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**Entitled**

**SIZING OF A 1.3KW STAND-ALONE PV**  
**SYSTEM**

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## *Dedications*

### ***I dedicate this thesis:***

- ✓ *To my dear parents.*
- ✓ *To my brothers.*
- ✓ *To my sisters.*
- ✓ *To my teachers.*
- ✓ *To all my family.*
- ✓ *To my partner*
  
- ✓ *To all my friends.*
- ✓ *To all the promotion of Renewable energies in electrical engineering 2023/2024.*
- ✓ *And to all the people who helped us to carry out this work.*

**SUMMARY**

**LIST OF FIGURES ..... 1**

**LIST OF TABLES ..... 1**

**LISTE OF ABRIVIATIONS ..... 1**

**GENERAL INTRODUCTION ..... 1**

**CHAPTER I: GENERAL INFORMATION ABOUT PHOTOVOLTAICS ..... 1**

    I.1 INTRODUCTION ..... 2

    I.2 PHOTOVOLTAIC SOLAR ENERGY ..... 2

    I.3 THE DIFFERENT TYPES OF PHOTOVOLTAIC SYSTEMS ..... 2

        I.3.1 Stand-alone photovoltaic systems ..... 2

        I.3.2 Grid-connected PV system..... 3

        I.3.3 Hybrid System..... 4

    I.4 THE PHOTOVOLTAIC CELL ..... 4

        I.4.1 Principle of operation of a photovoltaic cell ..... 4

        I.4.2 Photovoltaic cell technology. .... 5

            I.4.2.1 ilicium monocristallin : ..... 5

            I.4.2.2 Silicium poly cristallin : ..... 5

            I.4.2.3 Silicium amorphe : ..... 6

    I.5 ELEMENTS OF A PHOTOVOLTAIC SYSTEM ..... 7

        I.5.1. Photovoltaic modules..... 7

        I.5.2 Batteries ..... 7

        I.5.3 Battery types..... 8

        I.5.4 Regulator..... 8

        I.5.5 Inverter..... 9

        I.5.6 Charges ..... 10

    I.6 ADVANTAGES AND DISADVANTAGES OF PHOTOVOLTAIC ENERGY ..... 10

    I.7 CONCLUSION ..... 11

**CHAPTER II : SIZING OF A PHOTOVOLTAIC SYSTEM ..... 2**

    II.1 INTRODUCTION ..... 11

## SUMMARY

---

II.2 THE PURPOSE OF THE DESIGN.....	12
II.3. THE DESIGN STAGES .....	12
II.3.1. Description of the premises .....	12
II.3.2. Recording of meteorological data .....	12
II.3.3. Calculation of peak power .....	13
II.3.4 Choice of inverter.....	13
II.3.5. Panel Choice and Number Used in a Single Field .....	15
II.3.6. Choice of solar controller used in a single field .....	15
II.3.7. Choice of solar batteries used in a single field .....	16
II.4. PRESENTATION OF THE PVSYST SOFTWARE.....	17
II.5. SIZING STEPS WITH PVSYST SOFTWARE.....	18
II.5.1 Step 1, Designation of the project .....	18
II.5.2 Step 2, Determination of electrical requirements .....	18
II.5.3 Step 3 , D hourly distribution of the load .....	19
II.5.4 Step 4, Sizing the battery bank .....	19
II.5.5 Step 5: Dimensioning the PV field.....	20
II.5.6 Step6, Sizing the converter .....	20
II.5.7 Step 7, Orientation of the panels .....	21
II.5.8 STEP 8, LAUNCH OF THE SIMULATION:.....	21
II.6. THE SIMULATION REPORT AND INTERPRETATION OF THE RESULTS .....	22
II.7. CONCLUSION .....	24

## **CHAPTER III : STAGE OF IMPLEMENTATION AND STUDY OF THE COST OF THE INSTALLATION .....25**

III.1 INTRODUCTION.....	25
III.2 REPRESENTATION OF THE PROJECT.....	25
III.3 PROJECT IMPLEMENTATION .....	26
III.4 ELEMENTS USED IN THE INSTALLATION .....	26
III.4.1PV panels.....	26
III.4.2Battery .....	28
III.4.3 Inverter .....	29
III.4.4 MPPT .....	29

SUMMARY

---

III.4.5 Protective elements: .....	30
III.5 TOTAL ESTIMATED ESTIMATE OF THE INSTALLATION .....	34
III.5.1 Total Panel Estimate.....	34
III.5.2 Total Battery Cost Estimate .....	34
III.5.3 Total cost estimate for electrical cables.....	34
III.5.4 inverter Estimate .....	34
III.5.5 Regulator Estimate.....	34
III.5.6 Others .....	35
III.6 TOTAL ESTIMATED COST OF THE PHOTOVOLTAIC INSTALLATION IN PERCENTAGE: .....	37
III.7 ETUDE DE CHARGE .....	37
III.8 CONCLUSION : .....	38
<b>GENERAL CONCLUSION .....</b>	<b>39</b>
<b>REFERENCES .....</b>	<b>41</b>

## List of Figures

<b>Figure I. 1</b> : Diagram of a stand-alone PV system with battery. ....	3
<b>Figure I. 2</b> : Example of the structure of a grid-connected PV system .....	4
<b>Figure I. 3:</b> Silicium monocristallin .....	5
<b>Figure I. 4:</b> poly cristallin .....	6
<b>Figure I. 5:</b> Silicium Amorphe .....	6
<b>Figure I. 6:</b> Batterie de 150 Ah/12V .....	8
<b>Figure I. 7:</b> Symbolic diagram of the inverter .....	9
<b>Figure II. 1:</b> Designation of the project in PVSYST. ....	17
<b>Figure II. 2:</b> Our project in PVSYST (project2024) .....	18
<b>Figure II. 3:</b> Determination of electrical requirements.....	18
<b>Figure II. 4:</b> Hourly load distribution.....	19
<b>Figure II. 5:</b> Sizing of the battery bank .....	19
<b>Figure II. 6:</b> Dimensioning of the PV field.....	20
<b>Figure II. 7:</b> Sizing of the converter. ....	20
<b>Figure II. 8:</b> Orientation of the panels. ....	21
<b>Figure II. 9:</b> Launch of the simulation. ....	21
<b>Figure II. 10:</b> Summary of results report. ....	22
<b>Figure II. 11:</b> The ratio of general parameters. ....	23
<b>Figure II. 12:</b> Report on the user's energy requirements. ....	23
<b>Figure III. 1:</b> M'sila univ. Electrical Engineering Laboratory .....	25
<b>Figure III. 2:</b> Panel nameplate	<i>Figure III. 3: PV panel</i> .....26
<b>Figure III. 4:</b> The load-bearing structure of the panels .....	27

## List of Tables

<b>Table III. 1 :</b> The load-bearing structure of the panels .....	34
<b>Table III. 2:</b> Battery Estimates .....	34
<b>Table III. 3:</b> Total cost estimate for power cables. ....	34
<b>Table III. 4:</b> Inverter Estimate.....	34
<b>Table III. 5:</b> MPTT Regulator Estimate .....	34
<b>Table III. 6:</b> Others .....	35
<b>Table III. 7:</b> Total Estimated Circuit Breaker Prices .....	35
<b>Table III. 8:</b> Total estimate of the solar photovoltaic installation .....	36
<b>Table III. 9:</b> Energy balance .....	38

## Liste of abriviations

**PV** : Photovoltaic

**DC** : Direct current

**AC** : Alternating Current

**Pc** : Peak power of the PV generator [Wp]

**$\eta_{\text{sys}}$** : System performance  **$\eta_{\text{sys}}$**

**Ei**: Hours of maximum sunshine

**Ech**: Total Energy of Load

**PN** :Inverter Power Rating

**N** :Number of photovoltaic panels

**Pu**: Unit Power

**CAh**:Battery Capacity

**Ndaysof battery life**: Number of days of battery life

**DOD**: Depth of Discharge

**VBattery**:System Voltage

# General Introduction

Today, a large part of the world's energy production is provided by fossil fuels. The consumption of these sources gives rise to greenhouse gas emissions and therefore an increase in pollution. The additional danger is that excessive consumption of the stock of natural resources reduces the reserves of this type of energy in a way that is dangerous for future generations, and also in the face of the multiple economic and oil crises, science has taken an interest in the so-called renewable resources, which constitute a strategic sector and occupy a privileged place in the fields of research and development. [1].

