Sizing of a sustainable condensation system for the production of sweet water through the use of photovoltaic panels in La Mesa de los Santos, Santander, Colombia.

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Abstract. The objective of the project is to carry out the dimensioning of a photovoltaic system that allows its integration with a condensation system for the production of fresh water in isolated areas (Rural), in such a way that a sustainable condensation application capable of producing water is generated. sweet to supply small groups of inhabitants in areas where the basic supply of liquid is deficient. The study area is the Department of Santander, Colombia, specifically in the Municipality of los Santos and the area known as Mesa de los Santos, in which difficult geographical conditions are presented such as: altitude of 1650 meters above sea level and deficiency in aquifers. The methodological development proposes the analysis of the meteorological conditions of the area, the identification, selection and dimensioning of the condensing system and the photovoltaic system through the amp-hour method and the software system advisor model (SAM). Additionally, a CAD model is developed to obtain the complete schematization of the model and carry out a simulation process to analyze the behavior of the integration of the aforementioned systems. Finally, a techno-economic analysis of the proposed system is carried out.

Keywords: Electrolysis of water, prototype, Hydrogen production, photovoltaic system and CAD modeling.

1 Introduction

Water is the axis of the sustainable development of the regions and a key element in the socioeconomic development, the production of food, energy, ecosystems and for the survival of the communities [1] [2]. In addition to this, water plays a key role in adapting to climate change, generating a direct connection between the environment and society. [3]. Additionally, water is a right [4], which has been affected for various reasons such as: global warming [5], population growth [6], exploitation of fossil fuels, deforestation, natural phenomena, among others [7].

The scarcity of water in the world, currently generates 10% of the deaths of children in the world, it is estimated, on the other hand, that 8 out of 10 people do not have access to drinking water and live in rural or isolated areas, around 842,000 people in the world die from stomach affections as a result of the consumption of undrinkable water and that at least 1.8 billion people worldwide have access only to
contaminated water sources [8]. In the 2019 World Water Development Report, it was noted that improving water management in the world is essential to eradicate poverty [9]. According to the World Resources Institute (WRI), the Middle East and North Africa are the most affected areas in the world by lack of water [10] [11]. In Latin America and the Caribbean, the growing population in the suburbs around large cities has caused a supply impact, with rural areas being the most affected for the supply of drinking water. [12].

In Colombia, access to water is considered a fundamental right [4]. For this reason, the use of all sectors of the country must be guaranteed. The National Water Study (ENA) in 2018 presented by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) reveals that in capital cities such as Bogotá, Cali, Cartagena, Cúcuta, Bucaramanga, Montería and Tunja present a moderate water deficit While the Orinoquia, Pacific and Amazonia regions present surpluses, I feel the rural area in all cases the most affected [13] [14].

In Santander, Colombia, specifically in La mesa de los santos, there is currently a water shortage problem. Los santos is a municipality located 1,650 meters above sea level. This municipality is made up of several rural areas from which primary economic activities such as agriculture, poultry, mining and secondary economic activities such as tourism are derived, economic activities that are affected by the little supply of fresh water since it does not have many water sources, the closest river is the Chicamocha river and it is located in the lower part of the plateau at a height difference of 1200 meters and the low rainfall currently makes it even more difficult for communities to develop in rural areas. Eventual water pumping solutions are limited by electrical energy, either by high consumption required to drive the water from the Chicamocha river or by the absence of electrical power networks that allow energy to be transported to the required points. [15] [16].

Currently, renewable energies are widely applied in different world sectors, somewhat remedying the problem of water shortages [17] [18]. Desalination systems are a viable alternative for the drinking water production process, but their high operating cost makes it difficult to implement them in isolated areas with low economic power [19] [20]. This is why solar photovoltaic [21] and thermo solar [22] [23], have been integrated into these processes but continue to be costly. Thus, various small-scale solutions have been developed such as: desalination by conventional and solar distillation [24] [25], pumped supply by photovoltaic panels [26] [27], condensation systems assisted by Solar electric energy[28], among others, the latter, focuses on the use of a conventional cooling system under modifications to produce fresh water[29] [30].

