People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
University Blida-1

Faculty of science and technology
Renewable Energy Department

Graduation Thesis

In view of obtaining the Master's degree in Renewable Energies

OPTION: Photovoltaic Conversion

Theme:

Design and study of an intelligent house located in the municipality of Sally in the state of Adrar « smart solar house»

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الملخص:

تعتبر الجزائر من الدول الكبرى التي تسعى إلى الإنتقال الطاقوي ومن أحسن المناطق لاستغلال الطاقات المتجددة وخاصة الطاقة الشمسية والاستثمار فيها هي صحراء الجزائر الكبرى فقمنا بإجراء دراسة شاملة لمنزل عادي في ولاية أدرار وتحويله الى منزل شمسي ذكي. حيث قمنا بجمع المعلومات الضرورية لكل الأجهزة المستعملة في المنزل واستهلاكها للطاقة لعمل حسابات أكاديمية لتزويده بثلاث انظمة تعتمد على الطاقة الشمسية الحرارية والكهروضوئية. وقمنا أيضا بدراسة الجانب الاقتصادي للأنظمة حيث يساهم تزويد المناطق النائية في الصحراء بالمنازل الشمسية الذكية في رفع إقتصاد الدولة الجزائرية بالإيجاب حيث يساعد الشركة الوطنية "**Sonelgaz** " من ناحية ايصال الكهرباء بأسعار باهظة الثمن. استعنا بعدة برامج في انجاز هذا المشروع من بينها برنامج المحاكات " **PVsyst** " و في الأخير زودنا أنظمتنا بنظام أوتومات ذكي قابل للبرمجة يعتمد على " **Wifi** " لمتابعة و مراقبة أنظمتنا بصفة مستمرة و للبقاء على تواصل معها من اجل صيانتها.

الكلمات المفتاحية:

الطاقة الكهروضوئية ، الدراسة الاقتصادية ، برنامج محاكاة PVsyst ، المنزل الشمسي الذكي ، نظام االمراقبة الآلي الذكي.

Abstract:

Algeria is one of the major countries seeking to move energetically and one of the best areas to exploit renewable energies, especially solar energy, and invest in it is the Greater Algerian Desert. We did a comprehensive study of an ordinary house in Adrar State and converted it into a smart solar house. We collected the necessary information for all appliances used at home and consumed energy to make academic calculations to provide it with three systems based on solar thermal and photovoltaic energy. We also studied the economic aspect of the systems, where providing remote areas of the desert with smart solar houses contributes to raising the economy of the Algerian State in the affirmative, it helps the national company **"Sonelgaz "**in terms of electricity delivery at expensive prices. Then we used several programs to complete this project, including the **PVsyst** simulator software. Finally, we have provided our systems with an intelligent programmable automation system that relies on **Wifi** to continuously follow and monitor our systems and to stay in touch with them for their maintenance.

Keywords:

Photovoltaic energy, economic study, PVsyst simulation program, smart solar house, smart automation system.

Résumé:

L'Algérie est l'un des principaux pays qui cherchent à se déplacer énergiquement et l'un des meilleurs domaines pour exploiter les énergies renouvelables, en particulier l'énergie solaire, et investir dans elle est le Grand Désert algérien. Nous avons mené une étude approfondie d'une maison ordinaire dans l'État d'Adrar et l'avons transformée en une maison solaire intelligente. Nous avons recueilli les informations nécessaires pour tous les appareils utilisés à la maison et l'énergie consommée pour faire des calculs académiques pour lui fournir trois systèmes basés sur l'énergie solaire thermique et photovoltaïque. Nous avons également étudié l'aspect économique des systèmes, où fournir des zones reculées du désert avec des maisons solaires intelligentes contribue à élever l'économie de l'État algérien dans l'affirmative, comme il aide la société nationale **"Sonelgaz "**en termes de livraison d'électricité à des prix élevés. Nous avons utilisé plusieurs programmes pour compléter ce projet, y compris le logiciel de simulation **PVsys**t. Enfin, nous avons fourni à nos systèmes un système

d'automatisation programmable intelligent qui repose sur **le Wifi** pour suivre et surveiller continuellement nos systèmes et rester en contact avec eux pour leur maintenance.

Les mots clés :

Énergie photovoltaïque, étude économique, programme de simulation PVsyst, maison solaire intelligente, système d'automatisation intelligent.

Acknowledgements:

We would like to thank **Allah** for the courage and patience he offered us to achieve the realization of this thesis.

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Many thanks to our families for their moral and financial support and for their sacrifices.

Dedication:

I dedicate this modest work to my dear parents, especially to my mother who supported and encouraged me during these years of study. May she find here the testimony of my deep gratitude.

To my little sister Lamia and to my sister and brothers Achwak , Nabile, Raouf and Soheib. who shared with me all the emotional moments during the realization of this work. They warmly supported and encouraged me throughout my journey.

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To all my friends who have always encouraged me and helped me in this work and to whom I wish more success.

To everyone I love.

Zohra.

Dedication:

We thank ALLAH the Almighty for giving me the courage, the will and the patience to complete this present work.

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We thank all jury members for have agreed to judge this work.

We thank our parents, relatives and friends who helped us do this work.

Amhammed

Summary:

Chapter I: General information on solar energy and photovoltaic system

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I. General introduction:

Smart solar houses are innovative homes that harness the power of the sun to provide electricity, heating, and cooling in an efficient and sustainable way. The Wilaya of Adrar located in the south of Algeria, characterized by its hot and arid climate. In many remote areas of this region, there are houses that suffers from a lack of limited access to electricity and suffers from a lack of access to water because a low level of rainfall, which can have a significant impact on their daily lives. One solution to this problem is to use a smart Solar house which contains the photovoltaic (PV) system, solar pumping and other thermal systems, to provide electricity to households. This solution is both sustainable and cost-effective in the long run, as it reduces dependence on non-renewable sources of energy and eliminates the need for expensive electricity grid extensions operated by Sonelgaz (the national electricity company). Smart Solar house utilize solar panels to capture sunlight and convert it into electricity, which can be stored in batteries for later use, this system can provide electricity to power lights, fans, refrigerators, and other household appliances, enabling a more comfortable and sustainable way of life for residents. This renewable energy source is an ideal solution for regions like Adrar, which receive abundant sunshine throughout the year. In addition to the environmental benefits, the use of solar PV technology can also have a positive impact on the local economy. The installation and maintenance of these systems can create job opportunities for local residents, helping to stimulate economic growth in the region. The first step is to assess the energy needs of the household and to determine the size of the photovoltaic system required to meet those needs. This includes taking into account the number of appliances, the size of the living space, and the number of people living in the house. Once the energy needs are assessed, the next step is to design the photovoltaic system itself.

Overall, the smart solar house in Adrar state have the potential to play an important role in our transition to a more sustainable and renewable energy future.

Chapter I:

General information on solar energy and photovoltaic systems

1. Introduction:

In this chapter we talk about some essential bases in the field of solar energy in general and photovoltaic energy in particular. Solar energy is the energy that is produced by the sun also is a renewable energy source. It is one of the cleanest and most abundant sources of energy available and can be harnessed for various uses, including heating, lighting, and generating electricity. The most common way to harness solar energy for electricity production is through the use of photovoltaic (PV) systems.

2. The Sun :

The Sun is the star at the center of the Solar System planets. It is a planet of hot plasma. The sun radiates the most important energy for life because of the nuclear fusion reactions in its core **[01].**

The Sun's radius is about 695,000 kilometers and its mass is about 1,989 × 10^30 kg. The Sun is composed primarily of the chemical elements hydrogen 73% and helium 25% **[02]**. With much smaller quantities of heavier elements, including oxygen, carbon, neon, and iron. estimated to be brighter than about 85% of the stars in the Milky Way **[03].**

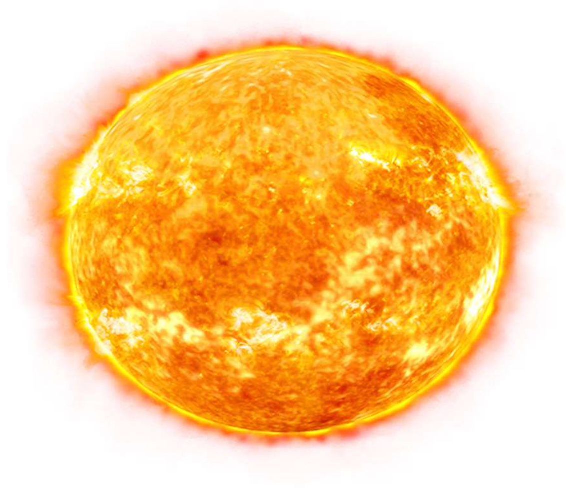


Figure I.1 : The Sun

3. Solar radiation :

Solar radiation is a general term for the electromagnetic radiation emitted by the sun. The electromagnetic spectrum organizes energy types by wavelength and frequency **[04].** The electromagnetic spectrum encompasses all types of radiation **[05].** The part of the spectrum that reaches Earth from the sun is between 100 nm and 1 mm. This band is broken into three ranges: ultraviolet, visible, and infrared radiation. Infrared radiation makes up 49.4%, contains wavelengths from 700 nm to over 1 mm of while visible light provides 42.3% [**06],** falls within the range of 400-700 nm. Ultraviolet radiation makes up just over 8% of the total solar radiation, contains wavelengths between 100-400 nm **[07]** Solar radiation can be captured and turned into useful forms of energy. And is also a key factor in the development of renewable energy technologies such as solar photovoltaic and solar thermal systems. These technologies use solar radiation to generate electricity or heat water for domestic or industrial use.

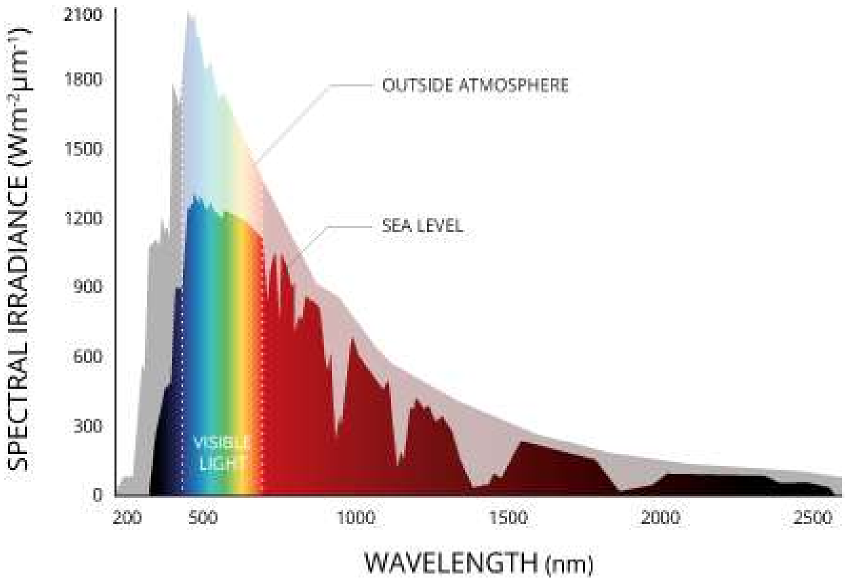


Figure I.2 : Solar radiation

4. Types of solar radiation:

Depending on the form in which it reaches the Earth:

4.1. Direct solar radiation:

This type of radiation penetrates the atmosphere and reaches the Earth's surface without dispersing at all on the way.

4.2. Diffuse solar radiation:

This is the radiation that reaches the Earth's surface after having undergone multiple deviations in its trajectory, for example by gases in the atmosphere.

4.3. Reflected solar radiation:

This is the fraction of solar radiation that is reflected by the earth's surface itself, in a phenomenon known as the albedo effect.

4.4. Global radiations:

The global irradiance is sum of all the radiations received, includes direct sunlight and diffuse sunlight and the radiation reflected by the ground and the objects that are on its surface, it is measured by a pyranometer **[08].**

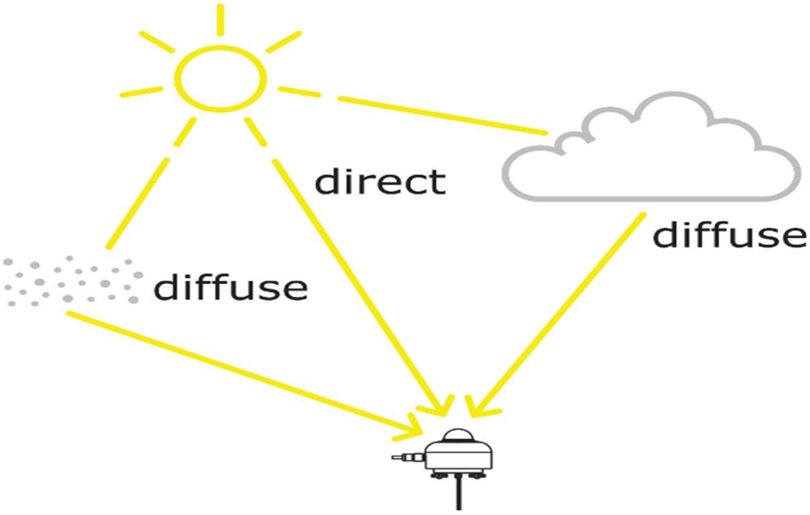


Figure I.3 : Types of solar radiation

5. Solar radiation measuring devices:

There are several advanced solar radiation measuring devices to get accurate results, and are varied depending on its role.

5.1. Pyrheliometers:

A pyrheliometer is an instrument for measuring direct solar irradiance. Sunlight enters the instrument through a window and is directed onto a thermopile which converts heat to an electrical signal that can be recorded, it mounted on a tracking system pointed towards the Sun. Typical pyrheliometer measurement applications include scientific meteorological and climate observations, material testing research, and assessment of the efficiency of solar collectors and photovoltaic devices **[09].**

Figure I.4 : Pyrheliometers

5.2. The Pyranometer:

pyranometer is a type of actinometer used for measuring solar irradiance on a planar surface and it is designed to measure the solar radiation flux density (W/m2) from the hemisphere above within a wavelength range 0.3 µm to 3 µm, are based on the Seebeck- or thermoelectric effect. The main components of a pyranometer are one or two domes, a black absorber, a thermopile, the pyranometer body and in some cases additional electronics. A typical pyranometer does not require any power to operate **[10].**

Figure I.5 : The Pyranometer

5.3. The Pyrradiometers:

The Pyrradiometer is a total hemispherical radiometer (solar and atmospheric) on a horizontal surface from a solid angle of 2π, used for exact determination of net radiation in short-wave and long-wave radiation range with two separately working receivers and with a built-in thermometer to determine reference temperature. Their sensitive surface is black and has a high emissivity **[11].**

Figure I.6 : The Pyrradiometers

5.4. The heliograph:

A heliograph is a solar telegraph system that signals by flashes of sunlight reflected by a mirror. The flashes are produced by momentarily pivoting the mirror, or by interrupting the beam with a shutter. it is used to measure the daily value of the sunshine duration at a point on the surface of the earth **[12].**

Figure I.7: The heliograph

6. Photovoltaic solar energy:

The photovoltaic solar energy is one of the most growing industries all over the world, is obtained by converting sunlight into electricity using a technology based on the photoelectric effect by which certain materials are able to absorb photons (light particles) and release electrons, generating an electric current. It is a type of renewable, inexhaustible and non-polluting energy **[13].**

7. Components of the photovoltaic system:

Photovoltaic systems generally consist of four necessary components: the solar PV panels, a charge controller, a battery bank, an inverter. And other components as a utility meter, an electric grid and protection components **[14].**

7.1. The photovoltaic generator:

Is an assembly of photovoltaic solar cells, The PV cell is composed of semiconductor material. It captures sunlight as a source of radiant energy, which is converted into electric energy in the form of direct current (DC) electricity. Solar panel technology is advancing rapidly with greater efficiency **[15].**

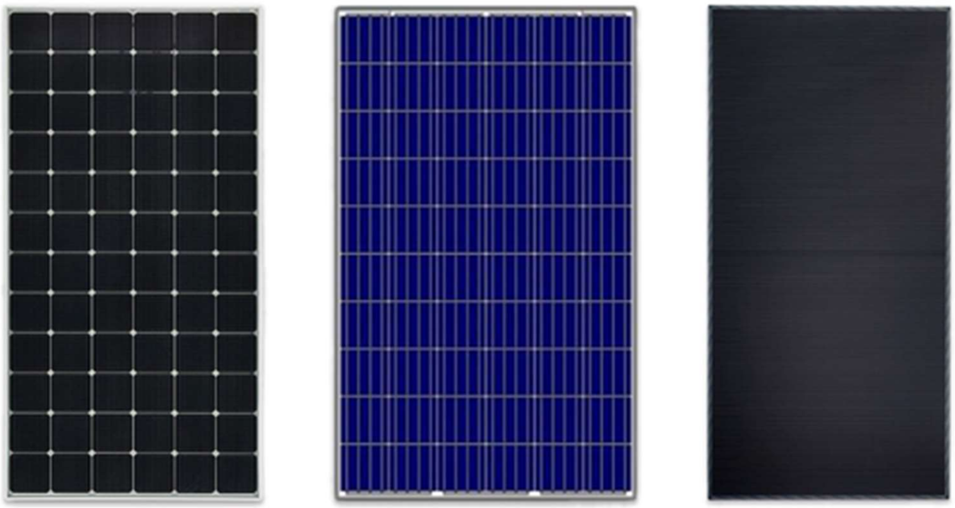


Figure I.8: The photovoltaic generators

7.2. <u>Six Main Components of a Solar Panel:</u>

•Solar photovoltaic cells (a series of silicon crystalline cells).