Renewable energies can be solutions because of their abundance and they are inexhaustible on the human time scale. Some of the main renewable energy resources include solar energy (the energy carried by solar radiation), wind energy, hydro-wind energy (these underwater wind turbines use ocean currents to generate electricity), biomass energy, geothermal energy and hydropower. Algeria, due to its geographical location, benefits from favourable conditions for the use of renewable energies, in particular solar energy of photovoltaic origin, and the introduction of these new energies could easily be envisaged on many sites. Algeria also has significant potential in solar energy and is just waiting for good exploitation. Photovoltaic electricity is an interesting technical and economic option and can be used at the same time as it is produced. It covers the electricity needs of various establishments such as lighting, water pumping and cold production. [2]. The optimization of photovoltaic systems is based on sizing criteria. The purpose of sizing a pv system is to have the most efficient electricity production to meet your consumption, so it is a question of finding a happy medium between your production and your consumption. Our work consists of the sizing and construction of a photovoltaic installation with storage, in which we are based on the use of a simple method that allows us to properly size the different elements of our system

To do this, we have subdivided our thesis into three chapters:

- The first chapter will be devoted to general information about photovoltaics, the different types of photovoltaic systems, particularly systems with batteries.
- In the second chapter, we will present methods for sizing stand-alone photovoltaic systems.
- The third chapter will be devoted to the presentation and practical implementation of our project, followed by an estimate for the complete installation

This work will of course be finalized by a general conclusion

**Chapter I: General information about photovoltaics**

### I.1 Introduction

Photovoltaic solar energy (or photovoltaic energy or EPV) is electrical energy produced from solar radiation through collectors or photovoltaic solar power plants. It is a renewable energy, because the Sun is considered an inexhaustible source on the human time scale.

In this chapter, we describe general information about the photovoltaic system, (the definition of photovoltaic solar energy, the different types of photovoltaic system, the PV cells, the elements of the PV system... etc.). [3].

### I.2 Photovoltaic solar energy

Solar photovoltaic energy comes from the conversion of sunlight into electricity within semiconductor materials such as silicon covered with a thin metal layer. These photosensitive materials have the property of releasing their electrons under the influence of external energy, this is the photovoltaic effect. The energy is provided by photons (components of light) that hit the electrons and release a direct electric current. The electricity produced is available as direct electricity or stored in batteries (decentralised electrical energy) or as electricity fed into the grid. A photovoltaic solar generator is composed of photovoltaic modules that are themselves composed of photovoltaic cells connected to each other [3].

### I.3 The different types of photovoltaic systems

#### I.3.1 Stand-alone photovoltaic systems

These photovoltaic systems are installed to ensure autonomous operation without the use of other energy sources. Generally, these systems are used in isolated and remote areas of the grid. Depending on whether or not electrochemical storage is used, stand-alone photovoltaic systems are classified as follows:

- **Stand-alone system without electrochemical storage:** This type of system does not require electricity storage, either because the energy production of the cells is sufficient in low light or because the load running time is not critical (e.g., water pump: the water tank serves as storage).[4]
- **Stand-alone system with electrochemical storage :** This is the most common

photovoltaic system. The PV field serves as a charger for the battery. Electricity can then be used at any time. For example, this system is well suited for lighting a home where electricity is needed when it is no longer daylight [4].

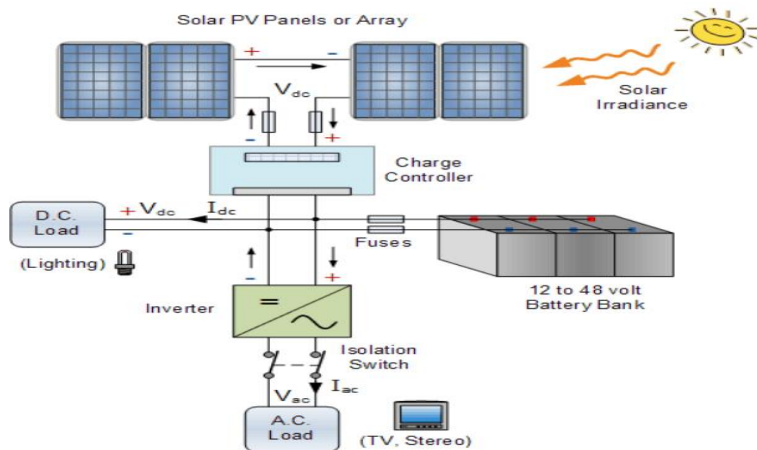
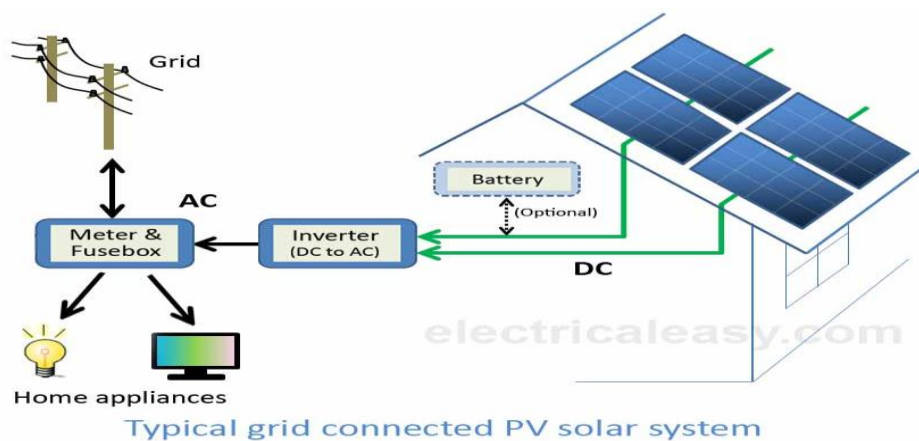


Figure I. 1 : Diagram of a stand-alone PV system with battery.

### I.3.2 Grid-connected PV system

Such a system is installed on a grid site. Generally on homes or businesses that wish to use a form of renewable energy and that benefit from good sunlight, see Figure (I.2). [5]

**Figure I. 2** :Example of the structure of a grid-connected PV system



### I.3.3 Hybrid System

These are systems that bring together energy sources of different types such as a wind power plant, a diesel generator or a cogeneration plant in addition to the photovoltaic generator. This type of installation is used when the photovoltaic array alone does not cover all the required energy [6].

## I.4 The photovoltaic cell

### I.4.1 Principle of operation of a photovoltaic cell

The operating principle of this cell is based on the photovoltaic effect. Indeed, a cell is made up of two thin films of a semiconductor, these two layers are doped differently:

- For the N shell, input of peripheral electrons
- For the P shell, electron deficit

These two layers thus present a potential difference. The energy of the light photons captured by the peripheral electrons (N-shell) allows them to cross the potential barrier and generate a direct electric current. To collect this current, electrodes are placed by screen printing on the two layers of semiconductor. [7]

### I.4.2 Photovoltaic cell technology. [8]

There are different types of solar cells or photovoltaic cells. Each type of cell is characterized by its own efficiency and cost. However, whatever the type, the efficiency remains quite low between: 8 and 23% of the energy that the cells receive. The most commonly used cells are:

#### I.4.2.1 Silicon monocrystallin :

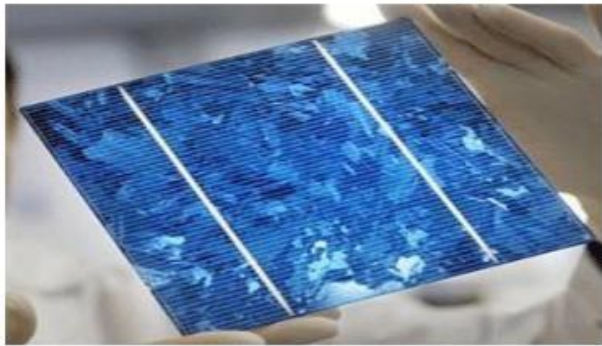
Monocrystalline cells are solar cells made from silicon crystallized into a single crystal. Their efficiency is 10 to 16%, but their manufacture is complex and energy-consuming.



**Figure I. 3:** Silicon monocrystallin

#### I.4.2.2 Silicon poly cristallin :

Polycrystalline cells are made from a block of crystallized silicon in the form of multiple crystals. Their average efficiency is 11 to 13%, and their production cost is slightly lower than that of monocrystalline cells



**Figure I. 4:** poly cristallin

#### **I.4.2.3 Silicium amorphe :**

Amorphous cells consist of very thin layers of silicon applied to a glass, flexible plastic, or metal backing. Originally, their efficiency was lower (6 to 10%), but technology is evolving rapidly, they work with low or diffuse illumination (even on overcast days, including under artificial lighting from 2 to 3000 lux).