The main objective of this paper is to present the dimensioning of a condensation system integrated into a photovoltaic electric power generation system, to produce fresh water, taking as an application the municipality of Mesa de los Santos, Santander, Colombia, generating the calculation of viable investment costs. The methodological development of the paper is presented in section 2 as well as the materials selected for the simulation process. Later in section 3 the sizing of the condensation system is presented, as well as the sizing of the solar system through the comparison between a static or direct method called ampere-hours and a dynamic methodology through simulation in the System Advisor software. Model (SAM) of free access, allowing to determine an autonomous system, capable of feeding the condensing system load. In the same section, the modeling in SolidWorks Software and its simulation are described to determine its behavior, as well as the techno-economic study of the proposed final prototype or model. Finally, section 4 describes the most relevant conclusions of the project. It is important to highlight that the project system is a sustainable system with easily accessible elements in the region or metropolitan area of implementation, positively impacting communities with basic needs in rural areas.

2 Methods and Materials

2.1 Methodology
For the development of the sustainable condensation system, Figure 1 presents the methodological work flow diagram, starting with the basic analysis of the meteorological conditions of the area through open access databases, then the module sizing is carried out, which consists of two subsystems: the
condensation subsystem and the photovoltaic electrical energy production subsystem. The first system must satisfy the needs of the project and produce water, from the condensation process through the use of a refrigeration equipment. The second system must have the capacity to supply energy to the consumption of the condensing subsystem, applying the amp-hour calculation methodology contrasted with the Software system advisor model (SAM), finally determining the size of the photovoltaic subsystem required.

Subsequently, the condensation system is modeled by using Solid Work, in order to have the equipment in a schematic way and perform a simulation of the behavior of the final sustainable condensation system. Finally, a techno-economic study is developed in order to know the future implementation costs of the project.

2.2 Software’s.
The programs or software’s used in the development of the project are mentioned below.

2.2.1 SolidWorks. SolidWorks [31] is a CAD software that allows mechanical modeling in 2D and 3D, which allows real-scale designs of systems and their simulation, based on established parameters. Which will be used to model the proposed condensation system model and its simulation, to analyse its behaviour.

2.2.2 Genetron Properties V.1.4. Genetron proprieties v1.4 [32] is an open access software that allows simulating the refrigeration cycle with different types of refrigerants and exports the results in exportable tables to Excel, as well as Pressure-Enthalpy and Temperature-Enthalpy diagrams.
2.2.3 Systems Advisor Model (SAM). System Advisor Model (SAM) [33] is a free techno-economic software for modeling various types of renewable energy systems where the possibility of developing photovoltaic systems from small to large scale is highlighted.

2.3 Condensation System. The equipment necessary for the development of the condensation system for the simulation is described below:

2.3.1 Evaporator. The evaporator is the element within the refrigeration equipment which the refrigerant reaches it at a low temperature, it runs through the framework of pipes that allows it to absorb heat from the surrounding environment through the aluminum fins, in a few words its function will be to reduce the temperature of the control volume until the air reaches condensation temperature. The evaporator to be used for the simulation is the one produced by the company Thermocoil de Colombia, with reference E 2x2x1000 4T.

![Figure 2. Evaporator [34]](image2.png)

2.3.2 Condenser. The condenser function will be to release hot air to the environment as a result of the understanding of the refrigerant, its manufacture is very similar to the evaporator since its very task as a heat exchanger, the difference is that the condenser yields heat to the environment and the evaporator receives heat from the environment. The condenser to be used has a performance of 544 Watt and is from the thermocoil company of Colombia.