•Toughened Glass - 3 to 3.5mm thick.

•Extruded Aluminium frame.

•Encapsulation - EVA film layers.

•Polymer rear back-sheet.

•Junction box - diodes and connectors.

Figure I.9: Six main components of a solar panel

7.2.1. Technologies and types of silicon-based photovoltaic cells:

There are three types of PV cell technologies that dominate the world market: monocrystalline silicon, polycrystalline silicon, and thin film (Amorphous silicon solar cells).

7.2.2. Monocrystalline solar panels:

Monocrystalline solar panels are made from monocrystalline solar cells. They have the highest efficiency rates, typically in the 15-20% range, better heat tolerance and less sustainable production methods but come at a higher price point than other solar panels. Monocrystalline silicon solar cells are manufactured using something called the Czochralski method, in which a crystal of silicon is placed into a molten vat of pure silicon at a high temperature. This process forms a single silicon crystal, called an ingot that is sliced into thin silicon wafers which are then used in the solar modules **[16].**

Figure I.10: Monocrystalline solar panel

7.2.3. Polycrystalline solar panels:

Polycrystalline solar panels are made of individual polycrystalline solar cells. Just like monocrystalline solar cells, they are made from silicon crystals. The difference is that, instead of being extruded as a single pure ingot, the silicon crystal cools and fragments on its own. These fragments are melted in an oven and formed into cubes which are cut into thin wafers. It's a less exacting production process than with monocrystalline cells, so it allows for more solar cells to be produced faster and less expensively. The blue-colored square polycrystalline cells fit neatly side by side, eliminating any empty space between the cells. Polycrystalline solar panels operate less efficiently than monocrystalline panels because the melted fragments of silicon afford less room for the electrons to move around. Polycrystalline panels generally have an efficiency rating of between 13% and 16% but it is the most used **[16].**

Figure I.11: Polycrystalline solar panel

7.2.4. Amorphous silicon solar panels:

These modules are of thin film of 1 µm thickness between the two panes of glass making them much more flexible and durable. Si-amorph PV generators perform better than those of Si-mono and Si-poly crystalline. Also perform better under elevated temperature conditions when compared with crystalline silicon cells. They are much cheaper to produce, their efficiency greatly reduced. Other types of thin film cells include: (CIGS) and (CdTe). These cell technologies offer higher efficiencies than amorphous silicon, but contain rare and toxic elements **[16].**

Figure I.12: Amorphous silicon solar panel

7.3. <u>Charge Controller :</u>

A charge controller regulates the flow of electricity from the PV generator to the battery. Its function is to regulate the voltage and current from the PV array in order to prevent overcharging and also over discharging of the battery to protect the life of solar panels and the attached battery. Also allow to select the type of battery that it’s connecting to. Some solar charge controllers feature an LCD display, while others are more basic and have dials you can turn to select voltage and other settings. More advanced charge controllers feature Bluetooth connectivity and are app-enabled as well **[17].**

There are two main types of solar charge controllers: PWM and MPPT charge controllers.

7.3.1. <u>PWM charge controllers:</u>

Stands for pulse-width modulation. These controllers are best suited for small systems; they are less expensive and less efficient than MPPT charge controllers.

Figure I.13: PWM charge controller

7.3.2. <u>MPPT charge controllers:</u>

Stands for maximum power point tracking. These controllers work well for larger off-grid systems, they are slightly more expensive than PWM charge controllers.

Figure I.14: MPPT charge Controller

7.4. The Batteries:

The solar Batteries accumulate energy created by the photovoltaic panels and store it to be used, in order to ensure the power supply in all circumstances. There are solar batteries operating at 2 V, 6 V or 12 V. Battery capacity is listed (in Amperes hour, Ah) are inversely proportional to the voltage, the batteries with the highest storage capacity are the 2V batteries. Batteries are electrochemical devices sensitive to climate, charge/discharge cycle history, temperature, and age. The performance of the battery depends on location and usage patterns. They are rated according to their "cycles". Deep-cycle batteries are capable of many repeated deep cycles and are best suited for PV power systems. The four main types of batteries used in PV solar power system are lead-acid, lithium ion, nickel cadmium and flow batteries **[18].**

Figure I.15: The Solar Batteries

7.4.1. The lead–acid battery:

The lead–acid battery is the first type of rechargeable battery ever created; it has relatively low energy density and suffers from short cycle lifespan. Including low numbers of charging–discharging cycles over their lifetimes, low discharge intensities, and slow charging rates. The lead–acid battery consists of two electrodes submerged in an electrolyte of sulfuric acid. A lead–acid battery's nominal voltage is 2.2 V for each cell. For a single cell, the voltage can range from 1.8 V loaded at full discharge, to 2.10 V in an open circuit at full charge. Are commonly used for renewable energy systems **[19].**

Figure I.16: The lead–acid battery

7.4.2. Flow battery:

A flow battery is a type of electrochemical cell where chemical energy is provided by two chemical components dissolved in liquids that are pumped through the system on separate sides of a membrane. Flow batteries depend on chemical reactions. Energy is reproduced by liquid-containing electrolytes flowing between two chambers within the battery. Though flow batteries offer high efficiency, with a depth of discharge of 100%, they have a low energy density, meaning the tanks containing the electrolyte liquid must be quite large in order to store a significant amount of energy. Cell voltage is from 1.0v to2.43v. Flow batteries, could one day usher in widespread use of renewable energy but only if the devices can store large amounts of energy cheaply and feed it to the grid **[20].**

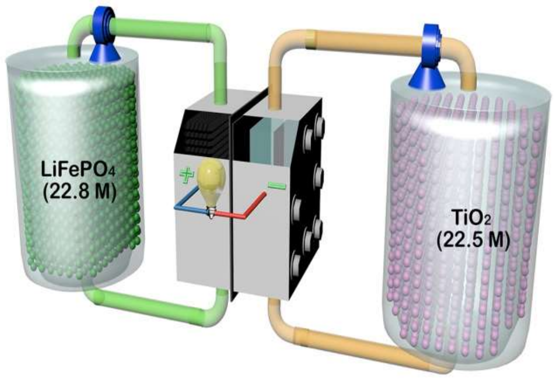


Figure I.17: Flow battery

7.4.3. A lithium-ion battery:

A lithium-ion battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry to store energy. And is a type of rechargeable battery. Lithium technologies enable the development of more efficient power storage systems that offer high energy density and performance and has a wide temperature adaptability, can be used -20 °C - 60°C, after the process of treatment, can be used in -45°C.Lithium battery is a kind of controllable, non-polluting energy storage type battery, and can be fully matched with solar street lighting system **[21].**

Figure I.18: A lithium-ion battery

7.4.4. <u>The nickel–cadmium battery:</u>

The nickel–cadmium battery is a type of rechargeable battery. It achieves 10 000 cycles at 15% depth of discharge (From 100 Ah to 1830 Ah (C120 rate)). And operate in extreme temperatures ranging from -30°C to +50°C. Ni–Cd cells have a nominal cell potential of 1.2 volts. Solar nickel cadmium battery is the best choice for photovoltaic applications, stand-alone hybrid systems and renewable energy applications.

Figure I.19: The nickel–cadmium battery

7.5. Inverter:

A photovoltaic inverter is a type of power inverter which converts the variable direct current (DC) output of a photovoltaic solar panel into a utility frequency alternating current (AC). They also act as the primary connection between the panels and the electrical distribution panel.

Figure I.20: Solar inverter

Solar inverters classified into four types:

7.5.1. Stand-alone inverter (off-grid inverter):

Stand-alone inverter is used for remote stand-alone application with battery backup where the inverter draws its DC power from batteries charged by PV array and converts to AC power.

Figure I.21: Stand-alone inverter

7.5.2. <u>Grid tie inverter:</u>

(Grid connected inverter) grid tie inverter is used specifically for grid connected application that does not require battery backup system. grid tie inverter converts DC power produced by PV array to AC power to supply to electrical appliances and sell excess power back to utility grid.

Figure I.22: Grid connected inverter

7.5.3. <u>Battery backup inverters:</u>

Battery backup inverters are special inverters which are used to draw energy from a battery, manage the battery charge via an onboard charger, and export excess energy to the utility grid. These inverters are capable of supplying AC energy to selected loads during a utility outage, and are required to have anti-islanding protection.

Figure I.23: Battery backup inverter

7.5.4. <u>Intelligent hybrid inverters:</u>

Intelligent hybrid inverters manage photovoltaic array, battery storage and utility grid, which are all coupled directly to the unit. Their primary function is self-consumption with the use of storage **[22].**

Figure I.24: Intelligent hybrid inverter

So, there are three main types of solar PV systems: grid-tied, hybrid and off-grid.

8. <u>Grid-tied solar systems:</u>

An on-grid solar system or grid tied, is a solar PV system which connects directly to the National Grid. This kind of Solar PV System is the most common amongst home and business owners. this solar system doesn't require a battery storage system, and is connected to the Grid directly via a Solar or micro inverter. As the solar panels convert sunlight into energy, your home uses this green energy supply to power your appliances. When you generate any excess solar energy, this electricity is exported back to the Grid.

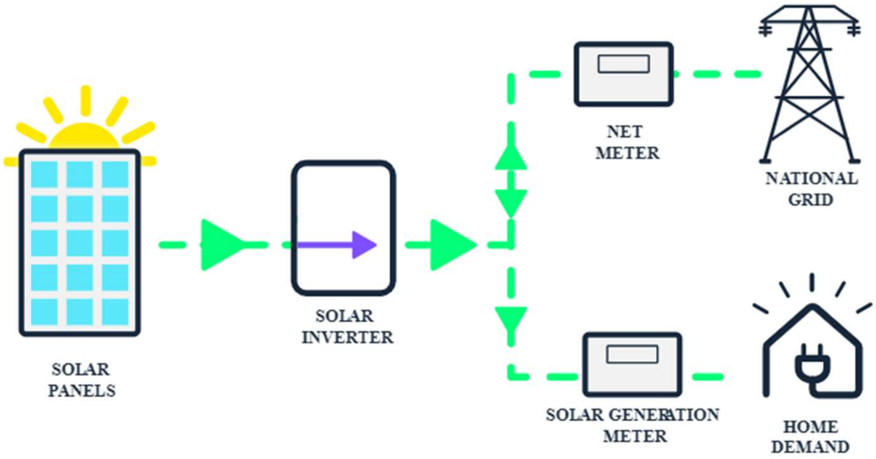


Figure I.25: Grid-tied solar photovoltaic system

9. Off-grid solar systems:

Off-grid system has zero ties to the national grid. With energy prices rising, energy independence is more in demand than ever. A complete Off-Grid Solar System contains everything you need to generate your own solar energy. Unlike hybrid systems. it tends to feature back-up generators and other types of renewable sources, to ensure your battery is charged fully all year round. it has the ability to provide electricity even in the remotest of locations.

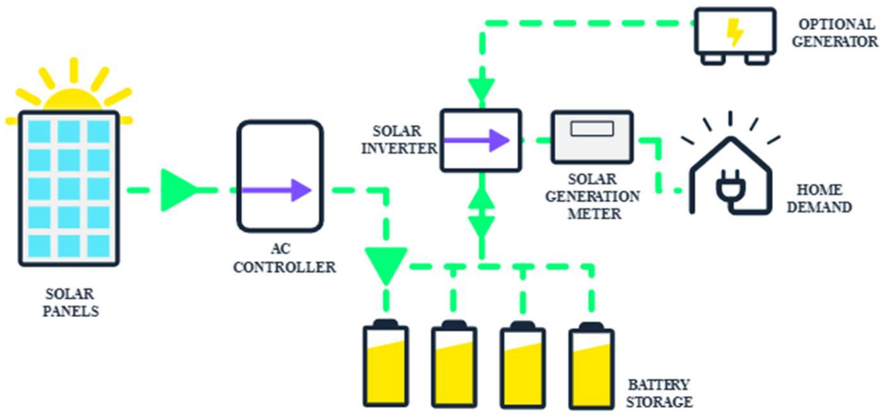


Figure I.26: Off-grid solar photovoltaic system

10.Hybrid solar systems:

Hybrid Solar systems combine the technology of Solar Panels and Solar batteries to create a green energy solution which provides a back-up supply of energy. Although a hybrid PV system remains connected to the National Grid, any solar energy generated is first stored in a home battery solution before going to the grid. it offers great flexibility, as when you have used up all your energy in your battery, you still have the ability to draw from the grid. This makes a hybrid solar system the perfect in between solution. A huge advantage of a hybrid solar system, is that you can expand your battery storage system at any time, and because you are still connected to the grid, you can also charge your batteries from cheap-off peak rates.

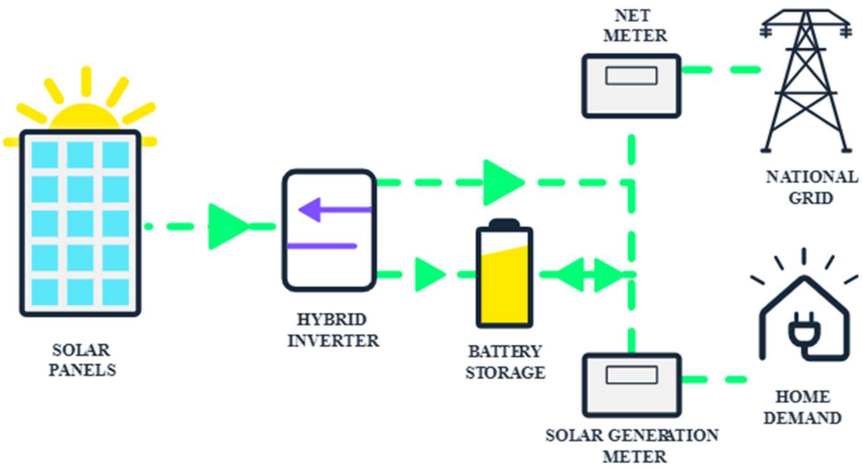


Figure I.27: Hybrid solar photovoltaic system

11.<u>Conclusion:</u>

The purpose of this first chapter was to introduce our work on solar energy in general and on photovoltaic energy in particular. we knew that a photovoltaic installation is a system which ensures the conversion of solar radiation into electrical energy using photovoltaic modules, in order to supply electrical loads, and it includes an electrical energy storage system represented by storage batteries. making it possible to overcome temporary climatic variations, followed by a charge controller which is an important electronic device in the automatic control of the state of charge of the batteries, aims to increase the life of the solar batteries, avoiding overcharges and deep discharge, therefore it is an essential element in autonomous photovoltaic installations. As well as the role of the inverter which remains essential to be able to supply our receivers with alternating current.

Finally, we saw the three main types of solar PV systems: grid-tied, hybrid and off-grid.

Chapter II:

Presentation of smart solar house and description of the studied site

1. Introduction:

In this chapter we will present the site studied (a house), furthermore talking about the criteria to select our components and to do our calculations. The most important thing is to present and introduce our smart solar home project.

