

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

Validation of an Agrivoltaic System by Energreen

FABIANA JIMENEZ | 48708

Work project carried out under the supervision of:

Professor Dr. Ricardo Zózimo
Tomé Salgueiro

10/01/2023

Abstract

The production of green energy is becoming increasingly important across various industries; however, it is still not sufficiently explored in the agriculture industry since farmers often do not have the time and financial possibilities to implement innovative techniques. AVC systems provide a dual usage of land through energy production, enabling farmers to use and monetize clean and green energy while not interfering with their daily business activities. Energreen demonstrates this business opportunity by implementing two pilot projects in farms, which serve as a base for future growth and provide a vision and outlook for the venture.

Keywords: AVC, PV, Agriculture, Circular Economy

Acknowledgement

Throughout the writing of this thesis, we have received great support and assistance. First, we would like to thank our supervisor, Professor Dr Ricardo Zózimo, who provided us with great guidance and lots of insightful information and whose expertise and knowledge were fundamental for writing this work project. We would also like to thank our tutor Tomé Salgueiro for his valuable guidance and help throughout this research to find the right direction and for always being available when we needed help.

In addition, we would like to thank especially Monica and her mother from GoBerry, João Caldeira, Nova SBE and especially our families, for having patience with us, where we could not have completed this Master's thesis without their support.

Table of Contents

1. INTRODUCTION	5
1.1 ORGANIZATION OF THE PAPER	6
1.2 DEFINITION AND EXPLANATION OF AVCS	7
1.2.1 <i>Definition of AVC systems</i>	8
1.2.2 <i>Types of AVC systems</i>	8
1.2.3 <i>Driving factors</i>	10
1.2.4 <i>Advantages and disadvantages</i>	11
1.3 IDEATION	12
1.4 THE TEAM BEHIND ENERGREEN	12
1.5 METHODOLOGY	13
2. VISION	15
2.1 START	15
2.2 HYPOTHESES AND ASSUMPTIONS	16
2.3 EXTERNAL VALIDATION	17
2.4 STRATEGY	18
2.4.1 <i>Business Model</i>	20
2.5 MARKET SIZE	23
2.6 LEGAL REQUIREMENTS	23
3. STEER	25
3.1 DEVELOPMENT OF THE MVP	25
3.1.1 <i>Customers</i>	26
3.1.2 <i>Challenges</i>	27
3.1.3 <i>Pivot</i>	28
3.2 SYSTEM SIMULATION	30
3.3 FUNDING OF THE MVP	33
3.3.1 <i>Requirements</i>	34
3.4 VALUE AND GROWTH	35
3.4.1 <i>Customer value proposition</i>	36
3.4.2 <i>System installer value proposition</i>	37
3.4.3 <i>Investor value proposition</i>	37
4. INDIVIDUAL LEARNINGS AND ENTREPRENEURIAL JOURNEY	38
4.1 FABIANA'S INDIVIDUAL LEARNINGS AND ENTREPRENEURIAL JOURNEY	38
5. BIBLIOGRAPHY	42
6. APPENDIX	45

List of Figures

Figure 1: <i>Standard layout of an AVC system</i>	8
Figure 2: <i>Ground-mounted AVC system</i>	9
Figure 3: <i>Stilt-mounted AVC system</i>	9
Figure 4: <i>PV-integrated greenhouse AVC system</i>	10
Figure 5: <i>Selection of the right crops</i>	16
Figure 6: <i>Strategic position of Energreen</i>	20
Figure 7: <i>Business Model 1</i>	21
Figure 8: <i>Business Model 2</i>	22
Figure 9: <i>Business Model Canvas for Energreen</i>	22
Figure 10: <i>Build-Measure-Learn feedback loop</i>	29
Figure 11: <i>Normalized energy production per installed kWp</i>	31
Figure 12: <i>Performance ratio of the PV system</i>	31
Figure 13: <i>Layout of the installation with PV, heating, and batteries (technical drawing)</i>	32
Figure 14: <i>Coverage of the consumption throughout the year</i>	33
Figure 16: <i>Feedback Loop</i>	39

List of Table

Table 1: <i>External validation interviews</i>	18
--	----

List of Abbreviations and Units

AVC – *Agrivoltaics*

PV – *Photovoltaics*

kW – *Kilowatt*

kWh – *Kilowatt*

1. Introduction

Sustainability and the production of green energy have moved more than ever to the center of attention for international politics and industries. Especially the given situation with the war between Russia and Ukraine has drastically intensified this matter; energy has become one of the most relevant geopolitical topics and is a scarce and valuable resource for many nations and individuals across the continent, as the resources on our planet are not infinite (King 2015). Nowadays, one of the biggest challenges for society is to make the transition from fossil fuels to renewable energy production, considering this one of the main drivers of climate change (Weselek, et al. 2019). Consequently, the effects of climate change and at the same time the increase in the world population to nearly 8 billion people have caused a major impact and have proven to be a threat to food security, causing competition for the land's limited resources to increase (Weselek, et al. 2019). As a synergistic combination opportunity to increase the share of renewable energies, the collaboration between solar PV and agricultural activity has been proposed, avoiding the negative impact of one another. The system has been first introduced by Goetzberger and Zastrow in 1982, proposing a dual usage of energy and food production. AVCs are considered the right step towards a sustainable future and solar energy projects are suspect to many subsidies and funding (European Commission 2022). The mission of this work project is to create a positive impact throughout various areas in the communities and the environment, contributing to sustainable development by tackling and targeting the Sustainable Development Goals (SDG) Agenda of the United Nations. Special focus is on the following SDGs: Goal 7 – affordable and clean energy, Goal 11 – sustainable cities and communities, Goal 12 – responsible consumption and production and Goal 13 – Climate action (UN 2022). The dual usage of producing energy and at the same time agricultural products can provide a great contribution towards the green energy transitions for the

European Union Energy goals 2030 to ensure the Paris Climate Agreement commitments (ECEEE 2019). Moreover, the system provides farmers with new innovative technologies that help to gain a competitive advantage, provide additional income, and hold up energy-consuming work.

This is accomplished by validating and implementing two pilot projects into berry farms in Sintra that function as exemplars for other farms and serves as a base for duplication to scale the business.

The name of the project is Energreen, created by the word Energy and Green. For the vision of the project, the goal is to become a company specialized in AVC systems implementation, gain a presence in the market by creating strategic connections in the agricultural and renewable energy sector, and become the go-to company for carrying out AVC projects.

1.1 Organization of the Paper

This report includes the group work in addition to the individual contributions of each group member, where the information can be found in the header of each page. The first part is focused on the introduction of the project, followed by background knowledge about AVC systems and further explanations that are relevant for a better understanding of the following areas. Later, a short explanation of how the idea was created is presented as well as information about the founders of Energreen. Further, the methodology chosen to investigate, and the structure of the project are introduced as well. The second part is focused on vision, where first, the hypotheses and assumptions are defined and explained. Following, the project kicked off and the stakeholders who played an important role in the external validation phase are presented. Next, the strategy, business model, and legal requirements are explained in detail. The third part covers the steer phase, this chapter entitles the pilot implementations with all the insights obtained in the second part, the development of the MVP with a description of its development and containing information about

the customers, the challenges faced, and how the project overcame those difficulties and adapted. This point is followed by the system simulation and the draft of the first pilot designed in collaboration with João Caldeira and the GoBerry farm. Later, the financial plan is presented together with the potential funding by the impact investment platform GoParity and the requirements that need to be fulfilled to be financed. This chapter is closed with an explanation of the value creation for each of the main stakeholders and a brief introduction to the growth opportunities. The fourth part is the accelerate chapter, it includes information about the future steps estimated and the scalability aspect of the project. The next part is based on the results and conclusion, where the group experience is shared including group dynamics and challenges, the AHA! Moments discovered along the entrepreneurial journey, followed by an analysis of the results of the experiment, learning and know-how evolved along the development process, endgame, and conclusion of the report. Following, the last part is the Individual Learnings and Entrepreneurial Journey, where each of the team members is presenting their key individual learnings throughout the project and the entrepreneurial journey they followed. The appendix is used to include further complementary material to support the growth and development of the project.

1.2 Definition and Explanation of AVCs

In the following part, AVC systems are presented and described in detail. It is an essential part of this work project and is key to understanding the concept behind the venture. Therefore, the system of AVC is briefly introduced, the different types of AVC systems are presented, as well as the driving factors and the advantages and disadvantages of the system are elaborated.

1.2.1 Definition of AVC systems

In the last recent years, the concept of AVCs has drastically increased in popularity and a lot of projects are being developed (Toledo and Scognamiglio 2021). AVCs provide a dual usage of agricultural land for food production and solar PV for the generation of energy (Marrou, et al. 2013). The usual setup of AVC systems, shown in **Figure 1**, provides additional protection to the crops that are usually growing beneath the system (Trommsdorff, Kang, et al. 2021). Additionally, it helps increase water availability by diminishing the evaporation of the water-irrigated (Elamri, et al. 2018). The PV system is often supported by a rack structure collocated parallel to the crop lines and the height of the rack can variate depending on the specifications needed to not disturb the growth and cycles of the plants.

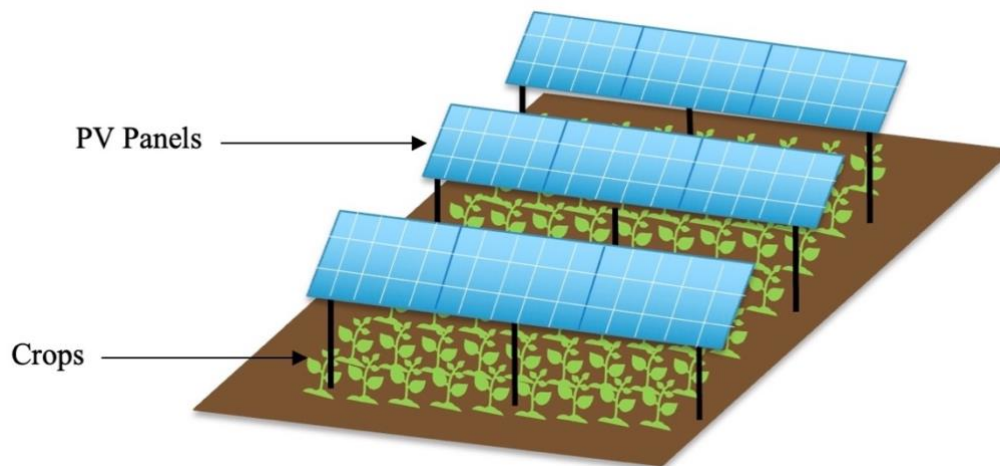


Figure 1: *Standard layout of an AVC system*

1.2.2 Types of AVC systems

As it has been mentioned before there is an existing competition between land-based PV farms and food production farms, increasing the innovation of how to implement PV systems in active land production. This results in different adaptations, giving rise to pioneering initiatives like the AVC

system, which has been shown to be performed in three basic ways. The factors that may vary between the three basic types are height and space which are usually adapted to the different types of crops, in addition to the tilt and orientation angles of the panels' (Toledo and Scognamiglio 2021). The first type of ground-mounted was proposed in the early 1980s (Goetzberger und Zastrow 1982). It is mounted near the ground with sufficient space between rows where the crops are accommodated as shown in **Figure 2** (Beylot, et al. 2012). The second type is named stilt-mounted and is organized with intermediate space for the plants. Those are situated between two to five meters above the ground, as can be seen in **Figure 3**. (Sekiyama und Nagashima 2019). The third and final type of AVC system is the PV-integrated greenhouse, which consists of placing the panels on the roof of the greenhouses, as illustrated in **Figure 4**. This is generally a good option for farms that already have greenhouses in place.



Figure 2: *Ground-mounted AVC system*

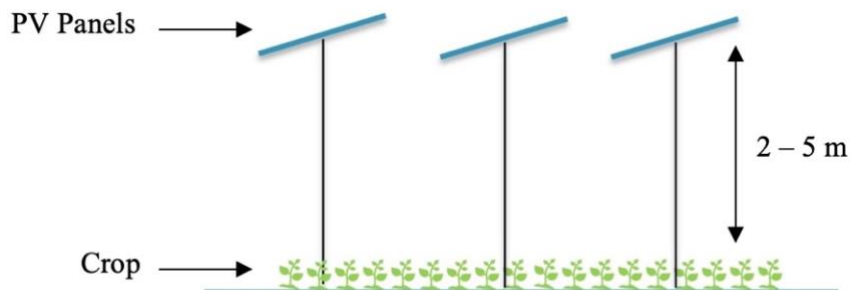


Figure 3: *Stilt-mounted AVC system*

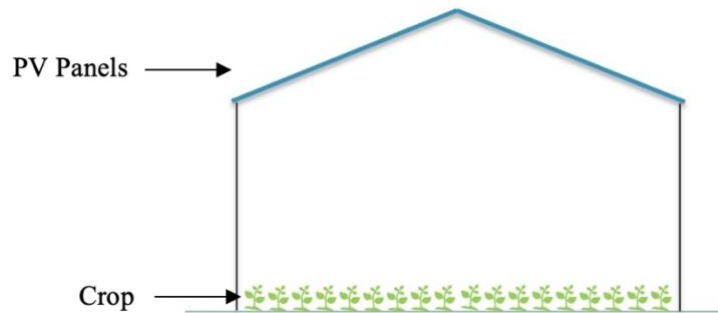


Figure 4: *PV-integrated greenhouse AVC system*

1.2.3 Driving factors

Different factors are driving this trend in comparison to common PV fields. Throughout the years some governments like Germany, Japan, the USA, China, India, and South Korea, have adopted policies to support the implementation of AVC systems and utilize the potential of this innovative technology on farming land due to the popularity in the growth of the technology (Giry und Monhanty 2022; Gorjian, et al. 2022). AVC systems are perceived as reliable, sustainable, and viable techno-economic solutions for the clean energy generation (Choi, et al. 2021). In addition, this initiative provides the opportunity to avoid the current competition between land-based PV farms and food production farms (Toledo and Scognamiglio 2021), leading to an increase in land productivity while simultaneously benefiting the environment. This efficiency can support farmers by generating double income streams, where due to the double usage of the land, income can be earned through selling the energy to the grid or own usage, and by farming the fields. As a result, those additional income streams can especially help farmers who face low crop yields caused by climate disasters, inconsistent precipitation, and the rising cost of agricultural inputs like energy and fertilizers (Myers 2022). Additionally, there are many environmental benefits associated with

producing clean energy like fighting climate change, improving the health of society, and offering a more reliable and resistant system (Union of Concerned Scientists 2017).