![Figure 3. Condenser. [35]](image3.png)

2.3.3 Compressor. The compressor generates a force compressing the gas that comes from the evaporator in a gaseous state. This pressure increases the temperature of the gas that returns to its liquid state and heats up, the power required to carry out this work is 145 W. Therefore, the commercial
Danfoss BD250GH compressor would be used, with an operating voltage of 48V, maximum power of 250 W.

![Compressor]

**Figure 4.** Compressor. [36]

2.3.4 *Expansion Valve.* Element that throttles the flow of the refrigerant liquid to produce a sudden pressure drop forcing the liquid to evaporate, as a second option it is also possible to place a capillary tube but it could not be electronically controlled to open or close according to the pressure need, this in order to increase or decrease the temperature as the humidity and temperature of the environment are measured.

2.3.5 *Fan.* The LWFD200-EO model direct current fan of the Longwell brand will be used as a design parameter due to its favorable technical characteristics, commercial value and air flow. Commercially, direct current fans do not have a variety of manufacturers, however, fans used as heat extractors for cooling processors and / or computers can be presented as another possible solution, in which their capacity would be compensated with a quantity of them.

2.3.6 *Control.* To turn it on and off, the variable to be censored will be the temperature and humidity variable, whose data will be obtained by the DTH22 censor and managed by a development board of the Arduino platform that in turn will give the order according to the need, to be used a relay board.

2.4 *Photovoltaic panel*

For the selection of the panel, the respective comparison of different brands recognized by the Organization of consumers and users OCU in terms of power, quality and commercial value is made, these characteristics are reflected in **Table 1** in order to select the JKM355M-66H solar panel of the manufacturer Jinko solar, since it appears to comply with established requirements, it has representation and marketing in Colombia.

| PANEL BRANS | MODEL       | POWER | QUALITY | COST     |
|-------------|-------------|-------|---------|----------|
| SunPower    | SPR-X21-345| 345   | 97/100  | 441.65 € |
| REC         | REC 280TP  | 280   | 94/100  | 379.00 € |
| Panasonic   | VBHN3252J47| 320   | 94/100  | 275.88 € |
| JINKO       | JKM355M-66H| 355   | 92/100  | 125.72 € |
| AXITEC      | AXI265P    | 265   | 90/100  | 210.00 € |
| TRINA       | TSM-270PD05| 270   | 87/100  | 284.35 € |
| ALEXO       | X59        | 320   | 86/100  | 350.90 € |
| LG          | LG295S1C-A5| 295   | 85/100  | 490.00 € |
| SOLARWORLD  | SW280      | 280   | 84/100  | 266.20 € |
| ATERSA A265-P | A265-P    | 265   | 84/100  | 192.39 € |

**Table 1.** Solar Panel Selection
3. Results and analysis

3.1 Site

The municipality of Los Santos is located in the central region of the department of Santander, in the northeast of the country, on the western slope of the Eastern Cordillera, with an area of 284.74 km². It limits to the north with the municipalities of Girón and Piedecuesta, to the south with Jordán and Villanueva, to the east with the municipality of Aratoca and to the west with the municipality of Zapatoca. Hydrographically limits to the east and south with the Chicamocha river that separates it from Aratoca, Jordán and Villanueva; to the west with the Sogamoso river that separates it from Zapatoca [15]. The municipal head is located according to its geographical coordinates at latitude 6.756643, and longitude -73.103154 at a height of 1.650 meters above sea level. This location is taken as a geographical reference for the Project Development since it has an average annual radiation based on the IDEAM of 5.13 $kW/㎡^2$.