2. presentation:

The site we are studying is a house, located in the state of Adrar, a family house of **150** square meters, consisting of **07** rooms plus central one and a space, a roof,**03** showers,**03**bathrooms and kitchen.

3. Geographical location:

This house is located in the municipality of Sally. About 110km south of the state of Adrar with an area of 16683 **[23].** The site studied or to be fed is characterized by the following elements:

•Altitude:220m.

•Latitude:26,9610°.

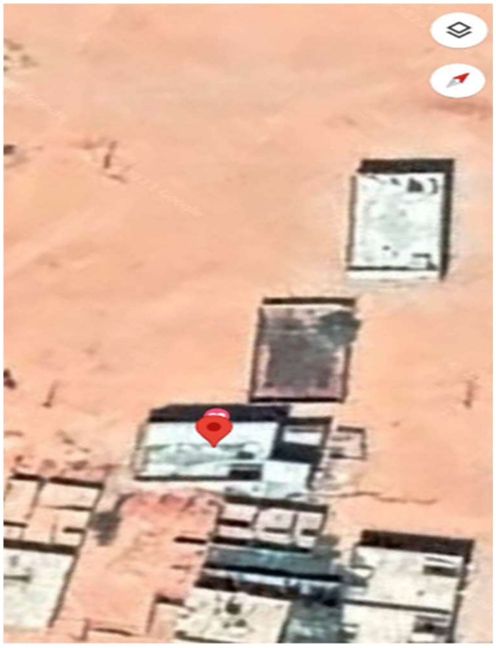
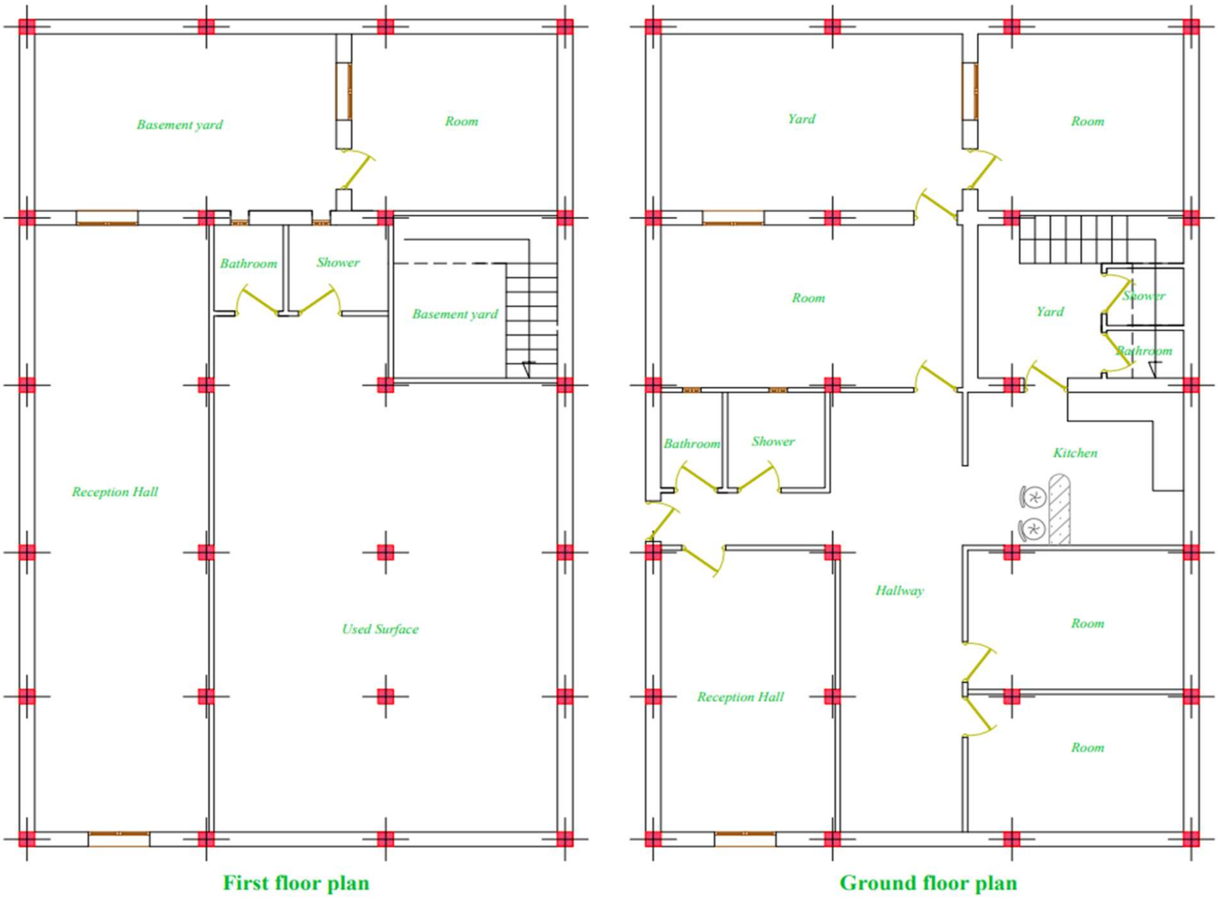


Figure II.1: Geographical location of the house in Adrar on google map

4. Architecture design for the house by AutoCAD:



5. Orientation and inclination of solar panels:

Inclination is the angle between the solar panel plane and the floor (horizontal plane). A panel tilted to 0° is flat against the ground or horizontal. And a panel tilted to 90° is vertical. The orientation is the angle between the solar panel and the South axis. At 0°the orientation angle corresponds to a sign facing south.90° east or west, 180° north **[24].**

5.1. orientation of the solar panels in Algeria:

In Algeria and more generally throughout the northern hemisphere the orientation due south is the best possible orientation for a photovoltaic module, and with this orientation we can produce the Maximum amount of electricity.

5.2. The inclination of photovoltaic modules:

The inclination corresponds to the slope of the module relative to the horizontal it's measured in "°".

•A 0° means the module is flat.

• A90° means the module is vertical.

And for annual collection, the angle sensor is fixed to the latitude of location. In winter, the optimum tilt angle is calculated by adding 15 degrees to your latitude, and subtracting 15 degrees from your latitude **[25].** And for annual collection, the angle sensor is fixed to the latitude of location.

6. Selection the components of PV system:

The criteria we should follow when want to select the right inverter for our installation is:

6.1. Efficiency:

We should look for efficiency of 90%-95% or higher. The efficiency of inverter means: how much power delivered from the batteries will be converted or transferred to our home when it's operating. In perfect conditions a good peak efficiency rating is around 94-96%.

6.2. Temperature range:

Inverters are sensitive to extreme heat. Pay careful attention to the temperature range if we want to make our installing in our garage or anywhere where it could be exposed to extreme temperature.

6.3. Surge capacity:

Refers to how much short-term overload can the inverter handle .so we should make sure that the inverter we select has this surge capacity included.

6.4. Warranty:

Warranties start at one year and typically range from 3 to 5 years.

6.5. UL listings and certifications:

Off-grid inverters have a few different certifications required in the US for safety and to ensure code compliance. Inverters for our home need to be UL 1741 listed. Mobile inverters used in boats an RV's this should carry UL458 certification.

6.6. Manufacturer:

Read as much as you can from the manufacturer this involves their history and reputation of course. If i would have to suggest a bunch of companies that are making really high quality Off-grid inverters, the list will be like this:

•SMA.

• OUT BACK POWER: for hybrid PV system that are connected to the grid and have battery bank backup.

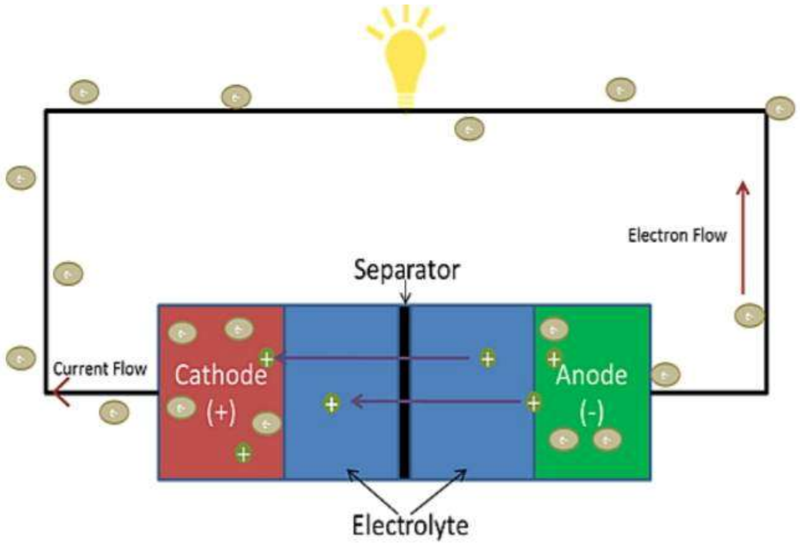
•Schneider electric: best for large off-grid PV system.

•Magnum energy: best for cabins and small homes.

•Morningstar: really good for small off-grid systems.

7. Selection of the batteries:

This component of our off-grid PV system is responsible for storing the energy produced by the solar modules for those of low or no solar irradiance**.** It's used also to store the electrical energy in a chemical form and then releasing it as direct current in a controlled way. All batteries contain a positive and a negative electrode immersed in an electrode, the whole assembly being within a container **[26].**



•For choosing the best batteries bank for our PV system. We have five main technical specifications:

7.1. Nominal capacity (or rated capacity):

The energy that can be stored a battery is known as the battery's capacity which is measured in of "Amps-hour". All deep cycle battery manufacturers will provide the total capacity of a battery in Ah (Amps-hour).

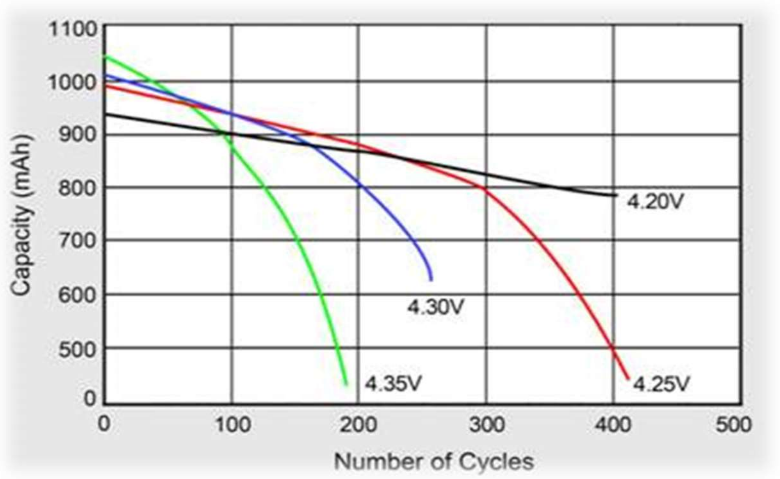


Figure II.2: Nominal capacity of the solar battery

7.2. <u>Depth of Discharge (DOD):</u>

Is the percentage of the battery capacity that can be regularly discharged without damaging the battery or reducing its lifespan.

Most the batteries need to retain some charge at all times due to their chemical composition. If we use 100% of our batteries its useful life will significantly be shortened.

Most manufacturers will specify a maximum DOD for optimum performance. •Lithium batteries can typically be discharged to 80% or 90%.

•Lead -Acid batteries will only go down to 40%or 60%.

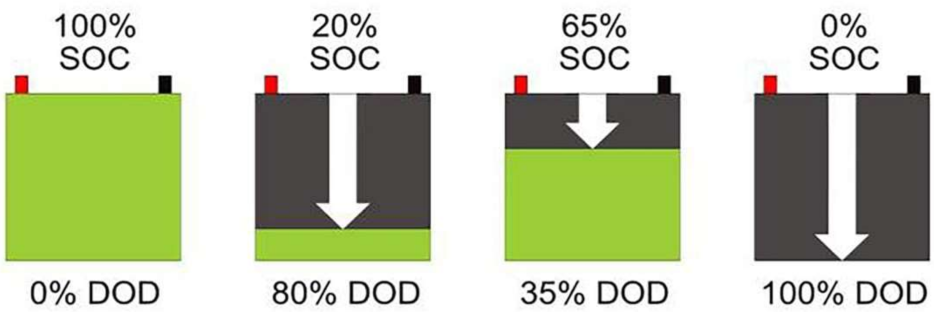


Figure II.3: Depth of Discharge of the solar battery

7.3. <u>Round Trip Efficiency:</u>

Batteries round trip efficiency represents the amount of energy that can be used as a percentage of the amount of energy that it took to store it measured in (%).

<u>For example:</u>

If you feed five kilowatt hours of electricity into your battery and you can only get four kilowatt hours of useful electricity, then battery has a 60% round trip efficiency (6kwh divided by 10kwh equals 60%).

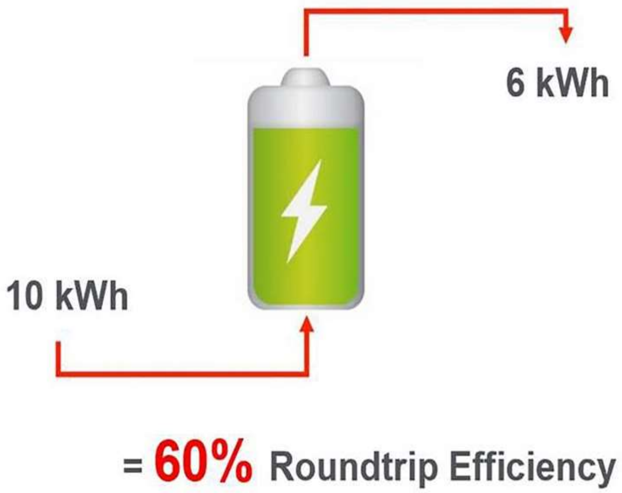


Figure II.4: Round Trip Efficiency

7.4. Cycle life:

Is the number of charge discharge cycles that are battery has before it's considered to have reached its end of life.

•Lithium batteries will typically have a cycle life of 4000 to 10000cycles.

•Lead acid batteries might have as low as 1000 cycles only.

7.5. Life span:

Described as a total life of a battery before it loses its storage capacity and needs to be replaced.

The general range of a solar battery is between 5 to 15 years depending on the battery technology.

Figure II.5: Life span of the battery

8. How we select the right charge controller:

Selecting an efficient and properly designed charge controller is key to longevity and efficiency your entire PV system. Solar charge controllers are rated and sized by the solar arrays current and system voltage, most commonly we can find MPPT charge controllers of 12, 24 and 48 volts.

The charge controllers amperage ratings normally run from 01 to 80 A. Now this charge controller rating is given by the output amperage that they can handle **[27].**

For example:

Let's assume that we have chosen t install a system of 1600 watts and a battery bank running on 48 volts DC.

Power=V×I.

1600=48V×I.

I=1600/48.

I=33.3 A.

We still want to adjust it's value by 25 percent to take into account any special weather conditions that might cause the solar module array to produce more power than is normally rated for like in extraordinary bright conditions or reflections of snow for instance.

So**, I=33.3A +25%=41.6 A.**

In this case we'd probably just a 60 A MPPT charge controller like the outback power" Flex Max 60 A " which is a very close match. There's no problem to go with a larger controller other than the additional costs of course. This would allow you to expand the size of your system later down the road if your load demands change or you eventually feel that you need a little bit more power. All you need to do next is find a reliable local supplier and purchase charge controller rated at the current we've just calculated.

9. Selection for solar pumping system:

Solar pumps are very popular in the field of mini-systems drinking water supply. Historically diesel generators have been widely used to address rural pumping station electrical supply problem. However, the operation of diesel engines requires many hours of maintenance (replacement of filters, filling of fuel tanks, drains). Conversely, solar pumps require only a minimum of attention and some types of pumps can even WO << RK for up to 5 years without any intervention. Their daily functioning as the sun goes by in automatic and unattended. This type of solution is perfectly suitable for applications located far and monitoring of a diesel solution is difficult **[28].**

Pumping covers a large majority of needs:

• Domestic.

•The provision of drinking water.

•Livestock.

•Irrigation.