**Figure I. 5:** Silicium Amorphe

## **I.5 Elements of a photovoltaic system**

Our study is based on the autonomous system so we will detail it much more by presenting their components:

### **I.5.1. Photovoltaic modules**

The modules are an assembly of a photovoltaic cell (or cell) mounted in series, in order to obtain the desired voltage (12V, 24V, etc.). The photovoltaic cell is the basic element in radiation conversion. Several cells are associated in a module which is the smallest surface of transformable, demonstrable and demonstrable capacity on a site.

The modules are grouped into panels, which are in turn combined to obtain photovoltaic arrays as required.

Photovoltaic cells are mainly made of crystalline silicon, which is used in monocrystalline or multi-crystalline form in wafers or ribbons or in semi-thin layers on substrates according to recent technologies.

The modules are combined in series and parallel to obtain high power and the desired voltage. Each PV cell is protected against heating by mounting a diode called "bypass diode" in parallel which short-circuits. Also, a PV module is prevented from being a receiver by putting in series at each branch a diode called "non-return diode" with a negligible voltage drop. [9].

### **I.5.2 Batteries**

The fact that solar energy is not available over the entire period of operation of the system being powered requires the use of batteries in stand-alone installations to store energy. In our work we use **"gel" batteries.** [10]



Figure I. 6: Batterie de 150 Ah/12V

### I.5.3 Battery types [3]

In stand-alone solar systems, the main uses are:

- a. **Lead-acid batteries:** are the most economical investment for a multi-source system and have the advantage of being more than 90% recyclable. However, these batteries are susceptible to misuse and their lifespan is often much shorter than that of the electricity-generating device. Indeed, lead-acid batteries in their current technology do not accept deep discharges very well. The depth of discharge is indeed responsible for the degradation of these batteries, leading to a noticeable reduction in their lifespan when used in extreme conditions.
- b. **Alkaline batteries (Ni/Cd and Ni/MH):** are much more robust but also more expensive. They are better suited to low temperatures. On the other hand, their recycling is complicated because of cadmium, which is a heavy and polluting metal.
- c. **Lithium batteries:** "technically" have the best performance. The self-discharge of Li-ion batteries is indeed low, while their stored energy density is relatively much higher.
- d. **"Gel" batteries:** The electrolyte is frozen by the addition of silica gel. In some batteries, phosphoric acid is added to improve the life in deep cycling.

### I.5.4 Regulator[3],[9]

Once the most suitable technology has been identified, it is necessary to focus on the sizing of the photovoltaic controller. It depends on 2 main criteria:

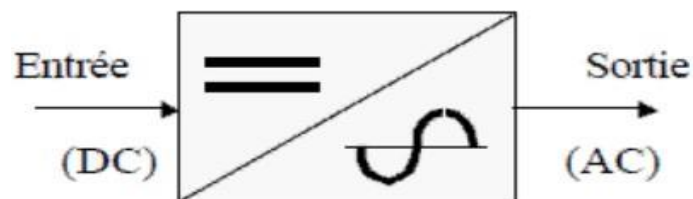
- **The nominal voltage** must correspond to that between the panels and the photovoltaic battery: 12, 24 or 48 Volts.
- **The maximum allowable current** through the regulator's input circuit must be greater than the current generated by the solar panels. This also applies to the output circuit.

There are several models of regulators of different powers:

- Shunt Regulator,
- Series Regulator,
- PWM Regulator,
- MPPT regulator.

### I.5.5 Inverter

An energy converter is a piece of equipment that is generally available either between the PV field and the load (without storage with continuous charging, it will be called a DC-DC converter) or between the battery and the load (it will then be called an inverter or DC-AC converter). The inverter is generally associated with a rectifier that transforms alternating current into direct current and whose role will be to charge the batteries and supply the installation's continuous circuit in the event of a long period without sunlight. [11].



**Figure I. 7:** Symbolic diagram of the inverter

To power equipment operating with alternating current, a device

- **Inverter Features**

- ✓ Lightweight inverters (low power), they provide output power from 100 to 10000W,
- ✓ Medium resistance inverters, they provide power ranging from 500 to 20000W,
- ✓ Robust inverters (of high power), They provide electrical power ranging from 10000 to 60000W.

### I.5.6 Charges

Loads are the elements that consume electrical power. The consumption of this electrical power depends on the characteristics of the load. There are resistive and inductive loads (lighting, heating, pumping, etc.). etc). [12].

### I.6 Advantages and Disadvantages of Photovoltaic Energy [3]

#### ❖ Advantages of Photovoltaic Energy

- ✚ Its free
- ✚ No pollution
- ✚ Its reliability and long plant life.
- ✚ Its fixed structure
- ✚ Its low maintenance cost.
- ✚ The installation does not produce any noise.

#### ❖ The disadvantages of photovoltaic energy

- ✚ The high cost of installation.
- ✚ The relatively low efficiency of the photovoltaic effect.
- ✚ The power is reduced when the weather conditions are unfavorable (clouds).

- ✚ The storage of electrical energy in chemical form (battery) is necessary for a stand-alone installation.
- ✚ Even though the electricity produced by a photovoltaic system is pollution-free, the manufacture, installation and disposal of panels have an impact on the environment.

### I.7 Conclusion

In this chapter we have presented general information about photovoltaic systems, photovoltaic solar energy and the different types of photovoltaic systems (stand-alone systems, stand-alone system without battery, stand-alone system with battery, hybrid systems, PV system connected to the electricity grid).

We also saw how the photovoltaic cell works and then the combination of the PV modules, the elements of a PV system and the advantages and disadvantages of photovoltaic energy.

**ChapterII :Sizing of a photovoltaic system**

## II.1 Introduction

For the realization of a photovoltaic installation, sizing remains an essential step. Sizing a PV system means determining all the elements of the PV chain, i.e. the size of the generator, the storage capacity, if necessary the power of a converter, or even the inclination of the modules and the operating voltage, according to loads such as the sunshine and the load profile. An oversized installation means additional costs, while an undersized installation means unreliability.

Whatever the methodology used and the precision with which the different components of the chain are taken into account, we are still faced with two types of estimates:

- the first is on demand, which in most cases is rather roughly defined because it is often not well known and which is subject to daily, weekly or seasonal fluctuations.
  - the second on the solar deposit, about which there is a crucial lack of representative data.
- This problem leads us to calculate the irradiation based on data relating to the site of the installation. This demonstrates that the reliability of a PV system is closely linked to dimensioning, which in turn is linked to the availability of reliable data.

The merit of a PV installation is often measured by its ability to provide energy in all circumstances.

Generally speaking, the parameters to be taken into account when designing and sizing a photovoltaic system are quite numerous and concern: [13]

- The location where the PV generator will be placed.
- The PV system (modules, regulator, converter and batteries).
- The charge.

## II.2 The purpose of the design

Dimensioning is an essential step in the design of photovoltaic systems. Indeed, the optimal sizing of such systems is obtained when the various components such as panels, batteries, inverter, regulator and cables are chosen adequately for a given solar resource and a given consumption profile. As sizing affects the price, quality and durability of a photovoltaic system in an isolated site, it is a crucial step in the implementation of the system. Thus, when looking to optimize the sizing of a stand-alone photovoltaic system, the goal is to determine all the sizing parameters of the system in order to minimize the various costs, while ensuring the power supply to the consumer without interruption[3].

## II.3. The design stages

### II.3.1. Description of the premises

The premises we have chosen is the Electrical Engineering laboratory located at the University of M'sila, University of Mohamed Boudiaf:

### II.3.2. Recording of meteorological data

For the sizing and construction of our autonomous photovoltaic system installation, we chose the m'sila site where the electrical engineering laboratory is located, the geographical and meteorological data are already imported by the PVSYST version 7 software.

The sizing of the PV generator is dictated by site conditions. To adopt the PV generator/battery capacities, at the charging conditions, it is essential to know the characteristics of the solar irradiation per day or per month, i.e. the average energy received on a given plane, at the same place where the PV generator will be located.

The data must be known for each month of the year. They can be obtained by national meteorological organizations or by calculations (computer tool), In our project the fireplace requires the following input parameters:

- Geographicallocation: M'sila, Algeria
- Latitude : 34.445 °N
- Longitude : -4.209 °E
- Soilreflectivity or Albedo: 0.20

- Time zone : UTC+1

### II.3.3. Calculation of peak power

To size the PV generator, three parameters are taken into account, the total energy of the load and the maximum hours of sunshine received on the plan of the modules and the System efficiency given by the following expression:[14].

$$PC = \frac{Ech}{H \times \eta_{sys}} \quad (II.1)$$

**Pc** : Peak power of the PV generator [Wp]

**$\eta_{sys}$** : System efficiency  $\eta_{sys}= 0.75$

**Ei**: Hours of maximum sunshine [h/day] Example M'sila:

**Ei**= 5.2 KWh/m<sup>2</sup>/day

**Ech**: Total Energy of Load

### II.3.4 Choice of inverter

The role of an inverter for a stand-alone site is to convert the direct voltage delivered by the battery bank into an alternating voltage to cover the needs of the electrical load.