1.2.4 Advantages and disadvantages

The agricultural sector has been greatly affected by climate change due to extreme and unpredictable weather conditions. One of the biggest advantages of AVC systems is, that they offer protection from extreme weather events (Toledo and Scognamiglio 2021). As with other advantages, the productivity of the land could rise by 60-70% (Dupraz, Marrou, et al. 2011). Also, the shade provided by PV modules helps to mitigate water evaporation during the warmest times such as summer, and it has been shown that shading can save between 14 and 29% of water, this will be determined depending on shading level (Marrou, Dufour and Wery 2013); Portugal is a country that sometimes faces droughts, and this benefit could be very useful. To further support this, the easement of soil erosion produced by the reduction of moisture evaporation in the soil has been shown to be supported by PV modules (Wu, et al. 2014). Finally, it is worth mentioning that an AVC farm can act as an autonomous energy source to power irrigation and pumping systems in places with electricity shortages or without grid supply, ensuring food security (Burney, et al. 2010). On the other hand, there are some disadvantages to AVC implementation, for instance, the high initial investment cost that is required to install AVCs, one that many farmers struggle to afford it. Further, not all types of crops are fitting well in combination with an AVC system and the way the different plants can behave under shading is difficult to predict (Mavani, Chauhan and Joshi 2019; Dupraz, Talbot, et al. 2011). In addition, dust generation from agriculture and accumulated on PV modules can negatively impact plant growth between PV rows, however, increasing the tilt angle of photovoltaic modules can help to decrease the amount of dust

accumulated on the surface. (Talbot, et al. 2014). Finally, there are still many countries where policy schemes are missing for the realization of AVC systems (Schindele, et al. 2020).

1.3 Ideation

The system of AVCs has been specifically highlighted by the pioneer, adventurer, environmental activist, and founder of Solar Impulse Bertrand Piccard at the Estoril conference at Nova SBE in 2022, where he presented his vision of the future and how to learn to face environmental challenges without affecting the economy and its growth (Cleantech Forum Europe 2022).

According to Bertrand Piccard, AVCs are among the most promising systems to accomplish the turn in producing green energy, fighting climate change, producing enough food for the world and as a result tackling the United Nations SDGs. To put this system into perspective, according to the renowned Fraunhofer Institute, only 4% of Germany's arable land would be needed to cover the country's current total electricity demand merely through solar PV (Trommsdorff, Gruber, et al. 2022). Moreover, Portugal is proven to provide excellent conditions for energy production with solar PVs, as some regions get close to 3000 hours of sun a year with moderate temperatures (Silva und Sareen 2020). Through the attendance at the Estoril conference, both authors of this working project were fascinated by the vision and decided to carry on with the idea in mind of implementing AVC systems in Portugal.

1.4 The team behind Energreen

According to Eva de Molone, some of the key success factors that are required to get to superior team performance are especially soft skills, like shared entrepreneurial passion and shared strategic vision (Molone 2019). Therefore, the team behind the startup Energreen consists of Fabiana

Jimenez and Maximilian Hauser, both Master's students at Nova SBE in Impact Entrepreneurship and Innovation. They have studied and lived in many different countries around the globe, including Canada, Mexico, Colombia, Scotland, the United States and Germany. Both founders studied together at the same university in Germany and have a business background in international management and supply chain management. Together, they have worked on many different projects and startups inside and outside of the university. Both share a passion for innovating existing processes, entrepreneurship, and renewable energies.

1.5 Methodology

This section provides an overview of the methodology and approach used to conduct our fieldwork project “Validation of an AVC System: An implementation into a Raspberry Farm in Sintra”. To initiate, the Lean Startup Approach by Eric Ries (2011) was selected as the base methodology for structuring the development of the project, as it discusses in detail how continuous innovation plays a major role in creating radically successful business solutions for today's entrepreneurs. “The Lean Startup is the application of lean thinking to the process of innovation” (Ries 2011). Moreover, the methodology was adapted to some extent for the purpose of this working project. In addition, a comprehensive review was conducted to build better background knowledge about AVC systems, the benefits of renewable energy for farmers and the environment, how AVC systems can help combat climate change, crops suitable for farming with AVC systems, and the different technological implementations. The secondary research was conducted by using common research engines, where 32 academic research papers from different researchers in the field were examined. Moreover, those were supported by several expert consultations. Furthermore, to understand the underlying problems and challenges, different field interviews were conducted with experts in PV,

system installers, financial advisors, and farmers. Consequently, new concepts were discovered and investigate.

2. VISION

The first step of combining management, processes, and discipline to accelerate a successful project is the vision phase. This is described and implemented accordingly to the lean startup approach by Eric Ries. In the structure of this chapter, the Strategy is presented before the Business Model due to the fact explained by Ries in his book that the Business Model is part of the strategy to achieve the project's vision (Ries 2011).

2.1 Start

Considering the secondary research, a comparison between different existing AVC systems was performed, as well as a deep analysis of all the potential crops to combine with the experiment. It indicated that some crops in Portugal have a higher turnover than others, as shown in **Figure 5** and are more suitable to grow under AVCs. Applying the results of the research, the investigation moved forward with a focus on the berries farms. In Portugal, berry farms are all over the country, however, the research was reduced to the area of Lisbon. Moreover, it was relevant to confirm the established hypotheses and assumptions by conducting some primary research. Some barriers were faced since there was weak contact access to experts and farmers. Eventually, it was achieved a connection with former professors, researchers, engineers, and farmers who were interviewed through different channels. Additionally, different funding options were explored through the EU Horizon fund, as well as the entity GoParity.

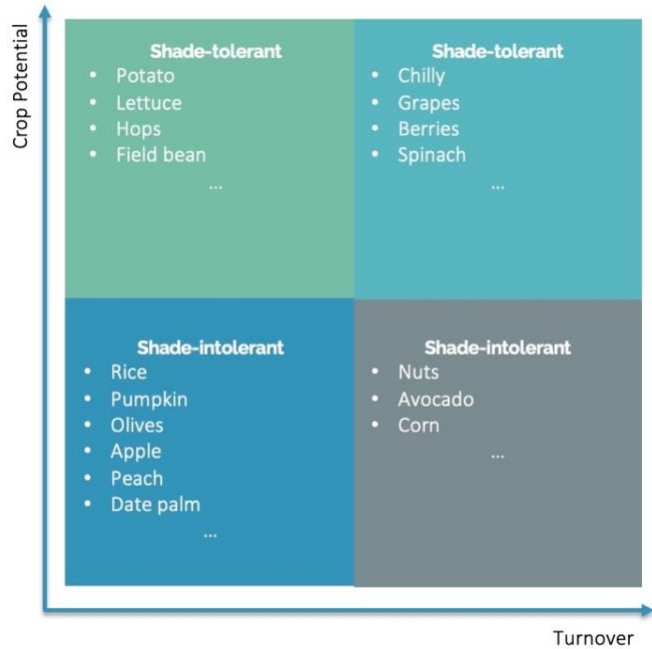


Figure 5: Selection of the right crops

2.2 Hypotheses and Assumptions

According to Ries, this part is the riskiest element of a startup's plan, where the most important assumptions are the value and the growth hypotheses (Ries 2011). Those rely on the foundation of field interviews with experts and farmers, as well as scientific papers and literature and are concluded at the end of this paper. Some of the hypotheses and assumptions were formulated prior to the research and determine the ventures engine of growth. This project is focused on investigating step-by-step the implementation of AVC systems in farms, with the long-term aim of building a strategic business venture and becoming the go-to company for AVC projects. The following are the hypothesis and assumptions that were made:

- 1- An AVC farm is more environmentally and economically efficient (*value*)

- 2- By implementing an AVC system, a harmonized circular economy is created since the plants will have higher yields and the solar panels will work more efficiently due to the cooler environment provided by the plants (*growth*)
- 3- AVC systems increase the potential for extended growing seasons (*value*)
- 4- A fruit farm such as raspberries or blueberries is an ideal combination to implement an AVC system (*value*)
- 5- Farmers often do not have sufficient capital to meet the high initial investment costs, thus, financing is often done externally (*growth*)

2.3 External Validation

The external validation process was conducted with the aim to better understand the requirements, regulations, concerns, and challenges of implementing AVC systems into farms. Four main interviews highly supported the progress of Energreen and helped to validate the identified business gap. First, the opportunity to have an interview with Luís Veiga Martins was introduced by the former Design Thinking course professor, Anne-Laure Fayard. Later, by investigating the area for potential farms, GoBerry was found and consequently, the chance to interview the owner Mónica Santos. After reaching an agreement with GoBerry, the master thesis advisor Tomé Salgueiro suggested the link to the engineer João Caldeira, who could potentially assist with the technical feasibility of the project. Finally, for the financial aspect, through the master thesis professor advisor PhD. Ricardo Zózimo, the contact to GoParity was established, resulting in a meeting with the CCO Manuel Nery Nina.

Interviewee	Expertise	Purpose	Interview type	Interview location	Interview date
Luís Veiga Martins	Associate Dean for Community Engagement & Sustainable Impact, and Circular Economy expert	Understand the benefits of Circular Economy for farms	Unstructured One-on-one interview	Online	06/ Sept/ 2022
Mónica Santos	Raspberry farm management (GoBerry Farm owner)	Explore collaboration opportunities for the project	Structured Interview	Sintra, Portugal	28/ Sept/ 2022
João Caldeira	Head of engineering in the Asunim Group	Help to build the simulation system for the project	Structured Interviews	Online	06/ Oct/ 2022
Manuel Nery Nina	Co-founder and CCO from GoParity	Discover financial support opportunities for the project	Structured Interview	Online	10/ Oct/ 2022

Table 1: *External validation interviews*

2.4 Strategy

Energreen is aiming to become a professional intermediary and strategic project developer for the implementation of AVC systems in the agricultural sector. The venture is tackling an identified business gap in the development of renewable projects. The strategy is to follow the think big start small approach of Eric Ries, with the goal of building a sustainable business based on the vision of Energreen (Ries 2011). The venture aims to become a fundamental link between farmers, system installers and investors across Europe and to establish through trust, know-how and experience a functional organization that is in constant exposure with farmers. Thus, the target is to have a standardized and uncomplicated process established for future customers, that can be individualized to some extent and serve as a direct point of contact for any renewable energy-related subject. To evaluate the progress, actionable metrics are being used, as certain parameters

for the project are required. Energreen aims to be the connective link that helps to plan the AVC systems and to collect all the required documentation and information to design the system. In addition, the venture makes sure the legal regulations are in place and the requirements are respected. Moreover, the system simulation is performed in cooperation with a partner and engineer, and a plan is elaborated on how the specific projects can be financed. Once the blueprint is prepared, Energreen is performing the installation together with a system installer considering all safety measurements necessary. Through a variety of long-term agreements with farmers and project investors, the strategy is to generate through an evolving business model a constant value return. Therefore, to build the foundation, a pilot project is developed on a farm to serve as a model and exemplar to be duplicated on other farms. Through that pilot project, the benefits, and challenges of an AVC implementation into a Raspberry farm are understood from the beginning of acquiring the customer to wrap up the project and receive the funding. With the buzz generated and by visiting specific fairs across Europe, additional contacts are established in the industry and leading to the possibility of landing new customers and AVC projects. As shown in **Figure 6**, Energreen is the bridge between three main stakeholders and without it, no project execution would be possible. The system installers and investors provide Energreen with the tools to build the solution for the customer.

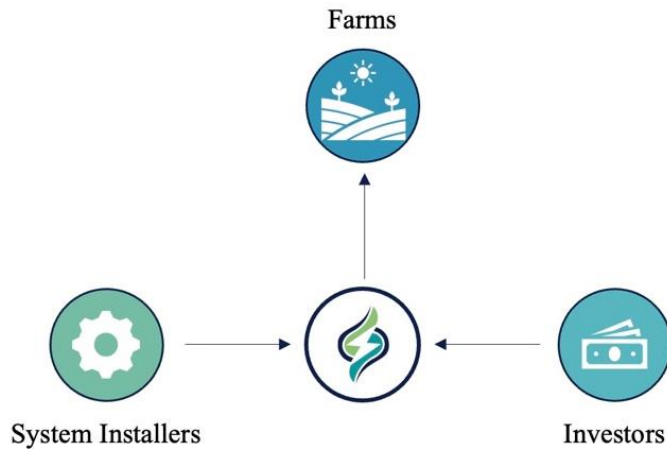


Figure 6: *Strategic position of Energreen*

2.4.1 Business Model

With the strategy in place, capturing the hidden value of the idea is the main objective of the business model (Ries 2011). The business model of the startup is to generate a constant financial return by making long-term agreements with farmers, system installers, and investors through the development of AVC projects. The venture is the link between the three main stakeholders, where the objective is to remain and obtain the primary exclusive partner for the farms regarding their AVC, after each successful project implementation. Energreen is planning to generate income through different channels, having in sight a business model that evolves over time, capital gained, and customers served. The first business model applies at the beginning of the venture and is performing the function of a classic intermediary, shown in **Figure 7**. The idea is that an extra 10% of the total costs are charged to all the expenses and invoices that occur when the system is installed. In addition, there will be an extra fee charged for any other expenses like maintenance, and consultancy, among other kinds of issues that may occur along the way with the system. An

additional service fee will be also billed every time revenue is generated. Through this, the venture will produce income with each project and can build a base capital.

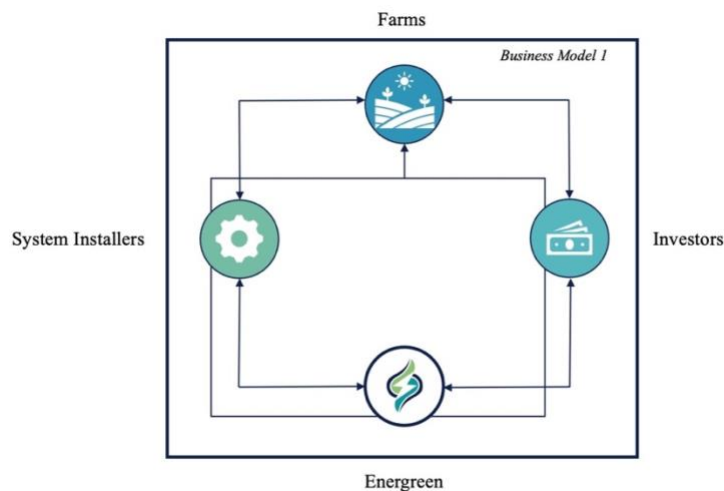


Figure 7: *Business Model 1*

The second business model is evolving out of the first one and it involves the sale and leaseback business model, demonstrated in **Figure 8**. It allows farmers that cannot finance the system to still use the energy that is produced through the AVC system at a discount and at the same time generate a constant income for Energreen. The AVC system is paid or purchased after the installation for a fixed price by Energreen and in return, the farmer leases the system back by paying a fixed price per kW for the energy the farm is using. At any point in time, the farmer has the possibility to buy back the AVC system that has been installed on their farm and can use the energy that is produced with the PV modules. The economic advantages for the farmer are, that there is not sufficient capital bound to the initial investment of installing an AVC system and moreover, the energy is purchased at a discount price compared to the energy from the grid. The economic advantages for Energreen are that there is a constant revenue generated through the energy that is used by the farms and after the system has been paid off, all the revenue generated from the system are profits. Additionally, the usual ROI of this system is very low in Portugal due to the respective climatic

conditions and usually about 5 years. A security deposit must be given from the farmer, to ensure in case of bankruptcy there is still an asset accountable. Moreover, Energreen is seeking to serve as a stakeholder in different projects.