The data of the meteorological conditions of the area is presented in the Table 2, which was taken from the website "Nasa Prediction of World wine Energy Recourses". This location is taken as a geographical reference for the Project Development since it has an average annual radiation based on the IDEAM of 5.13 $kW/㎡^2$.

| Month    | Relative Humidity % | g water/kg dry | Dew Point °C | Dry bulb Temperature °C | Humidity bulb temperature °C | Solar irradiation kWh/m² |
|----------|---------------------|----------------|--------------|-------------------------|----------------------------|-------------------------|
| January  | 73.84               | 14.02          | 16.3         | 21.13                   | 15.94                      | 5.19                    |
| February | 69.56               | 14.10          | 16.25        | 22.01                   | 15.85                      | 5.08                    |
| March    | 75.53               | 14.98          | 17.15        | 21.63                   | 16.86                      | 4.83                    |
| April    | 82.1                | 15.47          | 17.62        | 20.78                   | 17.41                      | 5.15                    |
| May      | 83.08               | 15.51          | 17.64        | 20.63                   | 17.42                      | 4.98                    |
| Jun      | 81.22               | 15.16          | 17.29        | 20.6                    | 17                        | 5.03                    |
| July     | 75.79               | 14.09          | 16.23        | 20.6                    | 15.82                      | 5.52                    |
| August   | 74.54               | 14.28          | 16.42        | 21.08                   | 16.04                      | 5.66                    |
| September| 74.84               | 14.42          | 16.5         | 21.17                   | 16.13                      | 5.28                    |
| October  | 83.74               | 14.97          | 17.11        | 19.94                   | 16.84                      | 5.1                     |
| November | 86.65               | 15.56          | 17.68        | 19.99                   | 17.47                      | 5.01                    |
| December | 82                  | 15.31          | 17.47        | 20.64                   | 17.18                      | 4.74                    |
| Annual   | 78.57               | 14.858         | 16.97        | 20.85                   | 16.66                      | 5.13                    |

3.2 Operating parameters of the condensing system

The water condensation system uses a conventional refrigeration cycle and the elements that make up its system, where the air is cooled and, in turn, is sent through aluminium channels within an estimated control volume and / or study equivalent to 6m³. This volume is taken into consideration according to the refrigeration capacity for the temperatures to work. The basic operating parameters of the refrigeration system are based on the data taking into account the temperatures of the dry bulb, wet bulb and dew point set out in Table 2, the resulting sizing provides information on the power for the
compressor or the unit of refrigeration, this element for its electrical consumption is an important part of the total load to be considered in the photovoltaic system.

After the identification of the meteorological parameters, equation 1 is applied, which allows the calculation of the cooling capacity of the condensation system[37]:

$$C = 230 \times V + (\# \text{PyE} \times 476)$$

(1)

Where:
- $C$ = cooling capacity in BTU
- 230 = Factor calculated for Latin America "Maximum temperature of 40 ° C" (given in BTU / hm³)
- $V$ = Volume of the area where the equipment will be installed, Length x Height x Width in m³
- $\# \text{PyE}$ = $\#$ of people + Appliances installed in the area
- 476 = Profit and loss factors contributed by each person and/or appliance

Being, $\# \text{PyE} = 1$, so:

$$C = 230 \times 6 + (1 \times 476)$$

$$C = 230 \times V + (\# \text{PyE} \times 476)$$

$$C = 1856 \text{ Btu}$$

$$C = 1856 \text{ Btu} \times \frac{0.29307107 \text{ W}}{1 \text{ BTU}}$$

$$C = 543.93 \text{ W}$$

In addition to the value of cooling capacity, the evaporator temperature must be taken into consideration since it is an element of the cooling system in charge of reducing the temperature of the surrounding air, therefore, this is estimated at 0 ° C since its temperature differential together with the ambient temperature, they affect the dew temperature for the average condensation for the study place. With these parameters, the data obtained for a basic refrigeration cycle is integrated into the free-use software Genetron properties V. 1.4 from the company Honeywell (See Figure 5).

