RESEARCH ARTICLE OPEN ACCESS

Errors in Interconnected Photovoltaic (SFV) Installations and their Impact on Power Generation

Gutiérrez-Villegas JC*, Murillo-Rodriguez VA**; Vejar-Ruiz S***; Urbina-Graciano JA**
**(Ingenieria Mecánica Eléctrica, Universidad de Guadalajara - Centro Universitario del Norte (CUNorte), México. Email: juan.gvillegas@academicos.udg.mx)*
*** (Ingeniería Mecatrónica, Universidad Politécnica de Zacatecas (UPZ), México)*
**** (Facultad de Ingeniería Mecánica Eléctrica, Universidad Autónoma de Coahuila)*
Corresponding Author : Gutiérrez-Villegas JC

ABSTRACT
The implementation of Interconnected Photovoltaic Systems (SFV) reduces the power consumption of the electrical network, being a good alternative in tariffs where the charge is solely for this concept. Implementing SFV interconnected to users with a tariff 1 Domestic High Consumption (DAC) is an alternative for reducing the electricity tariff; however, technical installation errors have been found which do not allow to take advantage of the maximum power that the system can generate.
This paper presents a historical analysis of the consumption obtained from bimonthly electricity bills and the generation of energy in a user which has an interconnected SFV system of 5 kWp in tariff 1 (DAC). It was found that the system injects approximately 30% of the total installed capacity. The generation data are shown with the SFV initially installed as well as the data after making modifications to the SFV system, increasing the power generation obtaining a greater injection to the network and improving the impact on the consumption billing.

Keywords - Interconnected Photovoltaic system (SFV) to the network, electricity tariff

Date Of Submission: 26-04-2019 Date Of Acceptance: 06-05-2019

I. INTRODUCTION

The growing technological development and population increase are demanding a greater consumption of energy resources. At the present, the energy sector worldwide depends on fossil fuels; even when a rational use of these resources is being made, it is necessary that investments are made simultaneously to develop the technology for the use of renewable energies. Therefore, to establish a long-term perspective of the processes and application of new technologies, the consumption of electric energy in the residential sector is analyzed, in order to distinguish patterns of electricity consumption.

Photovoltaic solar energy is an alternative to meet the growing demand for electricity. Mexico has a privileged solar resource because of its geographical location between the Tropic of Cancer and the Tropic Capricorn, which the European Photovoltaic Industry Association (EPIA) identifies as the Solar Belt [1]. This country is identified with a high potential for the use of this type of renewable energy with an irradiance of between 4.5 - 7 k Wh / m^2 in the normal plane [2].

Zacatecas, a state located in the center of Mexico, receives an irradiance of the order 5 kWh / m2 that places it above some European countries where there is a large amount of photovoltaic infrastructure installed [3]. This shows that solar radiation conditions are available for the installation of photovoltaic systems (SFV) for users in the region, which reduces the costs of electricity consumption.

Regarding the legislation of Mexico, on November 28, 2008, the Law for the use of renewable energies and the financing of the energy transition was published [4]; its objective is to regulate the use of renewable energies to generate electricity, but without generating energy for public service.

The Energy Regulatory Commission (CRE), on April 8, 2010, published the interconnection contract model for renewable energy source [5], which has the purpose of establishing the rights and obligations of a user that connects some source of renewable energy to the national electrical system.

When installing SFV with connection to the network it is necessary to take into account the current regulations and the technical recommendations of the manufacturers of the equipment used. Installations that do not comply with the norms and established recommendations have been found, preventing these systems from operating adequately, directly impacting on the generation of energy and as a consequence there is no significant impact on the reduction of the electricity bill.

In the billing scheme for users with a renewable energy source, the energy concepts included in the electricity bill for a domestic tariff with renewable energies and analyzed in this paper are:

- Network consumption: the energy that the bidirectional meter quantifies as demand by the user of the supply network.
- SFV generation (injected): energy that the bidirectional meter quantifies as delivered to the electricity network (Supplier).
- Accumulated energy: Energy delivered by the Generator (User) to the electricity network (Supplier) that was not possible to compensate in a given previous month and that accumulates for future compensations.
- Energy exchange: energy taken from the accumulated amount of the previous bimester and that will compensate the energy delivered by the Supplier in the billing period.

The objective of this work is to present the analysis of the historical consumption of electrical energy of a user in the DAC tariff who has installed an SFV connected to the 5 kWp network, but who has not been able to reduce the cost of the electricity bill. Modifications are proposed to improve the installation and verify its impact on the energy injection in the electric billing by CFE. The results of monitoring the power generation before and after making adjustments to the system using an energy quality analyzer are also presented.

II. MÉTODOS

Case study

In the present analysis, a user of the city of Zacatecas is taken as a case study. For the energy consumption, the bill is in DAC rate, and for the cost of the electric bill, an installation of an SFV system with connection to the network was chosen. By having the optimal conditions for power generation with the SFV, and after several months of being in operation, it has not been possible to reduce the cost of the electricity bill.

The review procedure of the analysis case is carried out as follows:

- Revision of the electric bill
- Inspection of the SFV
- Recommendations and modification of the SFV
- Analysis of the electric bill after the modification of the SFV
- Energy registration using the electrical network analyzer

The modifications made to improve the installation of SFV were:

- Elimination of the shading of the photovoltaic modules: this avoids that some ceda can operate in open circuit eliminating the generation of energy.
- Modification of the photovoltaic array with which two branches were installed in parallel to reduce the generated voltage: in this way, it is ensured that the voltage is not greater than the safety margin of the inverter and the protection can be activated to stop injecting energy into the network.

When carrying out the recommended modifications, the electric energy bill is analyzed for three bimesters in order to quantify the impact on the energy injection, and as a consequence on the electric bill.

For purposes of presentation the results, information on the consumption and energy cost of six bimesters is shown in which there is a tariff 1 with renewable energy.

III. RESULTADOS

The results presented correspond to a historical year of consumption and cost of electric power. In the first two bimesters, the SFV is operating but without generating the maximum energy level for which it was designed. In the bimester number three, the modification to the system is made, and from the fourth bimester the system operates in an appropriate manner.

Figure 1 shows the consumption and generation of energy by the user, as well as the energy to be invoiced and the energy that has accumulated. The observations that can be made are:

1. In the bimester of modification of the installation (bimester 3) of the SFV, a considerable reduction in the energy invoiced can be seen.
2. In all the bimesters energy generation is appreciated; however, as of the modification of the SFV (bimester 3), it increases considerably reducing the energy that is demanded from the network.
3. As of bimester 4, a bag of energy is applied in such a way that there is no consumption from the network by the user, and also there is energy accumulated for future compensation.
4. In the following bimesters, there is also no energy to be invoiced.

Figure 2 shows the cost of energy in the same period, observing that there is a significant reduction in the payment of electricity to the supplier, and that as of bimester 4 only the minimum payment per connection is made. In addition to the reduction of the requested kW-h of the network, there is also a reduction in the impact of IVA and the right of public lighting (DAP) since these are calculated from the energy demanded by the user, as can be seen in the figures 1 and 2. With the reduction of these two aspects, the impact on the invoice increases.

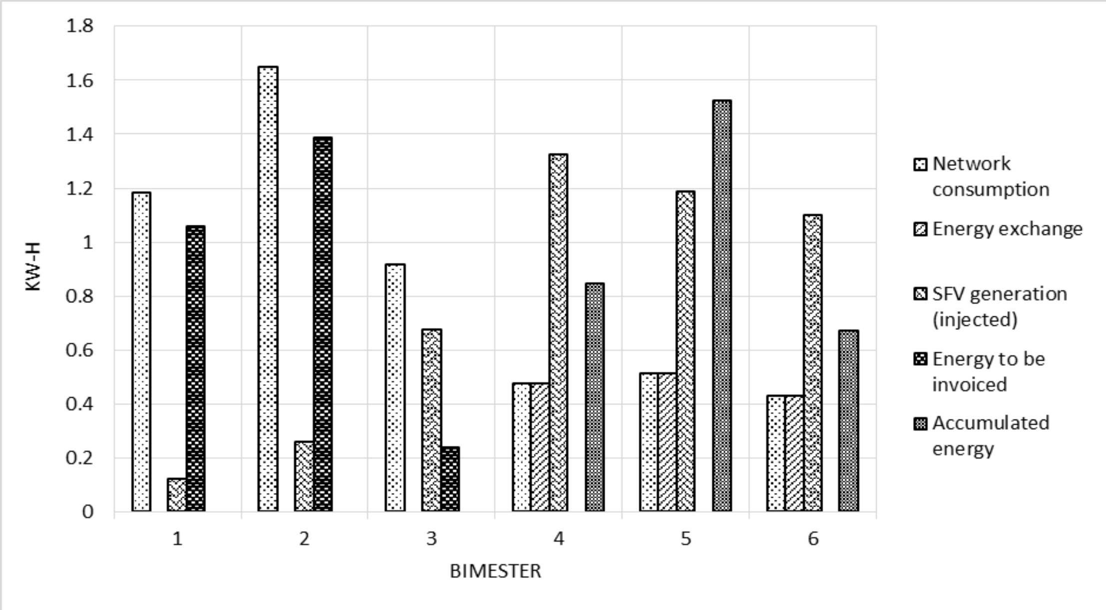

Figure 1. Generation and consumption by the user of one year

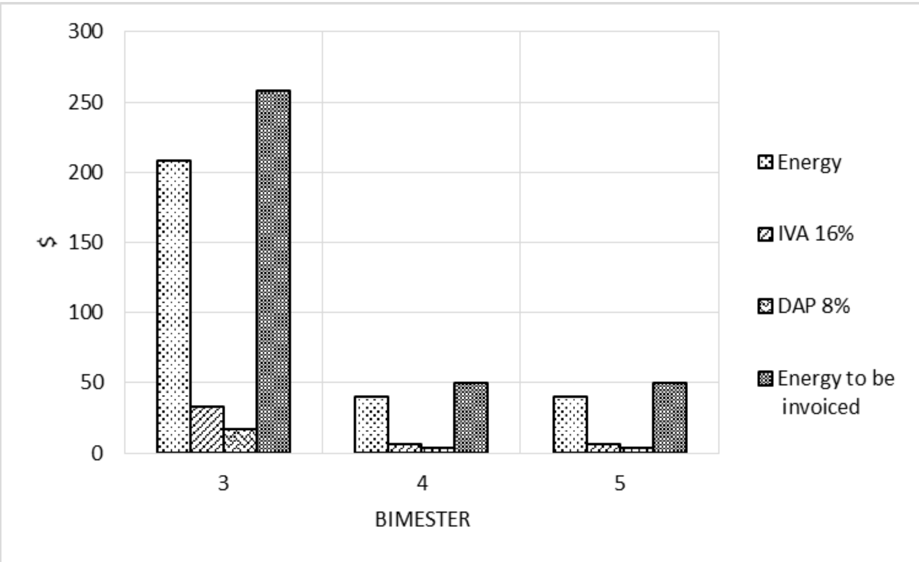

Figure 2. SFV energy cost

By reviewing the energy consumption before and after the modifications, it can be seen that the impact on billing is improved, being this the aspect that the user is interested in. This can be seen immediately in the billing of bimester 4 (Figure 2), reducing it only to the payment for the right to have electricity supply service.

In Figure 3, the result of performing the power measurement generated by the system is shown before making the improvement adjustments. It can be seen that the curve has several discontinuous points in which the power goes to a value of zero. This is because as the radiation increases depending on the time of day, the generated voltage also increases until it reaches levels close to the maximum value acceptable to the inverter.

Upon reaching the maximum level of generated voltage, the protection circuits are activated in the inverter, causing the system to stop injecting energy to the user's loads.

It was found that the energy generated and supplied by the system to the user was 6.5 kW-h which is a value well below the estimated energy in the dimensioning of the SFV.

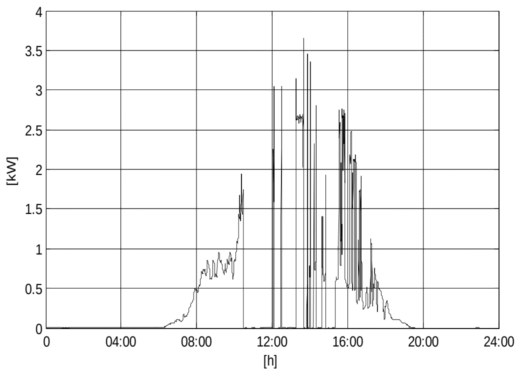

Figure 3. Energy generated before recommendations

Figure 4 shows the graph of the results obtained from measuring the power generated by the system after the modification recommendations were made, unlike the results shown in Figure 3, now a continuous curve is shown.

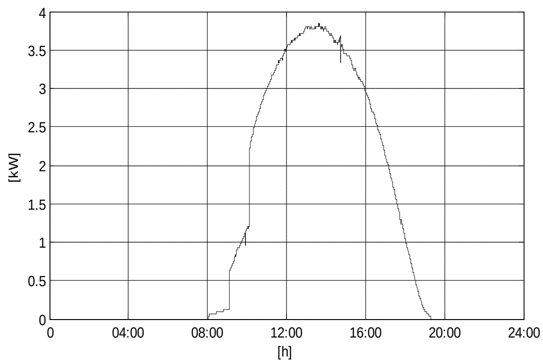

Figure 4. Energy generated after recommendations.

The energy generated by the system is 25.6 kWh, observing that the system is generating its maximum capacity.

When comparing the energy generated by the system before (figure 3) and after (figure 4) of the improvement modifications to the SFV, it can be seen that it increases four times with respect to the energy generated by the system initially.

IV. CONCLUSION

It is necessary to take into account the current regulations in each of the zones at the time of installing the SFV, as well as the manufacturer's recommendations since the best operation of the system will depend on the best operation of the system. In this case errors to be considered are detected in the installation:

- The effects of shading on modules and,
- The high generated voltage, caused by the large number of modules connected in series.

By eliminating shading and reducing the number of panels connected in series, the installation of the SFV is improved, enabling it to operate properly.

The benefits of the recommendations are:

- Operation of the SFV correctly
- Increase of the energy injected into the network by SFV (by 400%)
- Reduction of the electricity cost bill by the user
- The investment of the PV System is recovered in a short time.

REFERENCES

[1]. A.T. Kearney, «Unlocking the SunBelt Potential of Photovoltaics.,» Bruselas, 2010.

[2]. J. Mundo-Hernández, Benito de Celis Alonso, J. Hernández-Álvarez y B. d. Celis-Carrillo, «An overview of solar photovoltaic energy in Mexico and Germany,» Renewable and Sustainable Energy Reviews, vol. 31, pp. 639 - 649, 2014.

[3]. C. Muro, M. A. Saucedo, J. De la Torre y M. Reta, «Análisis de los niveles de radiación solar en el estado de Zacatecas para la implementación de sistemas fotovoltaicos,» Revista Investigación Científica, vol. 3, nº 2, Mayo - Agosto 2007.

[4]. Cámara de Diputados del H Congreso de la Unión, Ley para el aprovechamiento de energías renovables y el financiamiento de la transición energética, México, DF, 2008.

[5]. Comisión Reguladora de Energía (CRE), Contrato de interconexión para fuente de energía renovable, México, DF, 2010.

Gutiérrez-Villegas JC" Errors in Interconnected Photovoltaic (SFV) Installations and their Impact on Power Generation" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.05, 2019, pp. 33-36