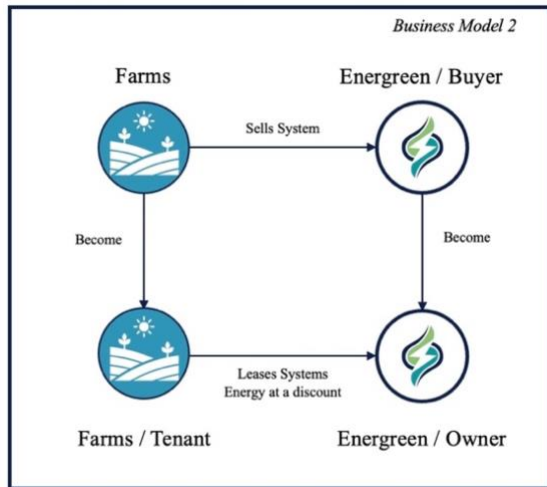


Figure 8: Business Model 2



Figure 9: Business Model Canvas for Energreen

2.5 Market Size

The market size of the business opportunity is hard to estimate, as AVC systems can be applied in various forms and layouts on different kinds of lands and terrains. However, according to the Precedence Research institute, focused on strategic market insights, the estimate for the global market size is around 3.17 billion \$ in 2021, expecting strong growth. For 2030, the predictive future market size is estimated at 8.9 billion dollars (Precedence Research 2022). Additionally, MarkNtel Advisors, a research, consulting, and data analytics firm informed growth at a CAGR of around 38% from 2022 to 2027 (MarkNtel Advisors, 2022). The growth is mainly driven by the increased customer satisfaction level, growing features, and advantages of the AVC integration, as well as the reduced price of AVC components. Additionally, the growing demand for effective cultivation equipment and rising innovative farming techniques drives this growth. To break this down to a more local level, the market size for AVC systems in Europe is estimated at 29% of the total market share, resulting in a predictive size of 2.5 billion dollars by 2030 (Precedence Research, 2022). In Portugal, there were in 2010 around 305,000 agricultural holdings registered, assuming a decline year to date, from which only around 4% are assumed to be potential customers for AVC systems. This would lead to a potential market size in Portugal alone of around 12,000 potential customers.

2.6 Legal Requirements

For Energreen to start the development and the operations, legal requirements are an essential part and must be examined prior to the start of the advancement of the projects. Portugal is a pioneer in both renewable energies and smart cities and is interested in making use of the multiple benefits of the energy transition. Therefore, the country enacted a law that facilitates active participation in

projects interested in investing in renewable energy resources. This law offers the legal framework necessary to provide support to renewable energy initiatives to become productive, consume, store, share and sell electricity without facing unreasonable constraints (Presidency of the Council of Ministers 2019). Portugal's ambition to become one of the countries at the forefront of the energy transition is embodied in ambitious targets for 2030, aiming to achieve a 47% share of energy from renewable sources in gross final consumption by 2030 it explains in the *Diário da República*, 1. a série, *Presidência Do Conselho De Ministros, Decreto - Lei n.o 162/2019* (Presidency of the Council of Ministers 2019; Almeida, et al. 2020). To initiate, for the license it is important to consider the size of the project, and whether the system installations would reach 350W. If a system is up to 350W no prior notification must be sent to the *Direção-Geral de Energia e Geologia (DGEG)*, but if it exceeds the number, it is necessary to submit a registration to the organization and wait until a certificate is granted. For the government to approve the project, there is a list of documents that need to be submitted including an AutoCAD graphic to assure that the system meets the government's regulations. Moreover, to carry out the projects, it is required to work together with a certified company or technician because it is important to take into consideration safety measurements and inspection rules by UPACs, in addition, if a system has a power larger than 30 kW, liability insurance is mandatory. About the number of solar panels to be installed, there is no determined limit number declared by Portuguese legislation. One of the reasons for installing a PV system is to create more independence, nevertheless, it is obligatory by law to have a contract with an energy supplier (Presidency of the Council of Ministers 2019), since the consumer will still need an energy supplier for cases when the energy produced by the PV system is not enough to cover consumption. However, there are always options such as accumulation systems to remain more independent (Solvasto 2020).

3. STEER

In this chapter, the development process of how the project builds from zero to pilot is explained. Initially, the idea was to implement a standard AVC system in a raspberry farm, however, the project went through the steering process, delivering different but successful results. The pilot supported by providing experience, knowledge and know-how and establishing valuable connections in the field. Additionally, it brings the convenience to document key insights and helps to improve the future process by standardizing procedures to implement AVC systems in other farms.

3.1 Development of the MVP

The minimum viable product (MVP) or pilot provides a way to display the value of AVC systems with the least resources in the shortest time (Ries 2011). According to Ries, it is considered a step forward in a theoretical inquiry since it is the first try of the product and if it results successful, it can help boost the development of the venture. To design an AVC system, several development steps were followed. The first step was to have a clear definition of the project and understand the impact it was intended to create. Second, for the location, it was decided to focus on Europe, more specifically Portugal. Third, the crop classification, where it was decided from all different crops which would be the ideal crop to conduct the case study. In general, the quality of cultivation depends on certain conditions such as light levels, temperature, availability of water and wind, among others (Lambers, Chapin and Pons 1999). In this case, the factor to be considered would be light, because it is the only one that is associated with the application of solar panels. There are different types of crops to grow under AVCs, however through the secondary research that was conducted it was decided to move forward with berries. This way GoBerry farm was found and

once they agreed to be part of the study, the area was analyzed. Additionally, the GoBerry farm was visited several days under different weather conditions, sunnier and less sunny days, to analyze which were the most stable points of sunlight, as can be appreciated in the pictures included in the Appendix. During the research, it was learned that the most important thing is to meet government requirements, efficient design, proper crop selection and techno-economic improvements of the AVC system (Giri und Mohanty 2022). After all the previous steps were aligned with the engineer, the MVP creation started. The blueberry farm of Mirtilos da Serra was conducted at a later stage through a recommendation from the owner of the GoBerry farm, who helped establish the contact.

3.1.1 Customers

The GoBerry farm is a raspberry farm located in Sintra in the North-west of the Lisbon area. The farm is managed and administrated by Mónica Santos and her mother with the support of 5 full-time employed workers from Nepal. Mónica is a young entrepreneur who enjoys her work and is open to innovations to gain a competitive advantage. In the summer month, the farm can produce up to 100kg of high-quality raspberries per day and in the lower temperature month only around 50kg, where most of the yield is thrown away due to the appearance of the fruits. In the winter month, there is no production possible, as the temperatures for raspberry production are too low and the plants need to be cut down completely for them to grow and rise strongly in spring. There are multiple different types of raspberries grown on the farm, that differ in size and red shading. The farm is selling most of the fruits in 125-gram boxes to France, Spain, Italy, and Germany. The layout of the farm is the following, the raspberry crops are protected under agricultural tunnels or macro-tunnels, that secure the plants from external conditions like extreme weather, birds, and insects. The farm is divided into 3 Agri-lines, the first line contains five longer agricultural macro-

tunnels with 62 meters each, the second eight tunnels are 40 m long each and the third seven tunnels are also 40 m long.

Mirtilos da Serra is a blueberry farm located in Sintra, that belongs to the Roseiro family. The family has a long tradition of being farmers and cultivating their land. During the pandemic, the family decided to take the step and realize the project of a blueberry farm, with the final purpose of reaching high-quality standards in the production of organic blueberries, an exclusive and branded product of Portugal. Their goal is to create the ideal conditions for the cultivation of blueberries with distinctive properties. Mirtilos da Serra is mainly selling its fruits on the Iberian Peninsula and is pushing to sell more fruits in Portugal. The layout of the blueberry farm is the following, the plants are growing in buckets that are placed on a foil on the ground. All plants are equally distributed across a big field with about 2 hectares of land.

3.1.2 Challenges

The idea of an AVC system can be considered complicated, achieving harmonized productivity by combining crops and PV systems is already a great challenge, as it aims to generate energy and at the same time have uninterrupted plant growth. Simultaneously, the application of the panels is expected to support the protection of the plants and decrease the evaporation of the water used in irrigating the plantation. The project is based in Portugal and studies on the development of the AVC sector in Portugal are few, providing very limited background knowledge. Overall, it evolved through extensive research and long conversations with experts and the client to achieve the project's first pilot. Along with the investigation and development of the project, other challenges were encountered. When the proposal was made, it was very important for the GoBerry farm to prove that the installation of solar panels would not interfere with the crops receiving enough

sunlight, which is quite necessary for the strength of the plant and its production. In addition, another difficulty was the set-up of the farm, the crops are organized inside agricultural tunnels making the application of a standard AVC system non-viable. Therefore, the project plan took a different turn by deciding to place the solar panels outside in an area located close to the crops and additionally, to implement a heating system inside the agricultural tunnels to provide the option to produce for a longer period in the year. Nevertheless, as a consequence of the lack of expertise, finding the best adaptable type of heating system and a supplier was difficult. There were some similar projects found in Morocco, but it was not possible to contact those farms due to the language barrier and contact information limitations. Moreover, the communication with the GoBerry farm was not constant and fluent due to the lack of time they had after a normal working day, which delayed the progress of the project many times. Also, it is a common challenge for intermediaries to be caught in the feedback loop process. Energreen needed to first, request the information from the farm to later share it with the engineer to then be able to continue working or redefine the system simulation and the same dynamic worked the other way around, receiving input from the engineer and sharing it with the farm to accept or decline the feedback. This converted the project into a timing challenge as well, it was highly dependent on the suggestions of the experts, developers, and farmers to be able to advance.

3.1.3 Pivot

As the project developed, challenges were faced and new information was applied, there were constant adaptations. By following the Build-Measure-Learn feedback loop from Eric Ries shown in **Figure 10**, allowed to reshape the next set of ideas. Initially, the proposal for the first pilot with the GoBerry farm was to install a standard AVC system, but due to the existing agricultural tunnels or greenhouses, the system design would not have been adequate. Therefore, it was essential to

work on a different approach, undertaking new research and consulting other concepts. For the benefit of the client, the plan was adjusted, introducing the idea of placing the PV system next to the crop area and, at the same time, installing a heating system inside the agricultural tunnels which would be powered by the energy produced by the newly installed PV system. The function of the heating system is to keep a comfortable temperature for the plants when the external temperatures fall below 10°C. This approach allows GoBerry to produce berries during wintertime when the fruit can be sold at its highest price. The first adaptation leads Energreen to the second potential pilot with Mirtilos da Serra due to various motives, the blueberry farm has no agricultural tunnels in place, offering the conditions to install a standard AVC system. Further, blueberry plants get stressed when they are too exposed to the sunlight, thus, the PV panels can offer the protection they need.

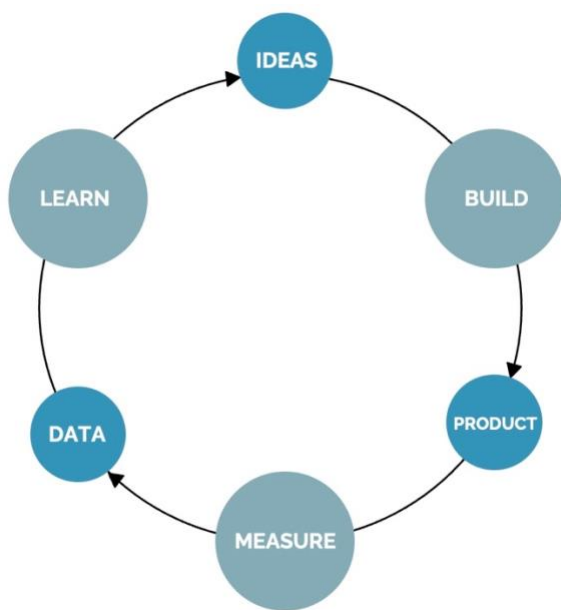


Figure 10: *Build-Measure-Learn feedback loop*

3.2 System Simulation

The system simulation for the MVP with GoBerry is undertaken by the engineer and designer João Caldeira through the software PV Syst. The full project simulation can be found in the Appendix of the report; demonstrates the conditions, feasibility, costs, and planning of the pilot project with GoBerry. The system simulation is based on the information provided through the various visits and information that have been collected throughout the process.

There are two types of system simulations available for the pilot project, one is the stand-alone solution of the PV modules and the other one is the more complex solution of the PV system with batteries to power the heating system during nighttime.

Overall Data on the farm:

The GoBerry farm is located at Latitude 38.84°N and Longitude -9.27°W. The altitude of the farm is 273m above sea level. From past data, the annual energy usage of 6,975.78 kWh and is currently paying 1,718.62 € per year for energy. Currently, the customer is paying 0.212 € per kWh to the grid. 87% of the Energy is used at the peak times of total energy usage, where 59% of the energy is assumed to be consumed during the daytime to power generators, pumps, and fridges and 41% of the energy is consumed during nighttime.

Base simulation of PV modules:

To cover the current demand of the farm, the system that is proposed for the requirements of GoBerry is a 4kW system, composed of 9 monocrystalline PV modules that have a peak power of producing 4905W and one inverter. The modules have a gross area of 23.5 m² and a cell area of 21.8 m².

Those modules are proposed to be placed close to the storage units on the farm, to shorten the cableways. The normalized energy production per installed kWp for this system is shown in **Figure 11** and the performance ratio over the year can be seen in **Figure 12**.

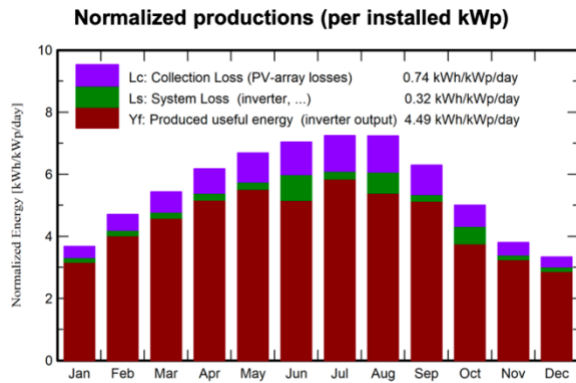


Figure 11: Normalized energy production per installed kWp

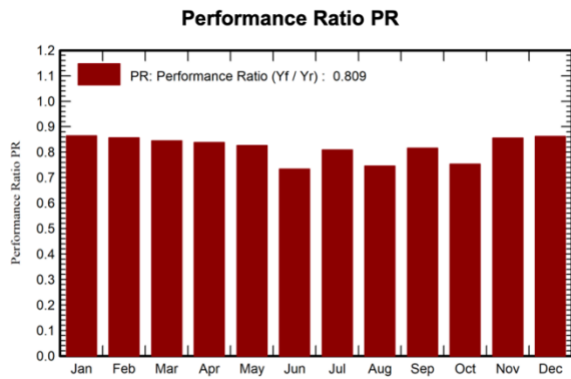


Figure 12: Performance ratio of the PV system

The initial investment for this option is 7,850.00 € and is planned to be amortized for the farm within 5.3 years, considering a 1% inflation. Expecting a running time of the system of 20 years, the overall return will be 22,893.12 €, with a price per kWh of 0.0681 €. The modules need to be installed at a 30° angle. More information like the technical proposal, information about the inverter

and the modules, the layout of the modules and the financial plan for this can be found in the appendix of this working project.

Simulation PV with batteries and heating system:

The second option is the more complex and more cost-intensive 6kW PV system, with an electric appliance for the heating and a battery system. The output of the PV system is estimated at 6.78kWp and the PV surfaces increase to 31m². There will be 12 monocrystalline PV modules installed, 1 inverter and 2 lithium iron phosphate batteries to store and release the energy overnight. The production forecast for the PV modules predicts a PV general output of 6.78kWh and an annual yield of 1,715.44kWh. The own power consumption for this model is estimated to be 65% through the system and 35% from the grid, where 5,161kg of emissions are expected to be avoided per year. The total consumption with the heating system is expected to be 9,369kWh and the batteries have a DC intermediate circuit coupling and generate a nominal output of 2.5kW, with a united storage capacity of 10.2 kWh. The system will be installed as shown in **Figure 13** and is estimated to drive the self-sufficiency of the farm to 79%.