The important criteria for choosing the inverter are:[14]

- **Load profile**: the inverter must provide the daily power according to the needs of the devices.
- **Rated power**: The inverter should have a higher power rating than the load, with a margin of 30%.
- **Inverter efficiency**: As previously stated, the inverter efficiency should be 95%.
- **Standby consumption**: the inverter must have a standby system or have practically zero no-load consumption.

- **Voltage and frequency stability:** the inverter must deliver a mains voltage of (220V AC) more or less approximate.
- **Protection:** The inverter must be equipped with overload and short circuit protection as well as high temperatures.

We can calculate the nominal power of the inverter by the following formula: [1].

$$P_N > 1.3 \times P_{Ch} \quad (\text{II.2})$$

**P<sub>N</sub>** : Inverter Power Rating

If:  $P_N \leq 500W$  →  $V_{Battery} = 24V$

If:  $500W \leq P_N \leq 1000W$  →  $V_{Battery} = 24V$

If:  $P_N > 1000W$  →  $V_{Battery} = 48V$

According to the formula (II.2) so we have:

$$P_N > 1.3 \times 350$$

$$P_N > 455W$$

### II.3.5. Panel Choice and Number Used in a Single Field

After assessing the electrical needs of a PV installation, the sizing of the PV field, which consists of calculating the peak power necessary for the proper operation of the installation.

To calculate the number of panels used in a single field, we have the following formula: [14].

$$N = \frac{P_c}{P_u} \quad (\text{II.3})$$

**N** : *Number of photovoltaic panels*

**P<sub>c</sub>**: PV Generator Peak Power [Wc]

**P<sub>u</sub>** : Unit power [Wc] [Power of a PV panel that you have chosen]

### II.3.6. Choice of solar controller used in a single field

The role of the solar controller, also known as a charge controller, is to:

- It limits the charge when the battery is fully charged.
- It slows down the discharge in order to avoid deep discharges.
- It continuously indicates the working status of the solar panel and the charging status of the solar battery.

The two main elements for choosing a charge controller are:

- The voltage between the panels and the batteries: the regulator must be able to accept this voltage (usually 12V, 24V or 48V).

- The maximum intensity of the regulator: the current of the regulator (in amperes, A) must be higher than the short-circuit current of the solar panels to which it is connected. A safety margin of 10% to 20% is not useless.

The most widely used regulator in photovoltaic technology is MPPT (Maximum Power Point Tracking), They allow the solar panel to operate at its maximum power point, or more precisely, at the optimal voltage for maximum power output.

To define the maximum current and the maximum voltage of the regulator that will help us choose the best regulator for our installation, we use the following expressions: [14]

$$I_{\max \text{ Reg}} = ICC \times N_{\text{Branches en parallèle}} \times 1.3 \quad (\text{II.4})$$

$$V_{\max \text{ Reg}} = VOC \times N_{\text{Panels in Series}} \times 1.25 \quad (\text{II.5})$$

### II.3.7. Choice of solar batteries used in a single field

The choice of batteries in the photovoltaic system is made according to the two most important criteria: the voltage and the capacity of the battery.

The expression to calculate the battery capacity is: [14]

$$C_{Ah} = \frac{E_{ch} \times N \text{ days of autonomy}}{V_{Batterie} \times DOD} \quad (II.6)$$

**C<sub>Ah</sub>** :Battery Capacity [Ah]

**E<sub>ch</sub>**: Total Load Energy [Wh/d]

**N' days of autonomy**: Number of days of autonomy in M'sila, i.e. = 1 day

**DOD**: Depth of Discharge = 0.8

**V<sub>Batterie</sub>**:System voltage (V) [depending on inverter power] = 12 volts.

#### II.4. Presentation of the PVSYST software

PVSYST is designed to be used by architects, engineers and researchers, but it is also a very useful educational tool. It includes in-depth contextual help, which explains in detail the procedure and models used and offers an ergonomic approach with a guide in the development of a project. PVSYST allows you to import weather data from a dozen different sources as well as personal data. PVSYST presents the results in a comprehensive report, incorporating specific graphs and tables. This data can be exported to another software.



**Figure II. 1:** Designation of the project in PVSYST.

## II.5. Sizing steps with PVSYSY software

### II.5.1 Step 1, Designation of the project:

We created a new project on the name Project2024 and we chose the geographical location m'sila, Algeria.

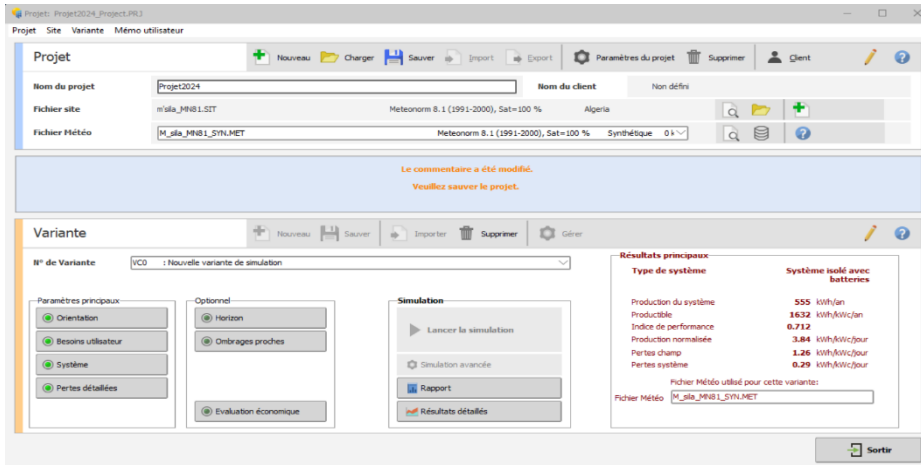


Figure II. 2: Our project in PVSYSY (project2024)

### II.5.2 Step 2, Determination of electrical requirements:

In "autonomous" mode, PVSYSY has a window where we will choose the estimated consumption. Power consumption and usage time. PVSYSY gives the estimate of the average daily and monthly consumption. In the context of our study and according to Figure (II.3), the results obtained are as follows:

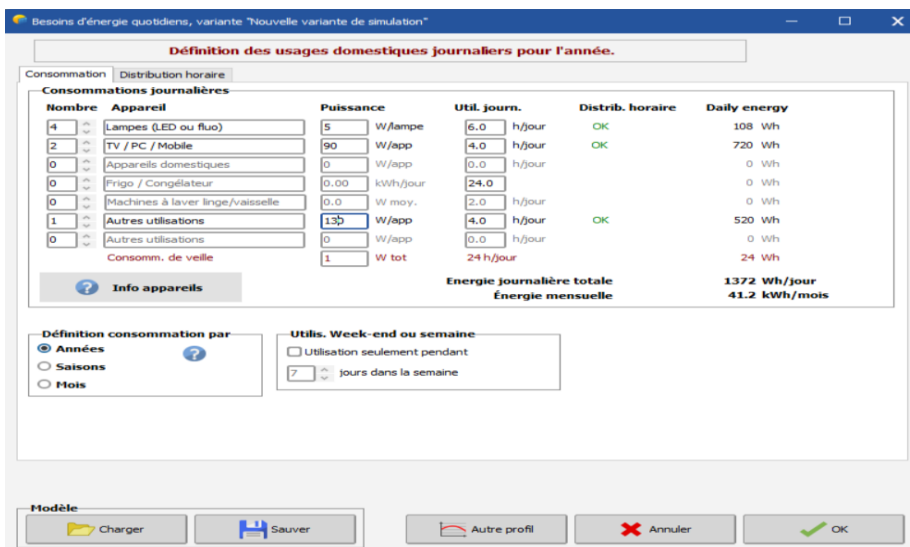


Figure II. 3: Determination of electrical requirements

### II.5.3 Step 3 , D hourly distribution of the load:

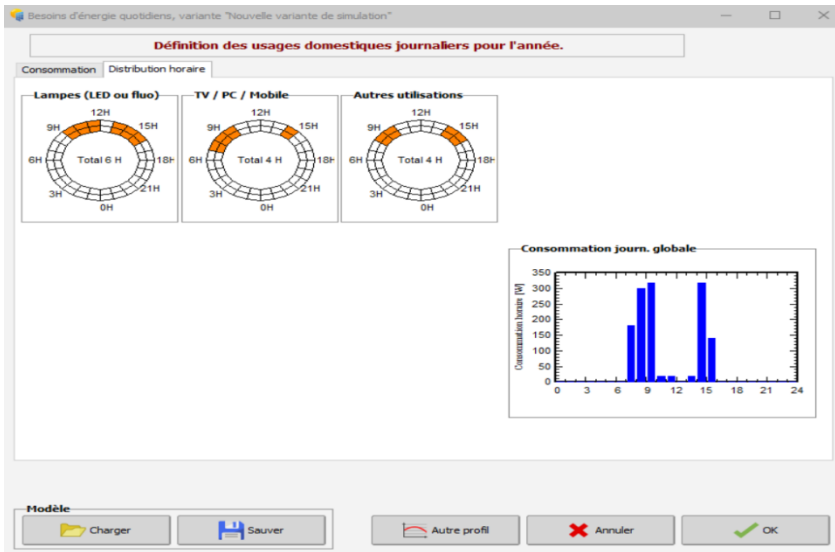


Figure II. 4: Hourly load distribution.