![Figure 5. Basic Refrigeration Cycle](image-url)
3.3 Photovoltaic System

For the sizing of the photovoltaic system, it is essential to use the electrical energy consumption of the refrigeration system, which will be in operation for 8 hours per day, the table presents the estimate of the load that is 1580 W / day.

| TYPE OF LOAD C.D.          | RATED POWER (W) | OPERATING TIME (H) | DAILY POWER (W/DIA) |
|---------------------------|-----------------|--------------------|---------------------|
| Compressor BD250GH.2      | 145             | 8                  | 1160                |
| Evaporator fan            | 25              | 8                  | 200                 |
| Condenser fan             | 25              | 8                  | 200                 |
| Control electronics       | 2.5             | 8                  | 20                  |
| **Total**                 |                 |                    | **1580**            |

3.3.1 Amp-Hour Methods. Once the fixed installed power has been defined, the real energy required is determined taking as a reference the standard efficiency of the batteries of 90%, being a factor that directly affects the power consumption reducing it to 1755 W. Subsequently, the coefficient is determined system performance taking into account the data in the Table 4 and applying equation 2.

| CONCEPTO                              | PERDIDAS EN % |
|---------------------------------------|---------------|
| Temperature del panel                 | 0.45          |
| Dirt and dust                         | 4             |
| Self-discharge of batteries           | 0.5           |
| Performance of the loading and unloading process | 7         |
| Regulators                            | 7             |
| Wiring from panels to regulator       | 1.5           |
| Wiring the rest of the installation   | 4             |

Taking the above information, equation 2 can be applied and the performance ratio (RT) determined

\[ PR = \left( 1 - \frac{P_1}{100} \right) \times \left( 1 - \frac{P_1}{100} \right) \times \cdots \times \left( 1 - \frac{P_n}{100} \right) \]

Replacing the values of the table in equation 2 we obtain:

\[ PR = \left( 1 - \frac{0.45}{100} \right) \times \left( 1 - \frac{4}{100} \right) \times \left( 1 - \frac{0.45}{100} \right) \times \left( 1 - \frac{0.5}{100} \right) \times \left( 1 - \frac{7}{100} \right) \times \left( 1 - \frac{7}{100} \right) \times \left( 1 - \frac{1.5}{100} \right) \times \left( 1 - \frac{4}{100} \right) \]

\[ PR = 0.78 \]

Then, we proceed to determine the number of panels required by the system to feed the capacitor charge, this calculation is developed with the application of equation 3.

\[ \# \text{de paneles} = \frac{L}{W_{Pl}X_{SP}X_{Fs}X_{PR}} \]

Where:
L = actual daily energy required.
Wp = peak watts of the photovoltaic module used in the installation.
HSP = peak sun hours incident on the plane of the panels.
FS = shade factor or shade loss coefficient
PR is the global factor of losses or performance ratio.
The selected panel is described in the materials section and with it the number of units required is estimated. The connection of the panels will be in parallel as this will allow to maintain the voltage between the panels and add the maximum current delivered by each one.

\[
\# de paneles = \frac{1755 \, W}{355 \times 4.75 \times 0.95 \times 0.78}
\]

\[
\# de paneles = 1.4045
\]

\[
\# de paneles \cong 2.
\]

Additionally, the auxiliary equipment of the photovoltaic system is determined where a battery with a capacity of 183 Amp-hours, a charge regulator of 100 Amp-hours and an electrical conductor of 1.32 mm² is required. Finally, the One-Line Diagram of the dimensioned system is made, which is presented in the Figure 6.

3.3.2 Sizing with System Advisor Model. The SAM simulation used the same meteorological data as the amp-hour calculation, as well as the same electrical energy consumption and the photovoltaic panel, differs from the previous estimate in the use of the SMA America reference inverter: SB2500V, the size of the system of project to 4 kWdc, being more than double the installed power, in order to cover the losses due to shadows and inefficiency of the solar panels. The simulation determines that 7 photovoltaic panels are required to cover consumption and Figure 7 shows the average annual production of the system where it is guaranteed that the power required by the system for its operation is produced from 10 am to 2 pm. As a plus point, a surplus will be generated that can be used to supply some equipment in the area (For this, an additional study must be carried out)
Finally, the one-line connection diagram of the system simulated by SAM is made (See Figure 8).