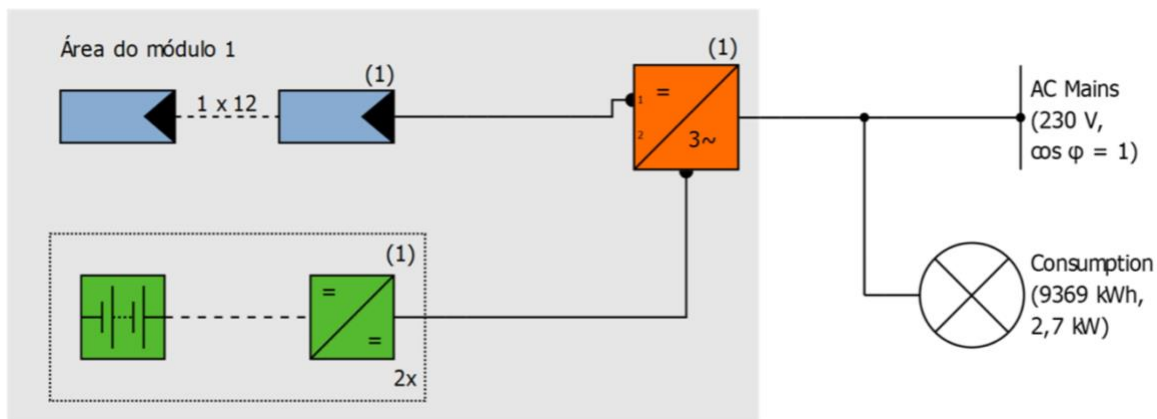


Figure 13: Layout of the installation with PV, heating, and batteries (technical drawing)

With this system in place, GoBerry keeps its plants at moderate temperatures never under 10°C and can produce berries over the wintertime. The price of the system is estimated at 12,500 € without the heating system. As shown in **Figure 14**, energy usage is more in winter than in summer, where still energy must be taken from the grid. The excess energy that is produced in the summer month is 3,914 kW and can be sold to the grid for approximately 0.14 cents per kW. More details of the system simulation can be found in the appendix of this work project.

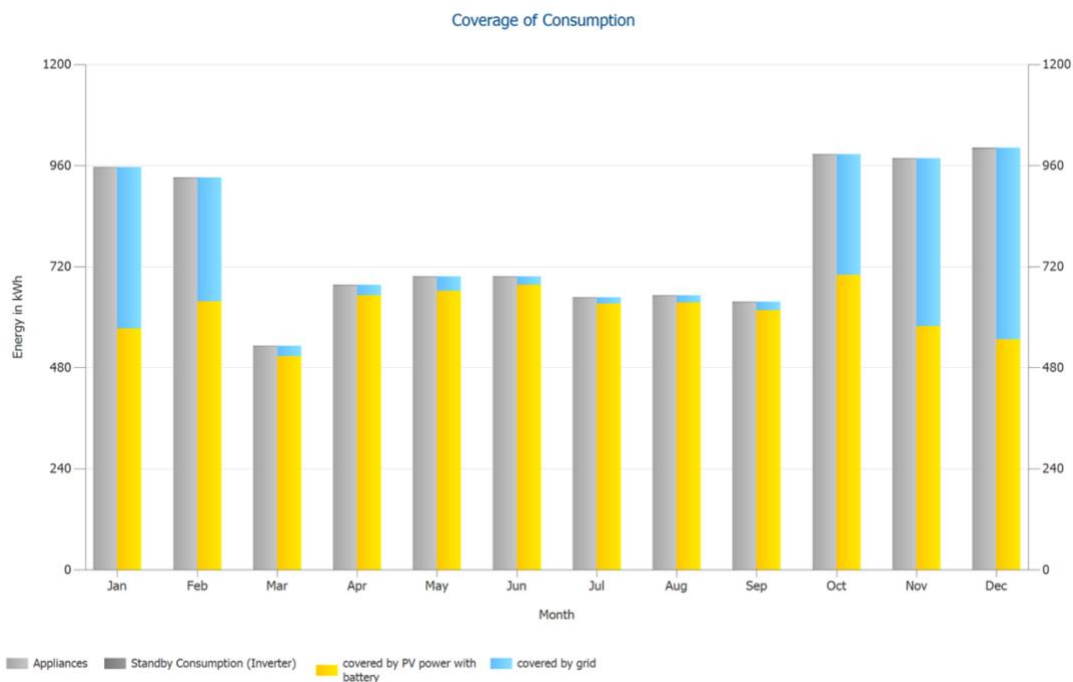


Figure 14: Coverage of the consumption throughout the year

3.3 Funding of the MVP

As Energreen does not have sufficient capital and GoBerry cannot finance the system with their own capital, the funding of the first project with GoBerry will be done through the Portuguese impact investment and crowdfunding platform GoParity. To know how much funding is necessary,

the owners of GoBerry still need to decide which option they would like to implement on their farm.

GoParity offers investment opportunities in sustainable projects to drive sustainable development across various industries. Investments at GoParity work the following, where any investor can invest from 5 € onwards in any of the projects open to funding, contributing towards the overall loan value. The investment is considered a loan from an investor to a project with fixed interest rates, terms, and periodic payments. The project's broad outline with GoBerry was presented on the 10th of October in a meeting with the CCO and Co-founder of GoParity Manuel Nery Nina, who provided valuable insights into finance and the realization of the project. Additionally, there has been another heads-up meeting on the 12th of December.

3.3.1 Requirements

To be listed on GoParity, there are different requirements, obligations, regulations, and documentation that need to be fulfilled. Each project is individually assessed by the GoParity team through reports from independent credit rating agencies and bank registries of financial activities, as only companies demonstrating sufficient financial stability to accommodate the loan payments are accepted (GoParity 2022). There is an initial listing fee charged by GoParity of 450 €, that allows projects to be listed on their platform. Projects need to have a minimum size of more than 15,000 €, however, there can be exceptions made in specific cases. Moreover, the project must contribute to the achievement of at least one of the 17 United Nations Sustainable Development Goals (SDGs) (CMA CGM 2021) and be aligned with the United Nations Goals of “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Encyclopedia, 2018). First, in the list, the company must at least have 2 years of

registered activity, whereas for specific cases of startups a P&L statement is required with a 3-year forecast. Next, the company must never have been convicted in a lawsuit. In addition, it must have a promoter who must be a legal representative of the company, in the case of GoBerry would be Monica Santos. Following this, the documentation that must initially be communicated is a clear description of the project and a financial viability model to ensure that the maturity of the loan is being calculated in a way that guarantees the monthly instalments will be paid by the savings generated in the electricity bill. Furthermore, the business model of the project needs to be introduced, as well as the impact that is generated through the project, by providing key metrics, for example, how much CO₂ has been avoided per year, how many MWh of clean energy have been produced and to which SDG's the project is contributing. Moreover, pictures and videos must be presented to provide a good visible understanding for the investors, as well as a brief presentation of the team involved in the project. Finally, to meet all the previously mentioned. The project is financially assessed and gets a credit rating from A to C, which determines the interest rate of the loan. The credit rating can be improved by providing assets of the projects as a financial liability and/ or financing part of the project through own assets.

Energreen and GoBerry are collaborating and providing all the documentation and materials for the project in close collaboration with João Caldeira to go live with the crowdfunding campaign on GoParity. Usually, similar projects are expected to have a positive return on investment within five to six years.

3.4 Value and Growth

The primary objective of Energreen with the implementation of AVC systems is to create a positive impact and value for all the stakeholders involved in the project, to help to grow on a monetary and

sustainable level. According to Ries, the value of a startup is not defined by the things created, but rather by the learning gained on how to build a sustainable business (Ries 2011). Therefore, several questions need to be answered to understand how to create value for the partners of Energreen in order to maximize the chances of success. As the venture is the link between the three main entities, the value that is created with this initiative is segmented into distinctive metrics. Those are the production of green energy, a financial return on investment, saving money, expanding the business, and accelerating the green energy transition are described accordingly in the following.

3.4.1 Customer value proposition

The customers of Energreen, and more specifically in the case of GoBerry and Mirtilos da Serra, are gaining value through the dual usage of their land through AVC systems. The farms can continue to grow and expand their business by having additional capital available in the long run. Additionally, there is the option of gaining additional income through the production and trading of the energy.

Moreover, the farmers are saving a lot of money on the cost of energy and for specific cases, the fast return on investment leads to receiving energy at no cost. Furthermore, the energy produced by the AVC system can power supplementary components like heating systems, providing a sufficiently warm environment for the plants to continue producing during off-seasons. By having higher incomes, the farms can invest more money into equipment and grow their operations. Moreover, the farmers are gaining a lot of knowledge on AVCs and a more sustainable way of farming.

3.4.2 System installer value proposition

AVC systems are still very absent in the present-day farming industry and offer a lot of value to explore and grow for system installers and engineers in the field. System installers are taking care of the technical feasibility, organize the materials and technologies, and take care of the installation. Especially in the Portuguese market, where systems are just about to be kicked off and implemented with small MVPs, there is a big gap to fill. Therefore, companies that are involved in early-stage projects can become pioneers in the market in cooperation with Energreen, providing great growth opportunities to position themselves well before encountering competition. Moreover, there is also a lot of money to be earned by providing the installation and technical development of AVCs.

3.4.3 Investor value proposition

For investors, institutional or private, the essential value and growth that is created is money, which is also the sole motivation for most investors to invest. With the investment in AVC projects, investors can have a quick return on investment and a safe opportunity to grow their money. Furthermore, through investments in AVC initiatives, investors contribute by saving CO2 emissions, helping to reduce the carbon emissions and to accelerate the green energy transition. By investing in projects with Energreen, investors could contribute to different SDGs, expect to save CO2, and produce clean energy. Additionally, those investments provide diversification for their portfolio to support sustainable project.

4. Individual Learnings and Entrepreneurial Journey

In the following part, each of the team members is presenting their individual key learnings, the entrepreneurial journey they took and the personal challenges they faced.

4.1 Fabiana's Individual Learnings and Entrepreneurial Journey

The startup journey is an opportunity to take charge of our destiny and what we would like to do in the near future, solve existing problems and have an economic and social impact. It sounds like a good plan, but the question is how to make it all possible. There is a process with different stages, learning, challenges, adaptations, and growth. A good way to define the process is to consider the Build-Measure-Learn feedback loop mentioned by Eric Ries in his book *The Lean Startup* (Ries, 2011). The process begins with the creation of the business idea. In the beginning, our team was not very clear about the direction we wanted to take. We had had other projects in the past in different sectors, such as sustainable hygiene products and aquaculture, and none of them worked because we felt we did not have a proper connection and understanding of the area. This time we wanted to work on something we were passionate about, an area we were genuinely curious about. The management showed to be focused on photovoltaic systems, not certain in what sense, but we kept investigating that path and eventually we were able to build our first version of Energreen, which is about the implementation of AVC systems on farms in Portugal. Immediately, we jumped into the Build-Measure-Learn feedback loop process, where we presented our idea, built it, worked on an MVP design, high-level measured the impact because it was too early to perform an in-depth analysis, obtained data, learned, and implemented feedback constantly. As Energreen's role is to be an intermediary, we got constant feedback from the client and the engineer, as shown in **Figure**

16, where we had a constant feedback loop, as their information was key to the project. The GoBerry farm or the engineer would provide input data that would be taken into account in the system and turn some output data that would be analyzed to provide positive or negative feedback. If the feedback was positive, we will implement it and if it was negative, we will redefine it.

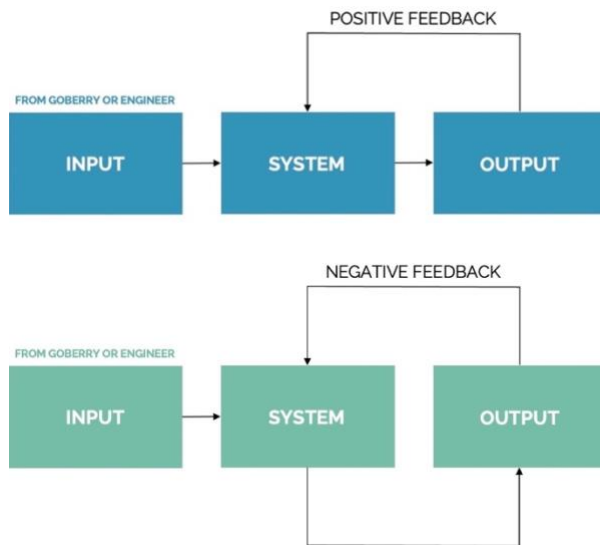


Figure 15: *Feedback Loop*

Learnings and the Know-how that has been developed throughout the project, the key unit of progress for startups are learning (Ries, 2011). The last 4 months have been a constant learning process for Energreen and for me personally. I stepped out of my comfort zone and my expertise; however, it has been the best decision for my final work project because I have had the opportunity to develop a very meaningful project for our society, the environment, and the future of the agricultural industry. Nowadays, the idea of becoming an entrepreneur is very popular, however, from my experience, there are some key learnings that I can share. One of the first steps of entrepreneurship is to identify a problem and I would suggest focusing on a limited problem, it is not necessary to try to change the world all at once. In relation to team dynamics, it is important to

keep in mind that teamwork is necessary and appreciate the collaboration with other stakeholders, no one achieves great things alone. Additionally, it is important to perform an analysis such as the five whys to ensure that the team has the same understanding of the project. Considering that the client often does not know what they need, in the case of Energreen, it was important for us to show them colorful graphs and figures in order for them to be able to better follow the information we shared. Also, it is essential to keep time in mind, from the moment the hypotheses are defined the next steps must be immediately driven, there will be many setbacks with the feedback loop that consumes time, and it is important to keep them in mind, at this point we were not able to manage time in the most efficient way possible. Those setbacks would make us feel frustrated from time to time, but it is important to preserve challenges as learning experiences. At last, it is very important to gather as much information as possible about the industry the entrepreneur is trying to penetrate.

For personal challenges, entrepreneurship comes along with uncertainty and consequently, challenges. I personally faced challenges since the beginning of the project. First, I found it difficult to achieve a concrete idea, there were many open questions and paths to take, and I did not feel confident about my expertise in the topics. From my side, I had no connections in the industry we chose, and the language barrier had an impact on communication, making it a painful process at the beginning. Later, during the development process, I was anxious to know if we were progressing or not. When we faced times of negative feedback or suggestions from experts, it was difficult to decide if should stick to our plan or if we should reshape the idea. Changes and adapting were not always simple. Even though we conducted much research and worked in close collaboration with the farm, I also felt worried about the quality of the system simulation and if it would meet the expectations. Moreover, being an intermediary makes time management a big challenge because we were always depending on the input of the other stakeholders. Also, defining

our two Business Model versions was not simple for me. And finally, securing funding is not the simplest step.