### II.5.4 Step 4, Sizing the battery bank:

We chose 12v lead acid batteries with a capacity of 150Ah Total battery count 4, 2 batteries in series and two on parallel.

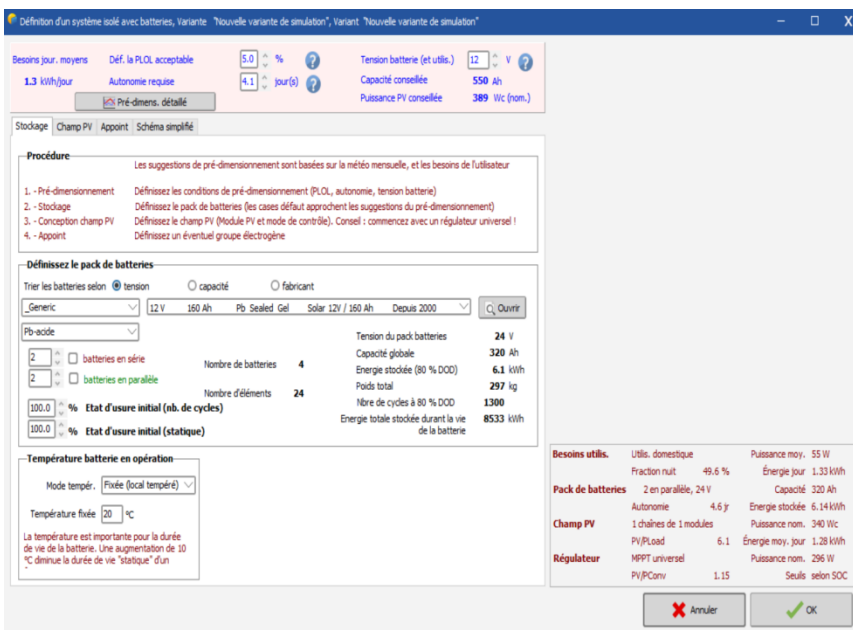


Figure II. 5: Sizing of the battery bank

### II.5.5 Step 5: Dimensioning the PV field:

the type of module chosen in the case of this study is of the type: 340W 28V monocrystalline.

With a PV field of 4 panels.

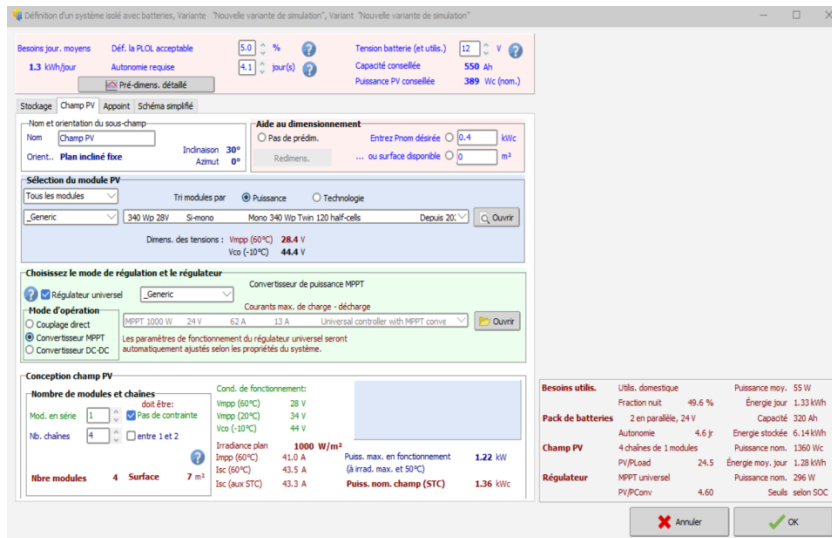


Figure II. 6: Dimensioning of the PV field.

### II.5.6 Step6, Sizing the converter:

We chose a 1000W 24V MPPT converter (62A – 13A)

The operating parameters of the universal controller will be automatically adjusted according to the properties of the system.

Figure (II.7) shows the electrical characteristics of the MPPT converter.

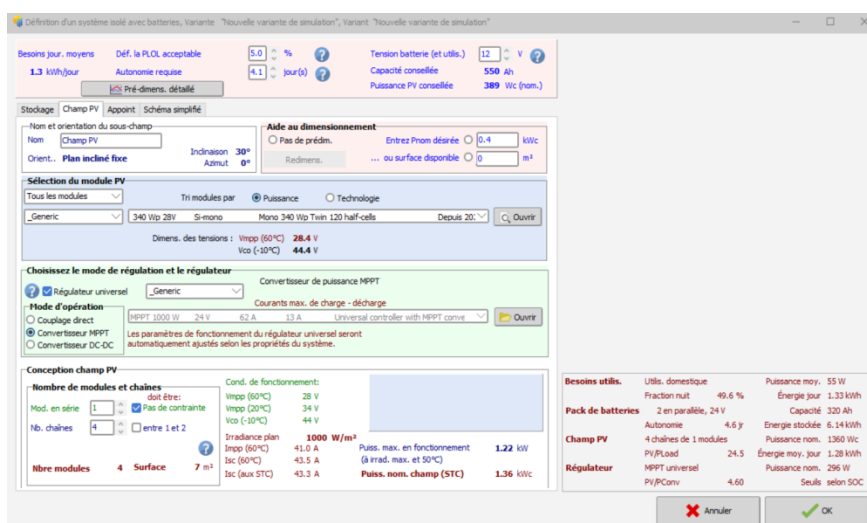


Figure II. 7: Sizing of the converter.

### II.5.7 Step 7, Orientation of the panels:

To estimate the optimal tilt angles of the photovoltaic modules in this region for which the energy gain is improved, we opted for an inclination of 30°

And the azimuth 0°.

Optimization compared to annual irradiation.

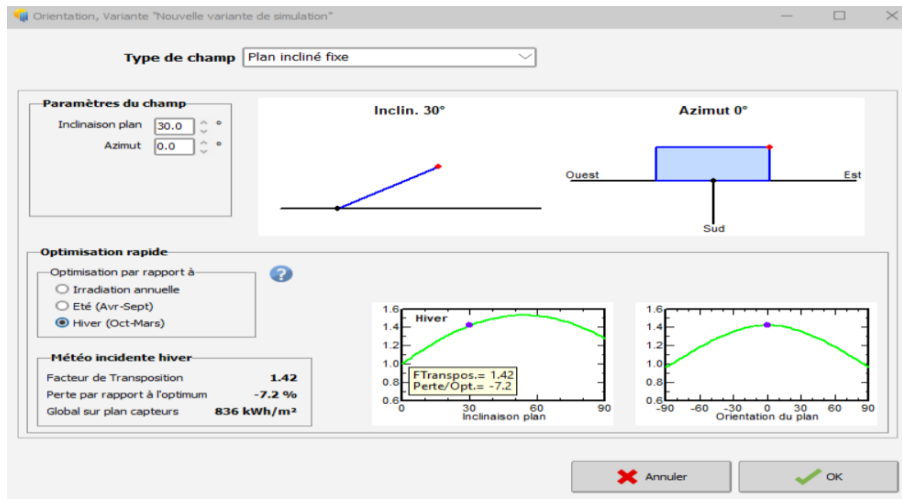


Figure II. 8: Orientation of the panels.