9.1. Types of solar pumping:

9.1.1. Pumping over the sun: (direct pumping system):

Pumping «with the sun» allows having a simple, reliable and less expensive photovoltaic system. Here the water is pumped and stored in a tank, over the day. Then we talk about hydraulic storage. Stored water will be distributed as required.

9.1.2. Indirect pumping: (Pumping with energy storage):

Here it is the electric energy that will be stored in batteries. Pumping will be possible even in the absence of the sun. Such a system is more expensive than the previous one, given the need to change the batteries, as they have a short lifespan **[29].**

9.2. Types of the solar pumps:

9.2.1. centrifugal pumps:

Are mechanical devices designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors called impellers **[30].**

Figure II.6: centrifugal pump

9.2.2. The volumetric pump:

Still called progressive cavity pumps use the volume variations of the pumped fluid to obtain an increase in pressure the fluid is first aspirated by the growth of a volume the pushed back by reduction of this same volume **[30].**

Figure II.7: The volumetric pump

9.2.3. surface pump:

Are always installed a height lower than this. These pumps must be primed .it means the section of pipe up stream of the pump must be filled with water to initiate suction of water **[30].**

Figure II.8: surface pump

9.2.4. Submersible pump:

The submerged pumps are therefore immersed in water and have either submersible motor with pump, the transmission of power is them through a long shaft connecting the pump to the motor. In the two cases, a discharge line after the pump allows elevations of several tens of meters, depending on the engine power **[30].**

Figure II.9: Submersible pump

10.Solar water heating:

Solar water heating system is a device that uses energy from the sun to heat water for use in homes or businesses. It typically consists of solar collectors (panels or tubes) that absorb heat from the sun and transfer it to a fluid that circulates through the system. The heated fluid is then used to heat water in a storage tank, which can be used for a variety of purposes, such as washing clothes, bathing, or space heating. Solar water heating systems are an efficient and environmentally friendly alternative to traditional water heating systems that rely on fossil fuels **[31].**

10.1. How They Work:

A solar water heating system works by absorbing sunlight and converting it into heat energy that warms the water in a storage tank or reservoir. Here are the steps involved **[31]:**

10.1.1. Solar collectors:

The system typically consists of flat or cylindrical solar collectors, which are often placed on the roof of a building. These collectors absorb sunlight and convert it into heat energy.

10.1.2. <u>Heat transfer fluid:</u>
A heat transfer fluid, such as water or antifreeze solution, circulates through the collectors to absorb the heat.

10.1.3. <u>Heat exchanger:</u>
The heated fluid is then pumped through a heat exchanger, which transfers the heat to the water in the storage tank.

10.1.4. <u>Storage tank:</u>
The hot water is stored in a well-insulated storage tank until it is needed.

10.1.5. <u>Backup system:</u>
In case of insufficient sunlight or high demand for hot water, a backup system, such as a gas or electric heater, is often used to supplement the solar system.

10.1.6. <u>Control mechanism:</u>
A control mechanism is used to regulate the flow of the heat transfer fluid and to control the backup system. Overall, a solar water heating system is an efficient and cost-effective way to heat water using renewable energy from the sun.

There are two kinds of systems: active and passive. The former has controls and pumps that circulate water, while the latter does not.

10.2. <u>Active Solar Water Heating Systems:</u>
Active systems use pumps and controls to circulate water or heat-transfer fluids through the collectors and into the storage tank. There are two subtypes of active solar water heating systems:

10.2.1. <u>Direct circulation systems:</u>
In a direct circulation system, pumps circulate water through the collectors and into the home or building. Direct systems are most commonly used in warm climates where freeze protection is not needed.

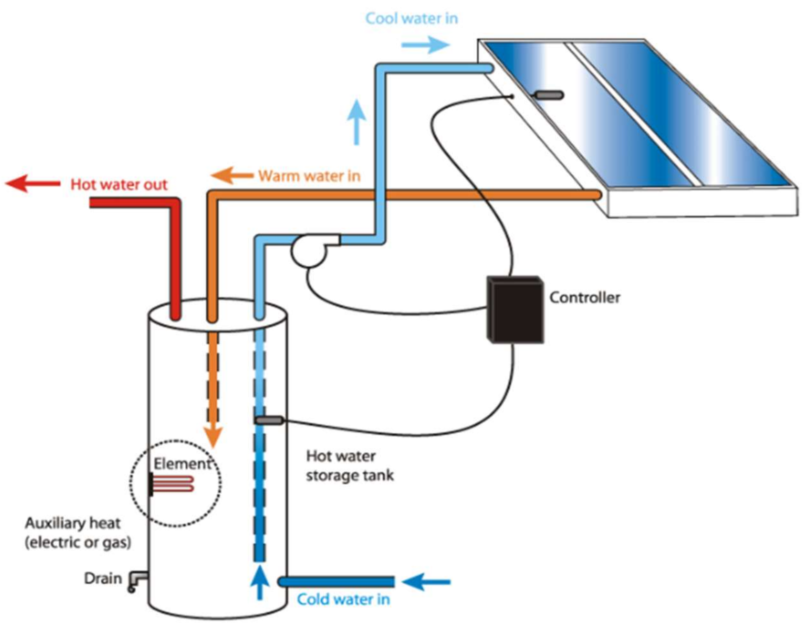


Figure II.10: Direct circulation system

10.2.2. <u>Indirect circulation system:</u>

In an indirect circulation system, pumps circulate a heat-transfer fluid through the collectors and a heat exchanger, which heats the water in the storage tank. Indirect systems are best for cold climates because the heat-transfer fluid can be a glycol solution, which is less likely to freeze.

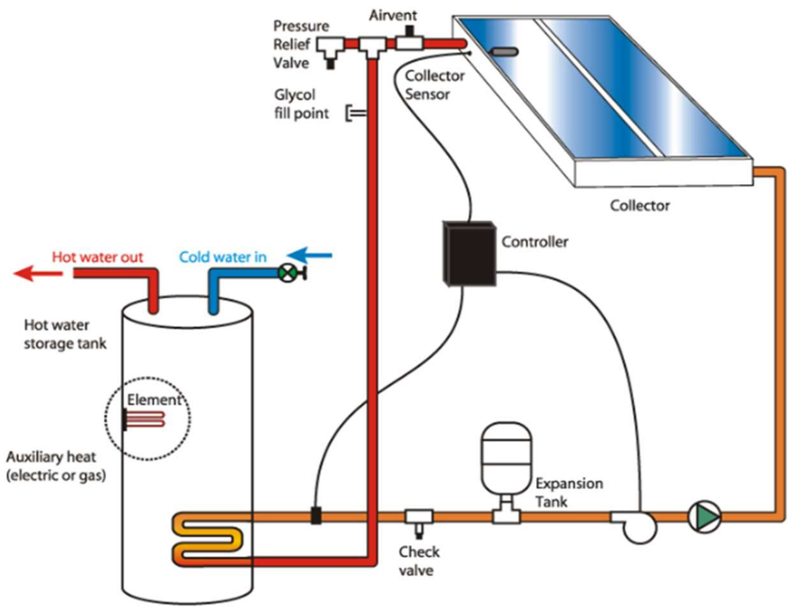


Figure II.11: Indirect circulation system

10.3. Passive Solar Water Heating Systems:

Passive systems do not use pumps or controls, relying instead on gravity and natural convection to circulate water or heat-transfer fluids through the collectors and into the storage tank. There are also two subtypes of passive solar water heating systems:

10.3.1. Integral collector-storage systems:

In an integral collector-storage system, the storage tank is integrated with the solar collector, so the system relies on natural circulation to move the water. These systems are best suited for warm climates where freeze protection is not needed.

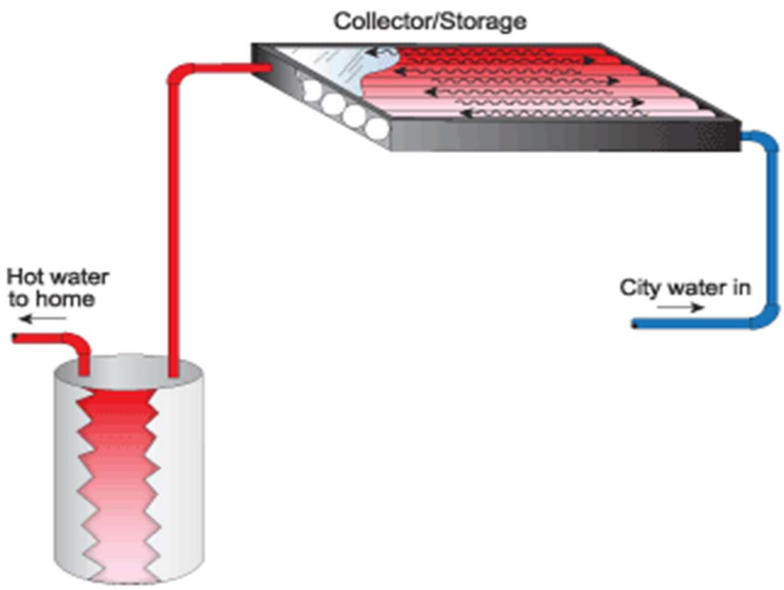


Figure II.12: Integral collector-storage system

10.3.2. Thermosyphon systems:

In a thermosyphon system, the storage tank is located above the solar collector, relying on gravity to move the water or heat-transfer fluid through the system. These systems are best suited for cold climates where freeze protection is important.

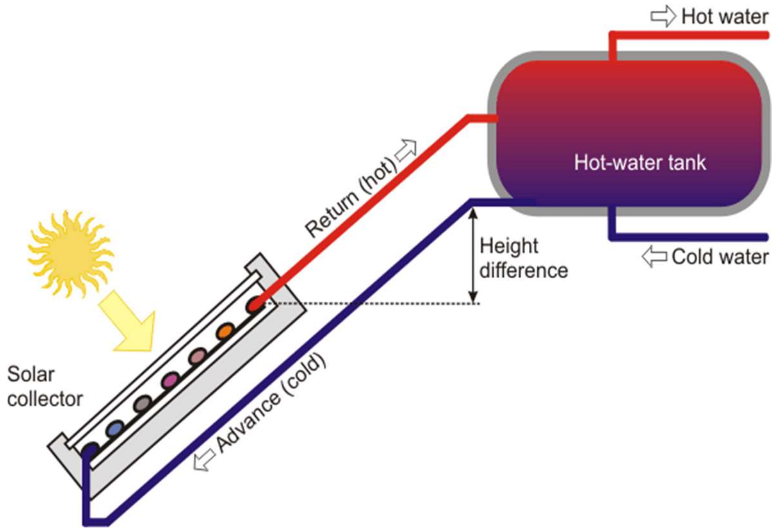


Figure II.13: Thermosyphon system

11. The steps to size for a solar water heating system:

Here are the steps to size for a solar water heating system:

11.1. Determine the hot water demand:

Calculate the amount of hot water your household uses per day. This can vary based on the number of occupants in the house and the type of equipment that demands hot water frequently.

11.2. Determine the solar resource:

Calculate the solar resource in your area by looking up the average daily sunlight hours and total solar radiation. Use this information to estimate the amount of energy that your solar collector can absorb and convert into usable heat.

11.3. Calculate the collector area:

The collector area is the surface area of the solar collector that is used to absorb sunlight and heat the water. Larger collector areas can heat more hot water, while smaller ones are less expensive. The best way to determine the collector area is to use an online calculator, or consult a professional to determine the appropriate size for the demand.

11.4. Determine the storage tank capacity:

After estimating the hot water demand and the solar collector area, the next step is to determine the size of the storage tank. The storage tank should be large enough to store the hot water that is not used in the day and prepare the hot water for use in the night or cloudy days.

11.5. Install the system:

Install and test the solar heating system to ensure it is functioning properly, and make any necessary adjustments to its operation. This will help to ensure it is operating as efficiently as possible.

11.6. Monitor performance:

Monitor the performance of the solar heating system over time to ensure it is meeting the hot water demand of the household. This will help you make any necessary changes over time, such as adjusting the collector area or storage tank capacity to meet the changing needs of your household.

12. Automate Programmable:

Integrating an automation program into a photovoltaic (PV) system is an efficient way to control and monitor system operations and improve its performance. The controller can be programmed to monitor battery charge levels, solar power generation, and other key system parameters. It can also be used to turn on and off devices such as pumps, fans, lights, heating and cooling systems based on system needs. In addition, the controller can be configured to send alerts or notifications in the event of system problems or failures, thus enabling rapid and efficient intervention. Finally, the use of a programmable logic controller can help improve the efficiency and reliability of the stand-alone photovoltaic system, which can result in lower costs and longer system life **[32].**

13. Smart solar house:

A smart solar house is a concept that combines sustainable energy generation through solar power with advanced automation and intelligent technologies to create an energy-efficient and environmentally friendly living space. It mainly depends on three smart systems that are powered by solar energy only by 100%. represented by the solar photovoltaic system, solar water heating and solar water pumping. The main objective is to provide a house located in Adrar with electricity and water from free environmentally friendly energy.

14. Conclusion:

The aim of the second chapter is to present the studied site that includes the house for the rules of solar systems. We also knew the criteria for selecting our components and the various elements through their characteristics in order to install an integrated system, and how to do our calculations, and also how to monitor the systems of the smart home, with a brief explanation of the smart home of our project.

Chapter III:

Dimensions and techno-economic of our smart solar house

1. Introduction:

In this third chapter present of the software that used to do the sizing. after that dimension of the three smart solar home systems. we calculated the electrical needs of the studied house, and then calculated the photovoltaic system sufficient to supply this house with electricity. Then we dimension the solar water pumping system to supply the house with water. with calculate the water heating system through solar thermal energy. also dimension the pv system with software of PVsyst. Finally study techno-economic of our systems.

2. Presentation of the software that used to do the sizing:

2.1. Presentation of "pvsyst" program:

PVsyst is a computer software program designed for the study, sizing, simulation, and data analysis of photovoltaic solar energy systems. It offers a range of features such as optimization of panel orientations and configurations, calculation of energy yields, and estimation of economic feasibility.

2.2. Presentation of "Dialux" program:

Dialux is lighting design software used by architects, lighting designers, and planners to plan and create lighting designs for indoor and outdoor spaces. It allows users to simulate and visualize different lighting scenarios and analyze the energy efficiency of lighting systems. Dialux offers a range of features, such as the creation of 3D models, calculation of illuminance levels, and the ability to import and export different file formats.

2.3. Presentation of "AutoCAD" program:

AutoCAD is a computer-aided design (CAD) software program used for 2D and 3D drafting and design. It allows for the creation of precise technical drawings and models used in architecture, engineering, construction, manufacturing, and interior design. AutoCAD supports a variety of file formats and features tools for geometry editing, dimensioning, annotation, and visualization.

3. Dimensions of PV system:

	Power(W)	**Number**	**Usage of time**	**P×N (W)**	**Energy (Wh/day)**
Lamps 01	12	17	03	204	612
Lamps 02	07	06	03	42	126
Fridge	400	01	24	16.66	400
Freezer	200	01	24	8.33	200
Fans	60	02	02	120	240

Computer	150	01	03	150	450
Dimo+TV	150	01	06	150	900
Humidifier	120	01	05	120	600
Air conditioner	2000	01	05	2000	10000
Divers	100	01	05	100	500
				PT=2911	**ET=14028**

Table III.1: Electrical needs after optimization

3.1. Inverter:

$$P\ inv = \frac{PT \times 1.25}{\eta}$$

Pinv = (2911×1.25)/0.98

Pinv = 3713 W

So, we choose an inverter off-grid 5000 W and 48 v

3.2. Battery:

N=01

$$N\ battery = \frac{ET \times N}{DoD \times C \times V}$$

$$N\ battery = \frac{14028 \times 01}{0.6 \times 250 \times 12}$$

$$N\ battery = 08$$

04 battery in series 12v×4= 48v / 02 fields in parallel 250×02=500 Ah

N=10h

N= 10/24 = 0.42

$$N\ battery = \frac{14028 \times 0.42}{0.6 \times 250 \times 12}$$

$$N\ battery = \frac{5892}{1800}$$

$$N\ battery = 04$$

3.3. Panels:

Panel of 450 Wc. Adrar : 850 W/m² and 65 C°

450 Wc ⟶ 1000 W/m² ⟶ $X = \frac{850 \times 450}{1000} = 382.5\ W$

X ⟶ 850 W/m²

T(Pmax) = 0.39 %

$X = (65 - 25) \times \frac{-0.39 \times 382.5}{100} = -59.67\ W$

X= 382.5 – 59.67 = 322.83 W

N=01

$$P\ fields = \frac{ET \times N}{Ir}$$

$$P\ fields = \frac{14028 \times 01}{10} = 1403\ W$$

3.3.1. Panels Number:

$$N\ panels = \frac{P\ fields}{Pmax} = \frac{1403}{322.83} = 04\ panels$$

02 panels of 450 W in Series and 02 parallel oak

Voc =49.3v × 2 = 98.6 v / Isc = 11.6A × 2 = 23.2 A

N=0.42

$$P\ fields = \frac{14028 \times 0.42}{10} = 589.1\ W$$

Panels Number:

$$N\ panels = \frac{P\ fields}{Pmax} = \frac{589.1}{322.83} = 02\ panels$$

02 panels of 450 W in series.

