Application of Matlab for simulating the operation of a photovoltaic system in conditions of Mexico.

Liliana Cortez[1], J. Italo Cortez[2], German Ardul Muñoz[1], Ernest Cortez [1],Gustavo Rubin Linares[2], Alejandro Paredes Camacho[1]

[1]Faculty of electronics, [2] Faculty of Computer Science

Benemerita Universidad Autonoma de Puebla, Mexico

Abstract—The insufficient production of energy in Mexico represents a deficit nearby to 36 TWh per year and greatly elevates its cost therefore restraining the development of the country. The design of effective and profitable facilities on the basis of solar modules is especially important. Software dedicated to the simulation of photovoltaic systems can realize extensive and precise analyzes, but they generally do not allow the user to modify the algorithms. This degree of freedom only is in an open architecture of MATLAB that allows east process of disposition to modify any existing routine or to include new. In the present work a program in Matlab of the simulation of the operation of a photovoltaic system on the basis of the mathematical models of its components was designed. Software includes the models of the solar panel, battery, investor (continuous-alternating), consumption and model of arrival of the solar radiation. Each one of the obtained models have been organized in a set of architectures with the purpose of to characterize traditional photovoltaic systems most of.

Keywords—Simulation, Solar radiation, solar Module, MATLAB, Accumulator

I. INTRODUCTION

THE insufficient production of energy in Mexico represents a deficit nearby to 36 TWh per year and greatly elevates its cost therefore restraining the development of the country. The fossil fuel use brings about the climatic changes, as well as, the greenhouse effect. All of these reasons urge the search for new power source, as is the case of solar energy. The abundance of solar energy in Mexico (in average more than 5 k Wh/día), make the design of effective and profitable facilities based on solar modules is especially important [1, 11].

Nowaday there is software intended to the simulation of photovoltaic systems such as Pvsyst, Hybrid, Ilse, Pvsol, Ashling, PvWatts, etc. The traditional tools of design before mentioned can carry out extensive and precise analyzes, but they generally do not allow the user to modify the algorithms.

This degree of freedom can only be given in an open architecture: MATLAB allows this process of disposition to modify any existing routine or to include new ones. The use of photovoltaic systems is common now, the solar energy has been used in systems of illumination, electrification, signaling, communication, means of reception for education via satellite in far located communities, heating, pumping and purification of water etc., but as it happens with every new technology, there is not sufficient investigation regarding the conditions of work and operation of these systems. When they are evaluated, designed or when economic analyses of the system for benefiting from solar energy are made a rigorous, detailed information is required, it requires precise and detailed information of the solar radiation.

II. DETERMINATION OF THE RESOURCE OF THE SOLAR RADIATION

The characteristics of the solar radiation are constantly variable. The atmospheric conditions, the climate, the geographic characteristics, among others, are the most important parameters that determine the solar radiation quantity that is received on a given point of the earth [2, 3, 12].

Several methodologies exist that can be used to determination the incident radiation on the terrestrial surface. From the 70´s several authors have developed physical-mathematical models of solar radiation [4, 5, 13, 14]. Some from the composition of the atmosphere and the study of the effects that they cause on the solar radiation, which establish a modeling through a series of atmospheric coefficients which determine the components direct and diffuse and from these the global one, on place of the terrestrial surface.

Other methodologies are based on the analysis of temporary series of measured values of radiation (normally global radiation in horizontal plane). Lately, this method is leaning additionally in satellite imageries that allow a greater space extension.

The proposed method by Iqbal is the one that better adapts to conditions of Mexico and consists of basically taking the partial coefficients that reflect the solar energy absorption by ozone, gases atmospherics, aqueous vapors and dispersion.

The equation (1) shows the method.

$$\tau\Sigma = \tau_{O_3} \cdot \tau_{gas} \cdot \tau_{H_2O} \cdot \tau_R \cdot \tau_A \qquad (1)$$

Where:

τ_{O_3} it is the transmittance of ozone. τ_{gas} is the transmittance by gases of the atmosphere. τ_{H_2O} it is the transmittance by aqueous vapors. τ_R is the transmittance of Rayleigh. τ_A it is the transmittance by aerosols (transmittance of Mie).

Taking into account the atmospheric, climatic conditions of the state of Puebla, the coefficients are obtained from the following way. The coefficients of (1) are determined by the following empirical relations:

$$\tau_{O_3} = 1 - \frac{0,0516 \cdot m_\phi}{(1 + 44,634 m_\phi)^{0,3035}}$$

$$\tau_{gas} = \exp - (0,0127 \cdot m_\phi^{0,26})$$

$$\tau_R = \exp - (0,0903 m_\phi^{0,84}) \; ; \quad ;$$

$$\tau_A = \exp - (0,095 m_\phi^{0,9})$$

$$\tau_{H_2O} = 1 - \frac{2,496 d_{H_2O} \cdot m_\phi}{6,385 d_{H_2O} \cdot m_\phi + (1 + 79,03 d_{H_2O} \cdot m_\phi)^{0,683}}$$

where: d_{H_2O} it is the density of humidity in the air. m_ϕ - it is the atmospheric mass

Later, the density of direct and diffuse solar energy is determined (2) and (3):

$$W_b = \int_{t_{вос x}}^{t_{зах}} E_h^0(t) \cdot \tau_\Sigma \, dt \qquad (2)$$

$$W_d = \int_{t_{вос x}}^{t_{зах}} E_h^0(t) \cdot 0,38(1 - \tau_\Sigma) \, dt \qquad (3)$$

Where - $E_h^0(t)$ density of solar radiation outside terrestrial atmosphere in the horizontal surface.

Considering all the previously equations described and taking the day of smaller radiation for the State of Puebla, Mexico, the characteristic curve of arrival of solar radiation to the State of Puebla can be obtained (figures 1, 2). The simulations were compared with experimental dates and modeled using the method of Liu-Jordan and they were verified, and the error is within the acceptable limits (figures 3).
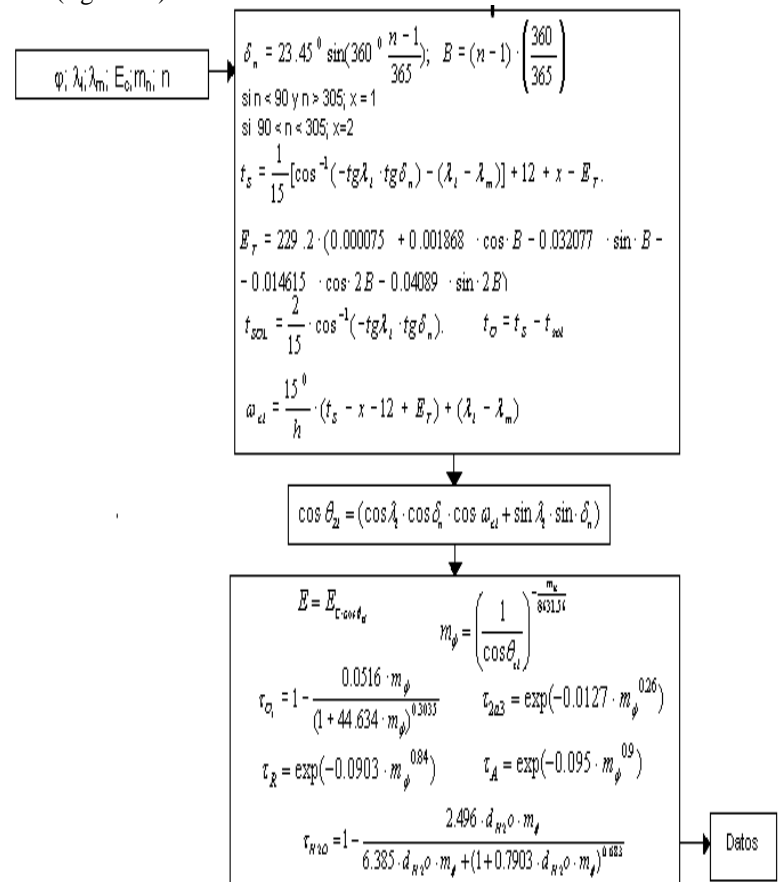

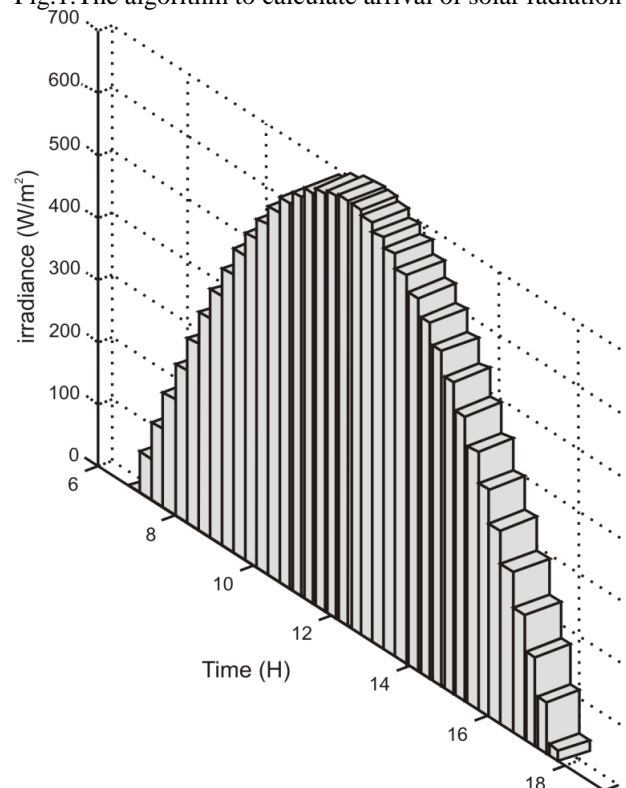Fig.1. The algorithm to calculate arrival of solar radiation

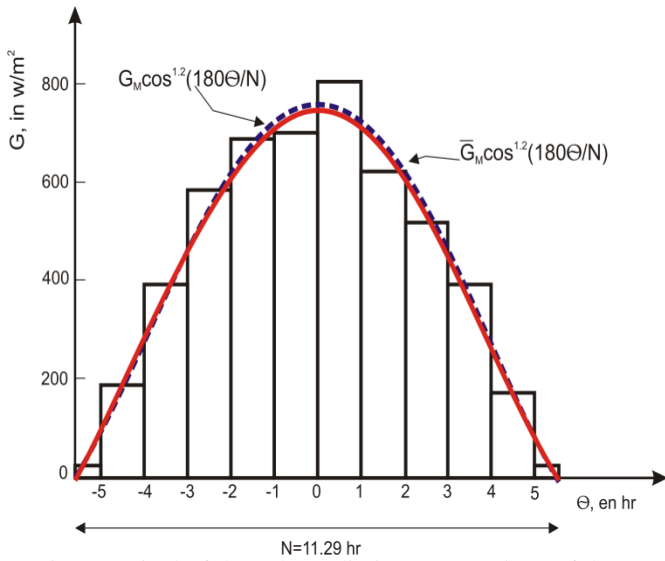Fig.2. Arrival of solar radiation for day 344

Fig.3. Arrival of the solar radiation (comparison of the methods Liu-Jordan, Iqbal and experimental)

III. SIMULATION OF THE ELEMENT OF A PHOTOVOLTAIC SYSTEM

Simulation tools provide the opposite view to the design tools. The user specifies the nature and dimensions of each component and the application provides a detailed analysis of the characteristics of the system. The accuracy of calculations and the simulation time required varies depending on the level of detail required and the type of data provided. They are used to verify the sizing of the system and investigate the impact of future changes in the systems being simulated.

Having the data of solar resource, it is possible to design an independent photovoltaic system that typically consists of a solar panel, an accumulator, a reverser and some consumer. In the first place we will describe to the solar panel which constitutes the main source of power for the whole photovoltaic installation [6, 7].

The equivalent model of the electrical circuit to use as the main element of the panel is formed by a current source that depends on the solar radiation in W/m2 (WRATH), of temperature in Celsius degrees (t), a shunt diode whose intensity of inverse saturation in series depends on the temperature and a resistance (RS), which represents the effect of the internal resistance of each solar cell and of the contacts of the generator as it is in fig.4.
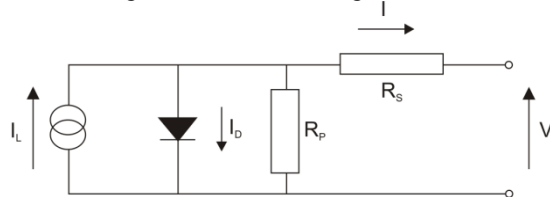

Fig.4. Equivalent Circuit of a solar cell.

The electrical behavior of the solar cell is detailed in the equation (4).

$$I = I_{FT} - I_0 (e^{(\frac{q(V + I \cdot R_S)}{m \cdot k \cdot T1})} - 1) \qquad (4)$$

The method of Newton-Raphson was applied who adapts to the design requirements. In this case calculation:

$$I_1 : f(I_1) = I_{FT} - I_1 - I_o (e^{(\frac{q(V + I \cdot Rs)}{m \cdot k \cdot T1})} - 1)$$

$$I_2 = I_1 - f(I_1) / f'(I_1)$$

The final equation is in (5).

$$I = I - (I_{FT} - I - I_0 \cdot (e^{(\frac{q(V + I \cdot Rs)}{m \cdot k \cdot T1})} - 1)) /$$
$$/(-1 - (I_0 \cdot (e^{(\frac{q(V + I \cdot Rs)}{m \cdot k \cdot T1})} - 1)) \cdot \frac{R_s}{m \cdot k \cdot T_1} \qquad (5)$$

The equation is solved by designing a program in matlab, taking into account the number of solar cells which has the photovoltaic panel. As we reached the main equation we now only need to find the coefficients from the following equation (6):

$$I_{FT} = I_{FT(T1)}(1 + K_0(Tr - T1)) \qquad (6)$$

T_r.- It is the reference temperature.
$I_{FT(T1)}$.- Is the photocurrent at the working temperatura T1, can be calculated as shown in equation 7

$$I_{FT(T1)} = \frac{I_{RA} \cdot I_{SC(T1,nom)}}{I_{RAnom}} \qquad (7)$$

K_o.- It is the ratio of short circuit current at T1and the sort circuit current at T2, as shown in equation 8

$$K_0 = \frac{I_{SC(T2)} - I_{SC(T1)}}{I_{Sc(T1)}(T2 - T1)} \qquad (8)$$

T2.- Working temperature 2, I_{RA}.-Solar Radiation 1 suns = 1000W/m², $I_{SC(T1)}$.- Current of short circuit at temperature T_1, $I_{SC(T2)}$.- Current of short circuit at temperature T_2.

$$I_0 = I_{0(T1)} \bullet \left(\frac{Tr}{T1}\right)^{\frac{3}{n}} \bullet e^{-\left(\frac{q \cdot V_G}{m \cdot k}\right)\left(\frac{1}{Tr} - \frac{1}{T1}\right)} \qquad (9)$$

V_G.- Diode voltage = 1.12eV for crystalline Silicon <1.75 for amorphous silicon.

$$I_{0(T1)} = \frac{I_{SC(T1)}}{e^{\frac{q \cdot V_{OC(T1)}}{m \cdot k \cdot T_1}} - 1} \qquad (10)$$

V_{OC}.- Open circuit voltage.
The photocurrent I_{FT} is directly proportional to solar radiaton I_{RA} (11) taking into account a constant of proportionality, according to the equation (7).

The terms of reference are: solar radiaton (I_{RA} = 1 sun = 1000 W/m^2), atmospheric mass (AM=1.5) and temperature (T = 25 ^{0}C).

$$I_{FT(T1)} = \frac{I_{RA} \cdot I_{SC(T1,nom)}}{I_{RAnom}} \qquad (11)$$

The relationship between the photocurrent and the temperatura is linear, according to the equation(6) and follows from the variation of photocurrent with temperature variation (12).

$$I_{FT} = I_{FT(T1)}(1 + K_0(Tr - T_1)) \qquad (12)$$

When the panel is short circuited and illuminated, the photocurrent flows in its entirety by the diode.

The value of reverse saturation current I0 to 25 0C was calculated from the short circuit current and open circuit voltage at this temperature (8). Finally the value of diode ideality factor m must be estimated. It can take values between 1 <m <2, a value of m = 1.3 can achieve good results.

So far we have found the coefficients of the equations described above, now we only introduce the panel data to simulate, these data appear in the specifications sheets and is provided by the manufacturer. In this case we use the photovoltaic panel Photowatt Type BPX 47 500 whit peak power of 48W and a work of 12V.

%A program that simulates the V-I characteristics curves of solar panel

```
For Rad=[200,400,600,xm]/1000;
        %xm, maximum radiation for the day n

Va=[0:0.5:21.5];
        %Working voltage

k = 1.38e-23;
        %Boltzman constant

q = 1.60e-19;
        %Electron Charge

A = 1.85;
        % Diode quality coefficient:=2 for
        Crystalline Silicon, <2 for Amorphous
        Silicon

Vg = 1.12;
        %Diode Voltage =1.12eV for Crystalline
        Silicon, <1.75 for Amorphous Silicon

Ns = 36;
        %Number of cells connected in series
```

```
%%%%%%%%%%%%%%%%%%%%%
 %%%  Datos del panel a simular  %%%
%%%%%%%%%%%%%%%%%%%%%%%

T1 = 273 + 25;
        %Working temperature 1

Voc_T1 = 20.9/Ns;
        %Open circuit voltage per cell to T1

Isc_T1 = 3.19;
        %Current of short circuit per cell to T1

T2 = 273 + 60;
        %Working temperature 2

Voc_T2 = 18.1/Ns;
        %Open circuit voltage per cell to T2

Isc_T2 = 3.29;
        %Current of shortcircuit per cell to T2
```

% In this part we introduce the temperature at which we want to work.

```
TaK = 273+Tc;
        % Working temperature

TrK = 273 + 25;
        % Reference temperature

    %%%%%%%%%%%%%%%%%
    %%%    Fin de los datos    %%%%
    %%%%%%%%%%%%%%%%%
```

% When Va=0, the current "light" generated a T1 is the same as the short circuit current a T1 (Iph_T1 = Isc_T1)
% The constant "a" can be calculated "Isc vs T"
```
        Iph_T1 = Isc_T1 * Rad;
        a = (Isc_T2 - Isc_T1)/Isc_T1 * 1/(T2 - T1);
                %Canstant Ko

        Iph = Iph_T1 * (1 + a*(TaK - T1));
                %Photogenerated current

        Vt_T1 = k * T1 / q;
                %Thermal Diode Voltage

        Ir_T1 = Isc_T1 / (exp(Voc_T1/(A*Vt_T1))-1);
                %Diode saturation current T1

        Ir_T2 = Isc_T2 / (exp(Voc_T2/(A*Vt_T1))-1);
                %Diode saturation current T2

        b = Vg * q/(A*k);
        Ir=Ir_T1*(TaK/T1)^(3/A)*exp(-b*(1/TaK-1/T1));
                %Saturation current

        X2v=Ir_T1/(A*Vt_T1)*exp(Voc_T1/(A*Vt_T1));
```

```
dVdI_Voc = -1.15/Ns/2;
        % dV/dI to Voc per cell

Rs =- dVdI_Voc - 1/X2v;
        % Series resistence per cell
        % Ia = 0:0.01:Iph;

Vt_Ta=A*1.38e-23*TaK/1.60e-19;%=A*kT/q
        %Ia1=Iph-Ir*(exp((Vc+Ia*Rs)/Vt_Ta)-
1);
        % Resolve for
        Ia:f(Ia)=Iph-
        IaIr*(exp((Vc+Ia*Rs)/Vt_Ta)-1)=0;
        % Newton Method: Ia2 = Ia1 -
f(Ia1)/f'(Ia1)
Vc = Va/Ns;
Ia = zeros(size(Vc));
        %Form a vector of zeros the same size as
        the vector Vc
        % Iav = Ia;

for j=1:5;
Ia=Ia-(Iph-Ia-Ir*(exp((Vc+Ia*Rs)/Vt_Ta)-1))/
(-1-(Ir*(exp((Vc+Ia*Rs)/Vt_Ta)-1))*Rs/Vt_Ta);
        End
```

For the design of the software, the number of solar cells available the photovoltaic panel counts. A photovoltaic panel Photowatt Type BPX 47 500 with a peak of 48W and a working voltage of 12V (figure 5) will be used and it will be compared to the manufacturer´s data (figure 6).
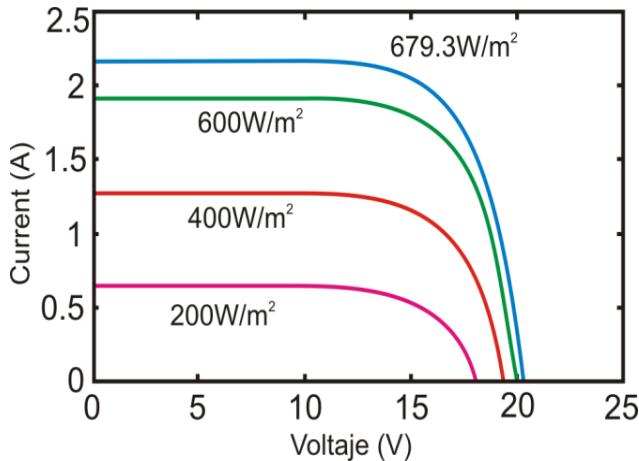

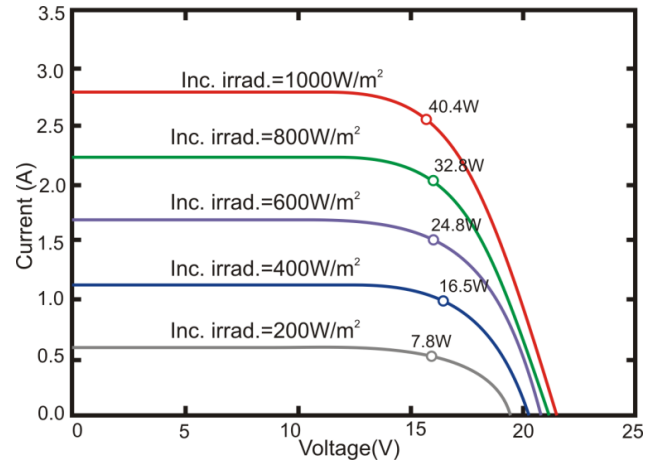Fig.5. Simulation of the characteristics of MS BPX 47 500.

Fig.6. Data of manufacturer of MS BPX 47 500

The accumulator has been traditionally considered merely as a simple device to store energy. But its use in independent photovoltaic system increases its importance by placing it in the center of the whole system as it is the one in charge of determining the works point and of feeding the loads when the radiation diminishes. For that reason it is necessary to have a model that allows to characterize its response in real conditions of work. The behavior of the electrochemical reactions that give rise within the accumulator hides a great complexity. The problem in the simulation of the seal with lead-acid accumulators by means of equivalent electrical circuits has been widely described in numerous articles [8, 9, 10]. The departure models approach their exposition from four different perspectives: characterization of the chemical reactions, obtaining of an equivalent electrical circuit in continuous, obtaining of alternating an equivalent circuit in and a pure functional description.

Once is available a suitable accumulator, the real problem can be approached: to anticipate the answer of the accumulator. In the short term the interest focuses on knowing the evolution the voltage and current in the terminals (tips) of the accumulator, whereas in the medium and long term it focuses on to predicting the evolution of the amount of energy that will store. It is necessary in addition to consider three aspects additional to evaluate the benefits of the chosen model: the involved variables of work, the situations in which they will be measured and the methods used for their measurement. The main magnitudes that will be used to characterize an accumulator will be the voltage, the current, the temperature, the internal resistance and the time constant.

In figure 7 the equivalent model of the electrical circuit developed appears to simulate the behavior of the accumulators under real conditions of work in photovoltaic facilities.
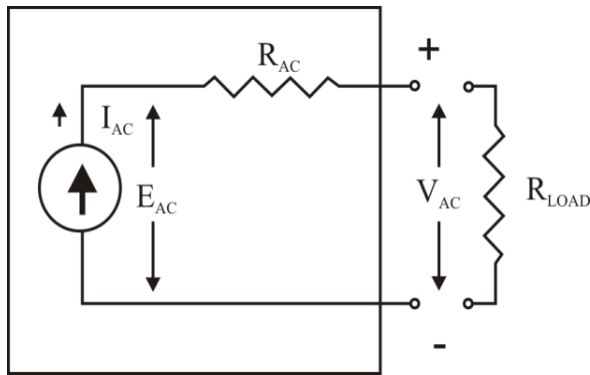
Fig.7. Basic electrical model of an accumulator

In (13) is the mathematical model of the accumulator.

$$\begin{cases} E_{AB} = E_p = E_{\text{н}} \pm \kappa \cdot Q \pm E_n \\ U_{AB} = E_{AB} \pm i_{AB} \cdot R_{\text{вн}} \end{cases} \qquad (13)$$

Where: $E_{\text{н}}$ - fem initial; E_p - fem equiponderate; κ - proportionality coefficient; Q-unloading capacity; E_{AB} - fem of the accumulator; $R_{\text{вн}}$ - internal resistance of the accumulator.

%A program that simulates the operation of a solar energy storage

```
disp('Enter the following data');
disp(' The voltage for the third customer is a 24 V');
        %Iab= Current in the accumulator

vol=input('Enter the battery voltage);
Consumer=input('Enter the consumer to simulate ');
d=1.24;
        % Electrolyte density (1.20-1.34 g/cm^3)

n=vol/2;
V=11.8;
        % Amount of electrolyte in the
        accumulator in liters

Cabhom=12.5*n;
        % Rated Accumulator

x=[1:24];
        % Working time (24 hours)
```

% In this part of the program there is chosen that behavior of the accumulator wants to observe in agreement to the type of consumer
        %Consumer1=home;

        consumer2=restaurant and

        consumer3=discotheque

```
if consumer= =1
        %Equations of load and of the current
        for the electrification of a house

iAB=0.00535554*x^4-0.25935*x^3+3.8608*x^2-18.026*x^1+15.977;
Q=0.0010711*x^5-0.064838*x^4+1.2869*x^3-9.013*x^2+15.977*x;
elseif consumer = = 2
        % Equations of load and of the current
        for the supply of energy of a restaurant

iAB=0.010054*x^4-0.49299*x^3+7.5044*x^2-37.845*x^1+42.352;
Q=0.0020108*x^5-0.12325*x^4+2.5015*x^3-18.923*x^2+42.352*x;
elseif consumer = = 3
        % Equations of load and of the current
for the supply of a discotheque

iAB=0.0041493*x^4-0.18852*x^3+2.2066*x^2  -2.5193*x-17.647;
Q=0.00082986*x^5-0.04713*x^4+0.73553*x^3-1.2597*x^2-17.647*x;
elseif consumer = = 4
        % Simulation of the prototype
        % Equations of load and of the current
        for the simulation of the prototype

iAB=0.0019212*x^4-0.089365*x^3+1.2733*x^2-5.7688*x+6.3506;
Q=3.8424e-4*x^5-2.2341e-2*x^4+0.42443*x^3-2.8844*x^2+6.3506*x;
else consumer = = 5
disp("The consumer who is elected does not exist")
end
```

% In this part of the program will introduce the equations of the accumulator
```
        Eh=0.32+(1.43*d);
        k=(2e-3)/V;
        % Coefficient of proportionality, V quantity of
electrolyte
        Epi=+0.075;
                % Constant

Ro=0.0091;
        % Internal resistance

Rb1=1-(Q.*(0.95/Cabhom));

Rb2=(Q.^2).*(3.7/Cabhom^2);

Rbh=(Rb1+Rb2)*Ro;
        % Internal resistance

Eab=Eh+k*Q+Epi;
        % emf source accumulator
```

Uab=Eab+iAB.*Rbh
            % Voltage at the battery terminals
plot(x,Uab);
title('Accumulator')
xlabel(time (H)'), ylabel('Voltage (V)')

In the fig (8, 9) are graphs for different loads following the amount from current month that circulates inside the accumulating S190 type.
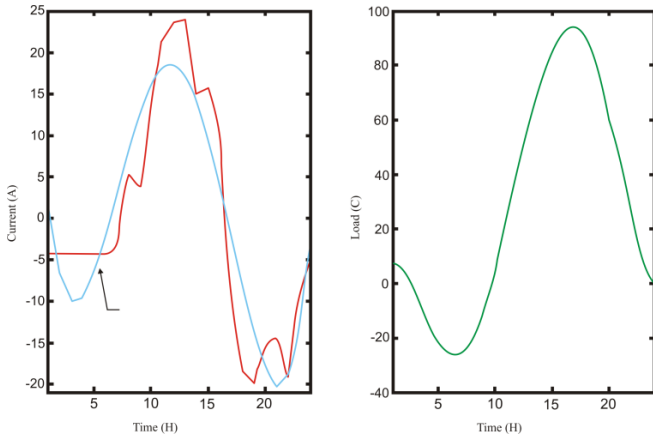

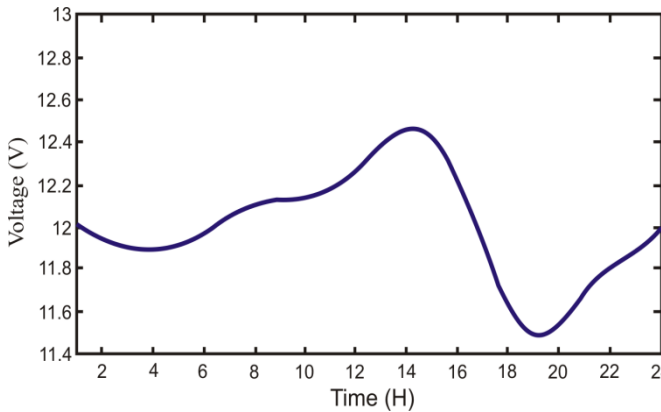Fig.8. Simulation of the current parameters and load of the accumulator.

Fig.9. Variation of the voltage of the accumulator.

The investor allows the current flow of a network of direct to a network of alternating.

The common investors work to 12 24 either 48 Volts with exits of 120 or 240 Volts to 50 or 60 Hertz.

The mathematical model of the investor that we are going to use can be represented like an equivalent resistance that depends on the voltage of exit of the accumulator and the power consumed by the system, as it shows equation to it (14).

$$R_{inv}(t) = \frac{P_{cons}(t)}{\eta_{inv} \cdot U_{AC}^2(t)} \quad (14)$$

Where: Pcons (t) - the consumed power, η_{inv} - quality factor of the investor, U_{AC} - voltage of the accumulator.

The result of simulation of operation of investor is in fig 10.
A program that simulates the operation of a CC to AC inverter

Rin = (Potcon)./(0.9.*Uab.^2)
plot(x,Rin);
title('Graphic Inversor operating energy supply to a housing')
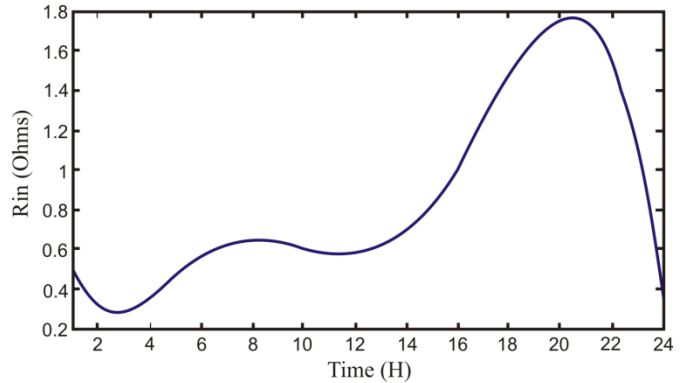xlabel(Time (H)'), ylabel('Rin (Ohms)')

Fig.10. Simulation of operation of investing Type PS 300

As an example, we are going to simulate the consumption of electricity of a house, which will be inhabited of continuous way. In fig.11, one is as the power consumption is distributed during a normal day of operation, in addition can be appraised the graph of the power that generates the set of solar panel BPX 47 500 (15 panels in series).
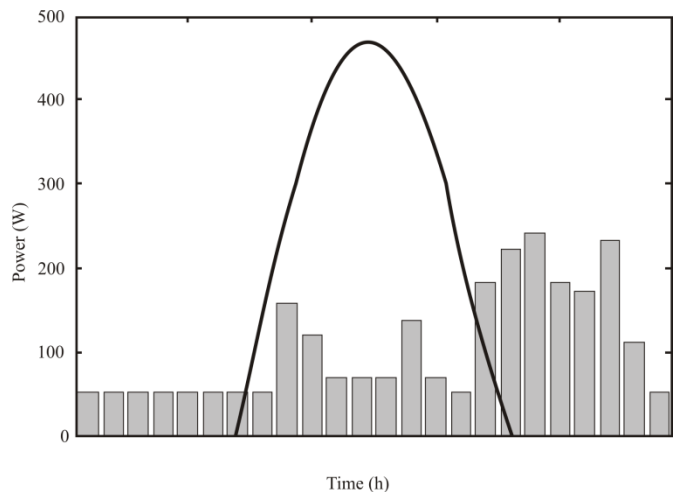

Fig.11. Supplying of electrical energy to a house.

IV. CONCLUSION

In the present work a program in Matlab of the simulation of the operation of a photovoltaic system was designed. Software includes the models of the solar panel, accumulator, invertor (continuous-alternating), consumption and model of arrival of the solar radiation.

Each one of the obtained models has been organized in a set of architectures with the purpose of to characterizing traditional photovoltaic systems.

The flexibility and power provided by MatLab, as well as the efficiency of the calculation algorithms, the great amount of mathematical bookstore available and mainly the graphical atmosphere at hand, were verified. The simpleness of their use has allowed interlacing a set of functions to create models of devices which in turn has allowed us to carry out a great number of simulations.

One of the derived advantages is being able to switch the parameters of the equipment to be simulated as well as to generate, at any given day of the year, the arrival of solar radiation on any over the surface of the Earth, based on the Iqbal method adapted to the conditions of the State of Puebla, considering its distinctive climatic circumstances and its height.

Finally, the use of data obtained through this investigation is intended for the future development of photovoltaic system in Mexico and to determine the economic effectiveness of its enforcement.

REFERENCES

[1] Goatish Alcor, Enrique. *Photovoltaic solar facilities*, Publishing Alcor, Third edition. 2000.

[2] Iqbal, Muhammad. *An introduction to pav radiation*, Academic Press, New York 1983.

[3] Almanza Salgado, R., Estrada-Cajigal Ramirez, V., Barrientos Avila, J. *Update of the Maps of Global Irradiation To pave in the Mexican Republic*. Series of the Institute of Engineering no. 547.2007.

[4] *Surface meteorology and To pave Energy* http://eosweb.larc.nasa.gov/sse/) of the Earth Science Enterprise Program of NASA. 2005.

[5] Mejía Eduardo A. *State-of-the-art of the investigation in solar energy in Mexico*. Notebooks FICA, Mexico 1999.

[6] Duke, A. Jacobson and D.M. Kammen, *Photovoltaic modulates quality in the solar Kenyan home systems market,* Energy Policy, 2002.

[7] *Dispersed Markets and Renewable Energies*. Electrical supplying of the Dispersed Rural Population. Program PAEPRA", http://energia.mecon.gov.ar, 2003.

[8] Tobis Seng, Dirk Uwe Sauer. *Detailed Modeling of Lead Acid Batteries Solar Under Typical Operations Conditions*, Eurosun, Freiburg, 1996.

[9] Massimo Ceraolo, *Dynamical New Models of Lead-Acid Batteries*, IEEE Transactions on to Power Systems, 2000.

[10] CH. Ehret, S. Piller, W. Schorer, A. Jossen, *For State or f charge determination lead acid batteries in PV applications*, 16th European solar Photovoltaic Energy conference, Glasgrow,2001.

[11] Lucian Milea, Orest Oltu, Claudius Teodorescu, Verona Muntean, Marius Stoian Photovoltaic energetic system - design and implementation 12th WSEAS International Conference on SYSTEMS, Heraklion, Greece, July 22-24, 2008

[12] A.S.Drigas, J.Vrettaros, L.G.Koukianakis, J.G.Glentzes A Virtual Lab and e-learning system for renewable energy source Proceedings of the 1st WSEAS / IASME Int. Conf. on EDUCATIONAL TECHNOLOGIES, Tenerife, Canary Islands, Spain, December 16-18, 2005.

[13] Nistor-Daniel Trip, Viorel Popescu*, Adrian Schiop Low Power Portable Renewable Solar Energy Source 2nd WSEAS/IASME International Conference on RENEWABLE ENERGY SOURCES (RES'08) Corfu, Greece, October 26-28, 2008.

[14] G. Tina, S. Gagliano Probability Analysis of Weather Data for Energy Assessment of Hybrid Solar/Wind Power System 4th IASME/WSEAS International Conference on ENERGY, ENVIRONMENT, ECOSYSTEMS and SUSTAINABLE DEVELOPMENT (EEESD'08) Algarve, Portugal, June 11-13, 2008.

Liliana Cortez. She did the Engineering and Master degree at the Polytechnic Institute of Kiev, Ukraine and the Ph.D. degree at the State Technical University of St. Petersburg, Russia. She is Professor at the Faculty of Electronic Sciences of the Benemerita Universidad Autonoma de Puebla

J. Cortez Italo. He did the Engineering and Master degree at the Polytechnic Institute of Kiev, Ukraine and the Ph.D. at the North West State Technical University St. Peterburg, Russia. He is Professor at the Faculty of Computer Science of the Benemerita Universidad Autonoma de Puebla.

German Ardul. Received the BSc degree in Electronic Engineering from Veracruz Institute of Technology en 1988. In 1990 he received the MSc degree in Electronic Systems from the National Institute of Astrophysics Optic and Electronic. He received the Ph.D degree from the University of Wales, Bangor in 2005. He is currently professor research of the Faculty of Computer Science of the Universidad Autonoma de Puebla.

Ernest Cortez. He finished his enginnering degree with a specialization in embedded systems at the Faculty of Electronic Sciences of the Universidad Autonoma de Puebla

Gustavo Rubin Linares. He did his engineering at the Faculty of Electronic, the Masters degree at the Institute of Physics of the Universidad Autonoma de Puebla and the Ph.D degree at the National Institute of Astrophysics Optics and Electronics. He is currently professor research of the Faculty of Computer Science of the Universidad Autonoma de Puebla.

Alejandro Paredes Camacho. He completed his engineering in Electronics Science in 2009