### II.5.8 Step 8, Launch of the simulation:

In the end, we launched the simulation to have the report of the results.

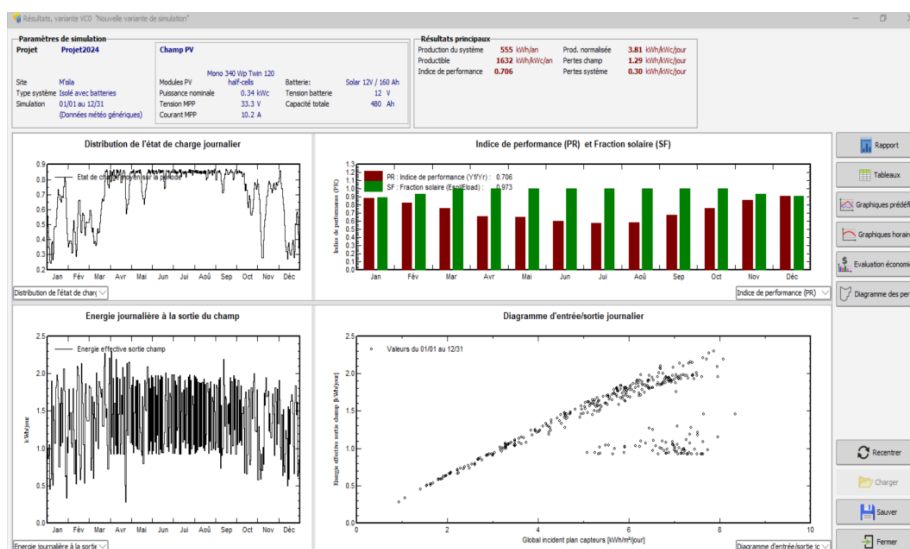



Figure II. 9: Launch of the simulation.

## II.6. The simulation report and interpretation of the results

After all simulation steps have been set up in the software, a simulation report is automatically produced with all results in the form of tables and figures.



**PVsyst V7.3.1**  
VCO, Simulé le :  
05/17/24 23:46  
avec v7.3.1

**Projet: Projet2024**  
Variante: Nouvelle variante de simulation

Résumé du projet			
<b>Site géographique</b>	<b>Situation</b>	<b>Paramètres du projet</b>	
M'sila Algeria	Latitude 35.73 °N Longitude 4.55 °E Altitude 484 m Fus. horaire UTC+1	Albédo 0.20	
<b>Données météo</b>			
m'sila Meteonorm 8.1 (1991-2000), Sat=100 % - Synthétique			

Résumé du système			
<b>Système isolé</b>	<b>Système isolé avec batteries</b>		
<b>Orientation plan capteurs</b>	<b>Besoins de l'utilisateur</b>		
Plan fixe Inclinaison/Azimut 30 / 0 °	Consomm. domestique Constantes sur l'année Moyenne 1.3 kWh/Jour		
<b>Information système</b>		<b>Pack de batteries</b>	
Champ PV Nb. de modules Pnom total	1 unité 340 Wc	Technologie Nombre d'unités Tension Capacité	Pb-acide, scellée, Gel 3 unités 12 V 480 Ah

Résumé des résultats			
Energie disponible	555.0 kWh/an	Productible	1632 kWh/Wc/an
Energie utilisée	472.9 kWh/an	Indice perf. PR	70.64 %
		Fraction solaire (SF)	97.26 %

Table des matières	
Résumé du projet et des résultats	2
Paramètres généraux, Caractéristiques du champ de capteurs, Pertes système	3
Besoins de l'utilisateur	4
Résultats principaux	5
Diagramme des pertes	6
Graphiques prédéfinis	7

Figure II. 10: Summary of results report.

## Chapter II: Sizing of a photovoltaic system

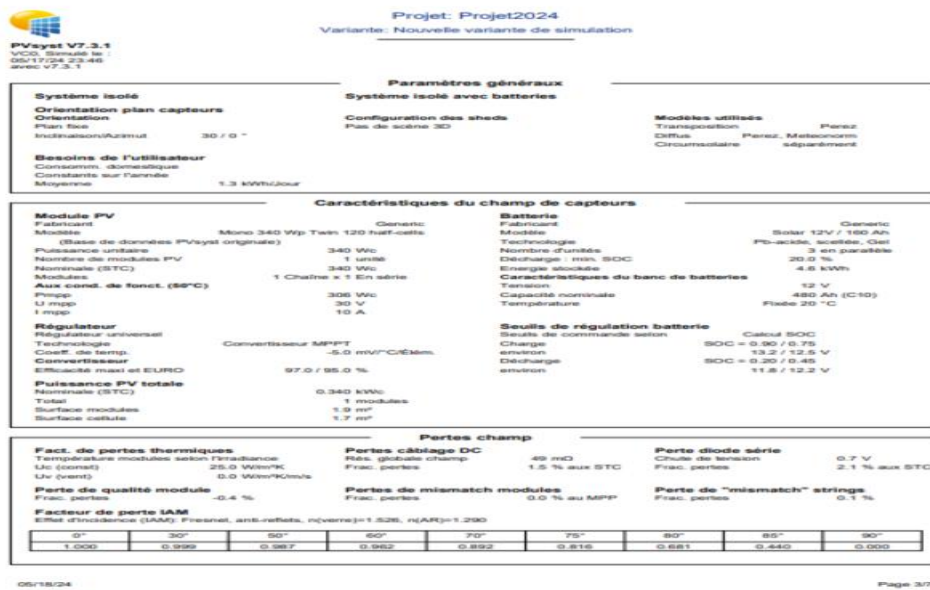


Figure II. 11: The ratio of general parameters.

The consumption of each household electrical appliance, the energy balance and the total daily energy of the installation is 1.3 kWh/day, as well as other information relating to the system under study are detailed in the table in Figure (II.11).

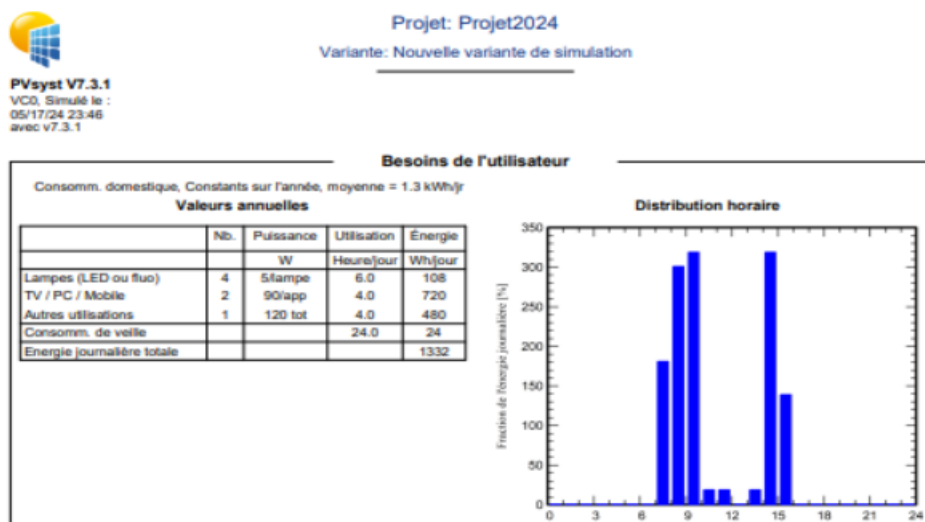


Figure II. 12: Report on the user's energy requirements.

## **II.7. Conclusion**

The use of the PVSYST software allowed us to study practically all the elements of the autonomous photovoltaic installation, specifying the electrical characteristics of each component.

The result of the simulation is presented in an automatic PDF file. Which will make our work in Chapter III easier.

**Chapter III :Stage of implementation and study of the cost of  
the installation**

### III.1 Introduction

In this chapter, we will present the steps in the implementation of the photovoltaic installation project with storage not connected to the grid for

Our work will be presented in two parts, the first will be devoted as already mentioned above to the presentation of the project as well as the different stages of the realization of the project. In the second part, we have drawn up an estimate for the installation.

### III.2 Representation of the project

The project consists of the construction of a PV installation with batteries for the electrical engineering laboratory of the Mohamed Boudiaf university, Wilaya M'sila.

Its geographical coordinates are:

- Latitude 35.74 N,
- Longitude 4.54 E



**Figure III. 1:**M'sila univ. Electrical Engineering Laboratory

### III.3 Project implementation

In this part, we have made a photovoltaic installation for the electrical engineering laboratory to turn on almost 1.3kw per day, this installation is composed of 4 panels of 340W, 1 off grid inverters of 2kVA, 4 batteries of 150Ah-12V, cables and protection elements. The inverter is connected with 4 panels, 4 batteries and an electrical cabinet. The cabinet is divided into 2 parts (DC side, AC side and control side).