5. Bibliography

- Almeida, M, C Marques, S Morgado, N Meio, and B Campos . 2020. "Distributed generation impact on the Portuguese distribution grid regarding power quality." *CIREN - Open Access Proceedings Journal* 477 – 479.
- Beylot, A, J Payet, C Puech, N Adra, P Jacquin, I Blanc, and D Beloin-Saint-Pierre. 2012. "Environmental impacts of large-scale grid-connected ground-mounted PV installations ." *Renewable Energy* 1-5.
- Burney, J, L Woltering, M. B Burke, R Naylor , and D Pasternak. 2010. "Solar-powered drip irrigation enhances food security in the Sudano-Sahel." *Proceedings of the National Academy of Sciences* 107(5):1848-53.
- Choi, C. S, S Ravi, I. Z Siregar, F. G Dwiyanti, J Macknick, M Elchinger, and N Davatzes. 2021. "Combined land use of solar infrastructure and agriculture for socioeconomic and environmental co-benefits in the tropics." *Renewable and Sustainable Energy Reviews* Vol. 151, 111610.
2022. *Cleantech Forum Europe*. March 30. Accessed December 10, 2022. <https://www.cleantech.com/event/cleantech-forum-europe-live/>.
- CMA CGM . 2021. " 2021 SUSTAINABLE DEVELOPMENT REPORT." NON-FINANCIAL PERFORMANCE REPORT, MARSEILLE.
- Dupraz, C, G Talbot, H Marrou, J Wery, S Roux, L Fabien, Y Ferard, and A Nogier. 2011. "To mix or not to mix : evidences for the unexpected high productivity of new complex agrivoltaic and agroforestry systems." *Resilient Food Systems for a changing world : 5th World Congress of Conservation Agriculture* Resilient Food Systems for a changing world : 5th World Congress of Conservation Agriculture.
- Dupraz, C, H Marrou, G Talbot, L Dafour, A Nogier, and Y Ferard. 2011. "Combining solar photovoltaic panels and food crops for optimising land use: Towards new agrivoltaic schemes." *Renewable Energy* 2725-2732.
- ECEEE. 2019. *European council for an energy efficient economy*. <https://www.eceee.org/policy-areas/2030-policy-framework/>.
- Elamri, Y, B Cheviron , J. M Lopez, C Dejean, and G Belaud. 2018. "Water budget and crop modelling for agrivoltaic systems: Application to irrigated lettuces." *Agricultural Water Management* 440-453.
- Encyclopedia. 2018. *Sustainable Development*. June 08. Accessed November 28, 2022. <https://www.encyclopedia.com/earth-and-environment/ecology-and-environmentalism/environmental-studies/sustainable-development>.
- European Commission. 2022. "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS." European Commission, Brussels.
- Giri, Nimay Chandra , and Ramesh Chandra Mohanty. 2022. "Agrivoltaic system: Experimental analysis for enhancing land productivity and revenue of farmers." *Energy for Sustainable Development* 54–61.
- Giry, N.G , and R. C Monhanty. 2022. "Agrivoltaic system: Experimental analysis for enhancing land productivity and revenue of farmers." *Energy for Sustainable Development* 54-61.

- Goetzberger, A, and A Zastrow. 1982. "On the Coexistence of Solar-Energy Conversion and Plant Cultivation." *International Journal of Solar Energy* 55-69.
- GoParity. 2022. *GoParity*. Accessed 11 15, 2022. <https://goparity.com/faqs/what-are-the-requirements-to-become-a-project-promoter%3F-16>.
- Gorjian, S, E Bousi, Ö. E Özdemir, M Trommsdorff, N. M Kumar, A Anand, K Kant, and S. S Chopra. 2022. "Progress and challenges of crop production and electricity generation in agrivoltaic systems using semi-transparent photovoltaic technology." *Renewable and Sustainable Energy Reviews* Vol. 158, 112126.
- King, Carey W. 2015. *American Scientist*. <https://www.americanscientist.org/article/the-rising-cost-of-resources-and-global-indicators-of-change>.
- Lambers, Hans, F. Stuart Chapin, and Thijs Pons. 1999. *Plant Physiological Ecology*. ESA Journals.
- Marrou, H, L Dufour, and J Wery. 2013. "How does a shelter of solar panels influence water flows in a soil–crop system?" *European Journal of Agronomy* 50:38-51.
- Marrou, H, L Guilioni, L Dufour, C Dupraz, and J Wery. 2013. "Microclimate under agrivoltaic systems: Is crop growth rate affected in the partial shade of solar panels?" *Agricultural and Forest Meteorology* 117-132.
- Mavani, D. D, P.M Chauhan, and V Joshi. 2019. "Beauty of Agrivoltaic System regarding double utilization of same piece of land for Generation of Electricity & Food Production." *International Journal of Scientific & Engineering Research* Volume 10, Issue 6, ISSN 2229-5518.
- Ministers, Presidency of the Council of. 2019. "DECREE LAW No. 162/2019." *Diário da República*. October 25. Accessed 12 04, 2022. <https://dre.pt/dre/en/detail/decree-law/162-2019-125692189>.
- Molone, Eva de. 2019. *What Makes a Successful Startup Team*. Harvard Business Review.
- Myers, Shelby. 2022. *FB.org*. 10. <https://www.fb.org/market-intel/analyzing-farm-inputs-the-cost-to-farm-keeps-rising>.
- Precedence Research. 2022. *Agrivoltaics Market Size, Growth Report, Trends, 2022-2030*. Ottawa, ON: Precedence Research.
- Revolu Sun. 2019. *Revolu Sun*. <https://massachusetts.revolusun.com/blog/carbon-footprint-of-solar-panel-manufacturing/>.
- Ries, Eric. 2011. *The Lean Startup*. New York: Crown Business .
- Schindele, S, M Trommsdorff, A Schlaak, Tabea Oberfell, Georg Bopp, C Reise, C Braun, et al. 2020. "Implementation of agrophotovoltaics: Techno-economic analysis of the price-performance ratio and its policy implications." *Applied Energy* Vol.265, 114737.
- Sekiyama , T, and A Nagashima. 2019. "Solar Sharing for Both Food and Clean Energy Production: Performance of Agrivoltaic Systems for Corn, A Typical Shade-Intolerant Crop." *Environments* 6(6), 65.
- Silva, Luís , and Siddharth Sareen. 2020. *Solar photovoltaic energy infrastructures, land use and sociocultural context in Portugal*. Taylor and Francis.
- Solvasto. 2020. *Investment, Photovoltaic, Self-consumption, UPAC*. 02 20. Accessed 11 02, 2022. <https://solvasto.pt/self-consumption-4/?lang=en>.
- Talbot, G, S Roux, A Graves, C Dupraz, H Marrou, and J Wery. 2014. "Relative Yield Decomposition: A Method for Understanding the Behaviour of Complex Crop Models." *Environmental Modelling & Software* 136-48.
- Toledo, Carlos, and Alessandra Scognamiglio. 2021. "Agrivoltaic Systems Design and Assessment: A Critical Review, and a Descriptive Model towards a Sustainable

- Landscape Vision (Three-Dimensional Agrivoltaic Patterns)." *Sustainability* (Italian National Agency for New Technologies) 13, 6871.
- Trommsdorff, Max, Simon Gruber, T Keinath, M Hopf, C Hermann, and F Schönberger. 2022. *Agrivoltaic: Opportunities for Agricultural and the Energy transition*. Germany: Fraunhofer Institute for Solar Energy Systems ISE.
- Trommsdorff, Max, Jinsuk Kang, Christian Reise, Stephan Schindele, Georg Bopp, Andrea Ehmman, Axel Weselek, Petra Högy, and Tabea Oberfell. 2021. "Combining food and energy production: Design of an agrivoltaic system applied in arable and vegetable farming in Germany." *Renewable and Sustainable Energy Reviews* Vol. 140, 110694.
- UN. 2022. *THE 17 GOALS*. <https://sdgs.un.org/goals>.
2017. *Union of Concerned Scientist*. December 20. Accessed 12 10, 2022. <https://www.ucsusa.org/resources/benefits-renewable-energy-use>.
- Weselek, Axel, Andrea Ehmman, Sabine Zikeli, Iris Lewandowski, Stephan Schindele, and Petra Högy. 2019. *Agrophotovoltaic systems: applications, challenges, and opportunities. A review*. INRA and Springer-Verlag France SAS, part of Springer Nature 2019.
- Wu, Z, A Hou, C Chang, X Huang, D Shi, and Z Wang. 2014. "Environmental Impacts of Large-Scale CSP Plants in Northwestern China." *Environmental Science: Processes & Impacts* 16 (10), 2432-41.
- Zoratti, L, L Jaakola, H Häggman, and L Giongo. 2015. "modification of Sunlight Radiation through Colored Photo-Selective Nets Affects Anthocyanin Profile in *Vaccinium* spp. Berries." *PloS one* 10(8).

6. Appendix

Energreen Company Logo



Energreen

Visits to the GoBerry Farm



GoBerry Farm's fruit before harvesting



GoBerry Farm's fruit after harvesting



The area proposed by GoBerry Farm to install PV system (drone view)



Area to install PV system at GoBerry Farm



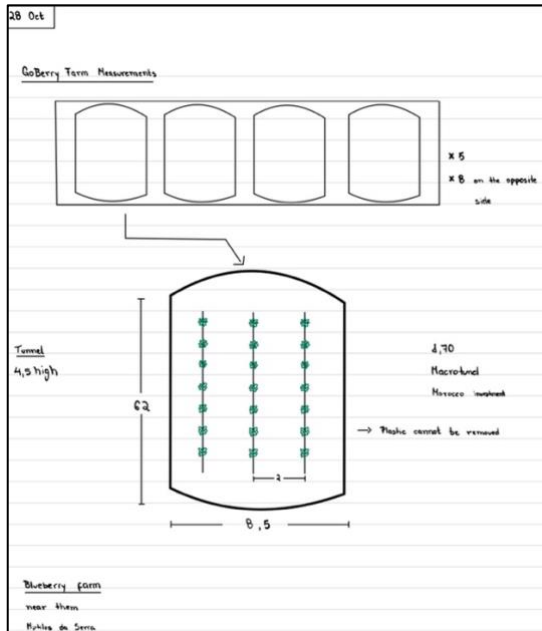
Goberry Company Logo



Quinta de Mirtilos da Serra



Meeting sketch



Development process of the MVP

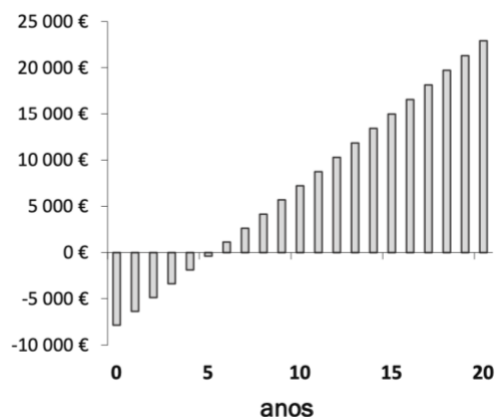
MVP Development Process

- 1 Project definition
- 2 Location definition
- 3 Crop selection
- 4 Crop classification
- 5 Farm's area study
- 6 Government requirements
- 7 Alignment with engineer
- 8 System simulation design

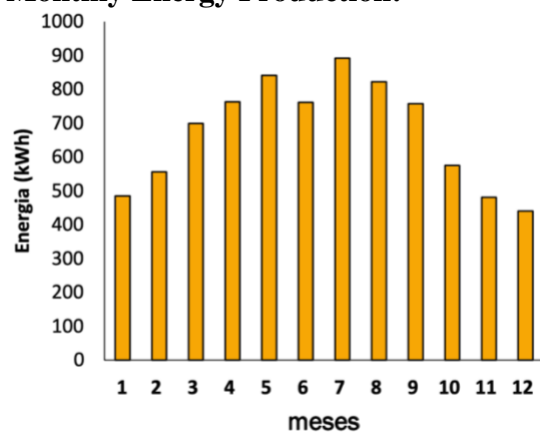
System Simulation for GoBerry:

PV System Go Berry – Option 1: 4kW System

Return on Investment (ROI):



Monthly Energy Production:



Financial Plan 4kW System:

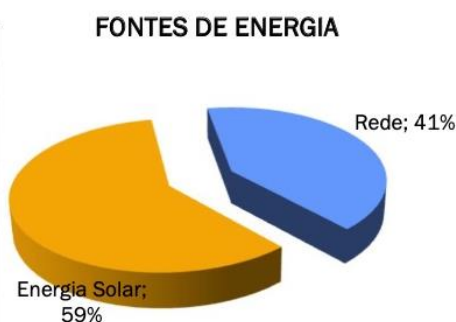
	Poupança	Despesas	CashFlow	Acumulado
Ano 0		- 7 850 €	- 7 850 €	- 7 850 €
Ano 1	€ 1 481	- €	1 481 €	- 6 369 €
Ano 2	€ 1 487	- €	1 487 €	- 4 882 €
Ano 3	€ 1 492	- €	1 492 €	- 3 390 €
Ano 4	€ 1 497	- €	1 497 €	- 1 893 €
Ano 5	€ 1 503	- €	1 503 €	- 390 €
Ano 6	€ 1 508	- €	1 508 €	1 118 €
Ano 7	€ 1 514	- €	1 514 €	2 632 €
Ano 8	€ 1 520	- €	1 520 €	4 152 €
Ano 9	€ 1 526	- €	1 526 €	5 678 €
Ano 10	€ 1 532	- €	1 532 €	7 210 €
(...)				
Ano 20	€ 1 600	- €	1 600 €	22 893 €

Technical proposal for 4 kW system – Auto-consumption system analysis:

ANÁLISE SISTEMA DE AUTOCONSUMO

Localidade	Almargem do Bispo
Consumo Anual de Eletricidade	7 186,20 kWh
Gasto Anual em Eletricidade	€ 1 763,50
Consumo em horário de Ponta e Cheia	100%
Tarifa	Tetra-Horario
Ciclo de Consumo	Ciclo Diário
Potência Contratada	13,8 kVA

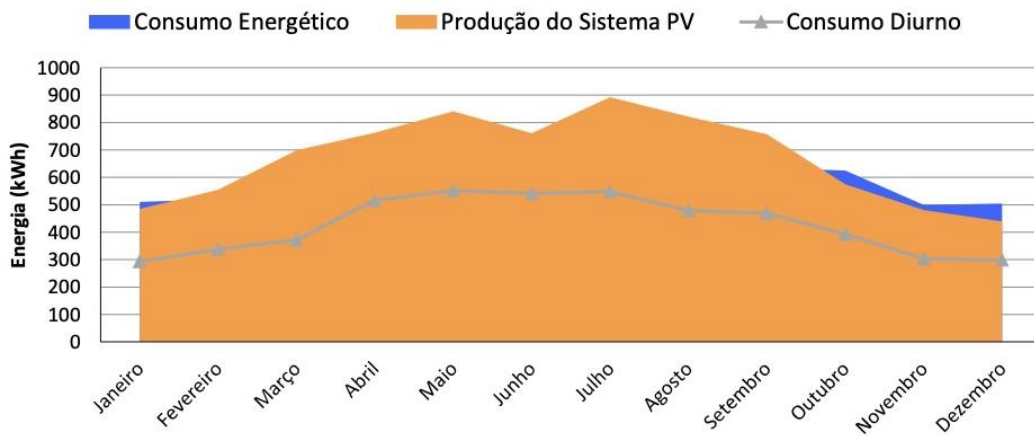
POTÊNCIA FOTOVOLTAICA	4 905 Wp
Potência nominal (inversores)	4 000 W
Número de módulos	9
Área bruta necessária	20,25 m ²
Energia produzida anual	8 072 kWh
Poupança anual na fatura	4 248 kWh
Poupança anual na fatura (€)	€ 911,71
Energia produzida excedente	47%
Energia produzida em HP e HC	98%
Energia Excedente	3 824 kWh
Valor de venda da energia excedente*	€ 569,81



