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.

Agrivoltaic System Validation:
Implementation into a Raspberry Farm

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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

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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.

2. 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.

2.1 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.

2.1.1 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.

2.1.2 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.

2.1.3 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.

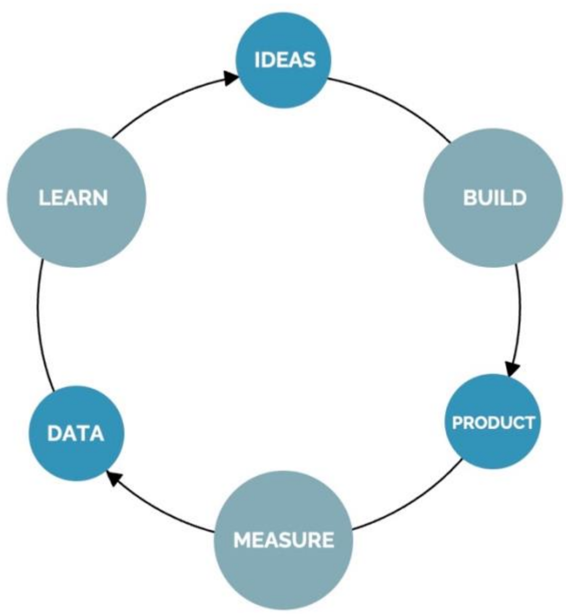

Figure 1: *Build-Measure-Learn feedback loop*

2.1 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**.

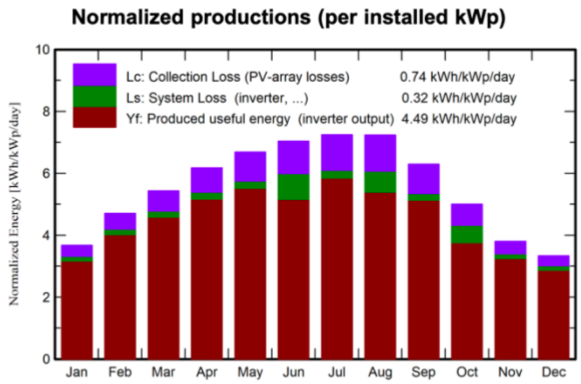

Figure 2: *Normalized energy production per installed kWp*

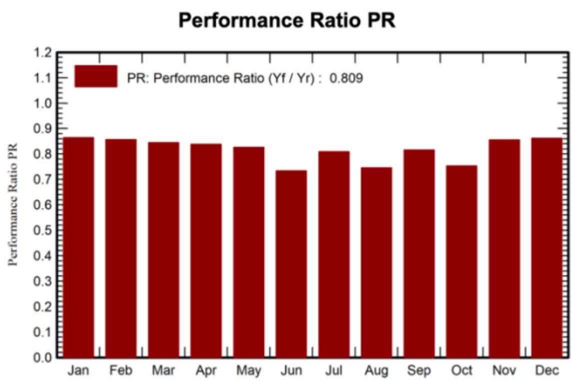

Figure 3: *Performance ratio of the PV system*

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%.

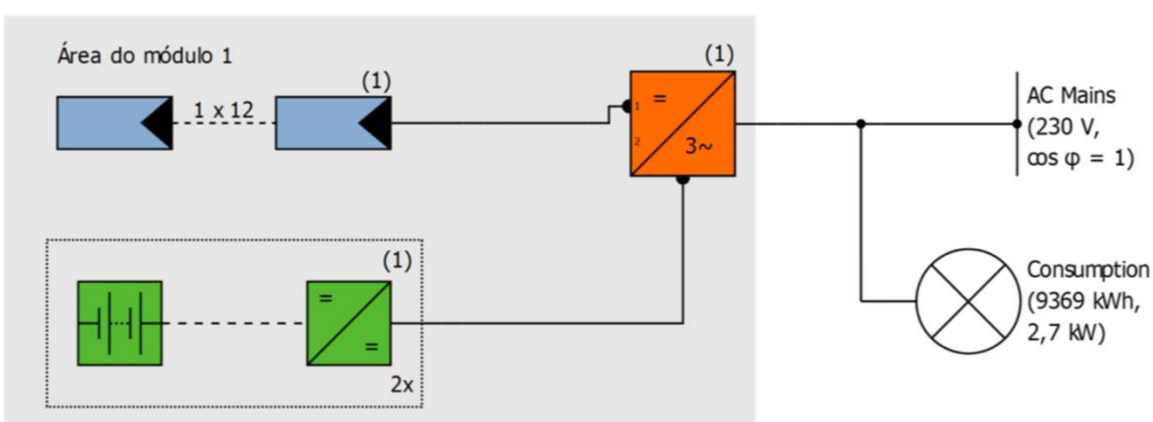

Figure 4: *Layout of the installation with PV, heating, and batteries (technical drawing)*

With this system in place, GoBerry keeps its plants at moderate temperatures never under 10ºC 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.

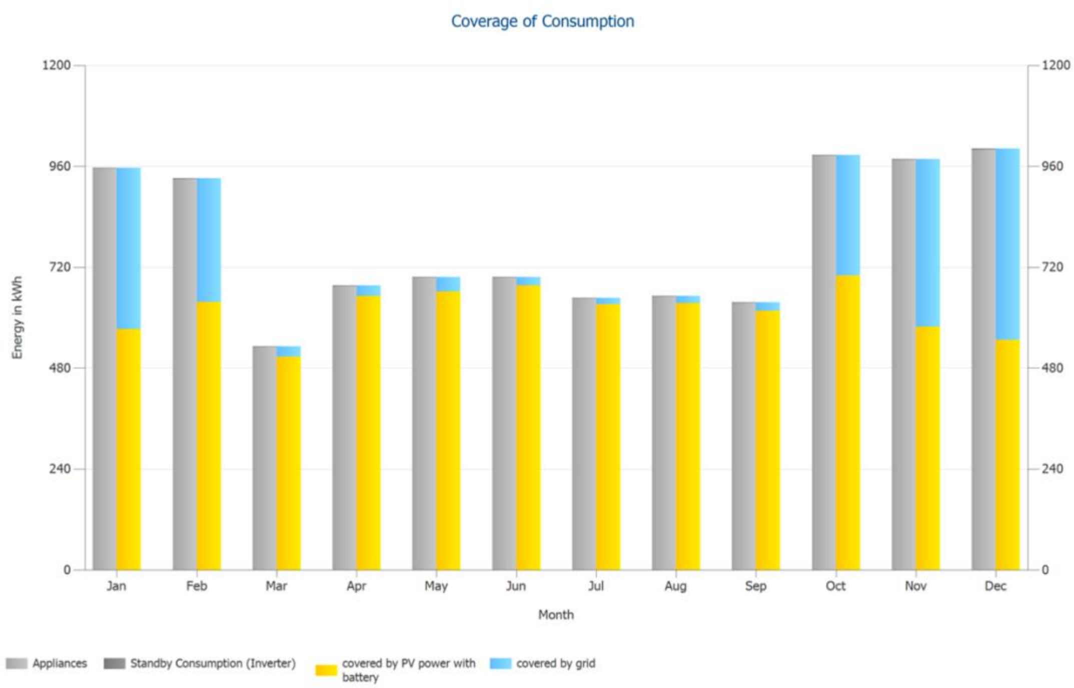

Figure 5: *Coverage of the consumption throughout the year*

2.2 Funding of the MVP

As Energreen does not have sufficient capital and GoBerrry 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.

2.3.1 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.

2.3 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.

2.4.1 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.

2.4.2 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.

2.4.3 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 CO_2 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 CO_2, and produce clean energy. Additionally, those investments provide diversification for their portfolio to support sustainable projec

3. ACCELERATE

As most decisions are not clear from the start of the venture, there are many more questions arising when accelerating and planning the next steps. According to Ries, the first critical step is to create a clear differentiation between which are the activities that will create the actual value, and which will only become a form of waste (Ries 2011). Therefore, in the following part, we are providing an outlook on how Energreen is proceeding with the projects and what the future steps of the venture are in alignment with the vision.

3.1 Grow

The future steps of Energreen are presented until the end of Q2 2023, where first, a short heads-up is provided to understand the current situation of each pilot project. The planning is divided between the two pilot projects of GoBerry and Mirtilos da Serra, as both are in different states of development. For a better representation and visualization, there is a timeline given in **Figure 15**, that illustrates the next steps of the MVPs in more detail.

3.1.1 GoBerry

The planning phase of the AVC project with GoBerry is almost complete, since most of the data, required documents, and design have been fulfilled. The project has obtained the system simulation with two possible solutions, where the solutions are presented to the owners of GoBerry beginning of 2023. The next steps for GoBerry are to take the decision if the pilot project should be implemented as the stand-alone PV solution, or with the batteries and the possibility of installing a heating system. Once they have met a decision, the internal planning process can start and the funding application considering the requirements necessary with GoParity can take place between January and February 2023, as shown in **Figure 15**. In this phase the project is entering the launch stage and is seeking to receive the required funding from GoParity investors. The last alignment call took place on the 12th of December, to inform the GoParity team about the current state of the project and to identify uncertainties and missing information. Usually, the funding of a project required around 30 days to be successfully completed. As soon as the funding has been received, the implementation can start and the PV modules, the inverter, and the cables can be ordered through the partners. The habitual delivery time for the PV modules can take up to 2 to 3 weeks, the inverter around 2 months, and the batteries within three months. Once the equipment is received the system can be installed and taken to go live at the GoBerry farm. The go live of GoBerry is expected to be between March and June if every delivery runs well. Once the system is installed, a couple of training sessions will take place with Mónica and her team about the fundamentals, how the system can be administrated, safety measures, and what requirements to set. From this point on, there is a continuous remuneration of the loan from GoParity to pay back the loan and the interest rate for the system. Energreen will continue to stay in constant contact with GoBerry, to get valuable insights and to support with system-related matters to ensure a positive value for the customer.

3.1.2 Mirtilos da Serra

Energreen is starting the implementation and planning of the second pilot project with the blueberry farm Mirtilos da Serra in the next weeks, where the first site visits and drafts are planned between December and January of the following year. For this project, there is an actual AVC system planned, as the layout of the farm is an ideal fit to place PV modules over the blueberry plants. In the meantime, Energreen is taking care of the planning and making sure, that all the necessary stakeholders are connected, and that the relevant information is provided to execute the project. With the experience gained from the first pilot, this pilot is expected to be developed in a shorter time. As shown in **Figure 15**, the project simulation for Mirtilos da Serra is planned between February and March 2023, where the implementation is expected to be at the end of June 2023, considering a buffer of two to three months. Looking at the funding options for this project is not clear yet if external funding is required, as this information hasn't been provided.