### III.4 Elements used in the installation

#### III.4.1PV panels

IF-BGM340-60 polycrystalline panels were used. Double glass structure, anodized aluminum frame, excellent resistance to extreme weather conditions (high humidity, heat).



Figure III. 2: Panel nameplate Figure III. 3: PV panel

- The orientation of the panels: due south
- L'inclinaison (30°)



**Figure III. 4:** The load-bearing structure of the panels



**Figure III.5:** The junction box connected to the panels

The connection of the panels and 4 panels, each panel has an input and an output, the connection was in relation to the  $I_{cc}$  and  $V_{oc}$  of the panel and the inverter.



**Figure III.6:** Installing the Panels

### **III.4.2 Battery**

4 gel batteries (12V, 150 Ah) were used



**Figure III.7 :** Battery park



**Figure III.8:** Connecting the batteries

### III.4.3 Inverter

We used 1 likou compliant brand inverter of (2kW-24V)



Figure III.9: 2kVA inverter

Figure III.10: the outputs of the inverter

### III.4.4 MPPT

We used 1 likou compliant brand MPPT Regulator of (12v/24v , 40A).

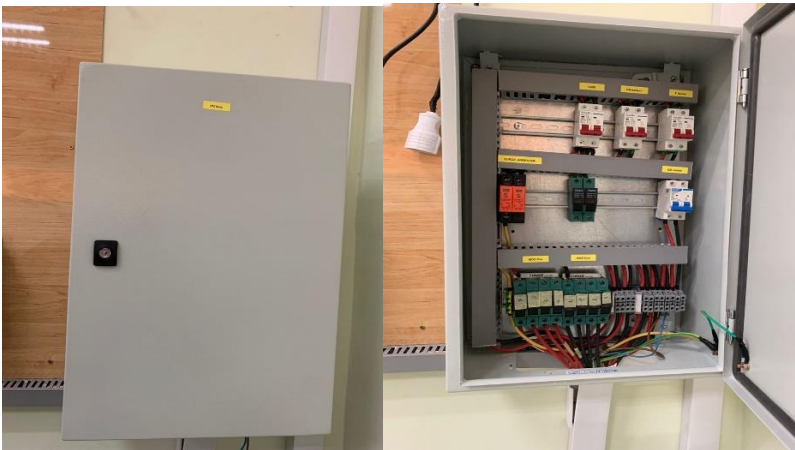


Figure III.11 : MPPT Regulator

### III.4.5 Protective elements:

#### ✚ The electrical cabinet:

It is a resistant box designed to protect electrical devices and distribute current to the various system switchgear.



**Figure III.12:**The electrical cabinet

**Figure III.13:**The protective elements

#### **Disconnecter:**

The disconnect switch is necessary in case you need to insulate the solar PV panels for maintenance or if something goes wrong with them.



**Figure III.14 :**Disconnect switch

### Lightning conductor:

It is a component that secures the electrical installation, as well as the appliances, in the event of a surge caused by lightning in the solar system. Its installation location is recommended at both ends of the DC power line (solar panel side and inverter/converter side)



**Figure III.15:** Surge arrester

### Circuit breaker:

It is a device that allows you to cut off the electricity in the event of a short circuit or overcurrent. Works the same way as a switch, but it triggers automatically.



**Figure III.16:** Circuit breaker

### Fuse Holder:

It is a device that protects the photovoltaic modules against short-circuit currents, at the same time, interventions can be carried out at the breaking point on the connected modules.



**Figure III.17:** Fuse Holder

#### **Fuse:**

Protective fuses in photovoltaic (PV) systems play a crucial role in ensuring the safety and reliability of solar installations. They are designed to protect system components from overcurrents that can occur due to short circuits or failures in the system. Fuses work by interrupting the flow of excessive current, preventing potential damage to solar panels, inverters, and other connected equipment.

In summary, protective fuses are indispensable components for maintaining safety, preventing property damage and ensuring the proper functioning of photovoltaic systems.



**Figure III.18:** fuse

#### **⚡The Ground spike:**

The ground stake in a photovoltaic (PV) installation is an essential element in ensuring electrical safety. It is used to direct leakage currents or surges, such as those caused by lightning, to the ground, protecting equipment and people from electric shock.

This stake is usually made of metal and is driven deep into the ground to ensure an effective connection with the ground. It is connected to the PV system's grounding system, which includes specific cables and connectors. Proper grounding is crucial for the proper operation and overall safety of the PV system, adhering to local and international electrical safety standards.



**Figure III.19:** Ground spike



**Figure III.20:** The Inverter, MPPT, and Electrical Cabinets After Installation

### III.5 Total Estimated Estimate of the Installation

Each technical study is accompanied by an estimated and quantitative estimate consisting of a unit and total price of each piece of equipment to have a financial estimate of an installation.

#### III.5.1 Total Panel Estimate

Type of panels	Number of panels	Unit price (DA)	Total price(DA)
IF-BGM340-60	<b>4</b>	<b>25000</b>	<b>100000</b>

**Table III. 1 :**The load-bearing structure of the panels

#### III.5.2 Total Battery Cost Estimate

Battery Type	Number of batteries	Unit price(DA)	Total price(DA)
6FM150G	<b>4</b>	<b>35000</b>	<b>140000</b>

**Table III. 2:** Battery Estimates

#### III.5.3 Total cost estimate for electrical cables

Electrical cable	Length	Unit price(DA)	Total price(DA)
Cable6 mm <sup>2</sup>	<b>45m</b>	<b>400</b>	<b>18000</b>
Ground Cable 6mm <sup>2</sup>	<b>45m</b>	<b>400</b>	<b>18000</b>

**Table III. 3:** Total cost estimate for power cables.

#### III.5.4 inverter Estimate

Inverter	Number of inverters	Unit price (DA)	Total price (DA)
2000VA/24V	<b>1</b>	<b>160000</b>	<b>160000</b>

**Table III. 4:** Inverter Estimate

#### III.5.5 Regulator Estimate

MPPT	Number of MPPT	Unit price (DA)	Total price (DA)
2000VA/24V	<b>1</b>	<b>10000</b>	<b>10000</b>

**Table III. 5:** MPTT Regulator Estimate

### III.5.6 Others

Elements	Price(DA)
MC4	450
Connection terminals	1440
Cable holder	3600
Embout de cablage vert 6mm <sup>2</sup>	1000
Peigne de raccordement	250
Cosse de cable	840
Baarrre de coupure	700
Rail de montage	500
Total price	8780

Table III. 6: Others

### Total price

Electrical cabinets	Price(DA)
3 circuit breakers (1AC+2DC)	15500
1surge protector	530
18 Fuse Holder+18 Fuses	8640
Total price	24670