V Pv array > V battery (and >Vonduleur) 98.6v > 48v

ELECTRICAL DATA(STC)							
Rated Power in Watts-Pmax(Wp)	425W	430W	435W	440W	445W	450W	460W
Open Circuit Voltage-Voc(V)	48.3V	48.5V	48.7V	48.9V	49.1V	49.3V	49.7V
Short Circuit Current-Isc(A)	11.23A	11.31A	11.39A	11.46A	11.53A	11.6A	11.74A
Maximum Power Voltage-Vmp(V)	40.5V	40.7V	40.9V	41.1V	41.3V	41.5V	41.9V
Maximum Power Current-Imp(A)	10.5A	10.57A	10.64A	10.71A	10.78A	10.85A	10.98A
Module Efficiency (%)	19.24%	19.46%	19.69%	19.91%	20.14%	20.37%	20.67%

Figure III.1: Datasheet for solar photovoltaic panel

3.4. Charge controllers:

Ie = Isc fields × 1.25 = 11.6 × 2 × 1.25

Ie = 23.2 × 1.25 = 29 A

I régulateur > Ie **So we choose a charge controller of 40 A**

3.5. Cable section :

$$S = \frac{2 \times \rho \times L \times I}{\mathcal{E} \times U}$$

ρ : the resistivity in (Ω.mm²/m)

L: the length of the cable in (m)

S: the section of the cable in (mm²)

3.5.1. Cable section between photovoltaic array and the charge controller:

$$S = \frac{2 \times \rho \times L \times I}{\mathcal{E} \times U}$$

U=98.6 v

I = 23.2A

ρ= 0.0177 Ω.mm²/m

Ɛ = 2 %

L= 8 m

$S = \frac{2\times0.0177\times8\times23.2}{0.02\times98.6}$ = 3 mm² So, S= 04 mm²

3.5.2. Cable section between the charge controller and the battery:

$$S = \frac{2 \times \rho \times L \times I}{\mathcal{E} \times U}$$

U=48 v

I = 23.2 A

ρ= 0.0177 Ω.mm²/m

Ɛ = 2 %

L= 1.5 m

$S = \frac{2\times0.0177\times1.5\times23.2}{0.02\times48}$ = 1.28 mm² So, S = 04 mm²

3.5.3. Cable section between the battery and inverter:

$$S = \frac{2 \times \rho \times L \times I}{\varepsilon \times U}$$

U=48 v

$I = \frac{5000}{48} = 104.16$ A

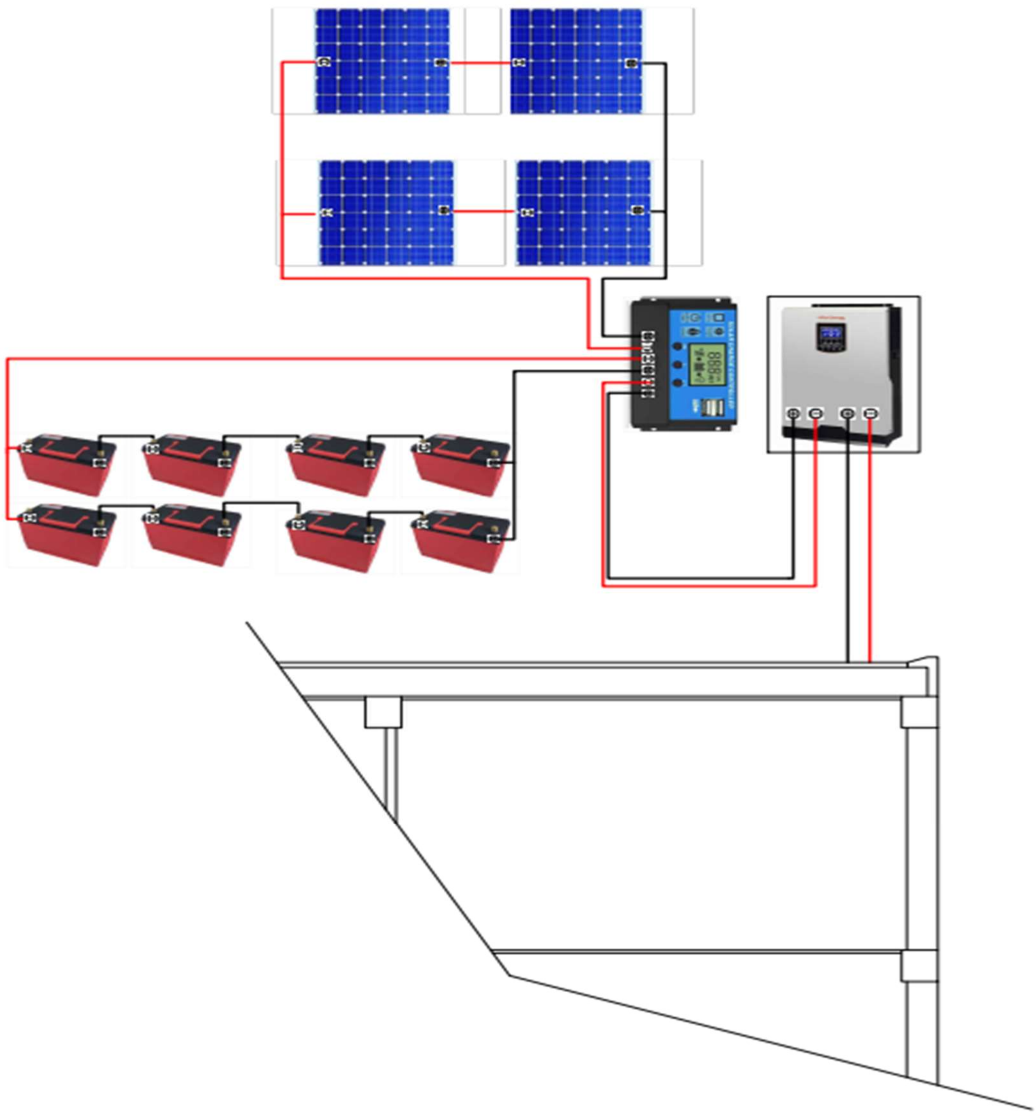
ρ= 0.0177 Ω.mm²/m

Ɛ = 02 %

L= 02 m

$S = \frac{2\times0.0177\times2\times104.16}{0.02\times48} = 7.68$ mm² So, S = 10 mm²

4. Design summarizes the result of PV system by AutoCAD:



5. Dimensions of Solar pumping:

This family consists of 08 persons and they have 03 goats and 02 chickens.

Step 01:

Determine the daily requirement (m^3/h). We have:

The Algerian person consume about 30 liters/day and from animals side, the goat consumes about 05 liters/day and chickens consume about 04 liters /day. / h

Calculations:

We have 08 persons live in these houses, so

$08 \times 30 = 240$ liters/day

We have 03 goats are raised, so

$03 \times 05 = 15$ liters/day

We have 02 chickens, so

$04 \times 02 = 08$ liters / day

Total daily requirement (liter) = 240+15+08 = 263 liters/day

But actually, this family law consumes even 1000 liter/day =1m^3/h that's why we prefer to choose the tank of 1000 liter.

We programme our pump to fill the tank in two hours by day (02 hour/day)

The water flow (m^3/h) $= \frac{\frac{01\ m^3}{day}}{\frac{02\ hour}{day}} = \frac{01}{02}$ $m^3/h = 0.5\ m^3/h$.

Step 02:

Calculate the total dynamic head (TDH) required for pumping the water:

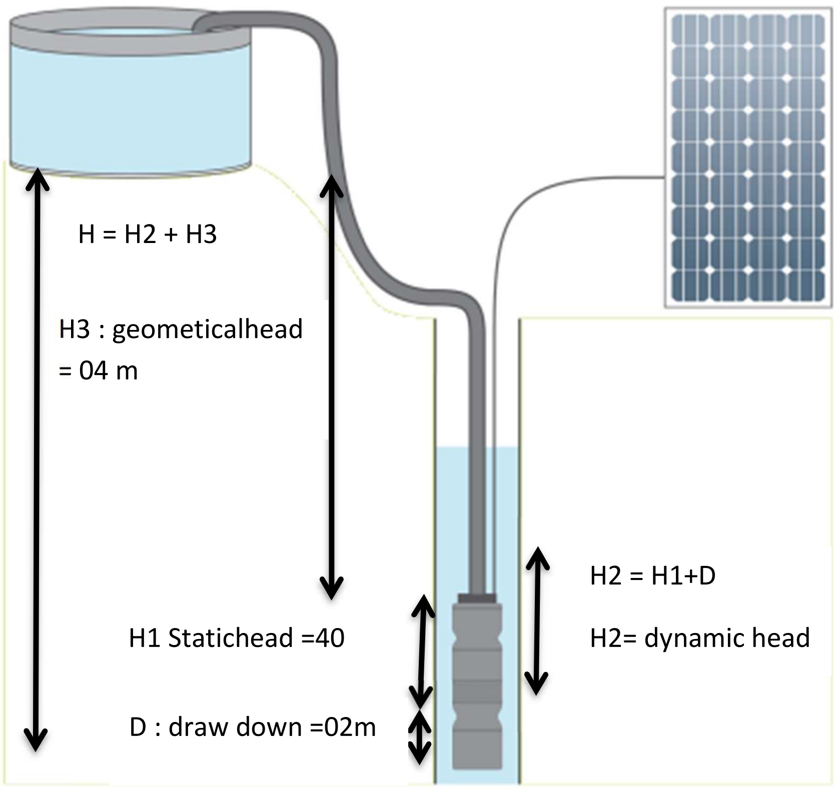


Figure III.2: Solar pumping system

TDH = H+ ΔH = 46 + ($\frac{46\times05}{100}$) = 48.3 wcm .

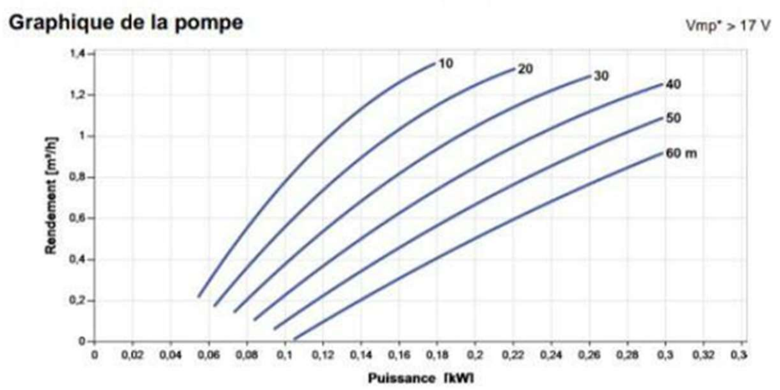
ΔH = 05 % of H

After the calculations we have: Ꞡ = 01 m³/h, H = 48.3 m

So, after the check we found the DC pump of "LORENTZ "company of 300 W, maxHead = 60 m.

So: $\mathbf{P} = \frac{\mathbf{K}\times \mathrm{W}\times\mathbf{H}}{\eta}$

From this curve we conclude that in the depth of 48.3 m and the flow rate of 0.5 m³/h we find that the real power of our pump that we need it is 172 W.



So, we can use one PV module of 200 W to power our DC pump. For PV module:

Manufacture	Trina solar
Power	200 W
Voc	36 v
Isc	7.7 A
Vmp	28.7 v
Imp	6.97 A

Table III.2: Datasheet for solar pumping panel

6. <u>Solar water heating:</u>

We note the increase in solar radiation during the day, and we also note that on the 23 of January the lowest value of solar radiation was recorded.

Figure III.3: Daily Global Radiation

We have an important amount of the direct and the global solar radiation.

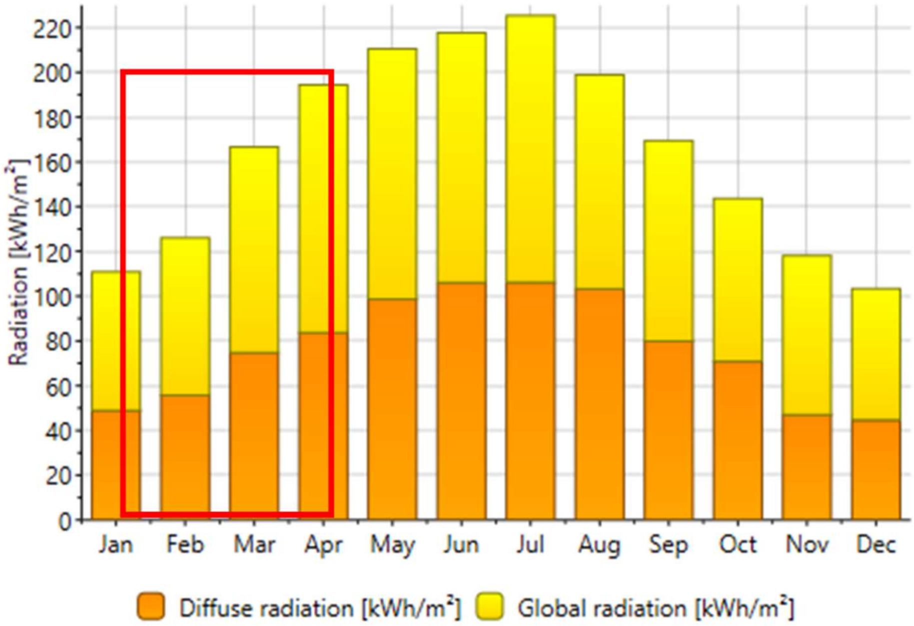


Figure III.4: Monthly Solar Radiation

We have solar radiation duration between 8 and 10 hours during the day.

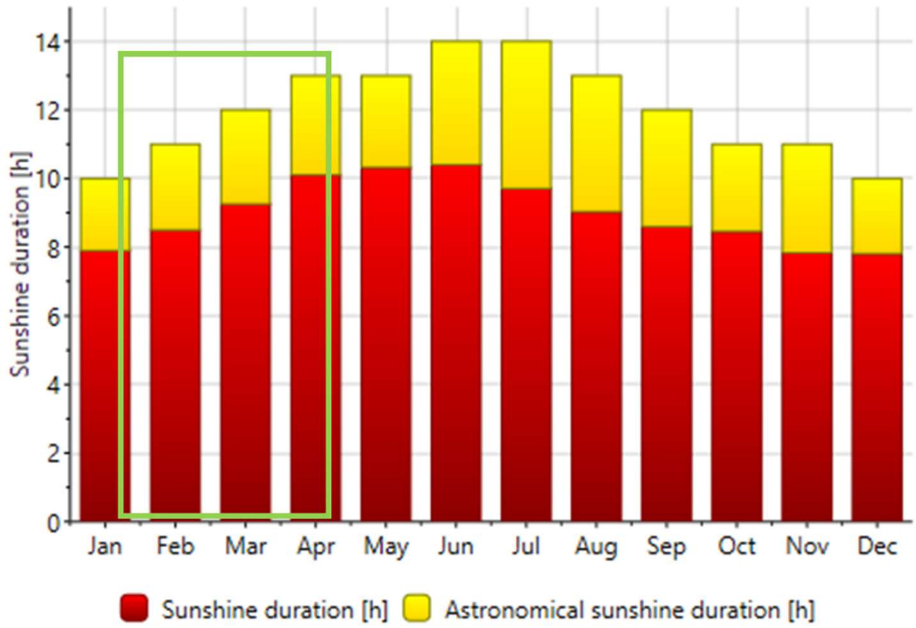


Figure III.5: Sunshine Duration

We note the increase in ambient temperature and this is due to the existence of an expulsive relationship between solar radiation and ambient temperature, which means that the higher the amount of solar radiation received in the area, the higher the ambient temperature.