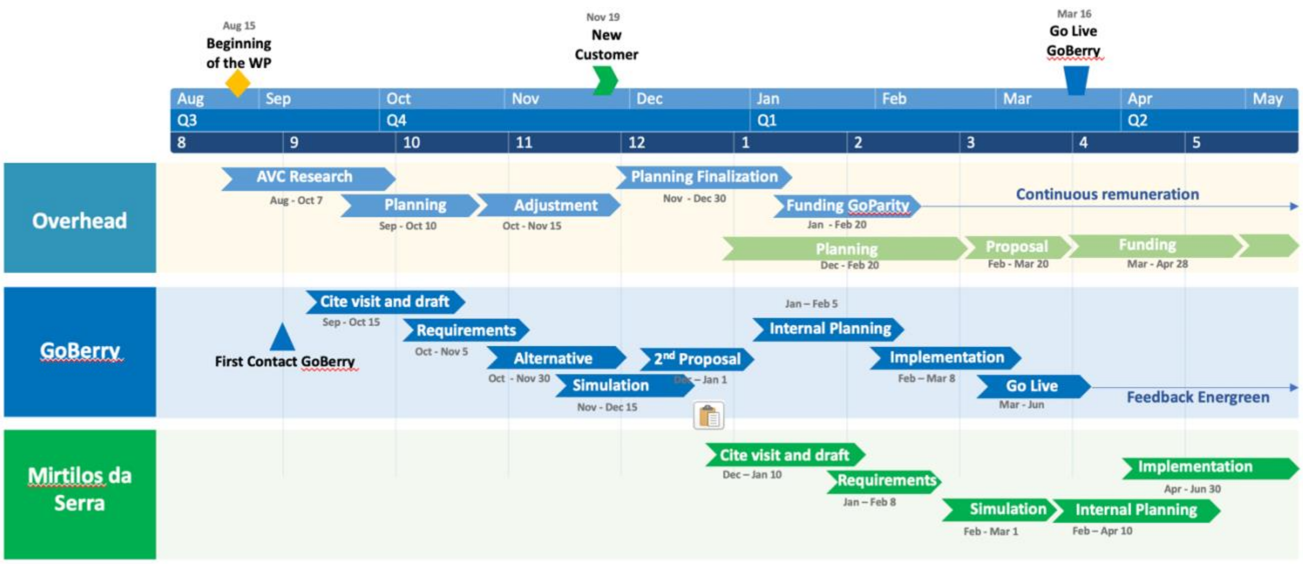

Figure 6: *Future steps of the MVPs*

3.2 Adapt

In the long term, the venture is seeking to develop more projects in Portugal and across Europe to launch and scale its business. The scaling phase of Energreen is taking place after the two pilot projects have been implemented and completed, and the feedback and learnings can be looped and applied. According to Ries, there are different aspects to consider when growing and scaling the business, as the lean startup only works, if the organization is adaptable, agile, and quick as the challenges that it faces. Especially considering the fact, that Energreen is planning to grow through the evolution of one business model into another one makes the scalability extremely interesting and challenging. At the same time, this underlines the adaptation of the organization. Therefore, the right timing must be found when to switch to the buy and lease back business model, as this is capital intensive and requires a lot of know-how and the right customers. "New customers come from the actions of previous customers" is identified as a source for achieving sustainable growth in a startup (Ries 2011).

For Energreen, there have been two primary ways elaborated past customers drive sustainable growth to attract new customers and scale the venture. The first one is the word of mouth, which is considered the most natural way. Successfully implemented AVC systems serve as a duplicator and satisfied customers tell their friends and colleagues about Energreen. This method has been proven with the acquisition of Mirtilos da Serra, as the contact got established through the owners of GoBerry. The other way to attract new customers is through fairs and paid advertisements. Many potential customers can be found especially at fairs and congresses, where specific interest groups meet. Those can be attracted by opening a paid stand and going into the conversation with potential clients to consult about the advantages of AVC systems on their farms.

Additionally, for the venture, there are crucial partnerships key for the development and the scaling, as Energreen is serving as an intermediary between the different parties. Especially relying on the engineer and designer João Caldeira exposes the venture to a potential dependency. Therefore, agreements have been made to align a common vision and to make sure, that also during the scaling he can provide his help. For future scalability, it is relevant to hire an engineer and bring those values inside the company, to ensure no dependency on external services.

4. Conclusion

In the following part, the conclusions of the project are presented. Enclosing the team journey with its dynamic, challenges, and learnings obtained throughout the journey. This part is followed by the Aha! Moments which were identified during the project development. Followed by a final analysis of the hypotheses initially determined to identify which were ratified and which were redefined. And finally, the endgame of Energreen's report. This section is not in the Methodology included, however, is required for the WP to conclude.

4.1 Energreen team journey

Energreen was able to find, connect, and establish a good and respectful group dynamic throughout the project, where each of the team members has its tasks and core strength to develop the project and push the venture forward. Energreen's team is composed of two entrepreneurs with similar professional backgrounds, both have learned a close way of problem-solving, teamwork, and organization, however, each member had different weaknesses and strengths which made the exchange of ideas productive. For the team, it was always important to keep a healthy environment allowing a positive knowledge transfer and at the same time, room for discussing issues and problems throughout the project. As each has weaknesses and strengths, this helped to align the distribution of the work and specialized areas. Maximilian Hauser showed excellent management in the ideation of the project and estimating mostly the technical and financial aspects of the first pilots, on the other hand, Fabiana Jimenez is able to handle effectively the communication with the stakeholders, such as approaching customers and coordinating all agreements with both system installers and financial institutions, creating the ideal combination between technical and social aspect and allowing a successful bridge between the three main stakeholders. When it came to the direction, it can be said that both team members were equally involved and finally, it is worth mentioning that both members are highly motivated and committed to the project. As the idea was born through an inspirational presentation from Bertrand Piccard, motivation and inspiration were present, but a lot of knowledge and relation to the idea of AVC systems was missing. The members of Energreen had only very little experience in agricultural economic activities and renewables, but the idea sparked, to use the unlimited resource of the sun even further than already, especially in a country like Portugal with many sunny days and to raise awareness of the potential benefits of AVC systems across the agricultural industry. Therefore, the first challenge as a group was to build background knowledge on agricultural activity in Portugal, classic PV systems regulation in Portugal, and all about AVC systems. Initially, the team did not count on the expertise in the topic but on the necessary tools and project management skills to tackle the gap identified. Following the investigation process, the next challenge started with structuring the project to approach potential clients with an organized proposal. In the case of Energreen, it was necessary to first define the type of crop which could better work with the project to then look for potential customers. Finding the GoBerry farm was not difficult, yet the challenge was to get in contact with them and agree on a visiting appointment. For the technical aspect of the project, Energreen was missing the network with experts, developers, and installers. Also, the question of whom to partner with, the unavoidable trade-off decisions and together as a team steering the wheel every time adjustments were needed. As Eric Ries said, every difficulty along the way is a learning opportunity which will take it to the objective of the project (Ries 2011). The learning experience was mutual, the farmers learned the potential of the project and Energreen learned many aspects of agriculture, renewable energy, and sustainability. Some of the other lessons learned have been that in order to achieve value creation it is necessary to become more familiar with the farmers' point of view and their priorities in this case, also that every process takes time, that sometimes it is necessary to look at problems from the outside to identify what is not working, that taking a step backwards is not a bad sign, but rather a good opportunity to stop, reflect, adapt and continue. During the development and the many conversations with the customer and engineer, became clear that farmers like to see charts or figures with colors to understand better the metrics from such a project. Finally, this project has reinforced the Energreen team's entrepreneurial mindset, demonstrating that it does have all the potential that was initially expected.

4.2 Aha! Moments

The first Aha! The moment was to recognize the idea is scalable and that there is more demand for it. The Energreen project started out of pure inspiration that led to identifying a great need and gap in the industry. The first objective was basically to develop a pilot, however, after research and several conversations with different potential customers, it was recognized that there is great business potential in the idea of developing AVC systems on other farms. It was evident that it has been a great success to manage the connection between farmers, installers, and financial institutions. Therefore, the Energreen vision was expanded, and it was decided to create a scalable business model.

The second Aha! The moment was captured while adapting to one of the obstacles that were faced during the development of the MVP with GoBerry, which is the heating system powered by the PV system. The moment it was realized that it was not possible to install the solar panels between the crops, one of the best discoveries and AHA! moments occurred. This led to the idea of installing a heating system inside the farm tunnels that would be powered by the new PV system that the farm would be equipped with, offering the farm not only the production of electricity for all the needs but also the benefit of continuing to produce even in the coldest periods of the year, giving way to a higher income since the fruits during that period can be sold at a higher price. This helped to understand that Energreen has the capacity to face different types of customers and their challenges. With the right know-how and connections, it is possible to offer a solution to each client.

4.3 Results of the hypothesis and assumptions

This subchapter is focused on the final results of the project pilots. During the “Planning and Starting” face Energreen defined hypotheses, a strategy, and two versions of the Business Model. After the definition, implementation, and results of the system simulation, now it is key to have a look at the insights gathered along the journey. By looking at the assumptions and the hypothesis that were made prior to the start of the project, it is crucial to come back and examine if those have been rejected or proven, for building a strategic business venture. As the planning for one of the pilot projects has been completed, a respective number of experiences and results have been gathered, in which some of the assumptions had to be redefined.

1- An AVC farm is more environmentally and economically efficient.

AVC systems are in general more environmentally friendly, as it produces green energy and at the same time avoid the usage of external energy sources that might have been produced through fossils. However as shown in the system simulation, for certain projects, there is still external energy required, since during nighttime, no energy can be produced via the PV modules, and it is needed to cover the night consumption. Moreover, the installation of the system and the production of the modules generate a carbon footprint, where one PV module needs about 50g of CO_2 in the production (Revolu Sun 2019). In addition, farms that are using AVC systems are more economically effective, as they will be generating extra income by selling the energy produced. This is not the case for the GoBerry farm as the price paid by the electricity providers is too low to be considered, nevertheless, the farm will still obtain a revenue stream by becoming more independent from the energy providers and enjoying the monetary benefits of the heating system implementation powered by the PV modules electricity generated. Additionally, the investment is paid off in a short time. In Portugal, the paid-off time is shorter compared to other European countries.