Table III. 7: Total Estimated Circuit Breaker Prices

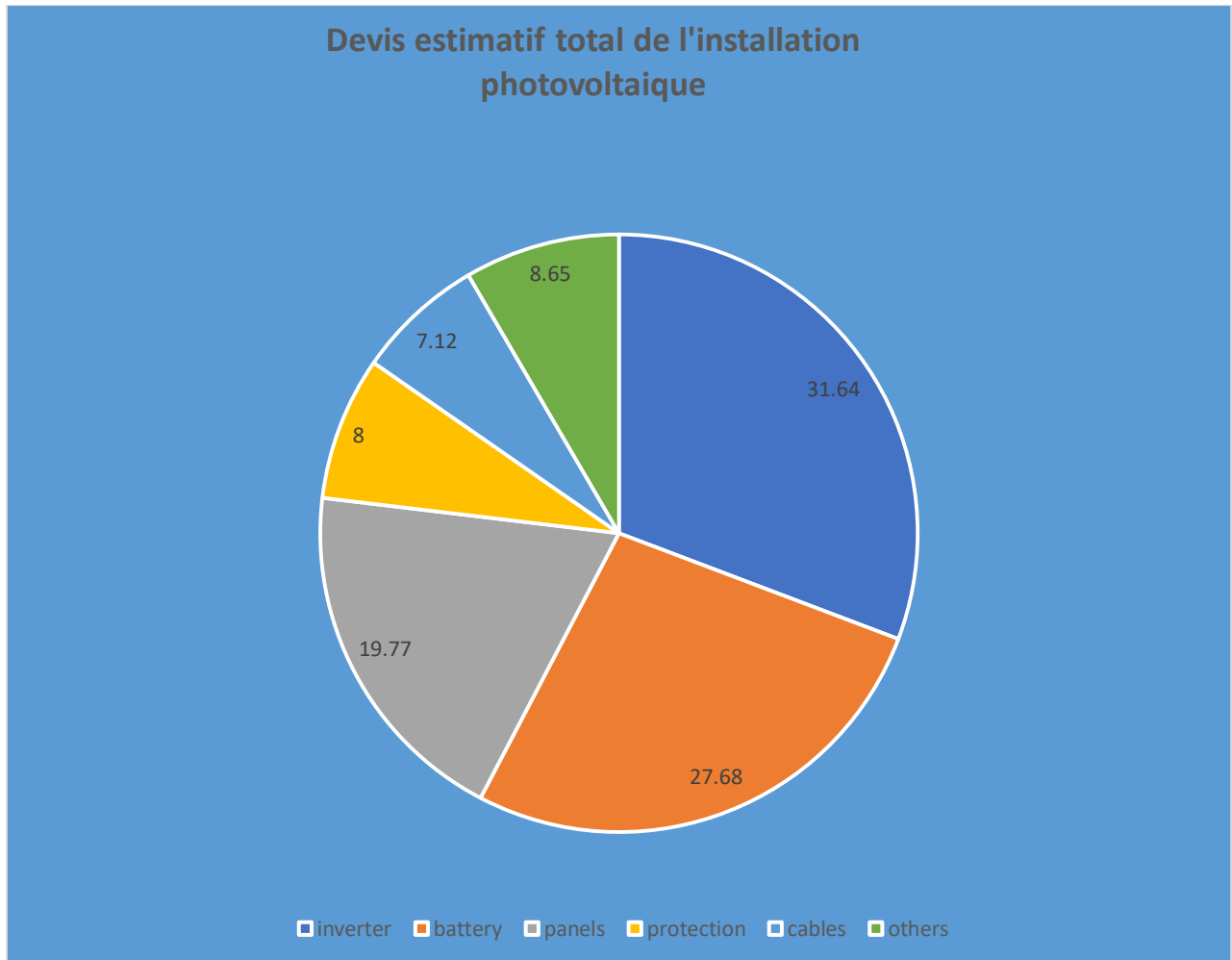
**Total price**

<b>Elements</b>	<b>Price(DA)</b>
Photovoltaic panels	<b>100000</b>
Batterys	<b>140000</b>
Inverter	<b>160000</b>
MPPT	<b>10000</b>
Electrical cables	<b>36000</b>
Load-bearing structure of the panels	<b>15000</b>
Load-bearing structure of batteries	<b>5000</b>
Electrical cabinet	<b>20670</b>
Junction Box	<b>8650</b>
Ground spike	<b>1500</b>
Others	<b>8780</b>
<b>Total price</b>	<b>505600</b>

**Table III. 8:** Total estimate of the solar photovoltaic installation

The total price of the installation is **505600DA**

### III.6 Total estimated cost of the photovoltaic installation in percentage:



**Figure III.20:** Percentage price of photovoltaic system components.

### III.7 Load study

This is an example of devices that we can power with the power we have produced, which is 1.3kw.

### Chapter III: Stage of implementation and study of the cost of the installation

Appareil	Quantite	Duree [Heures]	Puissance [watts]	Energie journaliere [Wh]
Pc/Mobile	2	4	90	720 wh
lampe	4	6	5	108 wh
Refrigerateur	1	24	15	370 wh
Total [wh]			1300wh	

**Table III. 9:** Energy balance

### III.8 Conclusion :

In this chapter we have presented the steps followed for the sizing and implementation of the photovoltaic installation with storage for a primary school, and we have been able to define the different elements necessary for the installation, as well as its protection. In the end we determined the cost of the latter.

## General conclusion

The work presented in this project concerns one of the most current applications of renewable energy, that of the use of photovoltaic solar energy. Photovoltaic solar energy is therefore of particular interest to developing countries: it is likely to improve the living conditions and productivity of geographically dispersed dwellings very quickly and at an optimal cost.

Our work was carried out in the following ways:

In the first chapter, we gave an overview of photovoltaic energy and the different photovoltaic systems in general. Their working principle and the different cells that make up the photovoltaic module, and the advantages and disadvantages of this type of energy. As well as the components needed for a stand-alone installation.

In the second chapter, we made a study of the methods of sizing a photovoltaic system. We chose a sizing method with the pvsyst.7 software, we dimensioned an autonomous photovoltaic installation located in the city of M'sila, Algeria. We have detailed the method of sizing the PV system, taking into account its estimated consumption from a configuration of electrical charges of the Electrical Engineering Laboratory .

For the last chapter, we have presented all the practical steps for the realization of the photovoltaic installation after study and dimensioning. Finally, we have carried out an economic study of the cost of the latter.

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## General Conclusion

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(Subsidiary of the SONELGAZ Spa group), 2017

## General Conclusion

النظام الكهروضوئي المستقل هو نظام للطاقة الشمسية يعمل بشكل مستقل عن شبكة الكهرباء المركزية. وتتكون بشكل عام من الألواح الشمسية التي تحول ضوء الشمس إلى كهرباء، ومنظم شحن للتحكم في شحن البطاريات، وبطاريات لتخزين الكهرباء المنتجة خلال النهار، وعاكس لتحويل الكهرباء المخزنة إلى تيار متناوب صالح للاستخدام، وربما مولد إضافي. لفترات انخفاض ضوء الشمس.

هذا العمل عبارة عن نظام مستقل بقدرة 1.3 كيلو وات، يتم تنفيذه على مستوى مختبر أبحاث الهندسة الكهربائية. وضعنا الألواح الكهروضوئية عند 33 درجة وقمنا أيضًا بإنشاء هيكل لاحتواء البطاريات، كما صنعنا خزانة كهربائية واقية، وأخيرًا صنعنا التأسيس. يُستخدم هذا النظام غالبًا في المناطق النائية حيث يكون الوصول إلى شبكة الكهرباء محدودًا أو مكلفًا. يمكنه تشغيل مجموعة متنوعة من التطبيقات، بدءًا من التركيبات المنزلية الصغيرة وحتى أنظمة ضخ المياه والاتصالات ومحطات الطقس والمزيد. إن الاستقلالية التي توفرها هذه الأنظمة تجعلها جذابة بشكل خاص للتطبيقات خارج الشبكة، مما يوفر مصدرًا موثوقًا ومتجددًا للطاقة في البيئات النائية.

## Abstract

A stand-alone photovoltaic system is a solar energy system that operates independently of the centralized electricity grid. It generally consists of solar panels that convert sunlight into electricity, a charge regulator to control the charging of the batteries, batteries to store the electricity produced during the day, an inverter to convert the electricity stored with usable alternating current, and possibly an additional generator for periods of low sunlight.

This work presents a 1.3 kW autonomous system, produced at the electrical engineering research laboratory. The photovoltaic panels were installed at 33 degrees, and a structure was put in place to contain the batteries. In addition, a protective electrical cabinet was built, and grounding was carried out. This type of system is often used in remote areas where access to the electrical grid is limited or expensive. It can power a variety of applications, from small household installations to water pumping systems, telecommunications, weather stations and many others. The autonomy offered by these systems makes them particularly attractive for off-grid applications, providing a reliable and renewable source of energy in remote environments.

### Resume

Un système photovoltaïque autonome est un système d'énergie solaire qui fonctionne de manière indépendante du réseau électrique centralisé. Il se compose généralement de panneaux solaires qui convertissent la lumière du soleil en électricité, d'un régulateur de charge pour contrôler la charge des batteries, de batteries pour stocker l'électricité produite pendant la journée, d'un onduleur pour convertir l'électricité stockée en courant alternatif utilisable, et éventuellement d'un groupe électrogène en appoint pour les périodes de faible ensoleillement.

Ce travail présente un système autonome de 1.3 kW, réalisé au niveau du laboratoire de recherche en génie électrique. Les panneaux photovoltaïques ont été installés à 33 degrés, et une structure a été mise en place pour contenir les batteries. De plus, une armoire électrique de protection a été réalisée, et la mise à la terre a été effectuée.

Ce type de système est souvent utilisé dans les zones éloignées où l'accès au réseau électrique est limité ou coûteux. Il peut alimenter une variété d'applications, des petites installations domestiques aux systèmes de pompage d'eau, en passant par les télécommunications, les stations météorologiques et bien d'autres. L'autonomie offerte par ces systèmes les rend particulièrement attrayants pour les applications hors réseau, offrant une source d'énergie fiable et renouvelable dans des environnements éloignés.