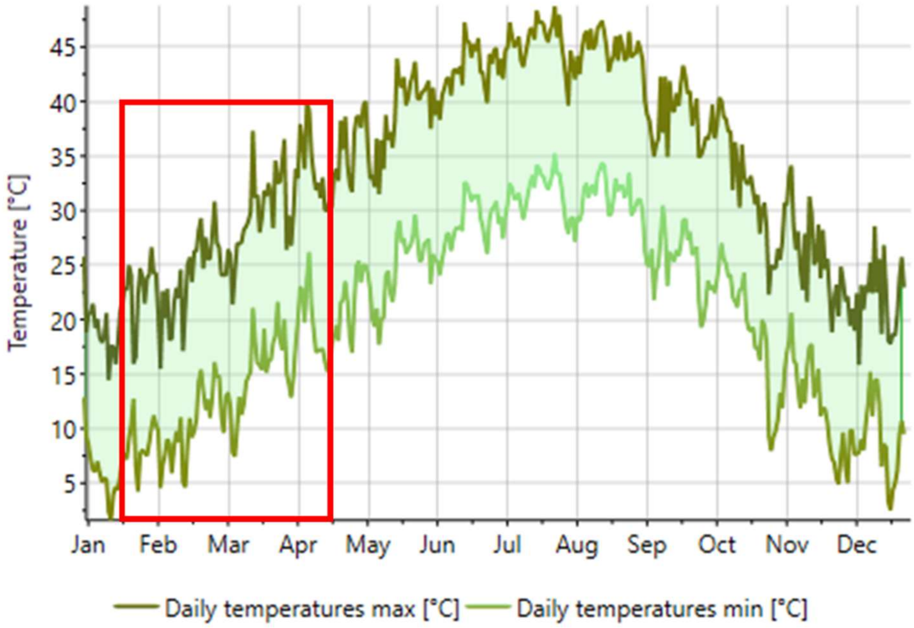


Figure III.6: Daily Temperature

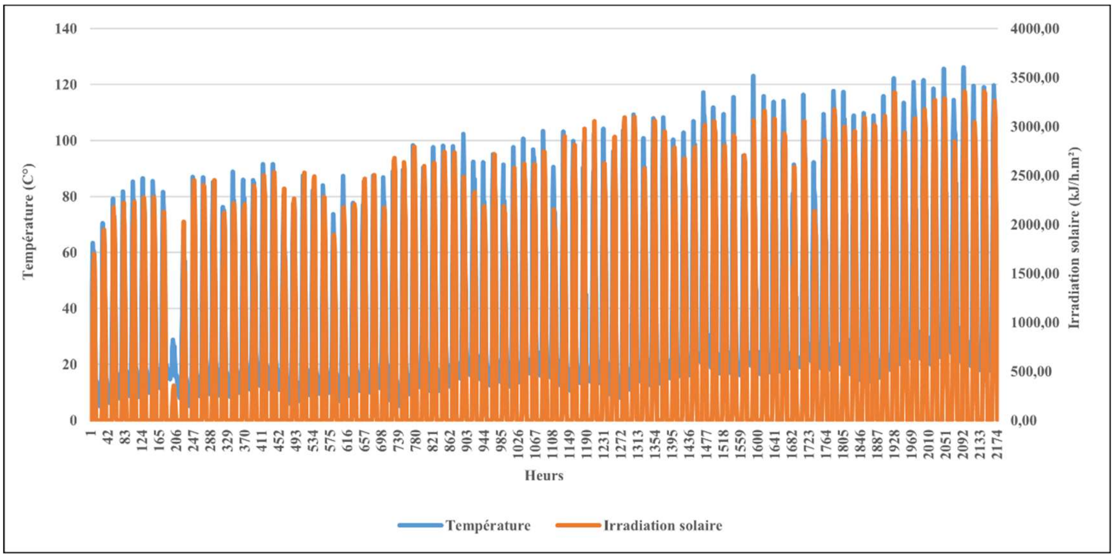


Figure III.7: Daily irradiation variation with sensor output temperature as a function of hours on 15 January to 15 April

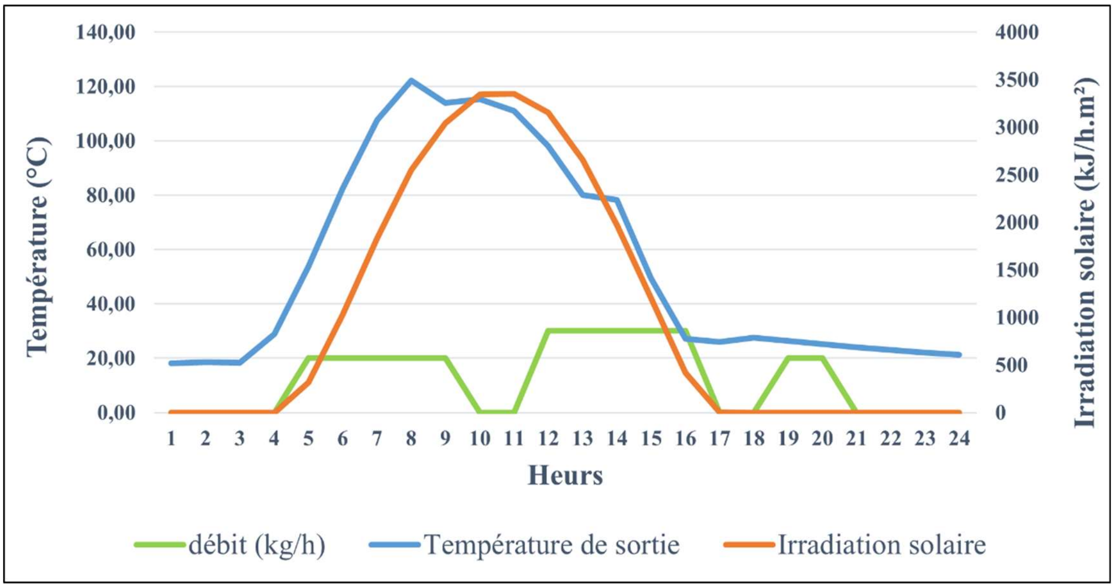


Figure III.8: Daily irradiation variation and sensor output temperature as a function of hours on 5 April (2261-2284)

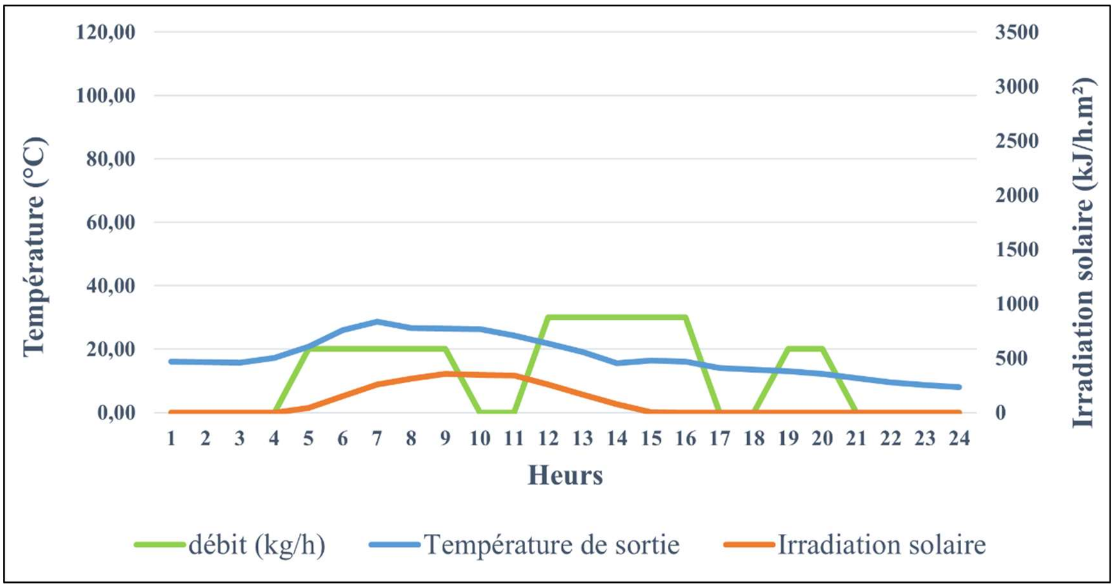


Figure III.9: Daily irradiation variation and sensor output temperature as a function of hours on 23 January (534-557)

here in this situation, we used our solar water heating system to heat the water in Winter season for the family member that They live in this house. But sometimes as we know it might happen some atmospheric disturbances, so we can use Some emergency solutions like use normal gas of Sonelgaz for keeping warm or heating the water or using the Traditional way of igniting coal.

7. Techno-economic of the three system:

7.1. PV system:

First scenario: N = 01 day

Components	Number	Price	Total
PV Module	04	42500	170000
Battery	08	68750	550000
Hybrid inverter	01	150000	150000
Charge controller	01	20000	20000
PV module structure	04	8775	35000
Battery structure	08	1875	15000
Cable			5531.25
Electrical cabinet			40000
Installation			98553.125
Total			1971062.5
		TVA (19) %	374501.875
		Total installation cost (DA)	2345564.375

Table III.3: Photovoltaic system cost for N= 01

Second scenario: N= 10 hours

	Number	Price	Total
PV Module	02	42500	85000
Battery	04	68750	275000
Hybrid inverter	01	150000	150000
Charge controller	01	20000	20000
PV module structure	02	8750	173500
Battery structure	04	1875	7500
Cable			5531.25
Electrical cabinet			40000
Installation			60053.125
Total			660584.375
		TVA (19) %	125511.031
		Total installation cost (DA)	786095.406

Table III.4: Photovoltaic system cost for N=10

TVA = 19% from the total price.

Installation cost = 10 % from the price of the equipment.

7.2. Solar pumping:

Components	Number	Price	Total
PV module	01	25987.5	25987.5
DC solar pump	01	150000	150000
PV module structure	01	8750	8750
Cable			26625
Electrical cabinet		40000	40000
Installation			25136,25
Total			276498.75
		TVA (19) %	52534.7625
		Total installation cost (DA)	329033.5125

Table III.5: Solar pumping system cost

7.3. Cable section:

7.3.1. Between the PV module and electrical cabinet:

$$S = \frac{2 \times \rho \times L \times Imax}{\mathcal{E} \times Umax}$$

Imax = Isc ×1.25

$$S = \frac{2 \times 0.0177 \times 4 \times 7.7 \times 1.25}{0.02 \times 28.7}$$

S = 2.37 mm² So, S= 04 mm²

7.3.2. Between the electrical cabinet and the pump:

Pump (300 W/ 48 v)

$Imax = \frac{300}{48} = 6.25$ A

$$S = \frac{2 \times \rho \times L \times Imax}{\mathcal{E} \times U}$$

$$S = \frac{2 \times 0.0177 \times 4 \times 6.25 \times 1.25}{0.02 \times 48}$$

S = 13.25 mm² So, S= 16 mm²

7.4. Solar water heating system:

Components	Number	Price	Total
Solar water heating (150L)	03	120000	360000
Accessories			30000
Installation			39000
Total			429000
		TVA (19) %	81510
		Total installation (DA)	510510

Table III.6: Solar water heating system cost

Installation cost = 10 % from the price of the equipment.

TVA = 19 % from the total price.

8. Allen-Bradley ControlLogix :

This (PLC) platform is popular programmable logic controller for controlling and automating various applications, including photovoltaic systems. We chose installing the Allen-Bradley ControlLogix in our photovoltaic system for controlling the PV panels and solar batteries, ON/Off of the pump, and temperature of the solar water heating.

First, we insert the voltage sensors to monitor the performance of the 04 photovoltaic panels, we also insert current sensors to monitor the charge levels of the 08 solar batteries of our PV system.

Secondly, we enter the depth sensors of the pump. this is to monitor ON / Off of the pump automatically.

Third we insert temperature sensors to monitor the solar water heating system and control the water temperature for domestic use.

programming side: We program everything we have entered on a platform Allen-Bradley ControlLogix and control it and communicate with the sensors through the Wifi network.

FigureIII.10: Allen-Bradley ControlLogix

9. Conclusion:

In the third chapter we have done all the calculations, dimension and selection of the various components of the three solar systems. We also saw how to use software PVsyst in sizing a solar photovoltaic system. and techno-economic of our smart solar house. And we summarized the results in a drawing by AutoCAD software.

II. General Conclusion:

One of the most important factors that makes the need to use it ,is difficult the electricity grid's access to certain areas or the exorbitant costs of connecting to the electrical grid،So we chose a house located in a remote area of Adrar State was supplied with solar energy and three solar systems were designed: It is the solar system isolated from the grid to provide this house's electrical power and solar pumping system to provide the necessary water, The water heating system was also connected to solar power during the winter period precisely, A theoretical study was carried out in which the amount of energy consumed per day was calculated and the ingredients needed to produce it were calculated. Then the amount of water needed for both people and animals were also calculated.

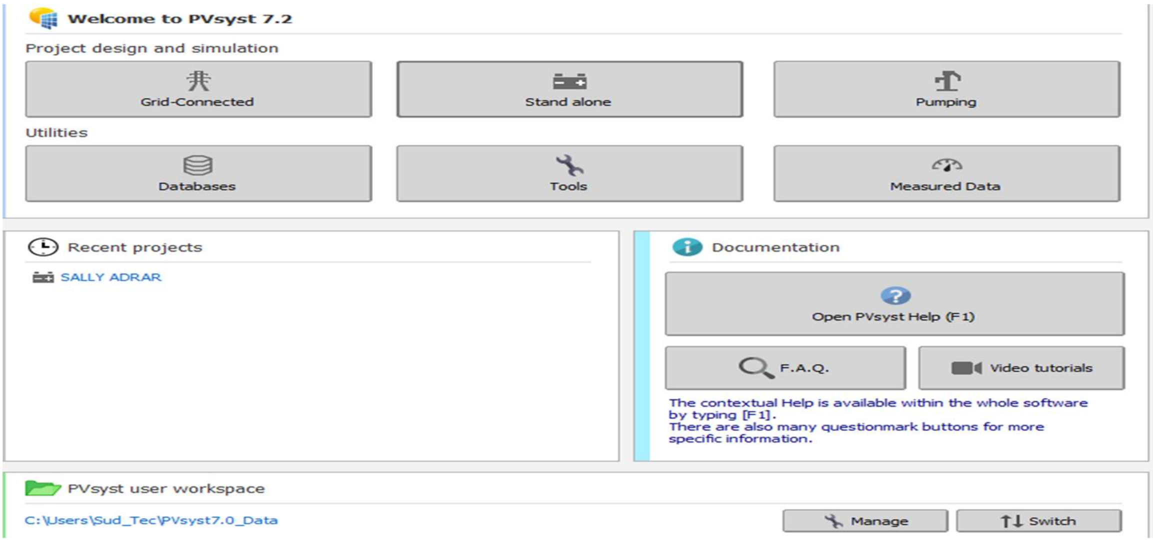
The amount of water needed to be heated daily was calculated by the thermal sensor. Then a simulation of each of the three systems was done using the two programs:
• PVsyst program.