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.*

The project has not yet reached the stage to prove or redefined this hypothesis, there has not been any experience gained to answer it. It is expected to be tested soon with the GoBerry MVP, followed by the Mirtilos da Serra MVP and then, further conclusions will be defined.

3- *AVC systems increase the potential for extended growing seasons.*

This hypothesis can be proven through different literature references and sources, as during extreme weather conditions like heavy rains, the panels provide the plant with extra protection. For the specific case of GoBerry, implementing the heating system will provide higher temperatures that lead to an extended growing season for the crops. With the pilot project from GoBerry Energreen is testing this soon in practice.

4- *A fruit farm such as raspberries or blueberries is an ideal combination to implement an AVC system.*

Crops such as chilly, berries and spinach are proven to be an ideal combination for AVC systems (Sekiyama und Nagashima 2019), as they are shade tolerant and have a high turnover rate (Marrou, Guilioni, et al. 2013). Therefore, Energreen is deciding to perform the first two pilots on berry farms, as they have an advantageous layout and conditions.

5- *Farmers often do not have sufficient capital to meet the high initial investment costs, thus, financing is often done externally.*

This hypothesis is partly correct, as most of the farmers in Portugal do not have enough capital to bear high investments like AVC systems and need to rely on external funding options, such as GoParity or the support of the European Union. However, there are a few farms that have enough capital to bear the costs. Moreover, throughout the process it was realized that for farmers there was a lack of time to analyze and implement innovative technologies. Therefore, they felt fortunate for the consultation of AVC systems that was provided by Energreen.

4.4 Endgame

In this working project, a framework was provided for the implementation of AVC systems into farms and how the venture is planning to scale its business after the pilots have been completed. This was accomplished by first validating, describing, and implementing a prototype of an AVC system into a raspberry farm and then pivoting the pilot to another berry farm. Furthermore, a vision for Energreen was established and a business model presented that provides value to all the stakeholders involved. The key hypotheses were tested and answered, by using external know-how from experts and the experience gained throughout this project. Although the MVP with GoBerry had to be adapted, the challenges were overcome, and a finalized planning was demonstrated. To conclude, Energreen has tested its hypotheses, provided its vision of the project with the aim to become a leader in the industry, 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.

5. 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.

5.1 Maximilian's Individual Learnings and Entrepreneurial Journey

Reflecting on the last month and the journey that we took with Energreen, there have been many experiences gained, learnings and knowledge acquired, and challenges faced.

I feel very identified with the purpose and the strategy of the venture and we found a gap in the market that has not been addressed accordingly. Moreover, our project creates a positive value for many different stakeholders with the implementation of AVC systems in farms. In addition, it delivers a sustainable and innovative solution for energy production. This project is something coming from my heart, considering that my grandparents were farmers and I always enjoyed spending time there, and now being a student at Nova SBE questioning established concepts. To have the possibility to innovate a part of this industry is a huge chance to take.

The key learnings I take with me from this project are the following: *Structure and good planning in advance save a lot of work* - one of the most crucial parts to developing a successful project is good planning. This saves a lot of effort and ensures focus on the key competencies by not wasting time with unnecessary tasks that lead to distraction throughout the project. *The Team is the most important asset* - as many entrepreneurs and founders say, the team is the main important asset, and a good team is crucial for a successful outcome of a project. To find someone that cares as much as you do about the project and is aligned with your work ethic and quality standard is key. Heterogeneity and discussions are highly relevant, but it is important that everyone pulls the same string together. *Dive deep into the topic to become an expert* - To become an expert in the field, it is necessary to dive deep into the matter and not only scratch the surface. Also, consider unfavorable opinions and look out for biases in the information. There is a lot of literature and articles available to learn and develop know-how on AVC systems and PV. I have acquired a lot of knowledge, especially in AVCs, but also renewables, energy, and crop farming. *It is important to talk to the right people* - For a successful implementation of the systems, it was necessary to speak with the right contacts, as they provided valuable insight like Manuel from GoParity, João Caldeira and Monica from GoBerry. Additionally, those contacts provided more contacts. *Dare to leave the comfort zone* – Seek feedback as many times as possible, as it is hard to realize when working and focusing on one goal, that you are aiming in the wrong direction. Therefore, it is important to get feedback and adapt the project to avoid getting stuck.

Throughout this project my personal entrepreneurial journey has evolved from knowing the theoretical approach of being an entrepreneur, to have hands-on experience, talking with customers, exchanging ideas with experts, and developing the venture. I got to change my mindset and way of thinking, where I realized more and more, that I want to create a positive impact and make my mark in the world and our society by building impactful ventures like Energreen.

This journey has been branded by many different obstacles and challenges that we needed to overcome. Especially taking into consideration the constant adaption of our pilots, the intercommunication skills to have everyone on board and sharing the same vision was fundamental. Moreover, I had and still have a lot of responsibility for the project and feel accountable to all the stakeholders. Another challenge was that I needed to develop my organizational and analytical skills, as those needed improvements at the start. Additionally, it was difficult to define the business model, as the goal was to scale the business and create value for all the stakeholders involved.

Overall, I set the fundament and the base to improve my skills and become an entrepreneur, become more open to social issues, and learned how to build solutions based on problems.

The group dynamic throughout the last months was very good, as each of us has weaknesses and strengths to compensate for each other. There has been a healthy environment created, that left room for discussions, misalignments, and misunderstandings, which then were openly addressed to find a common solution. Throughout our project, we have been very fortunate with the progress that was achieved, and I am very grateful for all the relationships we built. Moreover, I am looking forward to continuing to develop the venture by concluding the two pilot projects with GoBerry and Mirtilos da Serra and scaling up the startup.

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7. Appendix

Energreen Company Logo

Energreen

Visits to the GoBerry Farm

GoBerry Farm's fruit before harvesting

GoBerry Farm's fruit after harvesting

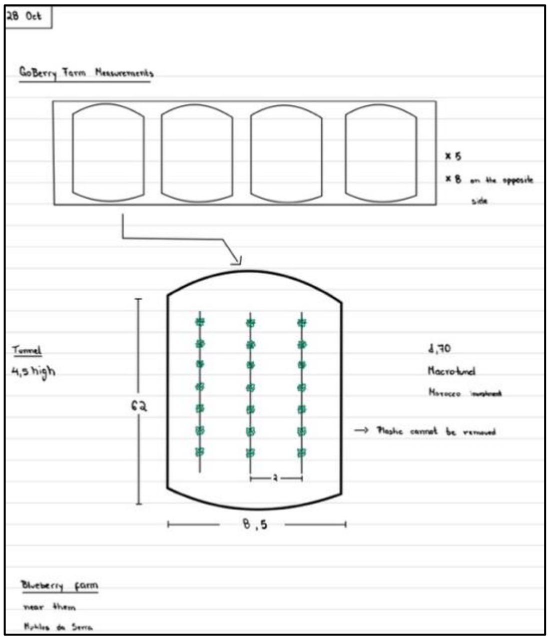
The area proposed by GoBerry Farm to install PV system (drone view)

Area to install PV system at GoBerry Farm

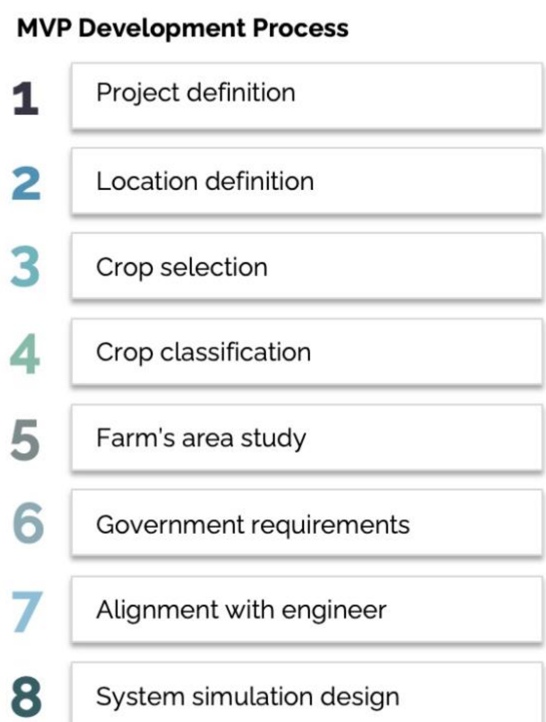
Goberry Company Logo

Quinta de Mirtilos da Serra

Meeting sketch



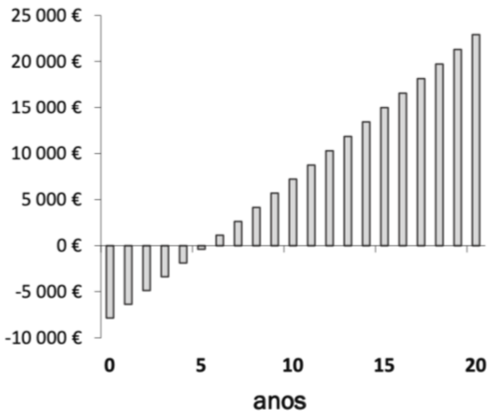
Development process of the MVP



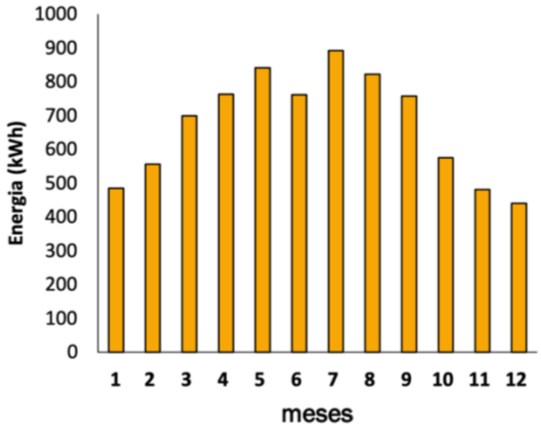
System Simulation for GoBerry:

PV System Go Berry – Option 1: 4kW System

Return on Investment (ROI):



Monthly Energy Production:



Financial Plan 4kW System:

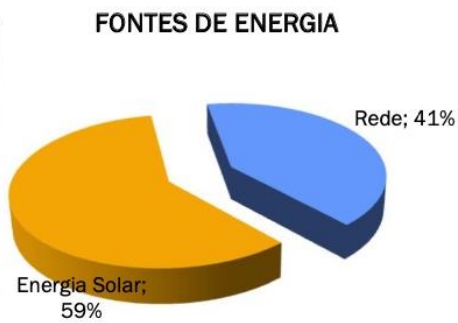
	Poupança	Despesas	CashFlow	Acumulado
Ano 0		- 7 850 €	- 7 850 €	- 7 850 €
Ano 1	€ 1 481	- €	1 481 €	- 6 369 €
Ano 2	€ 1 487	- €	1 487 €	- 4 882 €
Ano 3	€ 1 492	- €	1 492 €	- 3 390 €
Ano 4	€ 1 497	- €	1 497 €	- 1 893 €
Ano 5	€ 1 503	- €	1 503 €	- 390 €
Ano 6	€ 1 508	- €	1 508 €	1 118 €
Ano 7	€ 1 514	- €	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 Diario
Potência Contratada	13,8 kVA

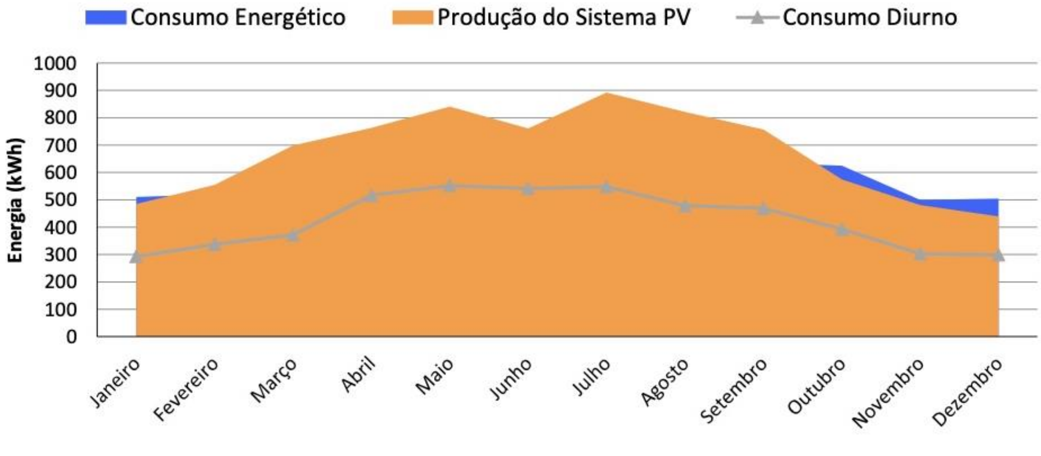
POTÊNCIA FOTOVOLTAICA	**4 905 Wp**
Potência nominal (inversores)	4 000 W
Número de módulos	**9**
Área bruta necessária	20,25 m2
Energia produzida anual	8 072 kWh
Poupança anual na fatura	4 248 kWh
Poupança anual na fatura (€)	**€ 911,71**
Energia produzida excedente	47%
Energia produzida em HP e HC	98%
Energia Excedente	3 824 kWh
Valor de venda da energia excedente*	€ 569,81



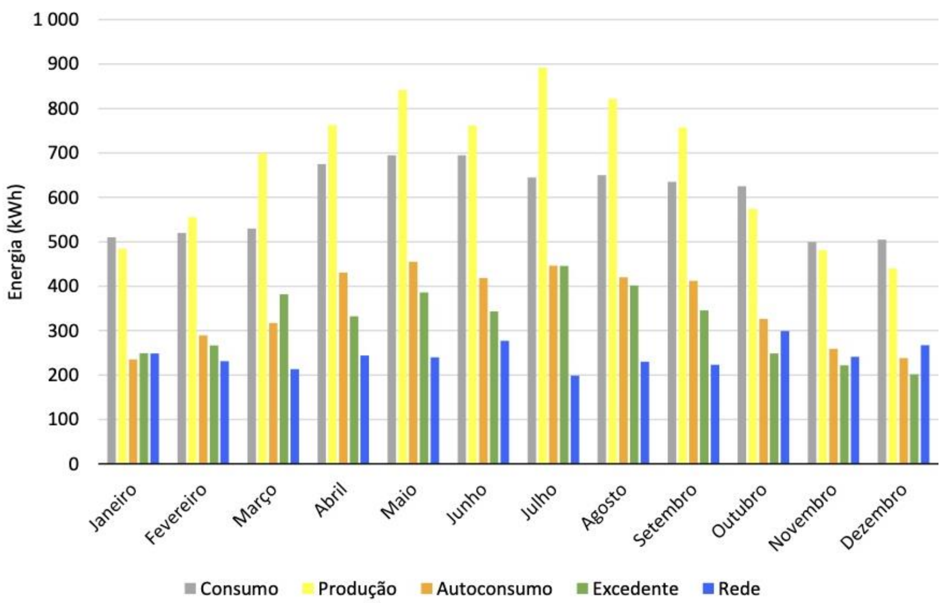
INVESTIMENTO INICIAL	**€ 7 850,00**
Inflação anual	1%
Amortização Autoconsumo (anos)	**5,3**
TIR Autoconsumo	18,6%
Poupança em 20 anos	€ 22 893,12
Preço do kWh solar produzido a 20 anos	€ 0,0681
Preço do kWh pago à rede no último ano	€ 0,212

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.

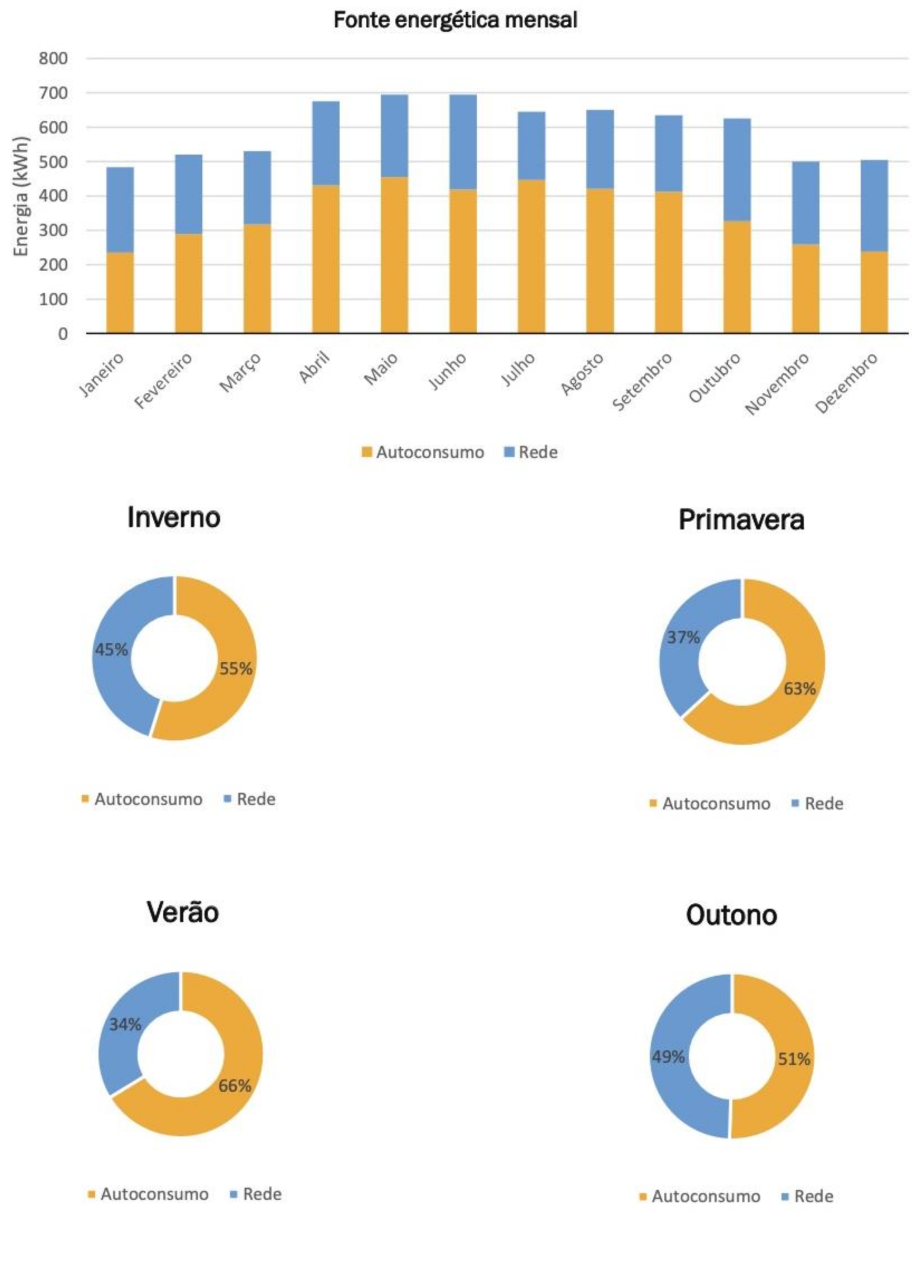
Medium Energy Production vs Consumption:



Monthly Energy Analysis:



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



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		Inverters	
Nb. of modules	9 units	Nb. of units	1 unit
Pnom total	4905 Wp	Pnom total	4000 W
		Pnom ratio	1.226

Results summary

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

Table of contents

General parameters, PV Array Characteristics, Array and system losses

General parameters

Grid-Connected System

No 3D scene defined, no shadings

PV Field Orientation

Orientation
Fixed plane
Tilt/Azimuth 30 / 0 °

Sheds configuration
No 3D scene defined

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Free Horizon

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Risen Energy Co., Ltd
Model	RSM110-8-545M
(Custom parameters definition)	
Unit Nom. Power	545 Wp
Number of PV modules	9 units
Nominal (STC)	4905 Wp
Modules	1 String x 9 In series
At operating cond. (50°C)	
Pmpp	4491 Wp
U mpp	258 V
I mpp	17 A

Inverter

Manufacturer	Huawei Technologies
Model	SUN2000-4KTL-M1
(Custom parameters definition)	
Unit Nom. Power	4.00 kWac
Number of inverters	1 unit
Total power	4.0 kWac
Operating voltage	140-980 V
Max. power (=>60°C)	4.40 kWac
Pnom ratio (DC:AC)	1.23

