# Solar radiation in urban projects: financial analysis of a photovoltaic system for a habitation house in the metropolitan area of monterrey, nuevo leon, mexico.

*Radiación Solar en Proyectos Urbanos: Análisis Financiero de Sistema Fotovoltaico para Casa Habitación en Monterrey, Nuevo León, México. fino*

**Javier Leal Iga** (Main and Contact Author)
Universidad Autónoma de Nuevo León, México. Facultad de Ingeniería Civil.
Av. Pedro de Alba s/n, San Nicolás de los Garza, N.L.
jlealiga@yahoo.com.mx

**Carlos Leal Iga**
Universidad Autónoma de Nuevo León, México. Facultad de Arquitectura.
clealiga@hotmail.com

**Manuscript Code:** 242
**Date of Reception/Acceptance:** 01-08-2014 / 01-12-2015.

**Abstract**
Photovoltaic systems have been presented as an alternative to the substitution of fossil fuel energy consumption in urban development projects around the world. Their implementation is however dependent on factors with high variability, such as the amount of solar radiation that reaches the ground, climate in the area, consumption patterns, among other things. All these are a direct function of the project's geographic location. However in the majority of cases, it is economic concerns that finally determine the feasibility of implementation. Therefore, this investigative paper carries out a financial analysis of the implementation of a photovoltaic system for two homes, one with a low degree of energy consumption, and one with a high degree of energy consumption, in the metropolitan area of Monterrey, Nuevo León, Mexico, taking into account all factors involved. Amortization tables are made with the results, where it is established the number of years required to recover the investment, with these is possible to financially evaluate the use of photovoltaic paneling that harness the solar resource in Urban Developments in the study area. Our results show that the compressive and flexural strengths of the recycled mortars decrease proportionally to the amount of natural sand replacement used. A similar behavior is observed for the shrinkage due to drying in mortars with low ceramic substitutions (10%, 20% and 30%). Based on these findings, we believe that the use of mortars made with recycled sand (with substitution contents lower than 30%) could be feasible in applications where the mechanical requirements are low.

**Keywords:** urban development, solar energy, financial analysis, watts-peak, geographic zone.

**Resumen**
Los sistemas Fotovoltaicos se han presentado como una alternativa a la sustitución del consumo de energías fósiles en el desarrollo de los Proyectos Urbanos alrededor del mundo. Su implementación depende de factores con alta variabilidad, como la cantidad de radiación solar que llega al suelo, el clima en la zona, las costumbres de consumo, entre otras. Todas ellas son función directa de la ubicación geográfica donde se ubique el proyecto. Además, en la mayoría de los casos el factor económico es el que determina finalmente la factibilidad de implementación. Así, en el presente trabajo de investigación, se efectúa un Análisis Financiero de la implementación de un Sistema Fotovoltaico para dos casas, una con consumos bajos y la otra con consumos altos, en la zona Metropolitana de Monterrey, Nuevo León, México. En donde se tome en cuenta todos los factores involucrados. Con los resultados se elaboran tablas de amortización, en las que se establece el número de años necesarios para recuperar la inversión, con ellas es posible evaluar económicamente el uso de paneles fotovoltaicos que aprovechar el recurso solar en Desarrollos Urbanos en el área de estudio.

**Palabras Claves:** desarrollo urbano; energía solar; análisis financiero, watts-pico, zona geográfica.

## Introduction

### State of the art

The use of renewable energy to satisfy the energy needs of urban centers has taken on special relevance in the present, owing particularly to the environmental degradation caused by traditional energy-generation systems that use fossil fuels (Ahumada et. al., 2010; PECAN, 2012). Besides, owing to its importance, studies have been carried out involving the energy sustainability of urban buildings, these include the work shown in Table 1, among others.

Solar power remains the most abundant source of energy on Earth, and so the harnessing of this energy remains the challenge of this century. The terrestrial atmosphere is a constantly variable filter for solar radiation; in this mass of air the absorption of solar radiation by ozone, oxygen, water vapor, and carbon dioxide is produced. Even seemingly empty environments contain gaseous molecules, dust, aerosols, particles, among other things that reduce solar radiation as it passes through the atmosphere (Stoffel et. al., 2010). We must also consider that the climates of the world obey the Sun-Earth relationship, as well as many geological and oceanic phenomena (Nahle Sabag, 2011). Therefore, to determine the potential isolation of a specific part of the planet, ground-level measurements are required in order to obtain a more exact representation of climactic variance.

Another factor to take into account is the increased frequency of the use of photovoltaic solar paneling to supply pollution-free ("clean") energy which also stimulates a decrease in expenses derived from the consumption of energy supplied through the grid of the electric power company (SENER S., 2009; CONAE, 2007).