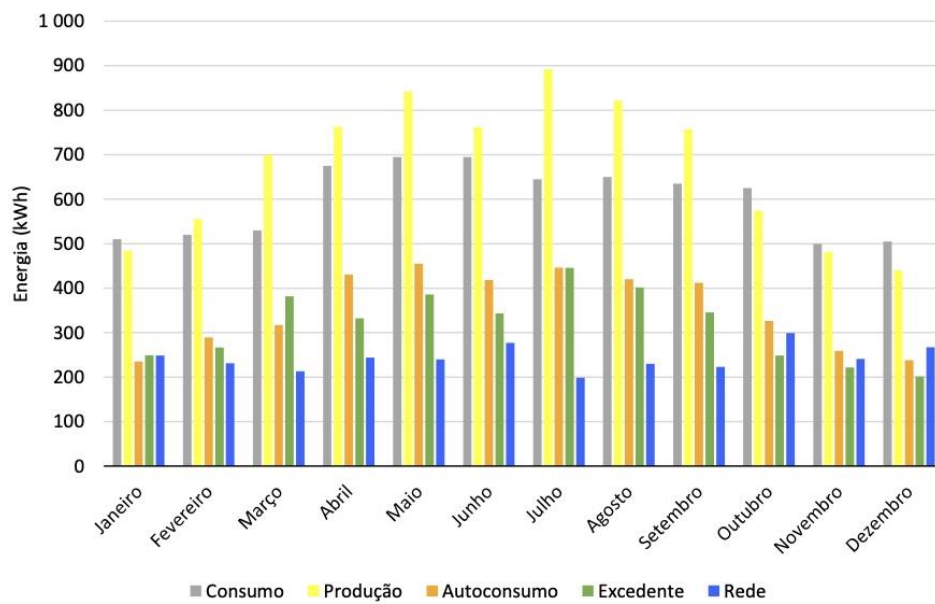
INVESTIMENTO INICIAL	€ 7 850,00
Inflação anual	1%
Amortização Autoconsumo (anos)	5,3
TIR Autoconsumo	18,6%
Poupança em 20 anos	€ 22 893,12
Preço do kWh solar produzido a 20 anos	€ 0,0681
Preço do kWh pago à rede no último ano	€ 0,212

Esta simulação de desempenho do sistema constitui uma estimativa não vinculativa baseada na informação sobre o consumo fornecida pelo cliente e informação de irradiação solar disponível para esta localização. A adjudicação da oferta detalhada e vinculativa prevê um levantamento mais detalhado ao local e o subsequente trabalho de engenharia para determinar a configuração e a localização final dos módulos, inversores e restantes componentes, análise dos consumos e tarifário escolhido.

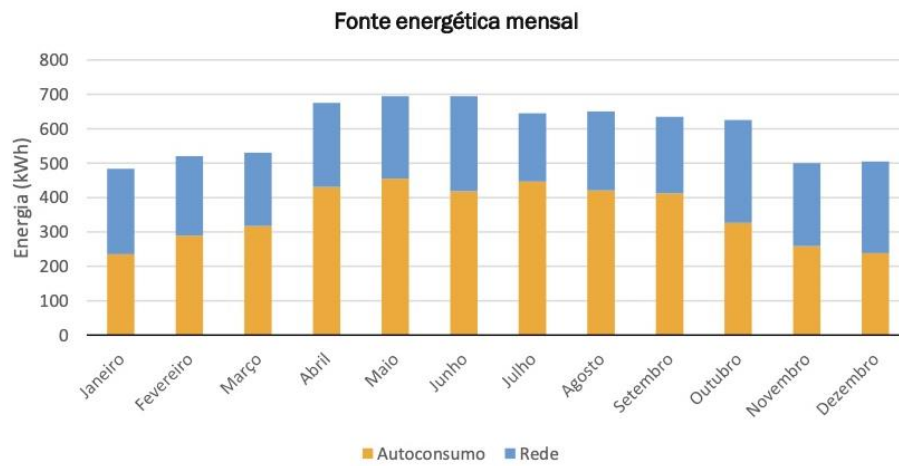
Medium Energy Production vs Consumption:



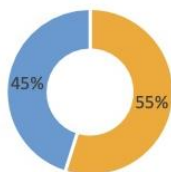
Monthly Energy Analysis:



Technical proposal for 4 kW system – Auto-consumption system analysis IV

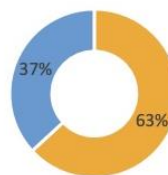


Inverno



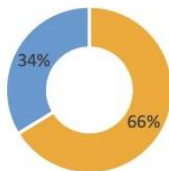
■ Autoconsumo ■ Rede

Primavera



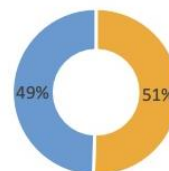
■ Autoconsumo ■ Rede

Verão



■ Autoconsumo ■ Rede

Outono



■ Autoconsumo ■ Rede

Modules Layout – Option 1



Project, system, results summary



PVsyst V7.2.21

VC1, Simulation date:
13/12/22 13:28
with v7.2.21

Project: Monica Santos

Variant: 4kW System

DC-PV Lda (Portugal)

Project summary

Geographical Site		Situation		Project settings	
Almargem		Latitude	38.84 °N	Albedo	0.20
Portugal		Longitude	-9.27 °W		
		Altitude	273 m		
		Time zone	UTC		
Meteo data					
Almargem					
Meteonorm 8.0 (1991-2013), Sat=66% - Synthetic					

System summary

Grid-Connected System		No 3D scene defined, no shadings			
PV Field Orientation		Near Shadings		User's needs	
Fixed plane		No Shadings		Unlimited load (grid)	
Tilt/Azimuth	30 / 0 °				
System information					
PV Array					
Nb. of modules	9 units	Inverters		1 unit	
Pnom total	4905 Wp	Nb. of units		4000 W	
		Pnom total		1.226	
		Pnom ratio			

Results summary

Produced Energy	8.05 MWh/year	Specific production	1641 kWh/kWp/year	Perf. Ratio PR	80.92 %
-----------------	---------------	---------------------	-------------------	----------------	---------

Table of contents

Project and results summary	2
General parameters, PV Array Characteristics, System losses	3
Main results	5
Loss diagram	6
Special graphs	7

AC wiring losses & Main results

AC wiring losses

Inv. output line up to injection point

Inverter voltage 400 Vac tri
 Loss Fraction 0.00 % at STC
Inverter: SUN2000-4KTL-M1
 Wire section (1 Inv.) Copper 1 x 3 x 2 mm²
 Wires length 0 m

Main results

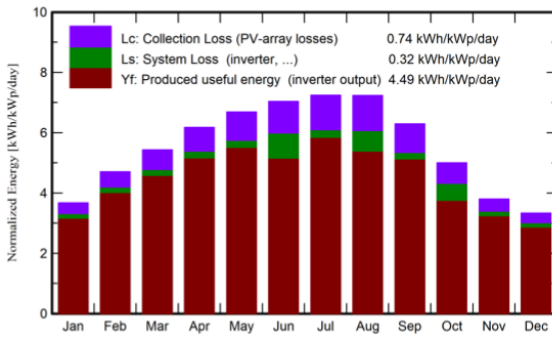
System Production

Produced Energy 8.05 MWh/year

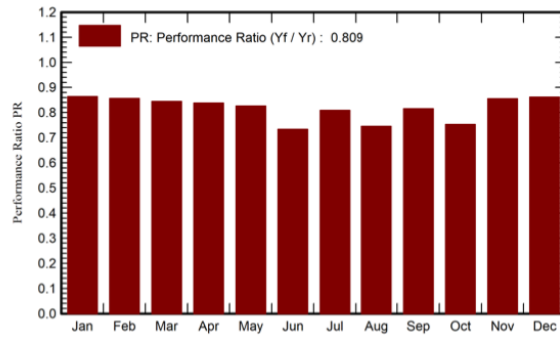
Specific production
 Performance Ratio PR

1641 kWh/kWp/year
 80.92 %

Normalized productions (per installed kWp)



Performance Ratio PR



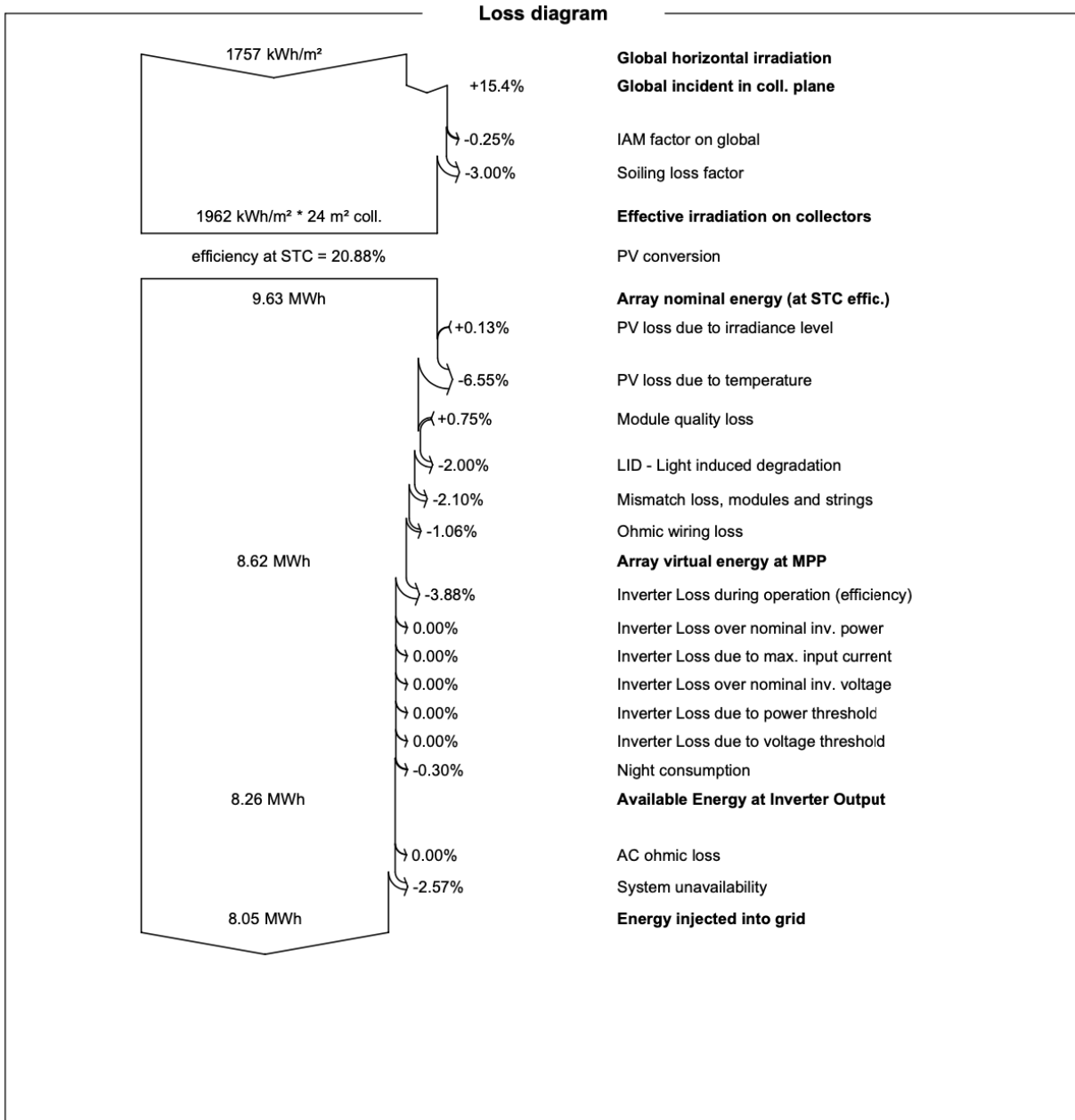
Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m ²	kWh/m ²	°C	kWh/m ²	kWh/m ²	MWh	MWh	ratio
January	70.0	28.29	10.78	113.8	110.3	0.505	0.482	0.863
February	91.3	32.96	11.30	131.7	127.6	0.577	0.553	0.856
March	135.9	51.05	13.41	168.4	163.0	0.727	0.697	0.844
April	170.0	67.73	14.78	185.2	179.1	0.793	0.761	0.838
May	210.6	72.86	17.67	207.2	200.1	0.875	0.840	0.826
June	224.1	69.76	20.28	211.2	204.0	0.883	0.760	0.734
July	233.8	60.52	21.96	224.4	217.1	0.928	0.891	0.809
August	212.9	59.27	22.86	224.2	216.9	0.924	0.820	0.746
September	159.5	51.72	21.01	188.9	182.8	0.787	0.756	0.816
October	113.6	39.50	18.43	155.0	150.1	0.658	0.572	0.753
November	73.9	31.93	13.62	114.1	110.5	0.501	0.479	0.855
December	61.5	26.26	11.51	103.4	100.2	0.459	0.437	0.862
Year	1756.9	591.83	16.50	2027.4	1961.7	8.619	8.047	0.809