Total PV power

Nominal (STC)	4.91 kWp
Total	9 modules
Module area	23.5 m²
Cell area	21.8 m²

Total inverter power

Total power	4 kWac
Number of inverters	1 unit
Pnom ratio	1.23

Array losses

Array Soiling Losses
Loss Fraction 3.0 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 243 mΩ
Loss Fraction 1.5 % at STC

LID - Light Induced Degradation
Loss Fraction 2.0 %

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): User defined profile

0°	20°	40°	60°	70°	75°	80°	85°	90°
1.000	1.000	1.000	1.000	0.996	0.973	0.931	0.852	0.000

System losses

Unavailability of the system
Time fraction 2.0 %
7.3 days,
3 periods

AC wiring losses & Main results

AC wiring losses

Inv. output line up to injection point

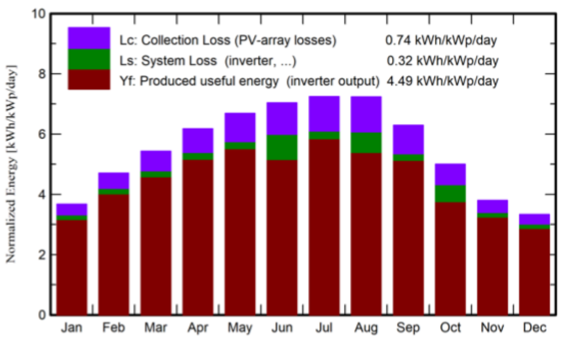
Inverter voltage	400 Vac tri
Loss Fraction	0.00 % at STC
Inverter: SUN2000-4KTL-M1	
Wire section (1 Inv.)	Copper 1 x 3 x 2 mm²
Wires length	0 m

Main results

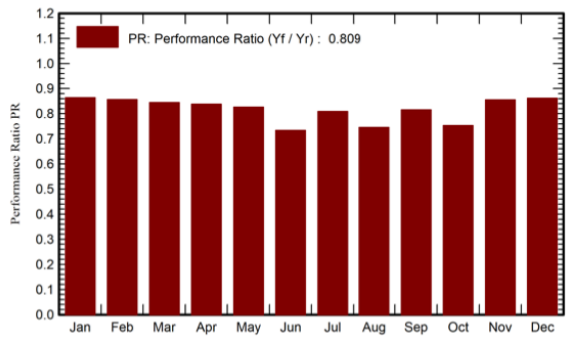
System Production

Produced Energy	8.05 MWh/year	Specific production	1641 kWh/kWp/year
		Performance Ratio PR	80.92 %

Normalized productions (per installed kWp)



Performance Ratio PR



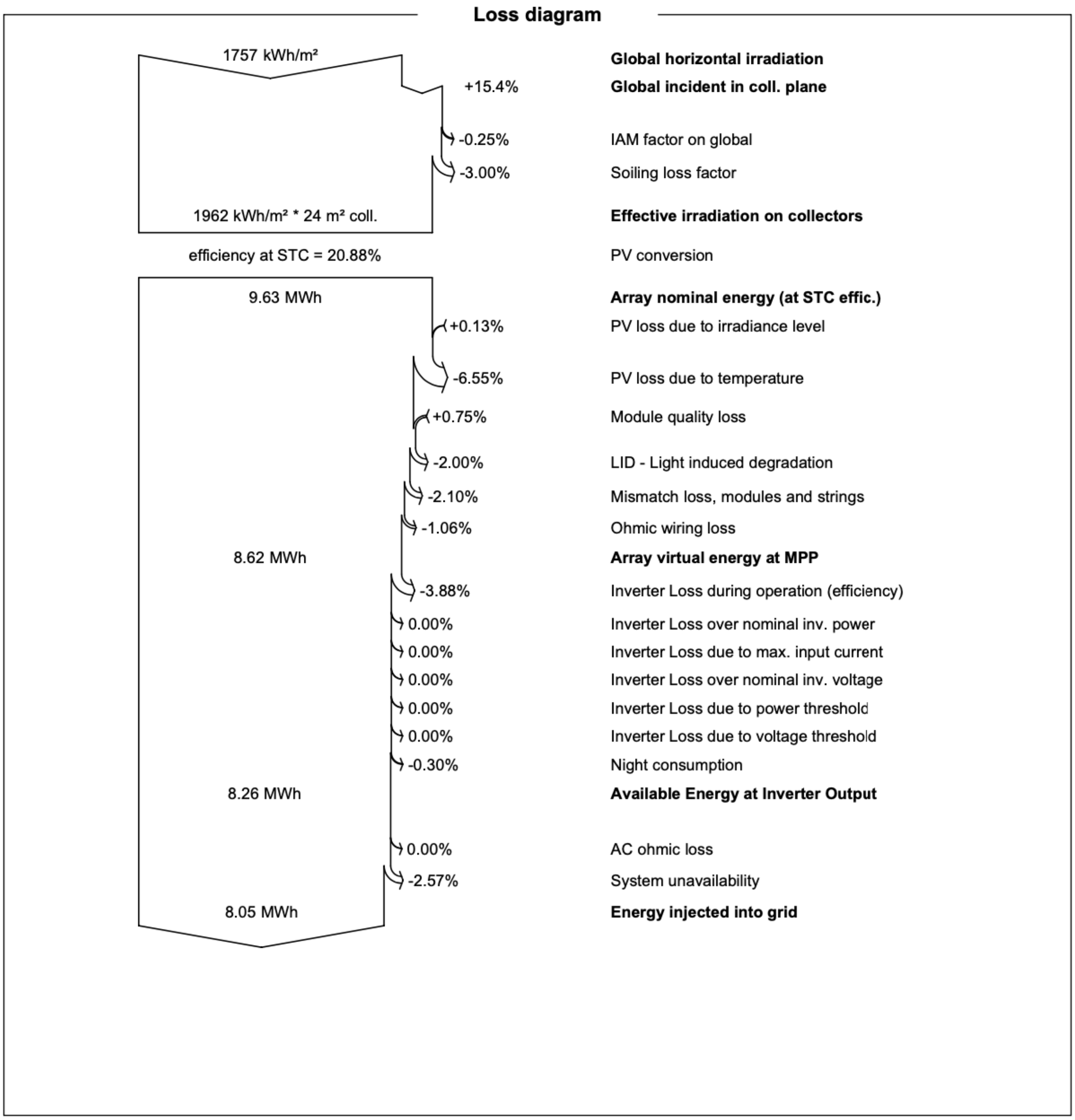
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR 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