Photovoltaic panels trap energy irradiated from the sun and supply it in the form of electricity. The harnessing of the solar resource to satisfy the electric requirements of a home depends in part on the conditions of the weather, and in another part on the area's patterns of consumption. This is due to the fact that the amount of solar radiation that reaches the ground depends on factors individual to the area such as latitude, cloud cover, humidity, dust and smog, among others.

Consumption patterns themselves depend, among other things, on the number, gender, ages and customs of the inhabitants, the area's climate, the magnitude of the variations of its temperature, humidity and daylight hours, which determine the type and time of use of heating and air conditioning equipment. On the other hand, economic concerns are paramount for decision making as regards the feasibility of photovoltaic panels in urban developments.

### Description of the problem

As can be seen from the large amount of factors involved and the variability of these same factors, which are tightly bound to weather, social, and spatial patterns of a given location, these studies become complex problems to solve. This investigative work presents an evaluation of the use of photovoltaic paneling through the financial analysis of two distinct cases of habitation representative of the different levels of consumption in a specific area of the metropolitan area of Monterrey, Nuevo León, México.

Using this evaluation allows us to establish the years required to recoup the investment of installing the system through the returns on savings on electricity generated by fossil fuels and subsequently substituted by photovoltaic paneling. Our two case studies are:

Case A) An average home in a neighborhood designed with bioclimatic criteria in mind, with low electric consumption according to the standards of the electric power company (CFE, 2013).

Case B) An average home with high consumption patterns according to the tariffs imposed by the electric power company (CFE, 2013), within the same area of study.

The electric power company manages different rates in Mexico, mainly depending on the geographical area, the level of consumption (or consumed quantity) and use (residential, industrial, commercial, agricultural, aquaculture or public services). Thus, the structure and fees are determined by the same company (CFE, 2013).

To carry out a financial analysis it was necessary to take into account all the mentioned factors, obtaining measurements of the amount of solar radiation at ground level for the area of study, and with these calculate the amount of energy that the photovoltaic panels would be able to supply.

## Materials and Methods

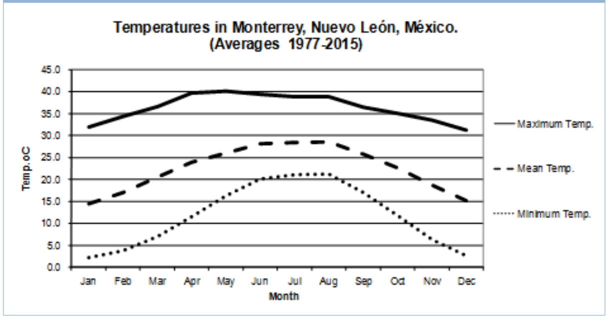
### Climate in the metropolitan area of Monterrey, Nuevo Leon, Mexico

Monterrey is geographically located at 25° 40' North Latitude and 100° 18' West Longitude, at an altitude of 540 meters above sea level, the climate is classified as extreme, mostly hot and dry, but with temperate temperatures at higher altitudes, with frost in the winter.

Monterrey has an average temperature of 23° C, though this can reach up to 43°C in the summer and less than 5° C in the winter. Average humidity is 62%, with strong rains in July, August, September, and October. Dominant winds come from the west and the southeast; the latter from the Huajuco canyon.

North winds are predominant in the winter, which blow with greater strength in February and March (INEGI, 1981). Figure 1 shows the statistics for average median, maximum, and minimum temperatures measured in the Observatory station Monterrey of the CNA (National Water Commission), in the period from 1977 to 2015 (CNA, 2015).

**Fig 1.** Temperatures minimum, maximum and mean in the Observatory station of the CNA. Latitude 25° 44' 01", Longitude 100° 18' 17", Altitude 515 meters above the sea level. Source: Comisión Nacional del Agua, 2015.




### Case Study in the Escobedo area

The following section describes the case studies in the Escobedo area within the metropolitan area of Monterrey, Nuevo León, México.

***Case A***

Figure 2 shows case study A (signaled as: 1- Franc. Vida, rhombus figure), which is located in the VIDA (Environmental Design Living) development in the suburb of General Escobedo, within the metropolitan area of Monterrey, Nuevo León. This development obtained the national price for habitation in 2007, in the category of sustainable habitable development for social interest (government funded) developments (IVNL, 2008).

During the building of this development the primary principles applied to its design were those of bio-climate and passive solar energy systems, and it corresponds to a habitation area belonging to a lower-middle socioeconomic level. The land of house in study has a surface of 90 m2; the construction is of 75.76 m2. The draft datum planes are; Plan site view (Figure 3), Architectural view of lower floor and upper floor (Figures 4 and 5) and a perspective view of the whole (Figure 6).