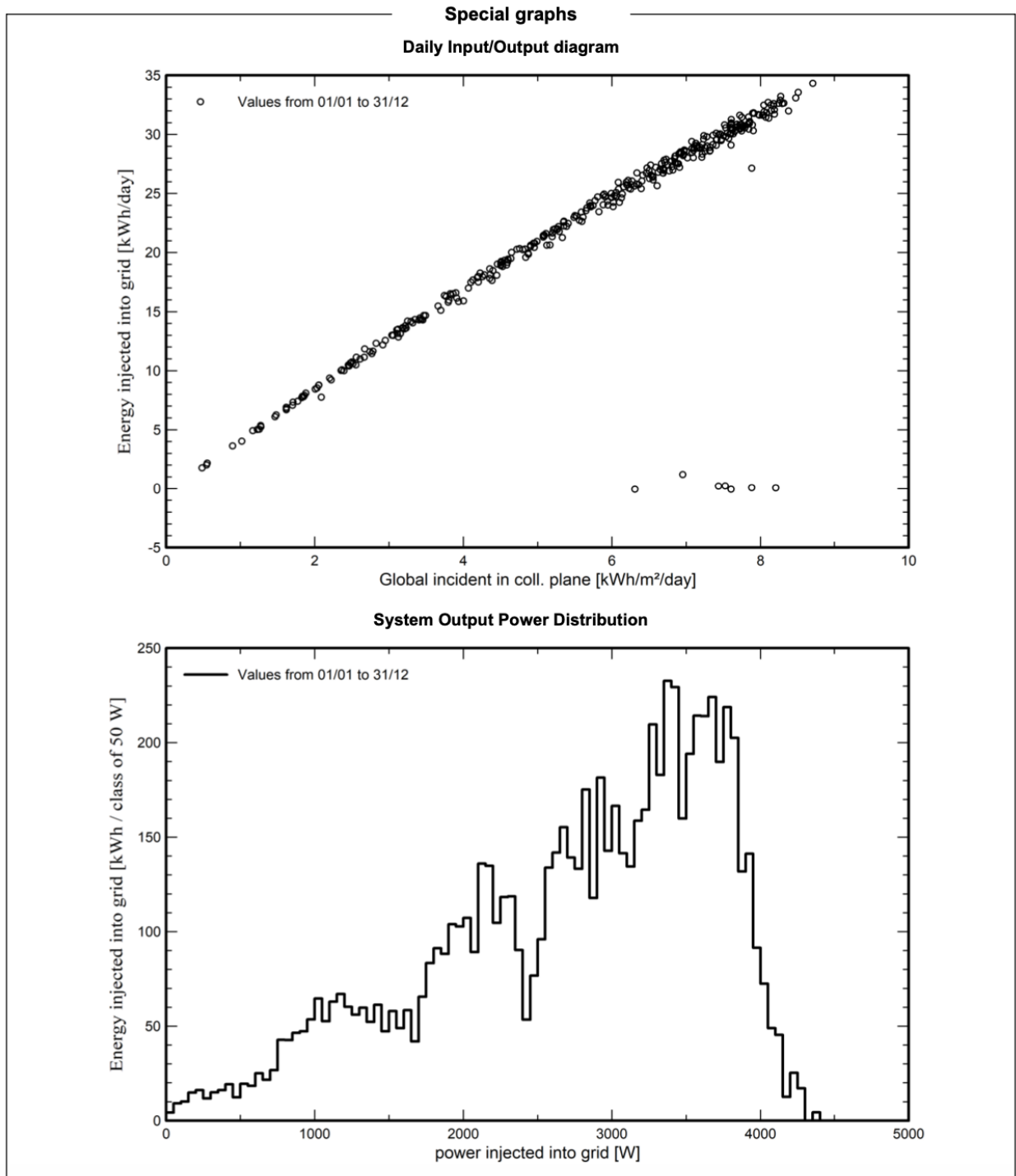
Legends

GlobHor Global horizontal irradiation
 DiffHor Horizontal diffuse irradiation
 T_Amb Ambient Temperature
 GlobInc Global incident in coll. plane
 GlobEff Effective Global, corr. for IAM and shadings
 EArray Effective energy at the output of the array
 E_Grid Energy injected into grid
 PR Performance Ratio

Loss diagram



Daily Input/Output diagram & System Output Power Distribution



PV module – Option 1



TITAN
HIGH PERFORMANCE
MONOCRYSTALLINE PERC MODULE


G5.6

Draft

RSM110-8-535M-555M

110 CELL Mono PERC Module	535-555Wp Power Output Range
1500VDC Maximum System Voltage	21.2% Maximum Efficiency

KEY SALIENT FEATURES

-  Global, Tier 1 bankable brand, with independently certified state-of-the-art automated manufacturing
-  Industry leading lowest thermal co-efficient of power
-  Industry leading 12 years product warranty
-  Excellent low irradiance performance
-  Excellent PID resistance
-  Positive tight power tolerance
-  Dual stage 100% EL Inspection warranting defect-free product
-  Module Imp binning radically reduces string mismatch losses
-  Warranted reliability and stringent quality assurances well beyond certified requirements
-  Certified to withstand severe environmental conditions
 - Anti-reflective & anti-soiling surface minimise power loss from dirt and dust
 - Severe salt mist, ammonia & blown sand resistance, for seaside, farm and desert environments
 - Excellent mechanical resistance:
wind load 2400Pa & snow load 5400Pa




















ISEN ENERGY CO., LTD.

isen Energy is a leading, global tier 1 manufacturer of high-performance solar photovoltaic products and provider of total business solutions for residential, commercial and utility-scale power generation. The company, founded in 1986, and publicly listed in 2010, compels value generation for its chosen global customers. Techno-commercial innovation, underpinned by summate quality and support, encircle Risen Energy's total Solar PV business solutions which are among the most powerful and cost-effective in the industry. With local market presence and strong financial bankability status, we are committed, and able, to building strategic, mutually beneficial collaborations with our partners, as together we capitalise on the rising value of green energy.

LINER PERFORMANCE WARRANTY

Inverter

Smart Energy Controller



Active Safety

AI Powered
Active Arcing Protection



Higher Yields

Up to 30% More Energy
with Optimizer ¹



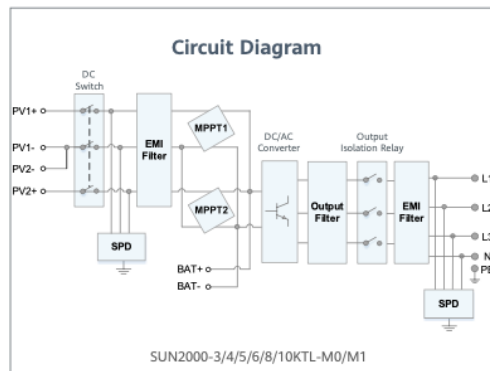
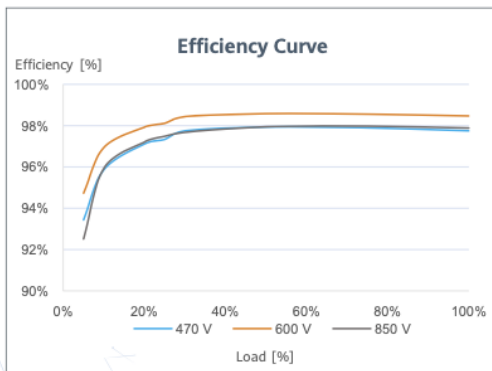
Battery Ready

Plug & Play battery interface ²



Flexible Communication

WLAN, Fast Ethernet, 4G
Communication Supported



¹ Only applicable to SUN2000-3/4/5/6/8/10KTL-M1 smart energy center.
² SUN2000-3/4/5/6/8/10KTL-M0 will be compatible with HUAWEI smart string ESS in Q1, 2021

PV system with Heating and Battery – Option 2: 6 kW System with Batteries

Modules Layout - Option 2.



Project Overview and PV System

Grid-connected PV System with Electrical Appliances and Battery Systems

Climate Data	Sintra, PRT (1996 - 2015)
Values source	Meteonorm 8.1(i)
PV Generator Output	6,78 kWp
PV Generator Surface	31,0 m ²
Number of PV Modules	12
Number of Inverters	1
No. of battery systems	2

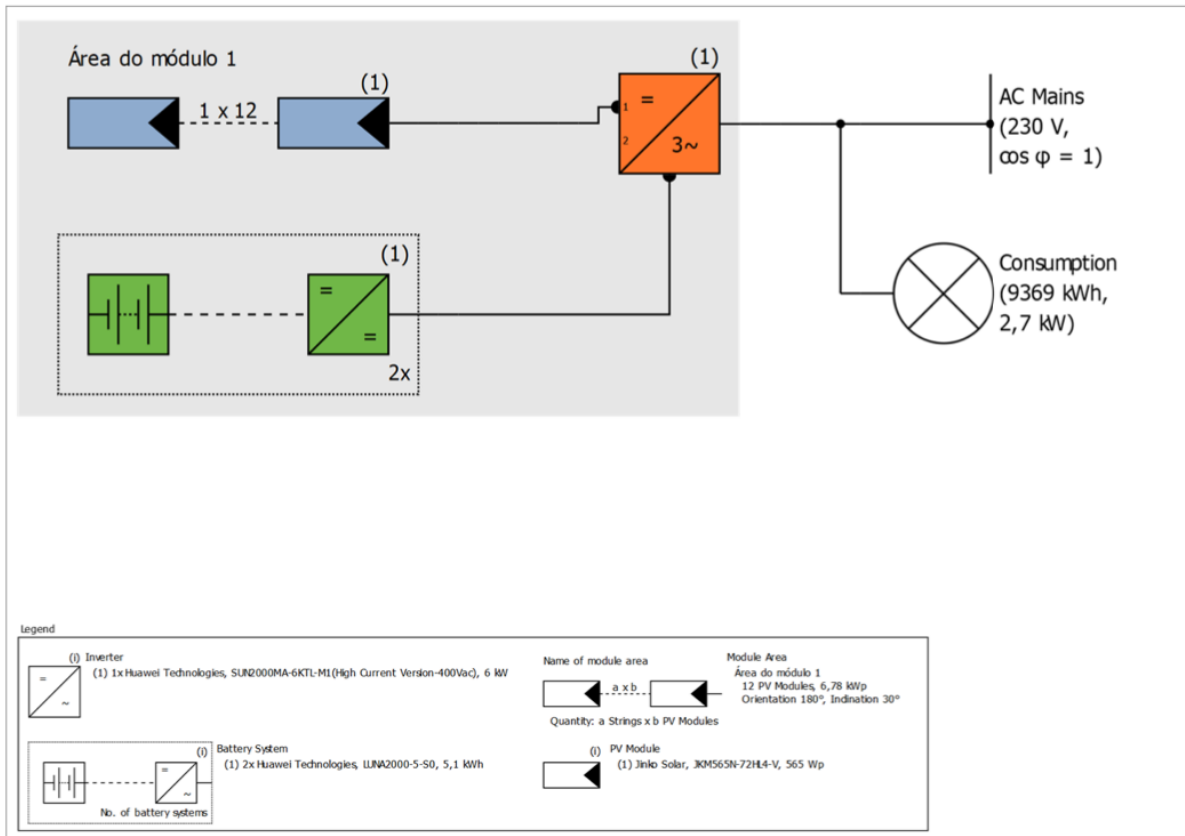


Figure: Schematic diagram

Production Forecast

Production Forecast

PV Generator Output	6,78 kWp
Spec. Annual Yield	1 715,44 kWh/kWp
Performance Ratio (PR)	86,53 %
PV Generator Energy (AC grid) with battery	11 332 kWh/Year
Direct Own Use	7 418 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Grid Feed-in	3 914 kWh/Year
Own Power Consumption	65,4 %
CO ₂ Emissions avoided	5 161 kg / year
Level of Self-sufficiency	79,0 %

System Setup

System Data

Type of System	Grid-connected PV System with Electrical Appliances and Battery Systems
----------------	---

Climate Data

Location	Sintra, PRT (1996 - 2015)
Values source	Meteonorm 8.1(i)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

Consumption

Total Consumption	9369 kWh
Consumos PVsol	9369 kWh
Load Peak	2,7 kW

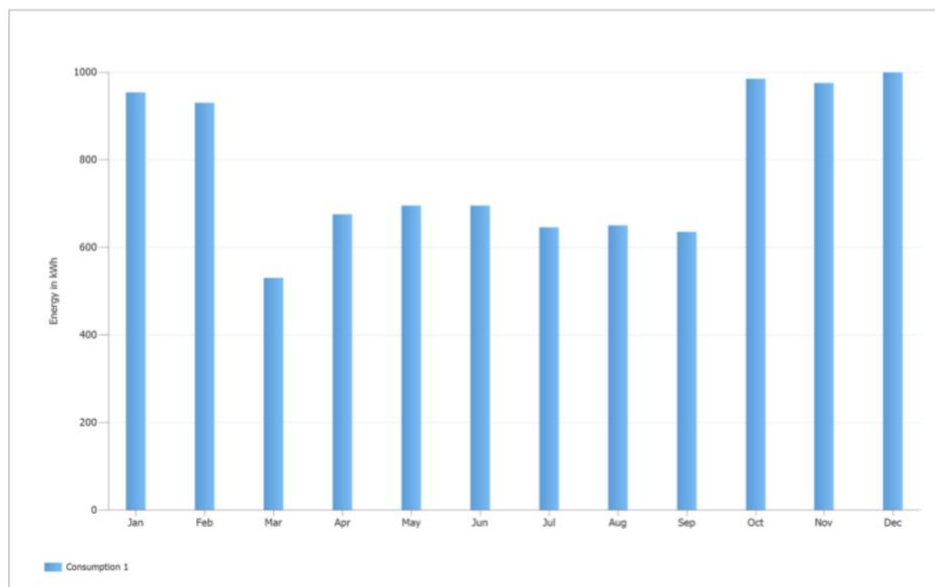


Figure: Consumption

Module Areas

1. Module Area - Área do módulo 1

PV Generator, 1. Module Area - Área do módulo 1

Name	Área do módulo 1
PV Modules	12 x JKM565N-72HL4-V (v1)
Manufacturer	Jinko Solar
Inclination	30 °
Orientation	South 180 °
Installation Type	Roof parallel
PV Generator Surface	31,0 m ²

Inverter configuration

Configuration 1

Module Area	Área do módulo 1
Inverter 1	
Model	SUN2000MA-6KTL-M1(High Current Version-400Vac) (v1)
Manufacturer	Huawei Technologies
Quantity	1
Sizing Factor	113 %
Configuration	MPP 1: 1 x 12 MPP 2: not allocated

AC Mains

AC Mains

Number of Phases	3
Mains voltage between phase and neutral	230 V
Displacement Power Factor (cos phi)	+/- 1

Battery Systems

Battery System

Model	LUNA2000-5-S0 (v4)
Manufacturer	Huawei Technologies
Quantity	2
Battery Inverter	
Type of Coupling	DC intermediate circuit coupling
Nominal output	2,5 kW
Battery	
Manufacturer	Huawei Technologies
Model	LUNA2000-5KW-E0 (v2)
Quantity	1
Battery Energy	5,1 kWh
Battery Type	Lithium iron phosphate

Simulation Results:

PV System

PV Generator Output	6,78 kWp
Spec. Annual Yield	1 715,44 kWh/kWp
Performance Ratio (PR)	86,53 %

PV Generator Energy (AC grid) with battery	11 332 kWh/Year
Direct Own Use	7 418 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Grid Feed-in	3 914 kWh/Year

Own Power Consumption 65,4 %

CO₂ Emissions avoided 5 161 kg / year

PV Generator Energy (AC grid) with battery



■ Direct Own Use
■ Down-regulation at Feed-in Point
■ Grid Feed-in

Appliances

Appliances	9 369 kWh/Year
Standby Consumption (Inverter)	21 kWh/Year

Total Consumption	9 390 kWh/Year
covered by PV power with battery	7 418 kWh/Year
covered by grid	1 972 kWh/Year

Solar Fraction 79,0 %

Total Consumption



■ covered by PV power with battery
■ covered by grid

Battery System

Charge at beginning	10 kWh
Battery Charge (PV System)	2 736 kWh/Year
Battery Energy for the Covering of Consumption	2 417 kWh/Year
Losses due to charging/discharging	294 kWh/Year
Losses in Battery	36 kWh/Year
Cycle Load	7,5 %
Service Life	13 Years