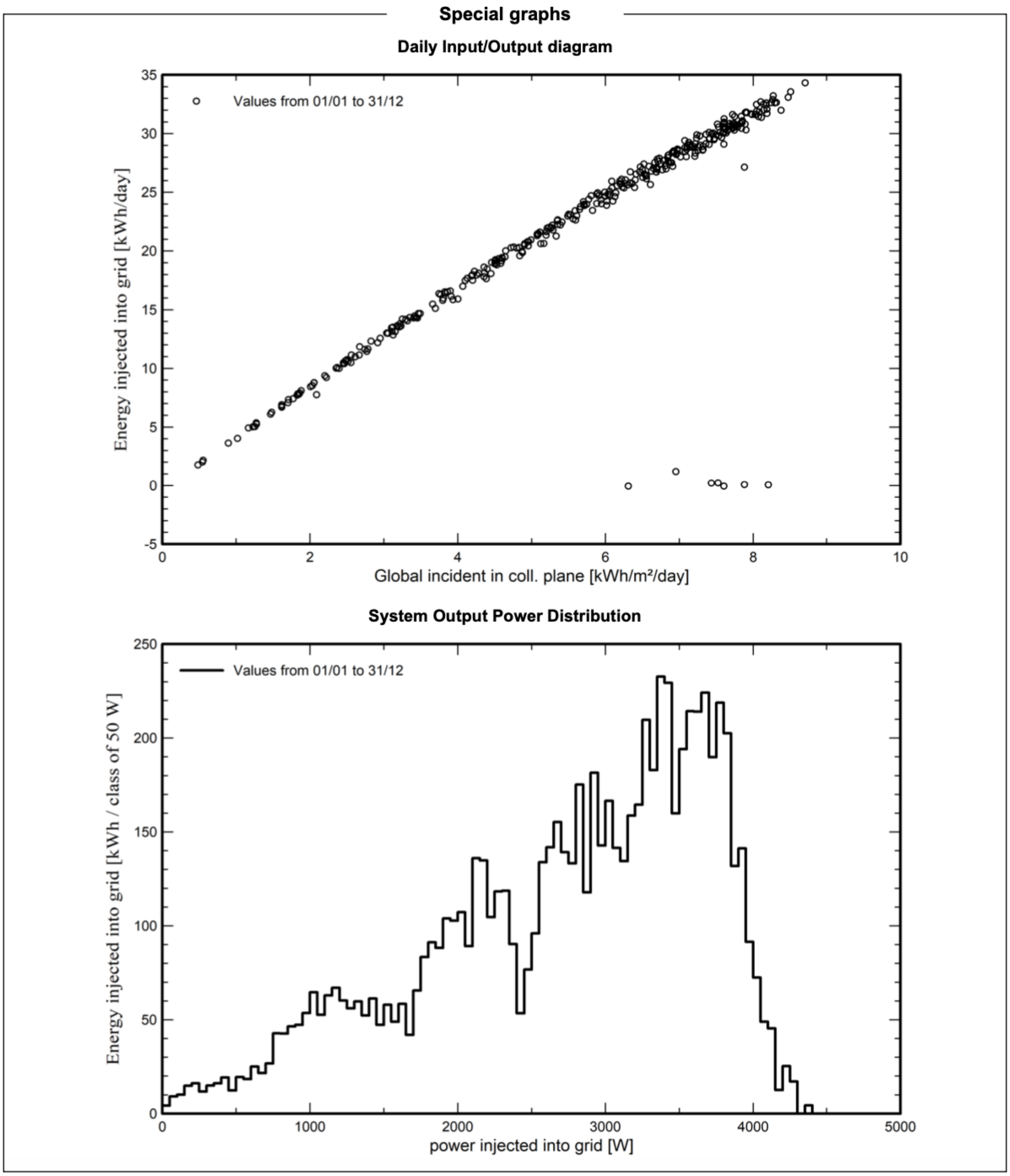
Legends

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

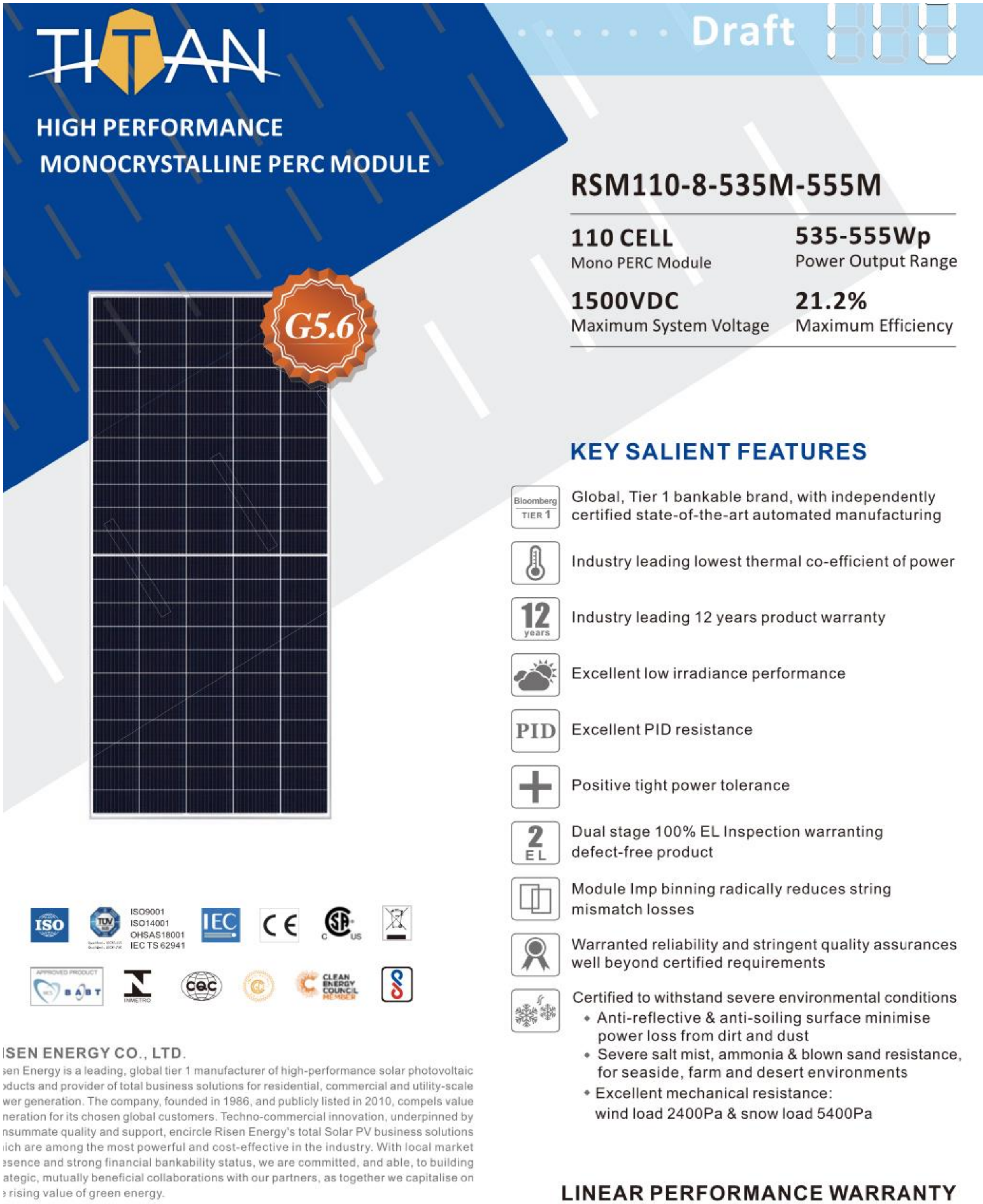
Loss diagram



Daily Input/Output diagram & System Output Power Distribution



PV module – Option 1



TITAN

HIGH PERFORMANCE
MONOCRYSTALLINE PERC MODULE

Draft

G5.6

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

- Bloomberg TIER 1 — Global, Tier 1 bankable brand, with independently certified state-of-the-art automated manufacturing
- Industry leading lowest thermal co-efficient of power
- 12 years — Industry leading 12 years product warranty
- Excellent low irradiance performance
- PID — Excellent PID resistance
- Positive tight power tolerance
- 2 EL — 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

ISO9001
ISO14001
OHSAS18001
IEC TS 62941

ISEN ENERGY CO., LTD.

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

LINEAR PERFORMANCE WARRANTY

Inverter

Smart Energy Controller

Active Safety

AI Powered
Active Arcing Protection

Higher Yields

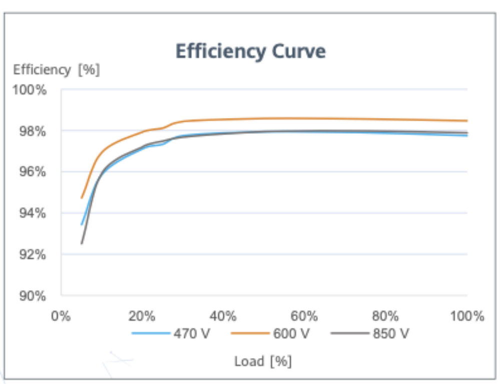
Up to 30% More Energy with Optimizer [1]

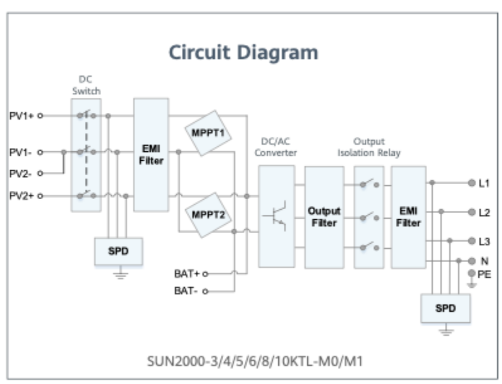
Battery Ready

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 m²
Number of PV Modules	12
Number of Inverters	1
No. of battery systems	2

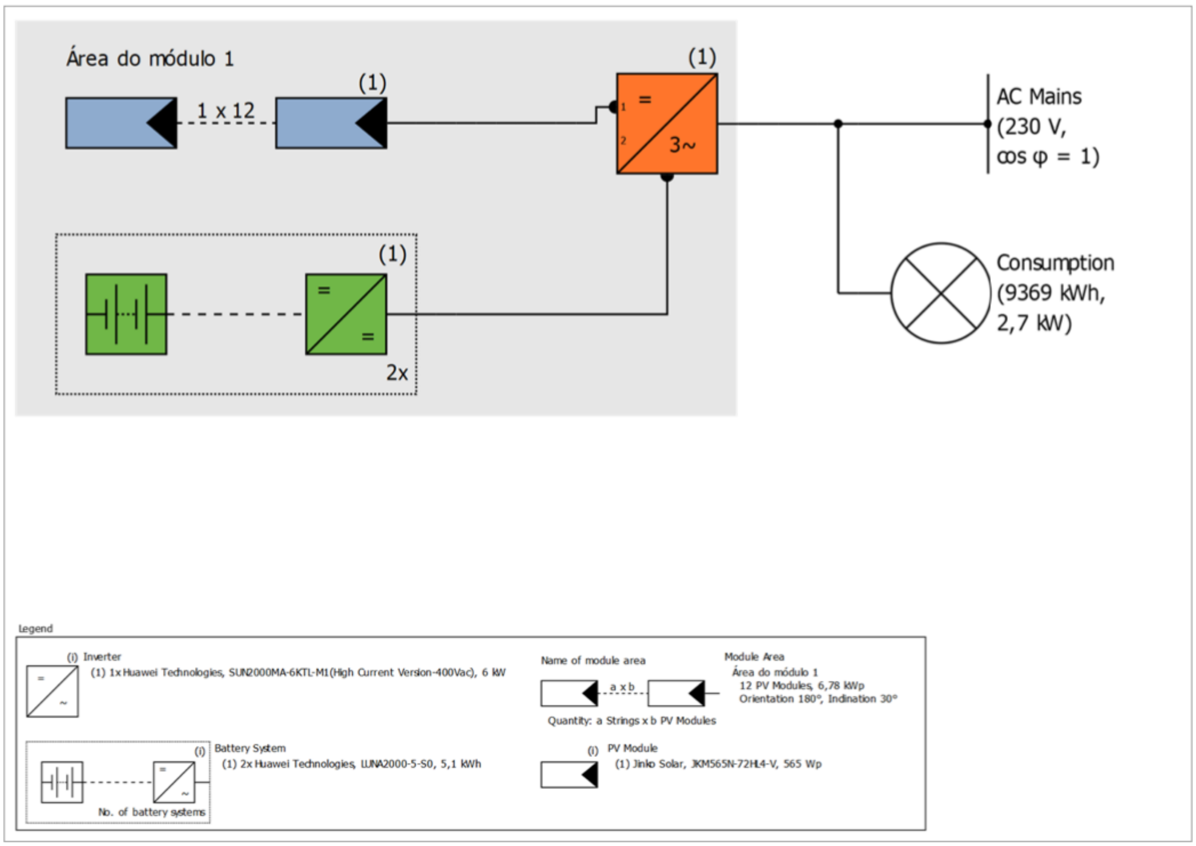


Figure: Schematic diagram

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

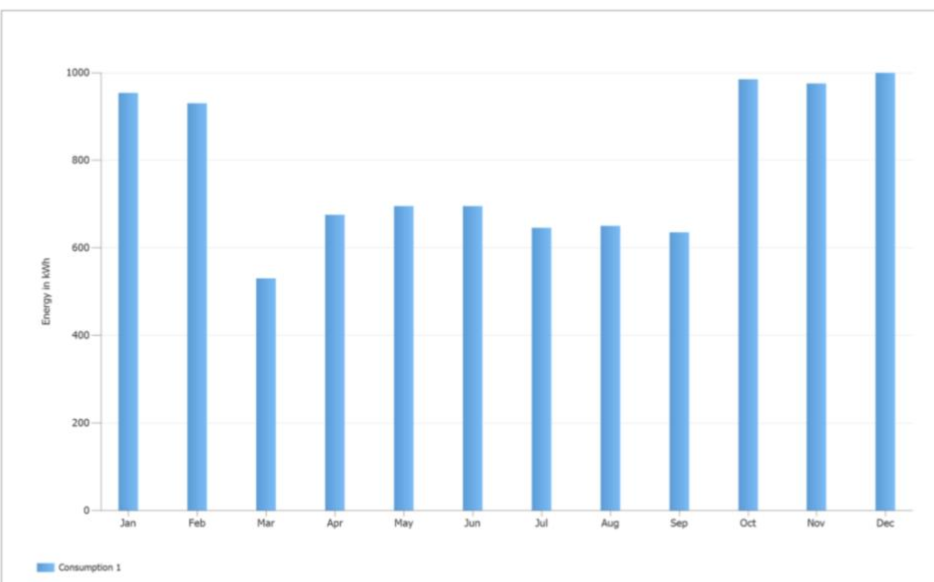


Figure: Consumption

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	m²

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	%
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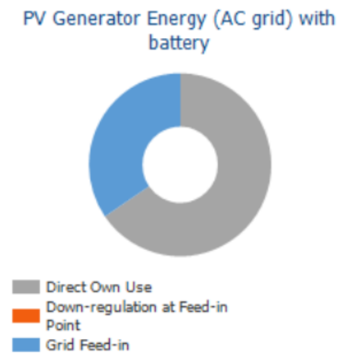
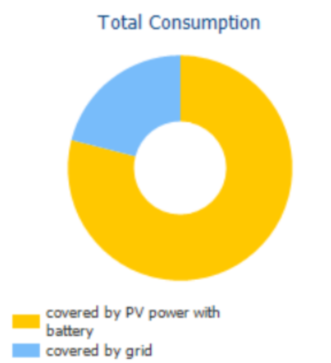