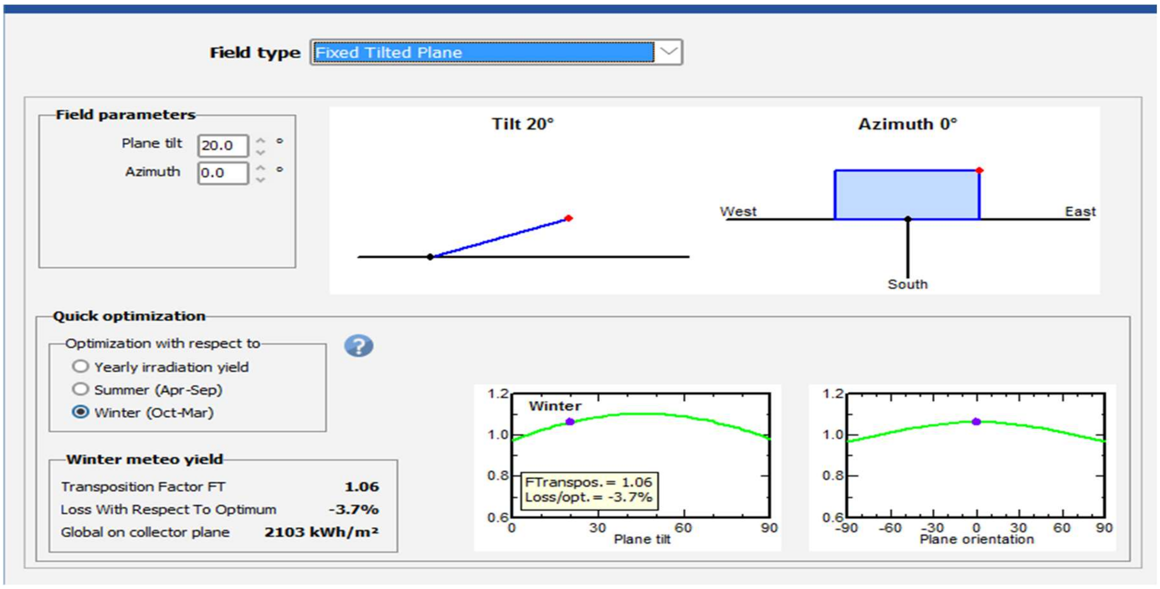
• Auto CAD program.

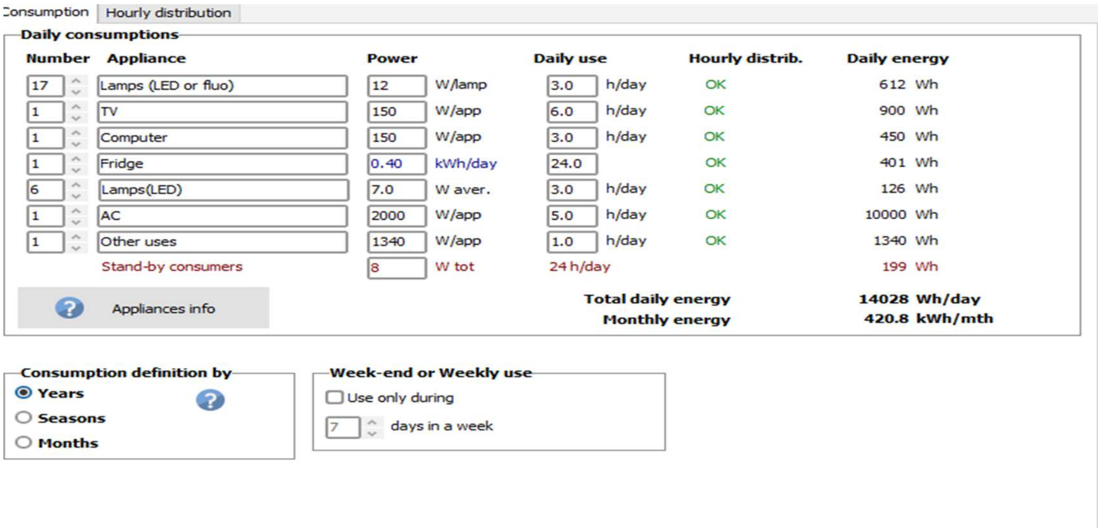
Finally, for an easy control and control process for the user in these solar systems, these systems have been connected to the "programmable automat " device which These systems are controlled remotely.

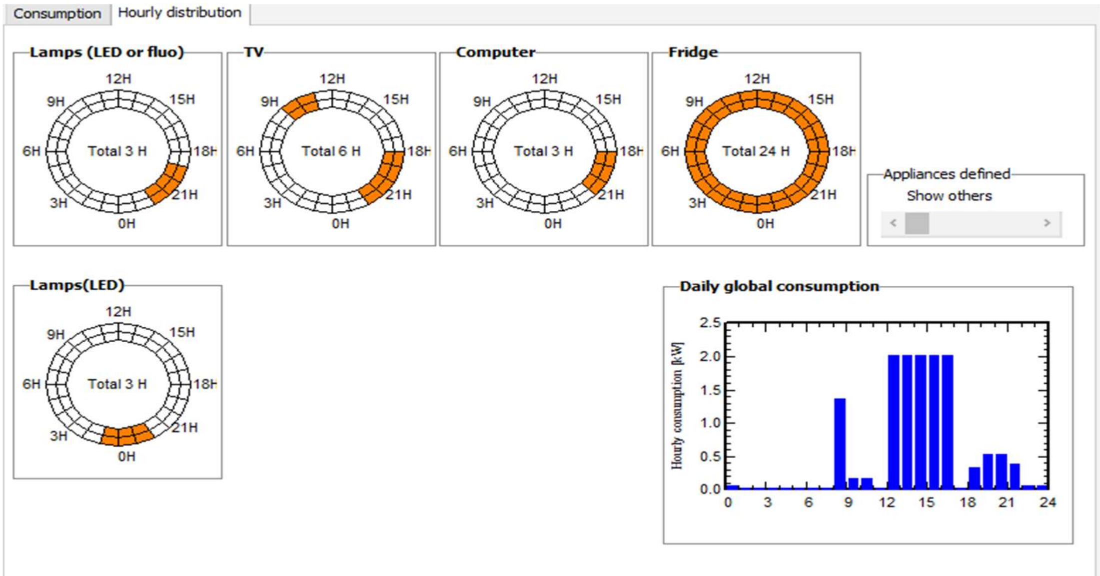
Annexe:

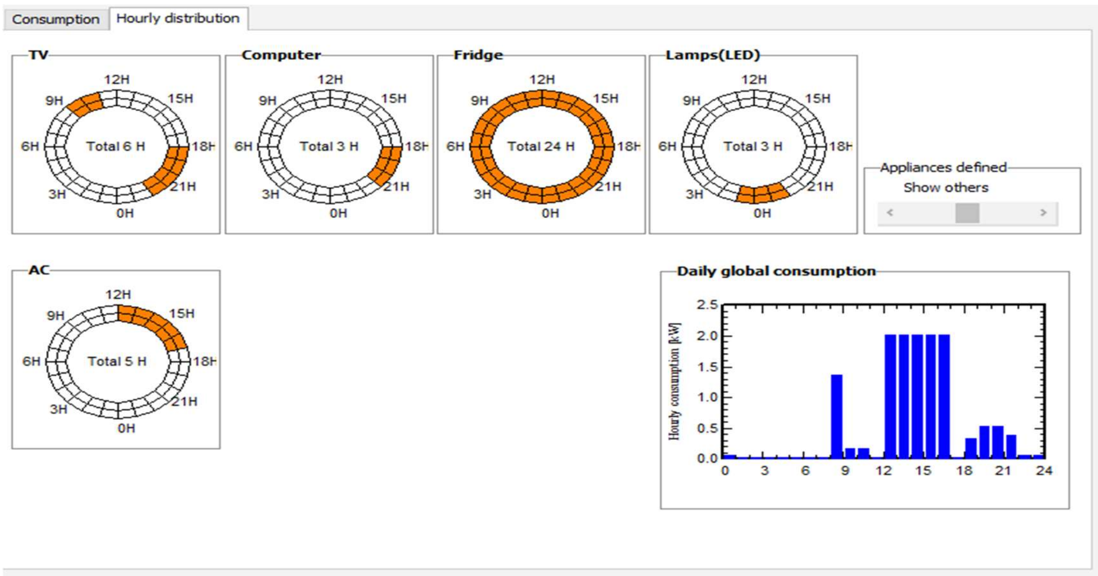
PV sizing by PVsyst:

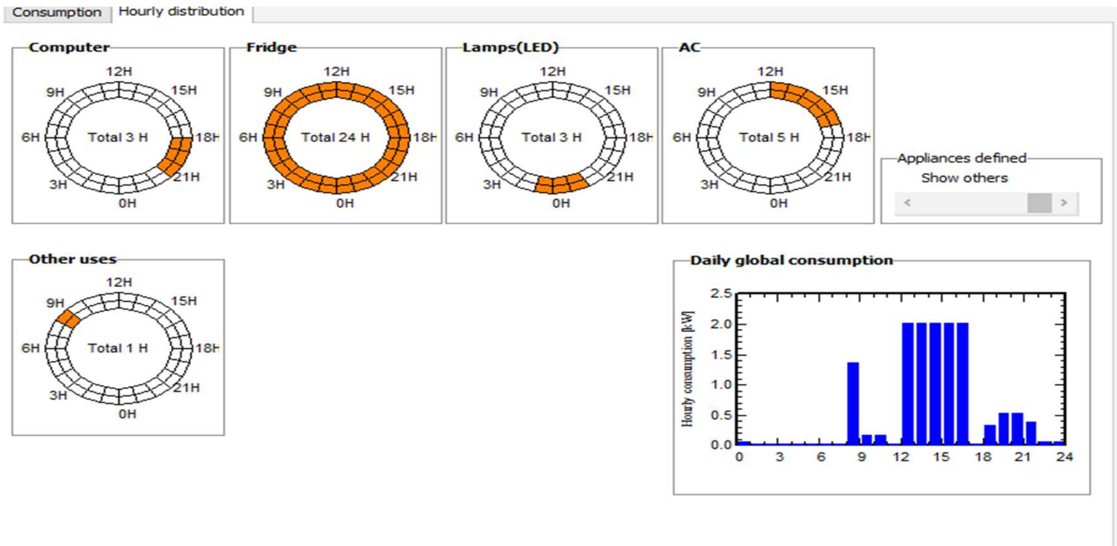


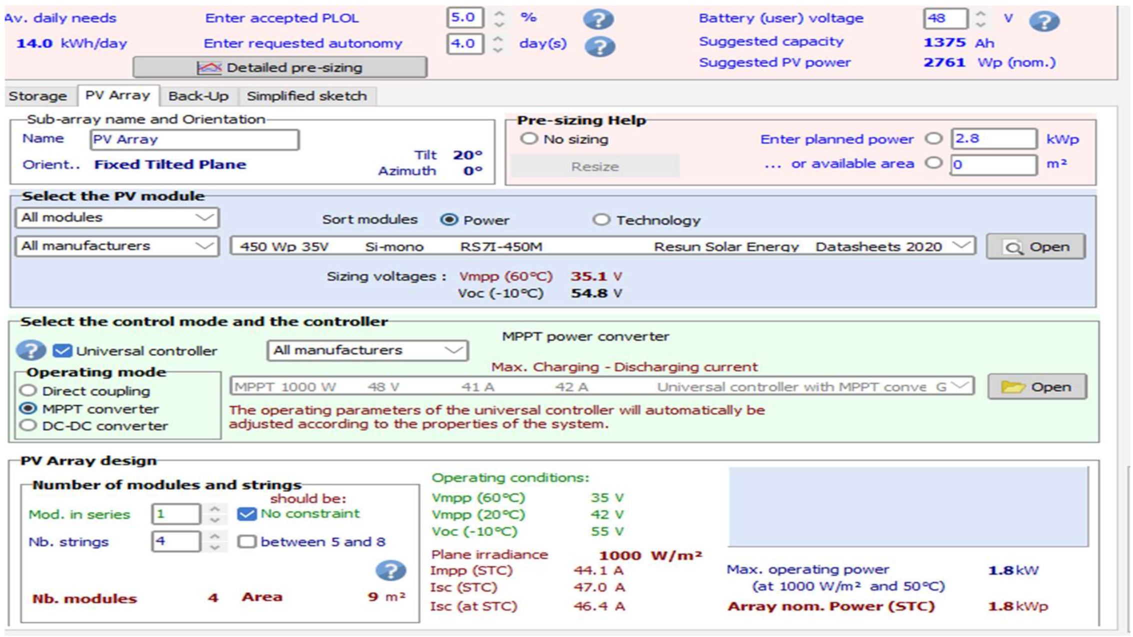



Consumption
Hourly distribution
Daily consumptions
Number
Appliance
Power
Daily use
Hourly distrib.
Daily energy
17 Lamps (LED or fluo) 12 W/lamp 3.0 h/day OK 612 Wh
1 TV 150 W/app 6.0 h/day OK 900 Wh
1 Computer 150 W/app 3.0 h/day OK 450 Wh
1 Fridge 0.40 kWh/day 24.0 OK 401 Wh
6 Lamps(LED) 7.0 W aver. 3.0 h/day OK 126 Wh
1 AC 2000 W/app 5.0 h/day OK 10000 Wh
1 Other uses 1340 W/app 1.0 h/day OK 1340 Wh
Stand-by consumers 8 W tot 24 h/day 199 Wh
Appliances info
Total daily energy 14028 Wh/day
Monthly energy 420.8 kWh/mth
Consumption definition by
Years
Seasons
Months
Week-end or Weekly use
Use only during
7 days in a week


Consumption
Hourly distribution
Lamps (LED or fluo)
Total 3 H
TV
Total 6 H
Computer
Total 3 H
Fridge
Total 24 H
Appliances defined
Show others
Lamps(LED)
Total 3 H
Daily global consumption
Hourly consumption [kW]


Consumption
Hourly distribution
TV
Total 6 H
Computer
Total 3 H
Fridge
Total 24 H
Lamps(LED)
Total 3 H
Appliances defined
Show others
AC
Total 5 H
Daily global consumption
Hourly consumption [kW]


Consumption
Hourly distribution
Computer
Total 3 H
Fridge
Total 24 H
Lamps(LED)
Total 3 H
AC
Total 5 H
Other uses
Total 1 H
12H
15H
18H
21H
0H
3H
6H
9H
Appliances defined
Show others
Daily global consumption
Hourly consumption [kW]
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24


Av. daily needs
14.0 kWh/day
Enter accepted PLOL 5.0 %
Enter requested autonomy 4.0 day(s)
Detailed pre-sizing
Battery (user) voltage 48 V
Suggested capacity 1375 Ah
Suggested PV power 2761 Wp (nom.)
Storage
PV Array
Back-Up
Simplified sketch
Sub-array name and Orientation
Name PV Array
Orient.. Fixed Tilted Plane
Tilt 20°
Azimuth 0°
Pre-sizing Help
No sizing
Resize
Enter planned power 2.8 kWp
... or available area 0 m²
Select the PV module
All modules
All manufacturers
Sort modules
Power
Technology
450 Wp 35V Si-mono RS7I-450M Resun Solar Energy Datasheets 2020
Open
Sizing voltages : Vmpp (60°C) 35.1 V
Voc (-10°C) 54.8 V
Select the control mode and the controller
Universal controller
All manufacturers
MPPT power converter
Max. Charging - Discharging current
Operating mode
Direct coupling
MPPT converter
DC-DC converter
MPPT 1000 W 48 V 41 A 42 A Universal controller with MPPT conve
Open
The operating parameters of the universal controller will automatically be adjusted according to the properties of the system.
PV Array design
Number of modules and strings
should be:
Mod. in series 1
No constraint
Nb. strings 4
between 5 and 8
Nb. modules 4
Area 9 m²
Operating conditions:
Vmpp (60°C) 35 V
Vmpp (20°C) 42 V
Voc (-10°C) 55 V
Plane irradiance 1000 W/m²
Impp (STC) 44.1 A
Isc (STC) 47.0 A
Isc (at STC) 46.4 A
Max. operating power 1.8 kW
(at 1000 W/m² and 50°C)
Array nom. Power (STC) 1.8 kWp

Report:

Version 7.2.0

PVsyst - Simulation report

Stand alone system

Project: SALLY ADRAR

Variant: New simulation variant

Stand alone system with batteries

System power: 1800 Wp

SALLY ADRAR - Algeria

PVsyst V7.2.0
VC0, Simulation date:
25/05/23 03:28
with v7.2.0

Project: SALLY ADRAR

Variant: New simulation variant

Project summary

Geographical Site	Situation		Project settings	
SALLY ADRAR	Latitude	26.96 °N	Albedo	0.20
Algeria	Longitude	0.03 °E		
	Altitude	220 m		
	Time zone	UTC+1		

Meteo data
SALI ADRAR
Meteonorm 7.1, Sat=100% - Synthetic

System summary

Stand alone system — **Stand alone system with batteries**

PV Field Orientation		User's needs	
Fixed plane		Daily household consumers	
Tilt/Azimuth	20 / 0 °	Constant over the year	
		Average	14.0 kWh/Day