![Figure 7. Annual Production -SAM](image)

### 3.4 Comparison of sizing methods

Table 5 presents the data of the Ampere-hour method and the simulation in SAM, where there is evidence of a difference in the results of each developed, this is because SAM in its dynamic simulation model takes into consideration the interaction of the radiation of the place, the photovoltaic generator and the inverter, obtained as a result that the necessary power must be dimensioned from 3 Kw, so that when generating it delivers the power of 1.5kw, therefore, SAM allows the user to select for the expected generation of seven panels of the reference JKM375HC66M, in the same way the result is evidenced by Figure 7, which, as already mentioned, the power required by the system on average annually is obtained from 10 am to 2 pm.
Table 5. Methods comparison

| Analysis method | Selected panel | Number of panels | Installed power |
|-----------------|----------------|------------------|-----------------|
| Amp-hours       | JKM355M-66H    | 2                | 710 w           |
| SAM             | JKM375HC66M    | 7                | 2625 w          |

For the purposes of the application, the data obtained by SAM regarding the photovoltaic generator and other equipment such as the regulator and batteries will be taken into account and those previously estimated within the calculations of the amp-hour method. These elements are the ones that will make up the team under study and economic evaluation.

3.5 Simulation in CAD – Real’s system

The modeling and simulation were carried out in the SolidWorks Software on a real scale, integrating the condensation system (refrigeration cycle) with the photovoltaic power system, the final result is presented in the Figure 9.

![Figure 9. CAD Modeling](image)

The simulation process was carried out in the following way: it starts with the air circulation in a control volume of 6m³ at a rate of 950m³/h or 15.83m³/s this value is due to the air flow delivered by the fan, in the same way in this way, they enter data for air temperature at the inlet of -5 °C so that once it is inside the control volume, it brings the air to dew point temperature. Of the 415 interactions, the software simulated the behavior of the air within the control volume as shown in the Figure 10, with constant temperature and fluid circulation throughout the control volume.
Finally, the software tabulates the results of the simulation represented in Table 6. Simulation’s result, where interesting data for the operational feasibility of the equipment are observed.

### Table 6. Simulation’s result

| Local Parameter                  | Minimum       | Maximum      | Average       | Bulk Average | Surface Area [m²] |
|----------------------------------|---------------|--------------|---------------|--------------|-------------------|
| Pressure [Pa]                    | 101325,00     | 917548,63    | 345563,85     | 366717,82    | 0,04              |
| Density (Fluid) [kg/m³]          | 2,01          | 3,14         | 2,53          | 2,51         | 0,04              |
| Velocity [m/s]                   | 201,40        | 781,49       | 671,40        | 688,50       | 0,04              |
| Velocity (X) [m/s]               | -366,39       | 474,86       | 47,35         | 39,96        | 0,04              |
| Velocity (Y) [m/s]               | -436,94       | -24,58       | -154,71       | -151,69      | 0,04              |
| Velocity (Z) [m/s]               | 37,54         | 765,83       | 608,62        | 635,19       | 0,04              |
| Mach Number [ ]                  | 0,29          | 1,13         | 0,97          | 1,00         | 0,04              |
| Mass Fraction of Water [ ]       | 0,01          | 0,01         | 0,01          | 0,01         | 0,04              |
| Mass Fraction of Air [ ]         | 0,99          | 0,99         | 0,99          | 0,99         | 0,04              |
| Temperature (Fluid) [°C]         | -2,00         | 2,00         | 0,00          | 0,00         | 0,04              |
| Temperature (Solid) [°C]         | -4181,91      | 2403,78      | -810,06       | -810,06      | 0,04              |
| Specific Humidity [kg/kg]        | 1,00          | 1,00         | 1,00          | 1,00         | 0,04              |
| Absolute Humidity [kg/m³]        | 0,01          | 0,02         | 0,02          | 0,02         | 0,04              |