Appliances

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	%



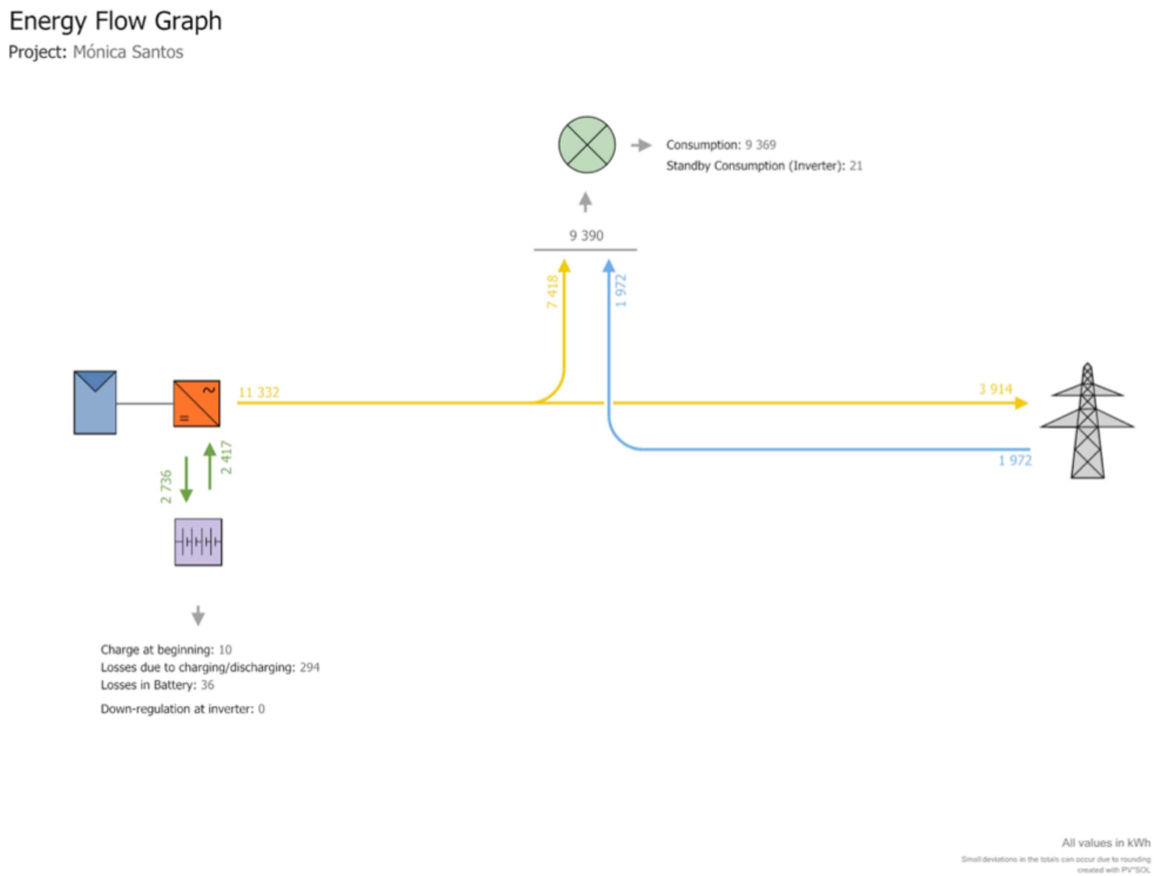
Battery System

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 Consumption and coverage over the year:

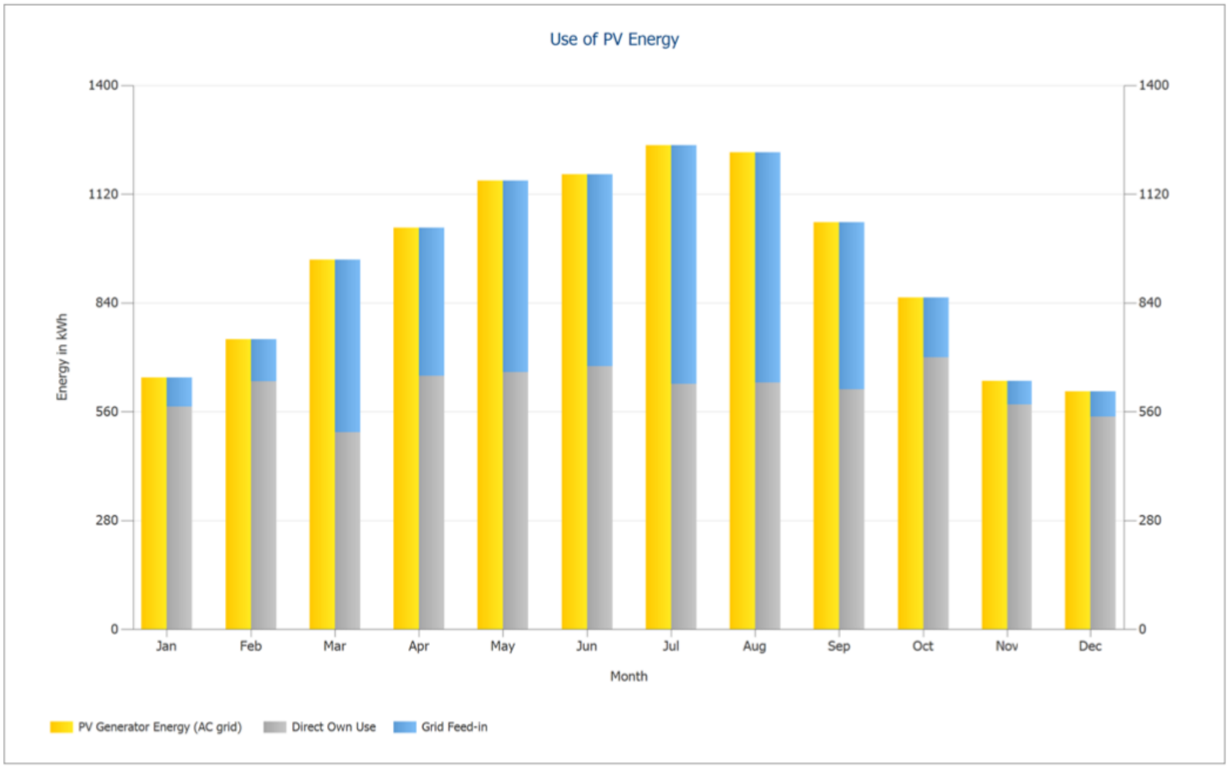


Figure: Use of PV Energy

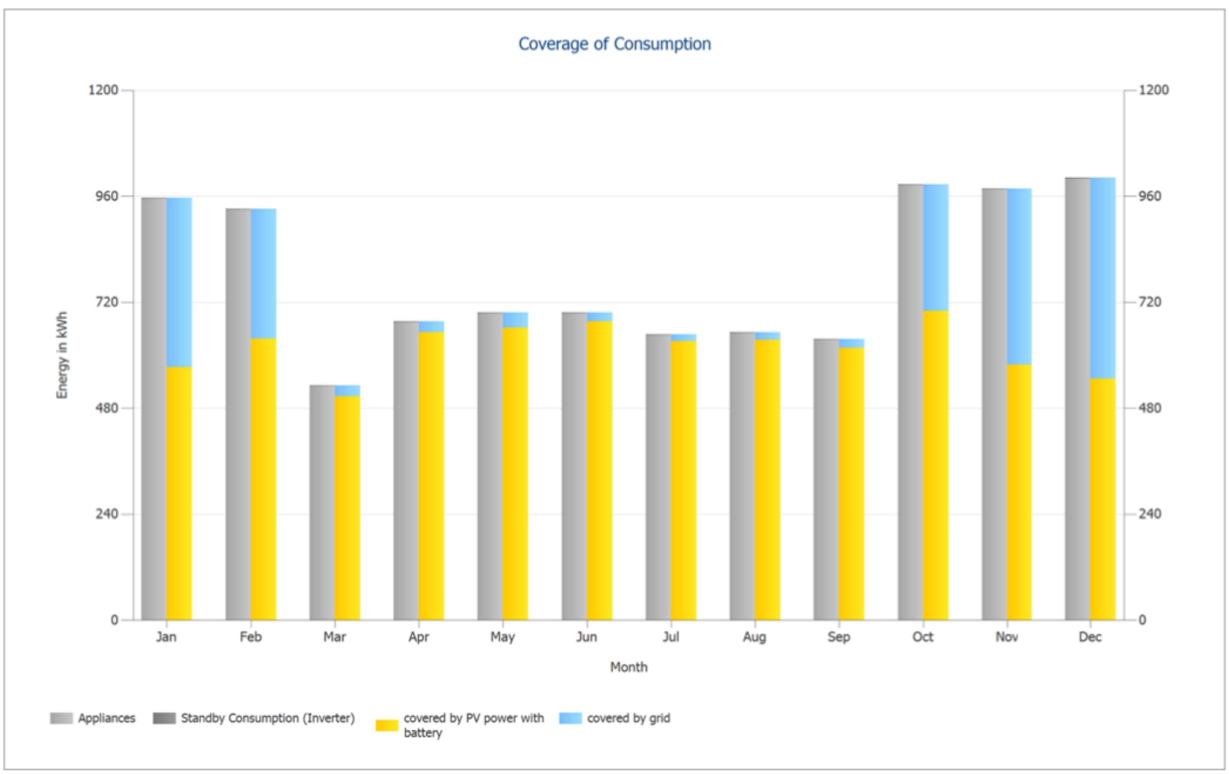
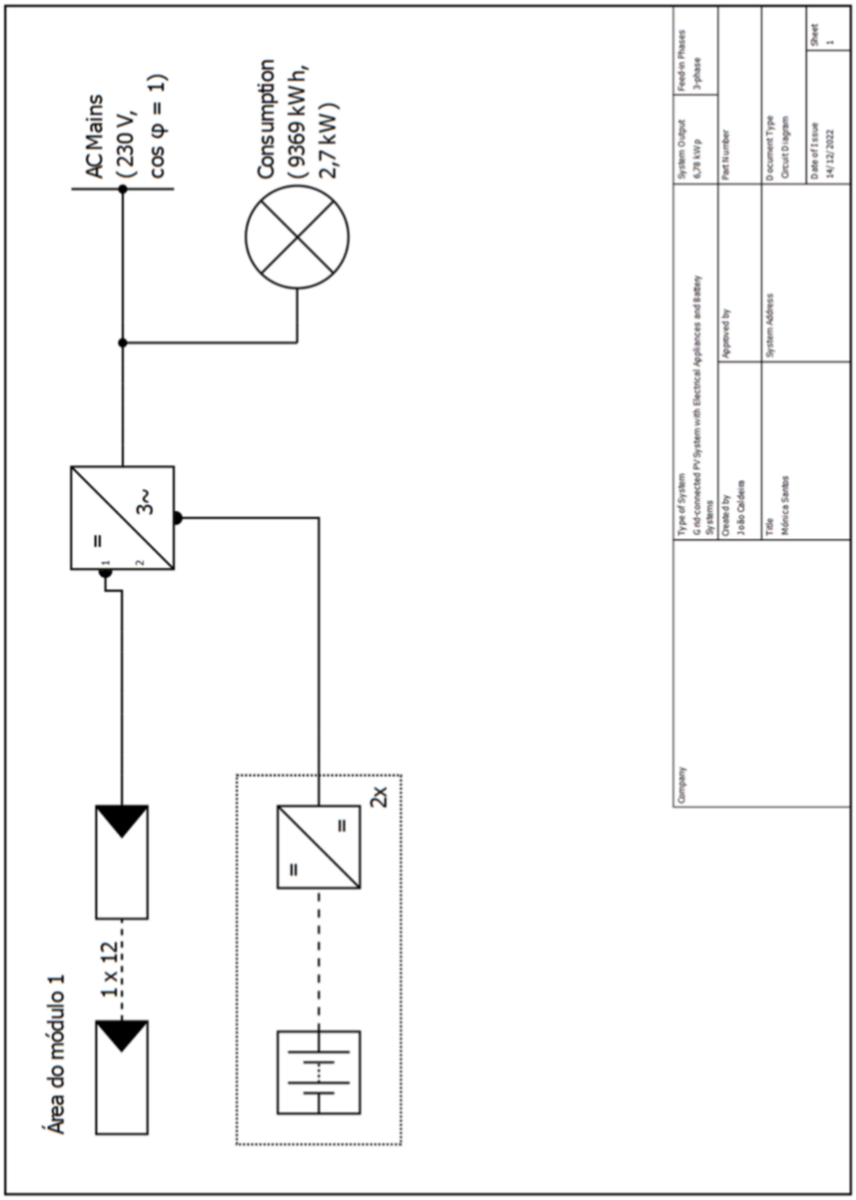


Figure: Coverage of Consumption

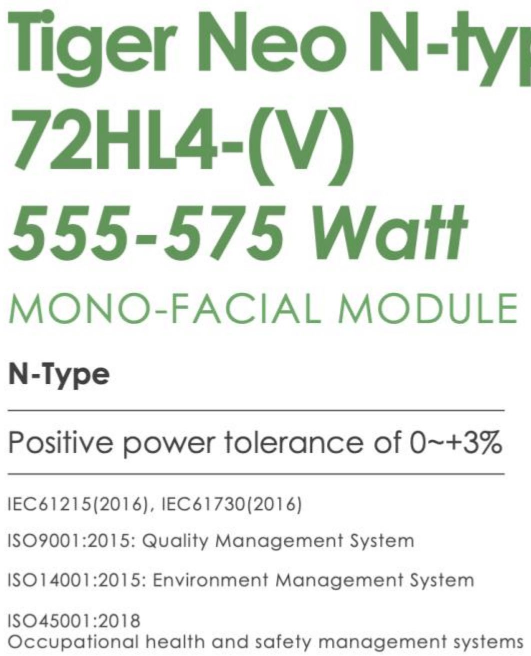
Plans and Parts List:



Parts List:

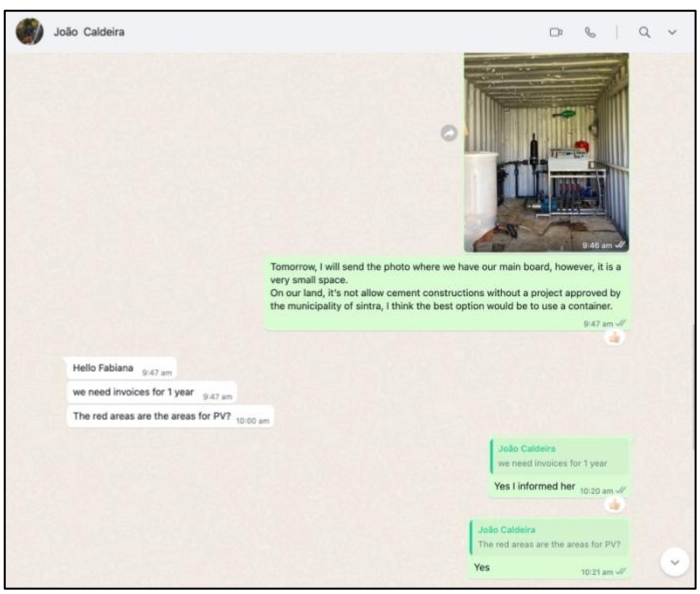
#	Type	Item number	Manufacturer	Name	Quantity	Unit
1	PV Module		Jinko Solar	JKM565N-72HL4-V	12	Piece
2	Inverter		Huawei Technologies	SUN2000MA-6KTL-M1(High Current Version-400Vac)	1	Piece
3	Battery System		Huawei Technologies	LUNA2000-5-S0	2	Piece

PV Modules Option 2

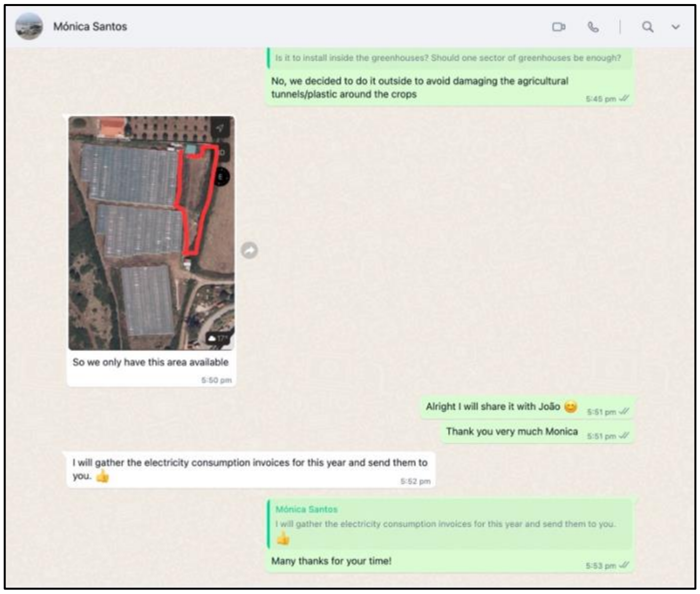


Communication:

Alignment with João Caldeira



Alignment with Mónica Santos



Email with João Caldeira

Re: Energreen Project Support Nova SBE

From: João Caldeira <joaocaldeira_91@hotmail.com>
Sent: Friday, October 28, 2022 4:27:33 PM
To: Fabiana Isabel Jimenez Lezama <48708@novasbe.pt>; Maximilian Hauser <48695@novasbe.pt>
Subject: RE: Energreen Project Support Nova SBE

Hello Fabiana and Max,

Sorry for my late reply but it has been a very busy week.

Since you are going there this weekend I leave you with the list of point you should verify during the visit.

- Monthly invoices describing the amount of energy consumed by the client in each phase of the day ("ponta"/"cheia"/"super vazio" and "vazio")
- If the client has a MV transformer you should be able to get the data from its consumption hourly or from 15m to 15min, it is called "Diagramas de carga" and you need to get specific login data from the client to have this data.
- Blueprints of the rooftop or construction area. If you cannot provide this please share a KMZ file with the Location;
- Location of the technical area where the client would like to install the inverters, counters and PV switch boards (a Wall with maximum 8x2m should be enough;
- Location of the main switch board of the client and its distance from the technical area to install the inverters (this is important to calculate the correct amount of AC cable from the Inverters to the Main Swtichboard)
- Location of the place where the cliente has its communications server or router so we can evaluate if it is possible to have remote monitoring of the plant locally and remotely.

Photographic survey

- Photos of the places where the modules will be installed, please take picutres from diferent angles se we can have a better perception of the shaded areas;
- Photos of the possible shading elements of the terrain such as trees, electric lines, lamp posts, antenas etc;
- Photos os the main switch board and the surrounding environment, a video would also be good.
- Photos of the main switch board with its doors open to make sure we have enough space to insert our MCCB, RCCB and additional protections;
- Photos from the interior of the building since the technical area (were we will be placing the inverters) to the main swtich board, this is importante in order to understand if we need to use existing cable trays or if we need to buy our own equipment;
- Photo of the place where we will install the inverters so we can understand if the material of the walls are good enough or if we need to build our own technical area.

Additional notes: