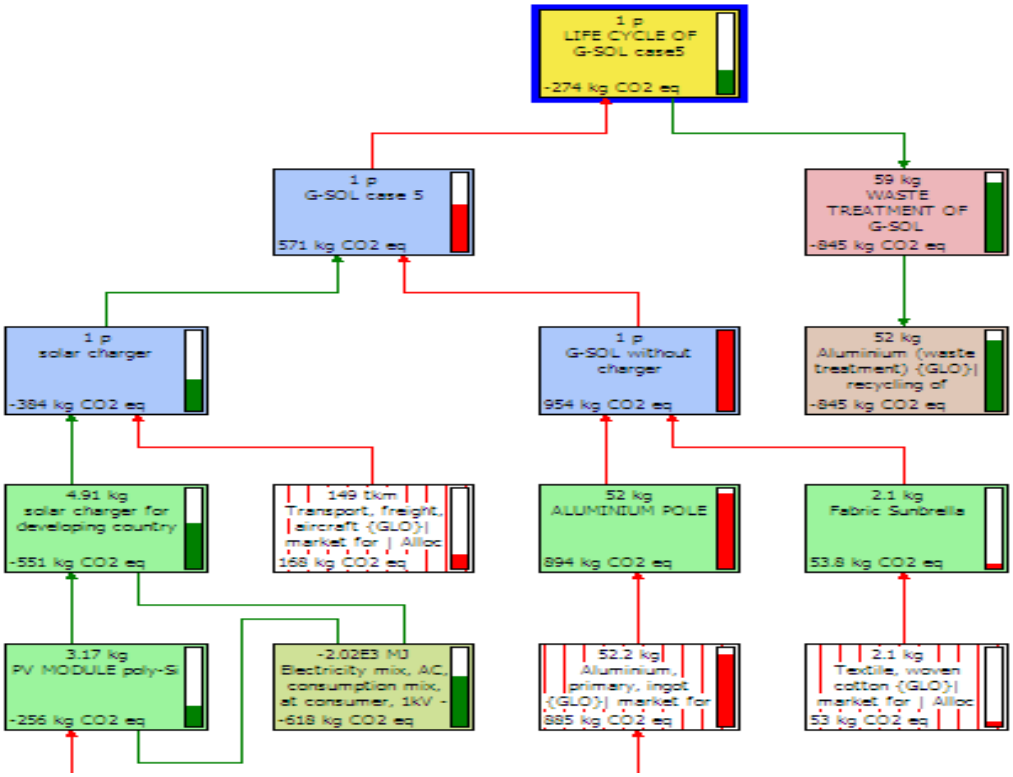


Fig. 37: Case 5: Solar charger for a developing country

The product was split into two assemblies: one is the G-SOL without the charger and the solar charger. The solar charger has its own life cycle and after the five years of usage it is not disposed on the contrary is sent through air transportation to Pakistan. The rest of the product is sent in the waste treatment already applied in the base case scenario as well. During these five years of extra life for the charger no subcomponent is replaced since their lifetime exceeds this time frame of ten years. Further, no disposal has been accounted for the charger.

It can be seen that the solar charger is positively contributing with 618 kg of CO_2-eq. savings during its use phase. Finally, the product solar charger has a positive contribution of 384 kg of CO_2-eq. This reduction is caused due to the PV module manufacturing and the transportation through airplane to Pakistan. On the other hand the life cycle of our product has increased its carbon saving to 274 kg of CO_2-eq., more than double of the initial scenario.

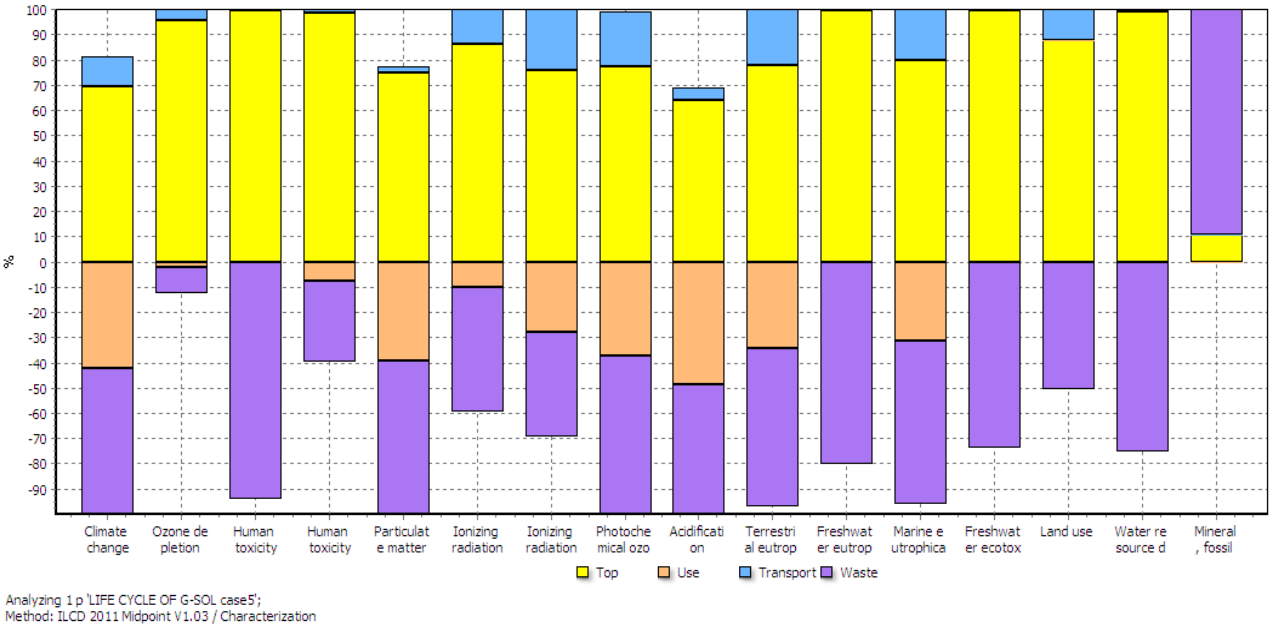


Fig. 38: Case 5: groups impact assessment

In Fig. 38 three groups have defined, i.e. use phase, transportation and waste and one ("top") includes the rest of the processes. Transportation increase the environmental impacts with its maximum value of approximately 24% in the category ionizing radiation. In the climate change it contributes around 12%. The use phase meets its highest value in acidification of 50% and climate change of 41%. It is interesting that the use phase contribution becomes comparable with the waste treatment in terms of positive effects; however the proper waste treatment for one more time is of paramount importance.

12 Conclusions and Recommendations

12.1 Conclusion

The initial hypothesis of green-forming G-SOL under the specific system boundaries is confirmed. G-SOL can be a parasol-micro energy charging station-which contributes positively to the environment by decreasing the total environmental burden that conventional products create. Mineral, Fossil and Renewable Resource Depletion is the impact category with the highest negative effect caused by our solution followed by Ozone Depletion while acidification with the lowest. The carbon footprint of G-SOL using Global Solar module was -151 kg of CO_2-eq. (even though its factory facility is located in China) compared to -128 kg of CO_2-eq. from the crystalline Silicon suppliers, taking into account the net effect of reducing greenhouse gas emissions from the solar electricity generation during the use phase. The net effect of reducing environmental load of -128 kg of CO_2-eq. which stemming from the base case scenario is equivalent with 13 UK's households CO_2 daily emissions [3]. Furthermore, it was clarified the importance of proper waste treatment. Aluminium is the material that contributes the most to the environmental load with 894 kg of CO_2-eq followed by the woven cotton fabric with 53.8 and the multi-Si module with 52.6 kg of CO_2-eq; however recycling it at the end of the product's lifetime can lead to a positive environmental contribution reducing its carbon footprint to 49 kg of CO_2-eq. This has to be taken into consideration by the team in order to design a recycling scheme for G-RooT's products. Finally, the sensitivity analysis on the waste treatment revealed that a potential reusing of the solar charger (not by the client but by a household in the developing world) could further increase the positive carbon footprint by 36%. The latter not only improves the environmental performance of our product but also providing solution to people in developing countries and gives additional motivation to our clients to use G-SOL instead of the conventional products.

12.2 Future development

This life cycle assessment report provided the author with a better understanding of LCA and the software Simapro. Furthermore, new ideas were generated that can further improve the business plan stemming from the life cycle assessment knowledge that was gained. The team now can better incorporate environmental thinking during the designing process. As in every LCA report it is crucial to document the assumptions and limitations of the system under investigation, the same was done into this one as well. However, a more detailed assessment is necessary in order to better claim the environmental benefits of G-RooT in the future. This can be achieved after our induction to the highway program of KIC incubator. Foreground data, directly from the chosen suppliers could be gathered and a more detailed system could be analyzed. In the same framework, it is in our plans to communicate again with ONYX solar (manufacturer of colored solar PV glass) and gather manufacturing data from their facilities (initially something like this was neglected but after our induction to highway we believe that it will be possible) in order to verify whether such a technology can be appropriate in terms of life cycle assessment.

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ANNEX

Solar calculations

Solar module of 20W nominal power 0.42%/^{o}C temperature loss coefficient

Month	Name	Days	Hdm (0) [MJ/m2.day]	Hdm(0) [Kwh/m2.month]	Tenv [ºC]	sunshine hours	G(0) [KW/m2]	Tcell [C]	Tcell-Tstc	del_P	Peff [W]	Energy
1	Jan	31	7.7	70.37	9	154	0.456948052	23.85081169	-1.149188312	0.482659091	20.09653182	3094.8659
2	Feb	28	10	85.12	9.9	162	0.525432099	26.97654321	1.97654321	-0.830148148	19.83397037	3213.1032
3	Mar	31	16.2	142.6	12	223	0.639461883	32.78251121	7.782511211	-3.268654709	19.34626906	4314.218
4	Apr	30	18.1	180	14.2	259	0.694980695	36.78687259	11.78687259	-4.950486486	19.0099027	4923.5648
5	May	31	23.1	226.3	16.8	317	0.713880126	40.0011041	15.0011041	-6.300463722	18.73990726	5940.5506
6	Jun	30	26	247.8	20.5	351	0.705982906	43.44444444	18.44444444	-7.746666667	18.45066667	6476.184
7	Jul	31	25.7	253.89	23.1	389	0.652673522	44.31188946	19.31188946	-8.110993573	18.37780129	7148.9647
8	Aug	31	24.1	221.7	23.2	380	0.583421053	42.16118421	17.16118421	-7.207697368	18.55846053	7052.215
9	Sep	30	18.3	181.35	21.2	201	0.902238806	50.52276119	25.52276119	-10.7195597	17.85608806	3589.0737
10	Oct	31	13.1	123	17.8	218	0.564220183	36.13715596	11.13715596	-4.677605505	19.0644789	4156.0564
11	Nov	30	7.9	85.56	12.8	176	0.486136364	28.59943182	3.599431818	-1.511761364	19.69764773	3466.786
12	Dec	31	6.7	69.6	9.4	163	0.426993865	23.27730061	-1.722699387	0.723533742	20.14470675	3283.5872
												56.6591695 kWh

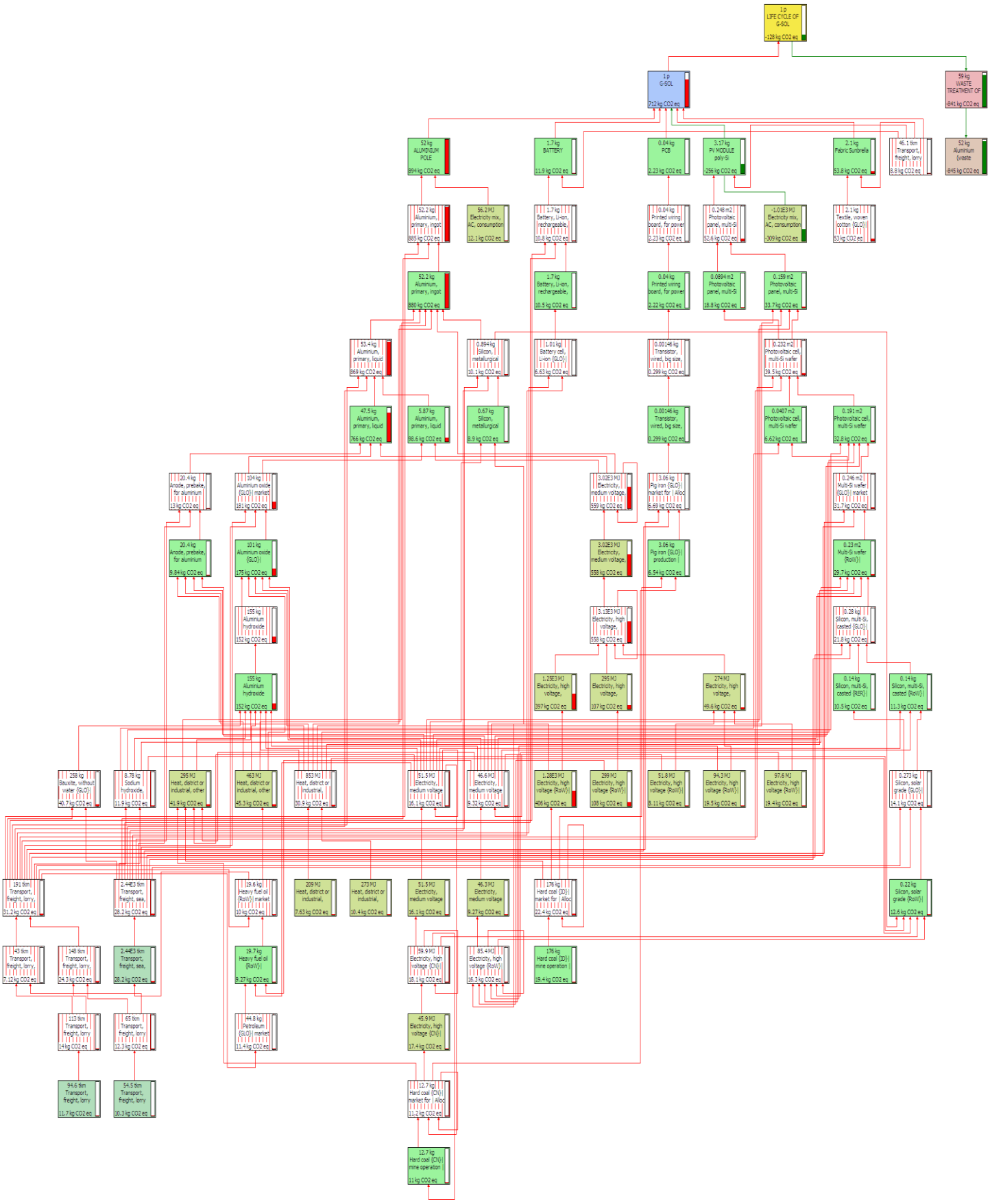

Fig. 39: Base Case LCA network

b

Interviews

Interviews with hotel owners or managers

Next step was to interview hotels owners or managers in order to validate our idea and to better understand their needs. Therefore, we started with a market place that we know since one of our team members is from there, and this is Mykonos Island in Greece. We interviewed six hotel owners or managers during the limited time of our stay there and due to our good connections on the island we were able to reach some hotel owners. Further, some hotel owners have into their acquisition more than one hotel on the island or in other islands which means that essentially we interviewed six persons of the hospitality sector and not just 6 hotels. We prepared a questionnaire consisting of two sections, the qualitative and the quantitative. The first is related more to general understanding of their environmental techniques or measures they employ, the way they operate, decision making process and understanding their needs. On the other hand, the quantitative was more specific since we introduced them the concept and we were trying to further understand them in order to design and build our solution on them and according to their feedback. The questionnaire is presented below:

Questions for the hotel owners/managers

Qualitative

1. Do you employ any sustainable techniques/measures in your hotel? If yes, what kind and why?
2. How is the decision making process? Who is responsible for these environmental techniques?
3. Implementing environmental management or simply try to be more green will: (5point scale going from 1=strongly disagree to 5=strongly agree and 0=do not know)
    - Increase profitability
    - Increase costumer satisfaction
    - Improve employee satisfaction
    - Improve relations with the community
    - Help your public relations
    - Give a marketing advantage over your competitor
    - Increase awareness
4. How did you increase your value proposition and/or your customer satisfaction? What was the best/most effective and the less effective action you did in this regards?
5. How much time do your clients spend in the open air spaces (pool, beach, sports courts)?
6. Do your clients use their electronic devices in the open air spaces? How often? Is there electricity access or they have to move when they run out of battery?
7. How and where do you buy your sunshades? How much do they cost? How often do you replace them? Are you satisfied?
8. How do you choose any supplier? What are your expectations from your suppliers? Any specific criterion?
9. How important is the design of the umbrella? Grade it from 1-10 with 1 to be 'not important at all' and 10 to be 'the most important'
10. How do you select from different designs? According to a specific theme or what is common in surroundings or following trend? (Do you have specialized designer or company to deal with all these issues?) Your sunshades are only installed for summer or are these fixed?

Quantitative

1. Our product provides shade and electricity for the hand held electronic devices of your clients. Sitting under the sun becomes more elegant and playful than ever before by exploring the solar power. What features would you look for in such a product?
2. Where do you think would be good to have plugins in this device? Do you want AC outlets or only basic USB charging capability?
3. Would you be interested for lightning at night as well?
4. We will be able to send you monthly report of electricity savings and your positive contribution towards environment. Would you be interested in these numbers? We will also publish you on our website with the same savings and contributions.
5. We believe that such a service will increase your customer satisfaction along with other measures that you have taken. How much extra would you be willing to pay for such a solution?
6. This is all from our side. Would you like to know anything about us? Or any other query?

Outcome-highlights of the interiews

At this point, it is worth to mention that the interviews were also recorded. The interviewees were politely asked to be recorded and they all accepted it. This fact increases the credibility of the written document and mainly gives us the

opportunity to recall any part of the interview at any time. Below are presented the highlights of the interviews, the answers they gave us to the question we ask them and some of their quotes.

Saint John (5* hotel)

Interviewee: hotel manager

Qualitative

1. they use natural gas for heating, cards for the electricity in the rooms and the system with the towels and the sheets that they only change them after the client's request
2. managing board; The managers and employs (not so often) are proposing new measures and the managing board is taking the decisions. The board is consisted from the owners and the hotel management representatives
3. a-3, b-4, c-2, d-5, e-2, f-5
4. 1.5-2 hours on average by the pool
5. 'yes of course, they use their devices a lot'; 'no there is no sockets close by, when they need to charge they have to go to the bars or the reception'
6. their umbrellas are not fixed, they are in parts but the base is fixed
7. 'I do not know'
8. ' I do not know'
9. design is very important (he grade it 10); They have to be according to the theme which is white

Quantitive

1. USB+socket
2. Not interested for light neither lockers
3. Interested for the numbers for their CO^2 savings
4. They choose their products through expositions, they go to many of them
5. Price he could not answer; 'it is very difficult question'
6. Final comment: 'It is very interesting what you are proposing me and I would like to see it'

Mykonian Grand (5* hotel and a chain of 4 hotels in Mykonos)

Interviewee: hotel owner

Qualititive

1. Cards for the electricity in the rooms, better glasses in the windows, system with the sheets and towels; They have faced problems from the clients for the system with the cards and the changing towels; 'Northern Europeans are pro environmental techniques, moreover they complain in case the cleaning lady by mistake change the towels or the sheets while on the contrary Americans prefer their comfort and complain when we do not replace them everyday. In general, though, 90% of our clients want environmental techniques and they see them as a positive contribution'
2. Decision are taken by the owner, engineers, management; They seeking continuously for new thing
3. a-4, b-4, c-2, d-5, e-4, f-4
4. Their clients pass 10 hours in open air spaces without taking into account the 8 hours of sleep; 'They prefer to stay in the hotel rather than go out'
5. '90% of my clients are using their devices by the pool, yes all the time'. There is no electricity there that is why the employed in the past solar chargers. The chargers, though, failed because of the technology- reliability.
6. Umbrellas from textile in white blue colour
7. 1663 euros per umbrella and they just bought them (1200 euros for the umbrella and 463 euros for the base) but because they have three hotels and they buy wholesale they have 50% reduction. ' It is a bought that every once in a while I have to replace or to change spare parts); Very important for him the wind resistance.
8. Their supplier is KETTAL (spanish company) but they are very disappointed from the spare parts and service since there is delay of 2-3 months
9. Design is number one criterion with the wind resistance to be the second and the spare parts supply or service the third.

Quantitative

1. 'I am very interested for the private beach the hotel has... Also for the pool'; 'I am very interested in all these environmental products, especially in such a product that increase my customers' satisfaction'
2. USB, light not interested due to battery.
3. 'Report with the savings is good to be used in a pres-list but do not spend time and money to create software.'
4. Service is very important for him
5. For the materials used, he proposed aluminium because the wood is not so resistant in the wind.

Mykonian Blue (GRECOTEL) (5* hotel and a chain of 28 hotels in Greece)

Interviewee: hotel manager-director

Qualitative

1. Thermosiphons, desalination, watering with recycled water, system with towels and sheets; 'Nationality is crucial, Germans are insisting for the towels and sheets while Russians want their comfort'.
2. Grecotel has a board for health and environment but final decisions are taken by directors
3. a-4, b-4, c-2, d-5, e-5, f-4
4. 180 out of 250 clients are staying inside the hotel during the day and at night they go out. 5-6 hours by the pool
5. 'very much, they are using their electronic devices a lot'
6. They do not have umbrellas because of the wind by the pool instead they use fabric but a lot of wooden umbrellas by the beach.

7. The design is very important (he grade it as 10); 'a red umbrella would have been ugly'

Quantitive

1. ' It sound very interesting'
2. ' Light sound beautiful' but he proposed also a small fridge
3. ' The report is also very interesting'; Further he informed us that some hotels of the same chain they have a board where they mention environmental techniques and results
4. For the price he answered 150 euros extra (even though he informed us that he has no clue about prices) however the thoughts he made were that they have 300 umbrellas in this hotel and they total cost would be 45000 euros more; 'yes 45000-50000 euros more, we can do it'

Filoxenia (5* hotel and a chain of 21 hotels in Cyprus and Greek islands)

Interviewee: hotel manager-director

Qualitative

1. Collecting oils, cards for the electricity in the rooms, they also aware and inform the staff for good housekeeping (for instance turning off lights when they are not used)
2. Managing board is taking the decisions, managers are proposing
3. a-1, b-3, c-3, d-5, e-4, f-4
4. Clients are passing a lot of time by the pool; '5 hours or more'
5. 'they use their iPhones and tablets full, all the time'; 'There is no electricity there and they have to move when they run out of battery'
6. umbrellas from textile and they choose their supplier based on the company profile, the service and the offer.
7. The design was graded as 9; Colour white and blue

Quantitive

1. 'very very clever this idea, I am happy we made this meeting... I think it add value to my company'
2. 'Report with the savings is interested but the for me it is more important that the energy won t be wasted'
3. I would spent around 3000 euros for such a product instead of making three advertisements in magazines, I would buy three of these umbrellas.'
4. Final comment: 'It is great, keep me updated, congratulation guys'

Mykonian Imperial (5* hotel and a chain of 3 more hotels in Mykonos)

Interviewee: hotel manager

Qualitative

1. ' I do not know any hotel in Mykonos that utilise somehow renewable energy'; system with the towels and the sheets (no washing every day), food left overs are given to poor or animals based on their condition; 'More and more clients though are asking for this (the system with the sheets and the towels)'
2. The manager is proposing and the owners are taking decisions
3. a-2, b-4, c-2, d-4, e-1, f-5
4. 2 -3 hours by the pool
5. 'Usually they do not use electronic devices'; However later he mentioned that: 'we have been asked for charging and we send a guy, he picks up the device, he charge it in the reception and then we return it back'
6. They change the umbrellas every year due to the humidity and the bamboo-wood quality
7. He does not know the supplier or the price

Quantitive

1. ' I suppose your umbrella will have something like an eye (he meant the panel) on the top of the cap'. He was not interested in something, which would have been different or modern.
2. He mentioned that they do not ask for charging and then he mentioned that they ask him in the afternoon when they are sitting out and the clients they are passing by the reception and they are leaving their phones
3. He started showing interest when we present him the concept of the CO^2 savings report

Sant Antonio Summerland (4* hotel)

Interviewee: hotel owner

Qualitative

1. System with sheets and towels
2. It is a family owned business and the owner is taking the decisions
3. a-2, b-3, c-2, d-5, e-4, f-5
4. a lot of time; 'more than 3 hours'
5. they mentioned that their clients spent a lot of time with their electronic devices; 'nobody can live without his iphone'; There is no electriciy there and this is the reason why they are planning to built a stone bench-table where they will provide sockets from the grid
6. they have the wooden umbrellas which every year they replace some parts of the bamboo and every 5 years they buy new
7. they did not know
8. they did not know
9. they grade the design as 8 out of 10
10. there is no specific designer working in the hotel, however they consult designers

Quantitive

1. USB would have been really useful and socket as well
2. 'lightning why not'
3. they are not interested in lockers
4. About the numbers of CO^2 savings and electricity production they answered: 'It would have been nice to have this information as well'
5. They seemed quite interested since they were thinking of finding a solution to provide electricity by the pool. Specifically about the price they mentioned: 'If each umbrella cost less than 2500 euros, I think everyone will buy it'

Conclusion

The acquired knowledge from these conducted interviews were more important than any paper or research reading on the hopitality sector. Initially, it offered us an insight on how these hotels are operating and a better understanding on what are they seeking for. It was observed that all these hotels are looking for environmental actions mainly because it is a trend to be green. Secondly, an action that implemented by one is then copied by all. A good example on this is the system with the sheets and the towels; they change the sheets or the towels with clean ones only after the clients' request. This firstly brought to the island three years ago by the manager of Santa Marina Hotel (a five star hotel in Mykonos) and the next year it was copied by every other hotel. However, almost everyone- hotel owners or managers- perceive sustainability as a burden to luxury hotels since for them the clients' comfort is the highest priority. For instance, not washing the towels and sheets indeed is appreciated by the Northern Europeans as an environmental measure but is depreciated by others as a paid service which is not offered. Therefore, they are struggling in being green and being luxury simultaneously. This was the reason why the majority of them were enthusiastic about our offer; It is green and it increase their customers' satisfaction. Further, we found out that their clients are extensively using their electronic devices by the pool. More specifically, about the product everyone confirmed that the design is important and the tolerance on the wind loads. Our assumption about lightning seemed not so useful to the majority of them since they have already lightning by the pool and the pool cannot be used after nine o clock at night by law. The lockers were also something that did not interest them since it gives an impression of unsafeness for their hotel. Last but not least, everybody was enthusiastic about the CO^2 savings, which can be used as a marketing tool.

Sales forecasting scenario

All of the first year clients will prefer the premium product since customization for them is of great importance. During the second year of operation, we are convinced that at least 80% of the five stars hotels and 20% of the four stars in Mykonos will employ our solution. At this point it is useful to mention our assumption, that 30% of the four stars hotels would employ the premium product while the rest will purchase the normal. The third year of operation, our company will be quite well established in the province and we believe that 32 five stars hotels in Cyclades, i.e. (640 premium shades) and 12 hotels of the four star, i.e. (4 premium and 8 normal or 80 premium shades and 160 normal) in the same region will employ our solution. In parallel we will increase our market share in Mykonos island and two more five star hotels and 20% absolute more four stars, i.e. 25 four stars hotels in Mykonos in total (more 4 hotels premium and 9 normal or 80 premium and 180 normal). During the fourth year, it is planned to participate in exposition (EXPO tourism) and this will further boost our sales. We believe that 30% of the

rest five stars hotels, (i.e. 72 hotels or 1440 premium shades) and 10% of the rest four stars hotels will be added to our clients catalogue (i.e. 58 hotels or according to our assumption 17 hotels will buy 340 premium and 41 hotels 820 normal sunshades). Further, our clients in Cyclades will be increased by 10% absolute in five star hotels (or 5 hotels and 100 sunshades) and by 10% absolute in four stars (12 hotels or 3 premium with 60 shades and 9 normal with 180 shades).

Additional tables

Table 32: Sales forecast considering 20% increase in number of sales

	2015	2016	2017	2018
NORMAL	0	120	408	1200
Mykonos	0	120	216	0
Cyclades	0	0	192	216
Rest of islands and Greek seaside	0	0	0	984
Sales from normal	0	180000	612000	1800000
PREMIUM	96	240	912	2328
Mykonos	96	240	48	0
Cyclades	0	0	864	192
Rest of islands and Greek seaside	0	0	0	2136
Sales from premium	192000	480000	1824000	4656000
Total sales (Euros)	192000	660000	2436000	6456000

Table 33: Sales forecast considering 20% decrease

	2015	2016	2017	2018
NORMAL	0	80	272	800
Mykonos	0	80	144	0
Cyclades	0	0	128	144
Rest of islands and Greek seaside	0	0	0	656
Sales from normal	0	120000	408000	1200000
PREMIUM	64	160	608	1552
Mykonos	64	160	32	0
Cyclades	0	0	576	128
Rest of islands and Greek seaside	0	0	0	1424
Sales from premium	128000	320000	1216000	3104000
Total sales (Euros)	128000	440000	1624000	4304000