### 3.6 Technoeconomic study

Table 7 shows the value of each of the elements that will make up both the cooling system and the photovoltaic generation system, taking into account manufacturing labor, consumable materials such as cables, connectors, hardware, among others, and the utility of the whole system.
Table 7. Cost system

| Item | Material | Quantity | Unit Value | Total cost |
|------|----------|----------|------------|------------|
| 1    | Photovoltaic panel - Jinko solar JKM375HC66M | 7        | 172,00 €   | 1,204,00 € |
| 2    | Regulator JN-MPPT-C 100A                     | 1        | 330,00 €   | 330,00 €   |
| 3    | Battery 12V 200A                             | 2        | 239,00 €   | 478,00 €   |
| 4    | Compressor BD250GH.2                         | 1        | 152,00 €   | 152,00 €   |
| 5    | Fan LWFD200-EO                               | 2        | 24,00 €    | 48,00 €    |
| 6    | Evaporator coil                              | 1        | 50,00 €    | 50,00 €    |
| 7    | Condenser coil                               | 1        | 50,00 €    | 50,00 €    |
| 8    | Expansion Valve Danfoss 068N2012             | 2        | 27,00 €    | 54,00 €    |
| 9    | Electronic control kit                       | 1        | 18,00 €    | 18,00 €    |
| 10   | Metallic structure                           | 1        | 500,00 €   | 500,00 €   |
| 11   | Electrical protection kit                     | 1        | 60,00 €    | 60,00 €    |
|      | Total material value                         |          |            | 2,944,00 € |
|      | Expendable 4%                                |          |            | 117,76 €   |
|      | Workforce                                    |          |            | 250,00 €   |
|      | Utility 15%                                  |          |            | 496,76 €   |
|      | Total                                        |          |            | 3,808,52 € |

3.6.1 Economic profitability. For profitability, it is taken into account that in Colombia a 20-liter container (bottle) has a commercial value of 2.2 Euros, if a daily expenditure of these 20 liters in a year is considered they are equivalent to 7,200 liters or 792 euros, it is also it has an average of 3.8% of inflation to obtain the evolution of the price of this product over the years.

Table 8. Profitability

|            |     |
|------------|-----|
| VAN        | 9722|
| TIR        | 21% |
| Payback (annual) | 6  |

The initial investment begins to generate profits from the sixth year, on the other hand the net present value (NPV) with a discount rate of 2.5% at twenty years generates € 9,722 in profits with an internal rate of return (IRR) 21% as evidenced in Table 8.

4. Conclusions
The state of the art presents evidence of technological developments and research, in which an attempt has been made to carry out this type of system looking for the condensation of the water in the air, but its main problem lies in the application of thermodynamics, which is why this Research sought to bring the air to dew temperature and thus improve the thermal efficiency of the equipment and therefore energy efficiency.

The refrigeration equipment was selected in continuous current in order to reduce costs when integrating the two systems (refrigeration-photovoltaic system) to propose a sustainable condensation system, which was reflected in the selection of the inverter without ignoring that at the time if working in alternating current, there would be gains in cooling power since a conventional compressor could be used.
The amp-hour method gives you an ideal equipment sizing and selection methodology, neglecting the losses existing in the photovoltaic system. Therefore, it is recommended to take it as an initial method, for the subsequent expansion of a dynamic system that allows a real evaluation of the operation of the system.

The increase in the number of panels from one dimensioning method to another did not significantly affect the budget and the economic profitability of the system. The flexibility of SAM to perform the dynamism of the system for one year is highlighted, allowing to have an adequate projection of the behavior of the photovoltaic system, guaranteeing the supply of electrical energy to the condensing system, which in turn, will remain active for around 8 hours a day producing fresh water.

Finally, a sustainable water condensation system is obtained, through the integration of a conventional cooling system and a photovoltaic system, having a reasonable investment cost and a payback time or return on investment, starting from 6 year. Taking into account that the useful life of the photovoltaic system is approximately 20 years, the initial investment would be repaid for 14 years.

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