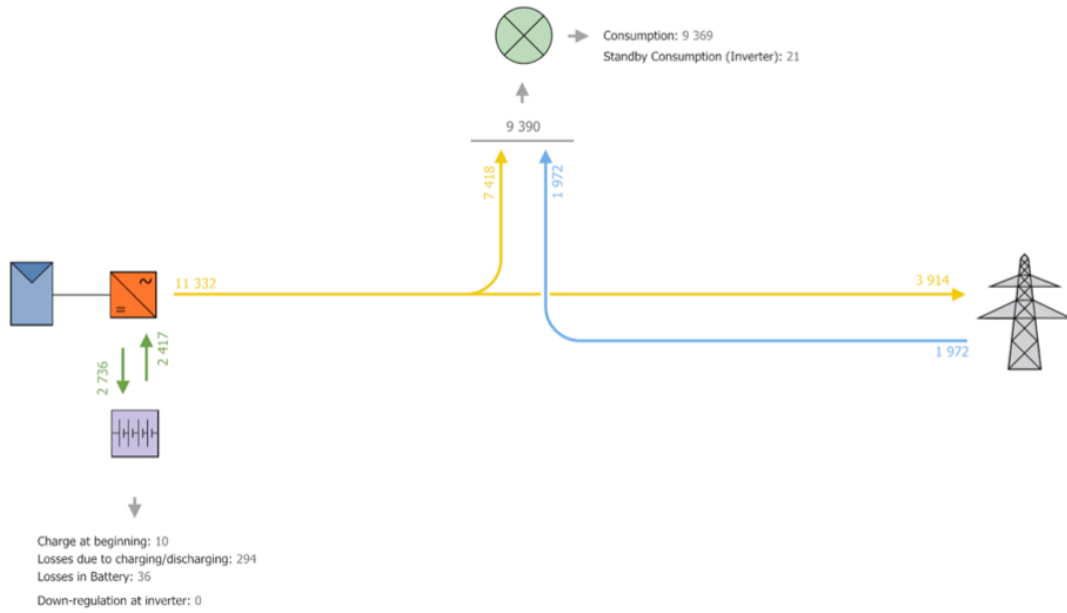
Level of Self-sufficiency

Total Consumption	9 390 kWh/Year
covered by grid	1 972 kWh/Year
Level of Self-sufficiency	79,0 %

Energy Flow Graph:

Energy Flow Graph

Project: Mónica Santos



All values in kWh
Small deviations in the totals can occur due to rounding
created with PV*SOL

Energy Consumption and coverage over the year:

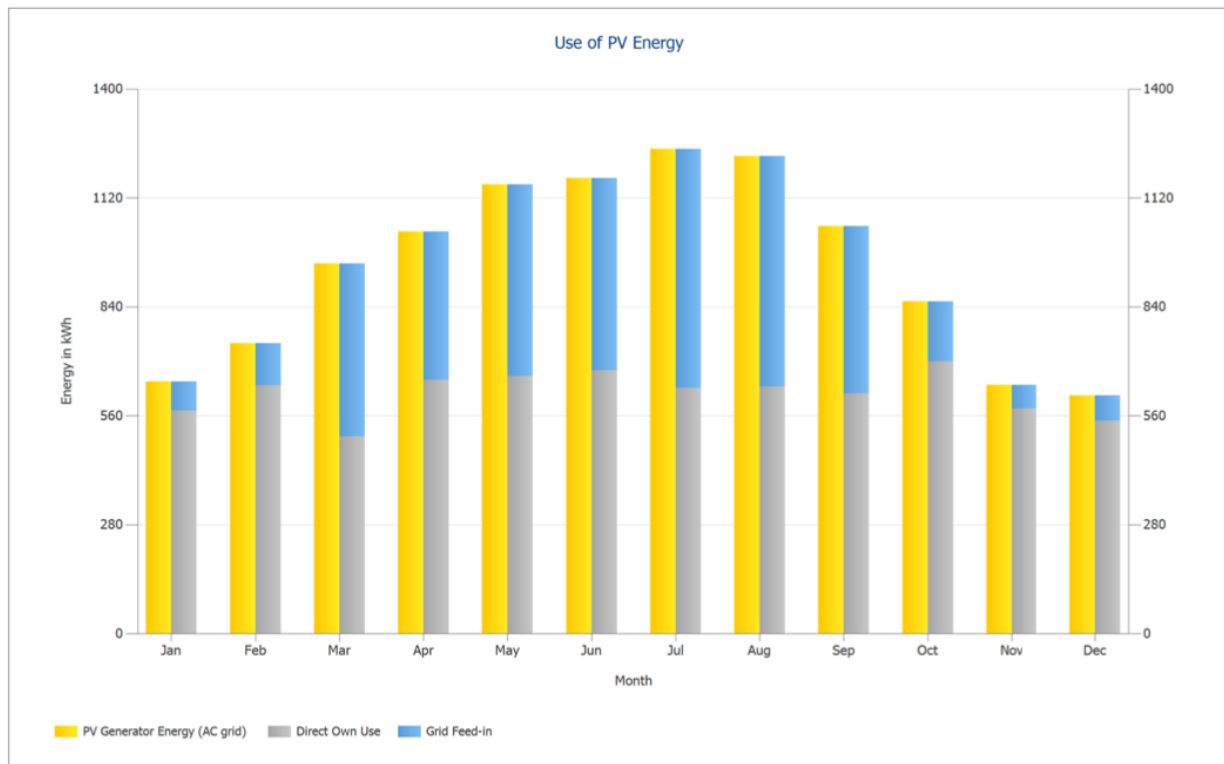


Figure: Use of PV Energy

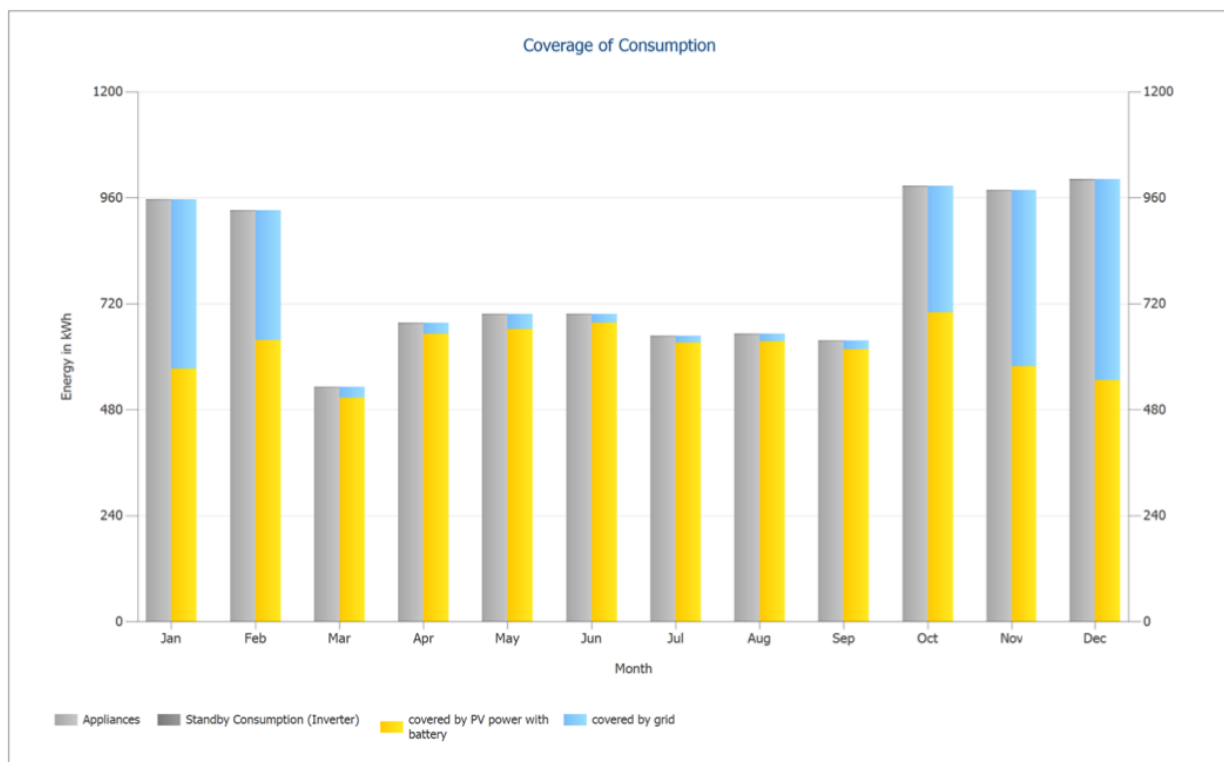
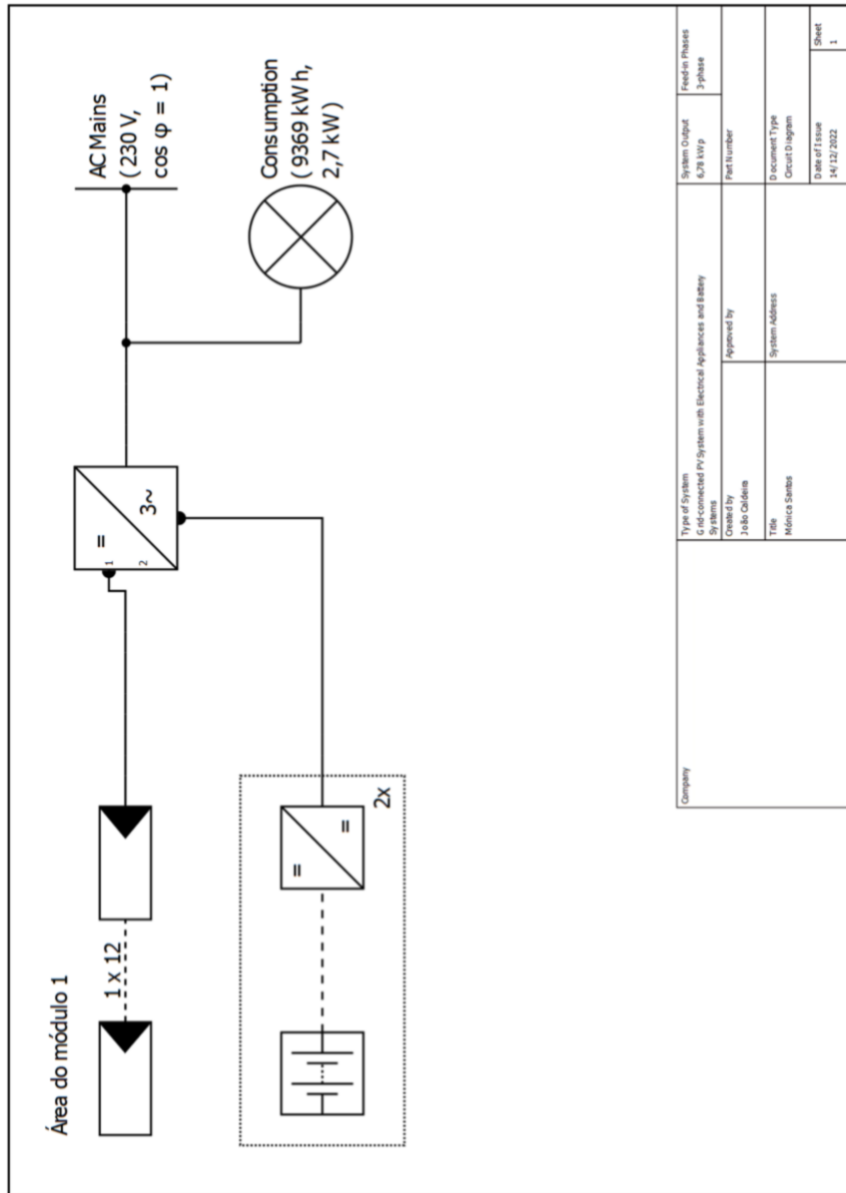


Figure: Coverage of Consumption

Plans and Parts List:



Parts List:

#	Type	Item number	Manufacturer	Name	Quantity	Unit
1	PV Module		Jinko Solar	JKM565N-72HL4-V	12	Piece
2	Inverter		Huawei Technologies	SUN2000MA-6KTL-M1(High Current Version-400Vac)	1	Piece
3	Battery System		Huawei Technologies	LUNA2000-5-S0	2	Piece

PV Modules Option 2

Tiger Neo N-type 72HL4-(V) 555-575 Watt MONO-FACIAL MODULE

N-Type

Positive power tolerance of 0~+3%

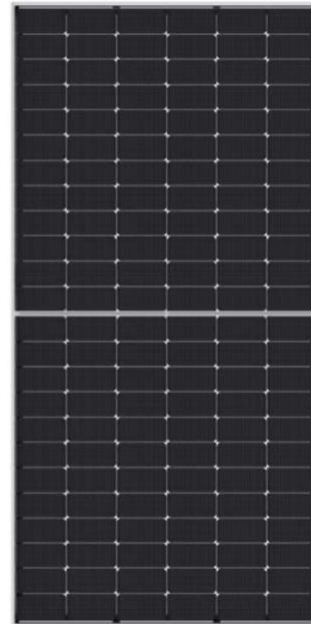
IEC61215(2016), IEC61730(2016)

ISO9001:2015: Quality Management System

ISO14001:2015: Environment Management System

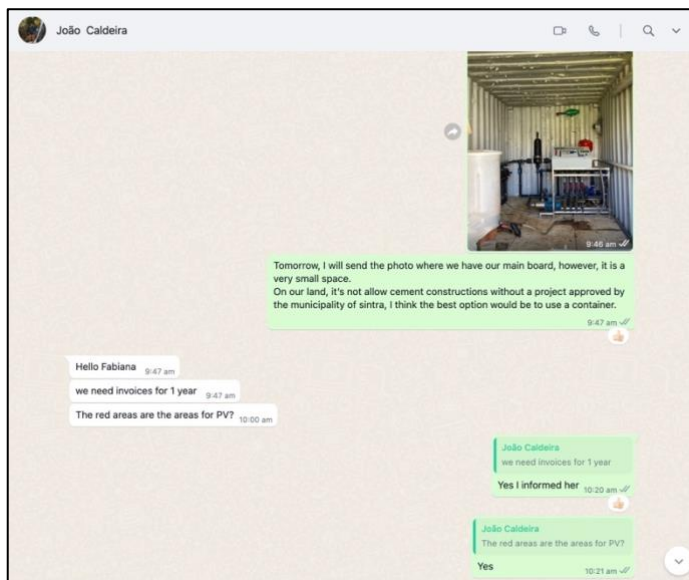
ISO45001:2018

Occupational health and safety management systems

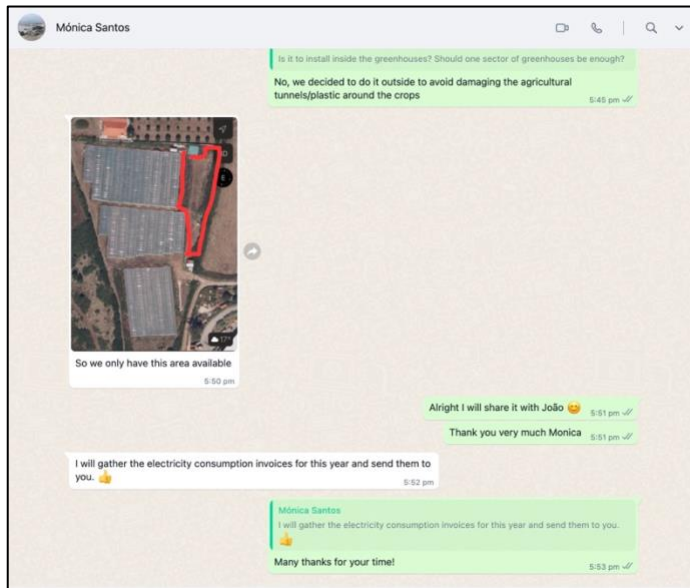


Communication:

Alignment with João Caldeira



Alignment with Mónica Santos



Email with João Caldeira