System information

PV Array		Battery pack	
Nb. of modules	4 units	Technology	Lead-acid, sealed, Gel
Pnom total	1800 Wp	Nb. of units	8 units
		Voltage	48 V
		Capacity	500 Ah

Results summary

Available Energy	3502 kWh/year	Specific production	1946 kWh/kWp/year	Perf. Ratio PR	71.82 %
Used Energy	3277 kWh/year			Solar Fraction SF	64.01 %

Table of contents

Project: SALLY ADRAR
Variant: New simulation variant

PVsyst V7.2.0
VC0, Simulation date:
25/05/23 03:28
with v7.2.0

General parameters

Stand alone system — **Stand alone system with batteries**

PV Field Orientation

Orientation		**Sheds configuration**	**Models used**	
Fixed plane		No 3D scene defined	Transposition	Perez
Tilt/Azimuth	20 / 0 °		Diffuse	Perez, Meteonorm
			Circumsolar	separate

User's needs
Daily household consumers
Constant over the year
Average 14.0 kWh/Day

PV Array Characteristics

PV module		**Battery**	
Manufacturer	Resun Solar Energy	Manufacturer	JINGSUN
Model	RS7I-450M	Model	6-GFM-250
(Original PVsyst database)		Technology	Lead-acid, sealed, Gel
Unit Nom. Power	450 Wp	Nb. of units	2 in parallel x 4 in series
Number of PV modules	4 units	Discharging min. SOC	20.0 %
Nominal (STC)	1800 Wp	Stored energy	19.2 kWh
Modules	4 Strings x 1 In series	**Battery Pack Characteristics**	
At operating cond. (50°C)		Voltage	48 V
Pmpp	1627 Wp	Nominal Capacity	500 Ah (C10)
U mpp	37 V	Temperature	Fixed 20 °C
I mpp	44 A		

Controller		**Battery Management control**	
Universal controller		Threshold commands as	SOC calculation
Technology	MPPT converter	Charging	SOC = 0.90 / 0.75
Temp coeff.	-5.0 mV/°C/Elem.	approx.	53.4 / 49.5 V
Converter		Discharging	SOC = 0.20 / 0.45
Maxi and EURO efficiencies	97.0 / 95.0 %	approx.	45.4 / 48.3 V

Total PV power

Nominal (STC)	2 kWp
Total	4 modules
Module area	8.8 m²
Cell area	7.9 m²

Array losses

Thermal Loss factor		**DC wiring losses**		**Serie Diode Loss**	
Module temperature according to irradiance		Global array res.	14 mΩ	Voltage drop	0.7 V
Uc (const)	20.0 W/m²K	Loss Fraction	1.5 % at STC	Loss Fraction	1.7 % at STC
Uv (wind)	0.0 W/m²K/m/s				
Module Quality Loss		**Module mismatch losses**		**Strings Mismatch loss**	
Loss Fraction	-0.8 %	Loss Fraction	2.0 % at MPP	Loss Fraction	0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

Project: SALLY ADRAR
Variant: New simulation variant

PVsyst V7.2.0
VC0, Simulation date:
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with v7.2.0

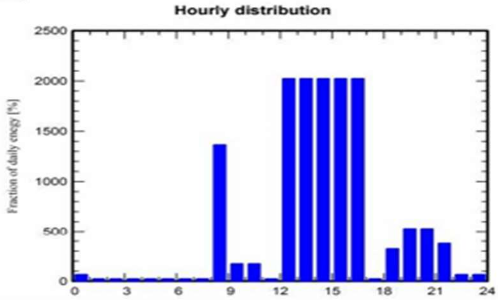
Detailed User's needs

Daily household consumers, Constant over the year, average = 14.0 kWh/day

Annual values

	Number	Power	Use	Energy
		W	Hour/day	Wh/day
Lamps (LED or fluo)	17	12W/lamp	3.0	612
TV	1	150W/app	6.0	900
Computer	1	150W/app	3.0	450
Fridge	1		24	400
Lamps(LED)	6		3	126
AC	1	2000W tot	5.0	10000
Other uses	1	1340W tot	1.0	1340
Stand-by consumers			24.0	200
Total daily energy				14028Wh/day

Hourly distribution



PVsyst V7.2.0
VC0, Simulation date:
25/05/23 03:28
with v7.2.0

Project: SALLY ADRAR

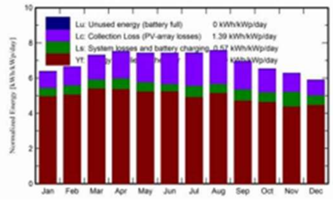
Variant: New simulation variant

Main results

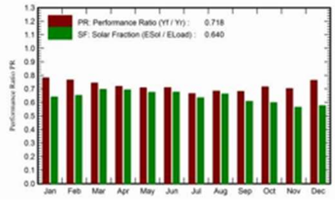
System Production

Available Energy	3502 kWh/year	Specific production	1946 kWh/kWp/year
Used Energy	3277 kWh/year	Performance Ratio PR	71.82 %
Excess (unused)	0 kWh/year	Solar Fraction SF	64.01 %
Loss of Load		**Battery aging (State of Wear)**	
Time Fraction	31.3 %	Cycles SOW	91.1 %
Missing Energy	1843 kWh/year	Static SOW	80.0 %

Normalized productions (per installed kWp)



Performance Ratio PR

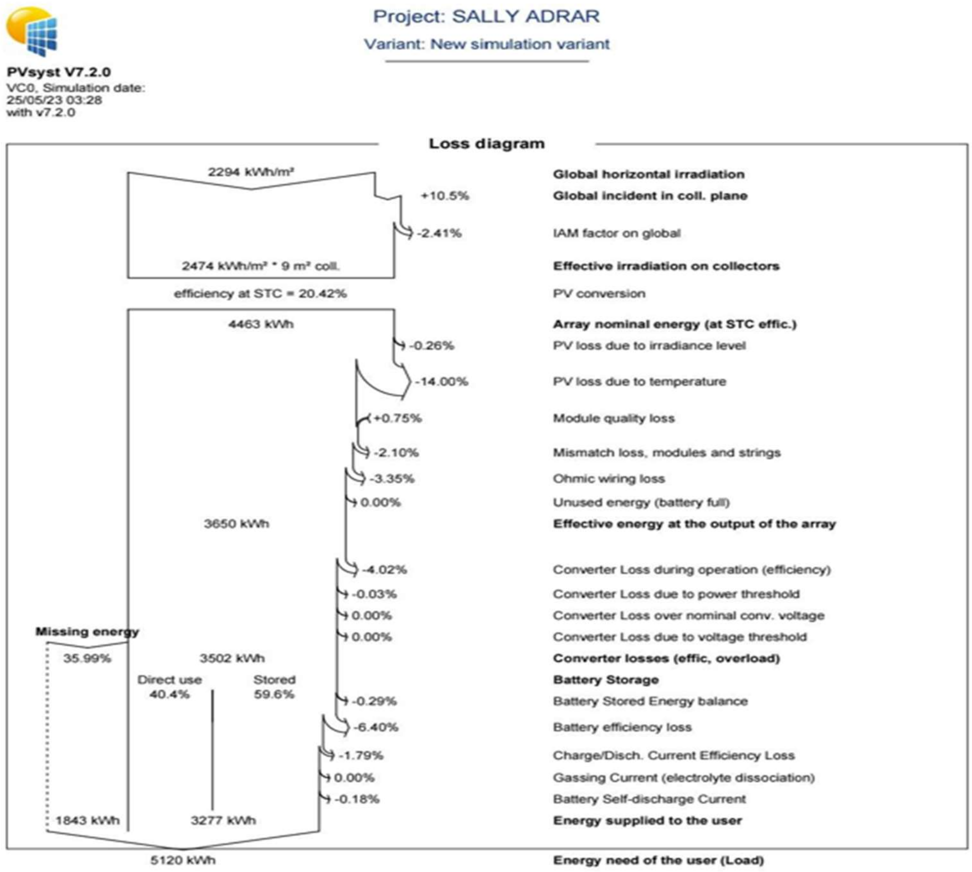


Balances and main results

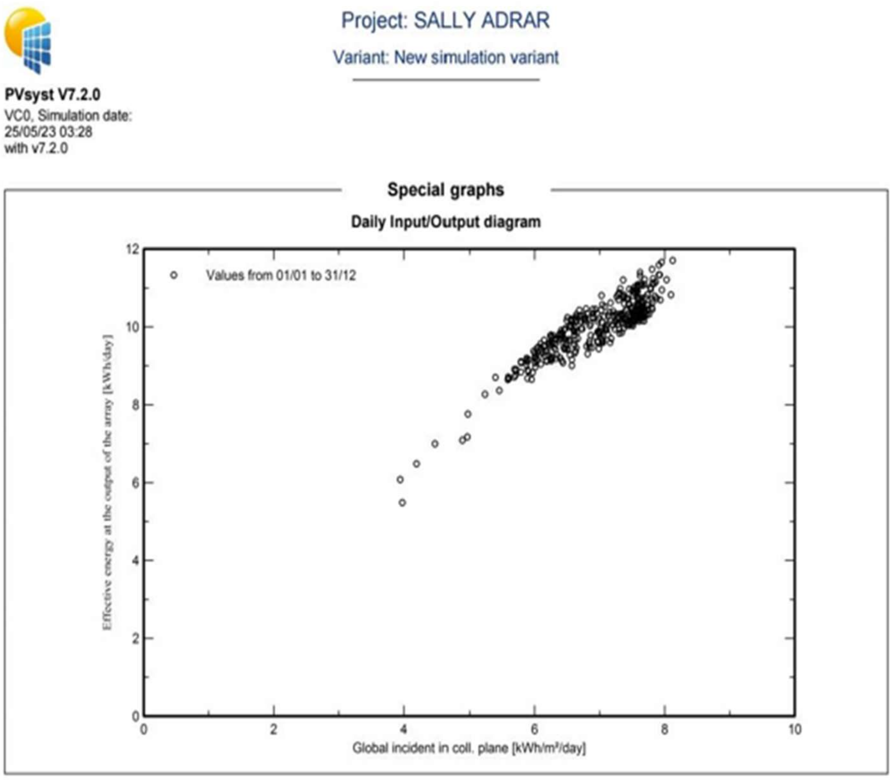
	GlobHor	GlobEff	E_Avail	EUnused	E_Miss	E_User	E_Load	SolFrac
	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh	ratio
January	144.2	193.2	293.1	0.008	156.1	278.7	434.9	0.641
February	148.9	182.2	271.3	0.008	136.5	256.3	392.8	0.652
March	199.9	221.6	318.1	0.000	131.6	303.3	434.9	0.697
April	218.3	219.7	311.4	0.000	129.2	291.6	420.8	0.693
May	238.1	224.1	309.8	0.008	141.5	293.4	434.9	0.675
June	237.5	216.6	293.8	0.008	136.4	284.5	420.8	0.676
July	242.3	224.3	298.7	0.030	159.0	275.9	434.9	0.634
August	233.3	228.7	304.9	0.022	146.3	288.5	434.9	0.663
September	191.4	203.4	278.4	0.000	165.0	255.9	420.8	0.608
October	169.3	198.0	279.5	0.016	174.3	260.6	434.9	0.599
November	141.8	184.1	272.2	0.009	182.8	238.0	420.8	0.566
December	129.4	177.8	270.8	0.000	184.1	250.7	434.9	0.577
Year	2294.4	2473.9	3502.1	0.109	1842.9	3277.3	5120.2	0.640

Legends

GlobHor	Global horizontal irradiation	E_User	Energy supplied to the user
GlobEff	Effective Global, corr. for IAM and shadings	E_Load	Energy need of the user (Load)
E_Avail	Available Solar Energy	SolFrac	Solar fraction (EUsed / ELoad)
EUnused	Unused energy (battery full)		
E_Miss	Missing energy		



Project: SALLY ADRAR
Variant: New simulation variant
PVsyst V7.2.0
VC0, Simulation date:
25/05/23 03:28
with v7.2.0
Loss diagram
2294 kWh/m²
Global horizontal irradiation
+10.5%
Global incident in coll. plane
-2.41%
IAM factor on global
2474 kWh/m² * 9 m² coll.
Effective irradiation on collectors
efficiency at STC = 20.42%
PV conversion
4463 kWh
Array nominal energy (at STC effic.)
-0.26%
PV loss due to irradiance level
-14.00%
PV loss due to temperature
+0.75%
Module quality loss
-2.10%
Mismatch loss, modules and strings
-3.35%
Ohmic wiring loss
0.00%
Unused energy (battery full)
3650 kWh
Effective energy at the output of the array
-4.02%
Converter Loss during operation (efficiency)
-0.03%
Converter Loss due to power threshold
0.00%
Converter Loss over nominal conv. voltage
0.00%
Converter Loss due to voltage threshold
Missing energy
35.99%
3502 kWh
Converter losses (effic, overload)
Direct use
40.4%
Stored
59.6%
Battery Storage
-0.29%
Battery Stored Energy balance
-6.40%
Battery efficiency loss
-1.79%
Charge/Disch. Current Efficiency Loss
0.00%
Gassing Current (electrolyte dissociation)
-0.18%
Battery Self-discharge Current
1843 kWh
3277 kWh
Energy supplied to the user
5120 kWh
Energy need of the user (Load)



Project: SALLY ADRAR
Variant: New simulation variant
PVsyst V7.2.0
VC0, Simulation date:
25/05/23 03:28
with v7.2.0
Special graphs
Daily Input/Output diagram
Values from 01/01 to 31/12
Effective energy at the output of the array [kWh/day]
Global incident in coll. plane [kWh/m²/day]
0
2
4
6
8
10
12

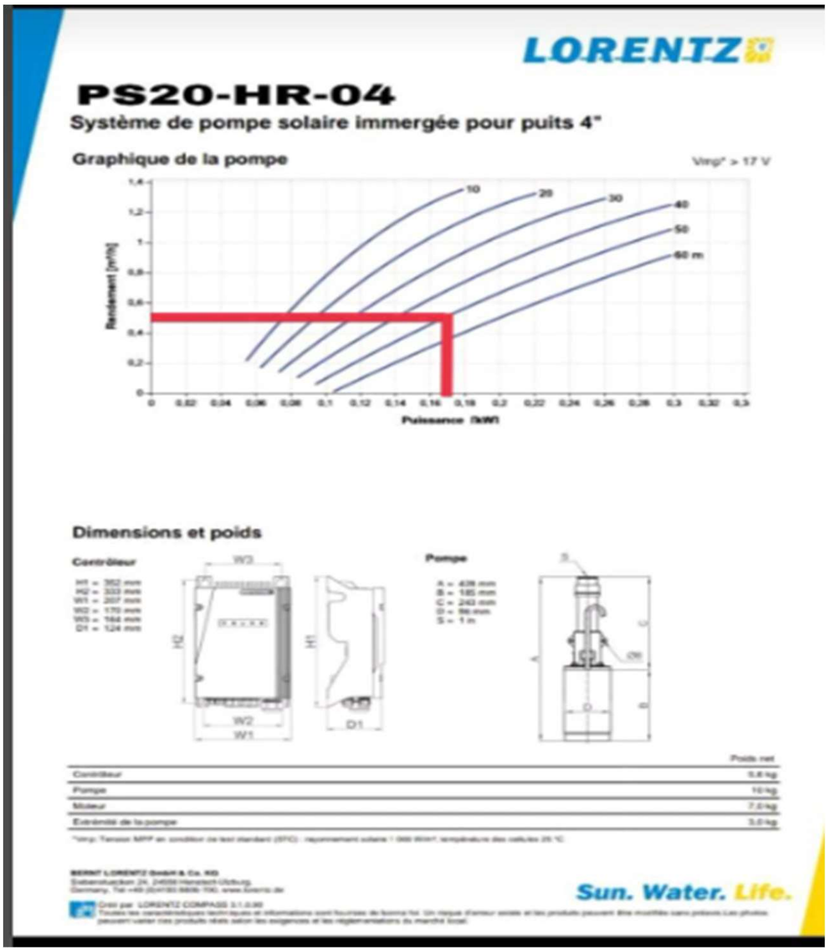


Figure: Pump data sheet

Reference:

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