***Case B***

Figure 2 also shows the location of the home taken as case study B, in the Cerradas de Anáhuac Residencial development (marked as: 4- Fracc. Cerradas de Anáhuac Residencial), which corresponds to a residential area with an upper-middle economic level, which is found within the same zone of the suburb of Escobedo, N.L.

The land of house in study has an area of 120 m2, the construction is of 168.83 m2. The draft datum planes are; Plan site view (Figure 7), Architectural view of lower floor and upper floor (Figures 8 and 9) and a perspective view of the whole (Figure 10).

In both cases, the roofs are made with concrete slab lightened with mud block of 15 cm of thickness and skate concrete of 5 cm, giving a total of 20 cm. Case A is located at 25.80 ° of latitude and - 100.39 ° of longitude, Case B is at 25.77 ° of latitude and longitude of - 100.27. Azimuth (orientation from due south) for the placement of solar panels is 12.13 degrees.

The idea is to evaluate the potential of harnessing of a solar energy systems, through of substituting the entirety of electric consumption of these homes with the energy generated for a solar panels system, taking into account the average monthly consumption of electricity in households in the study area.

**Figure 2.** Location of weather stations and case studies, within in the metropolitan area of Monterrey, NL.
Source: Using data from SIMA (2012) and IVNL (2008).


**Figure 3.** Plan Site view.

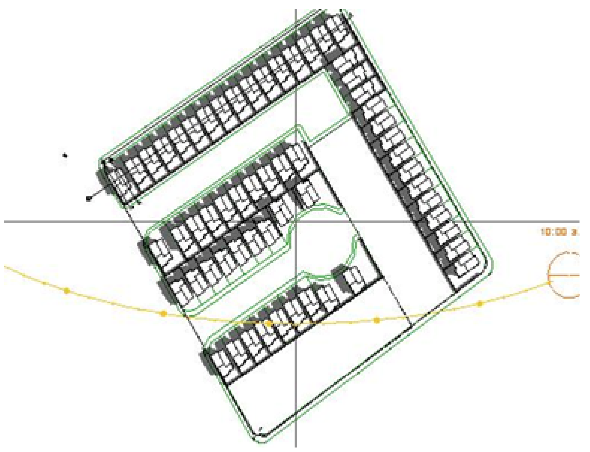


**Figure 4.** Architectural view of lower floor.

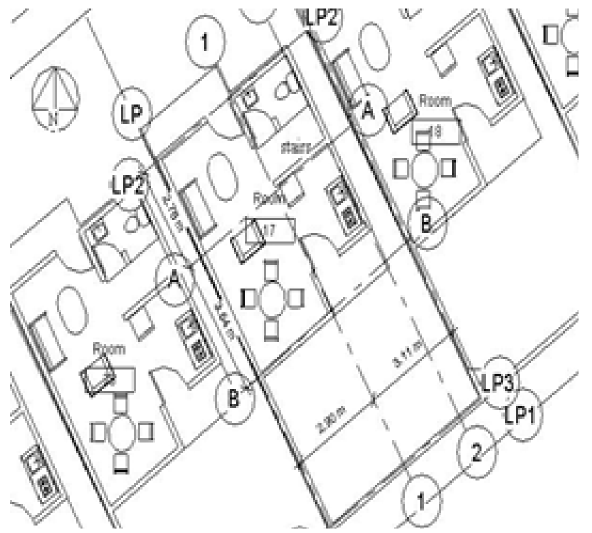


**Figure 5.** Architectural view of upper floor

**Figure 7.** Plan Site view.

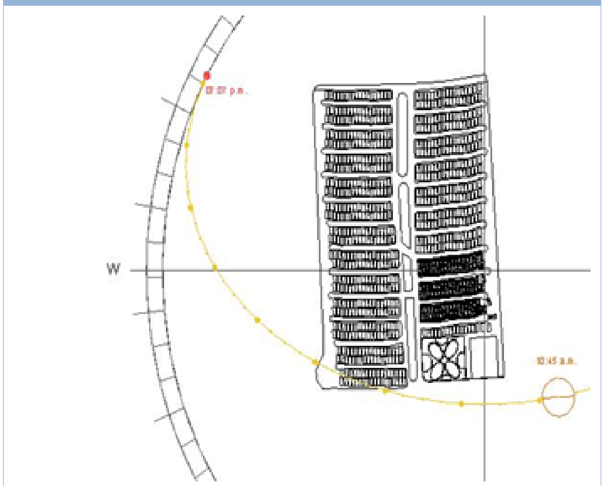


Figure 8. Architectural view of lower floor.

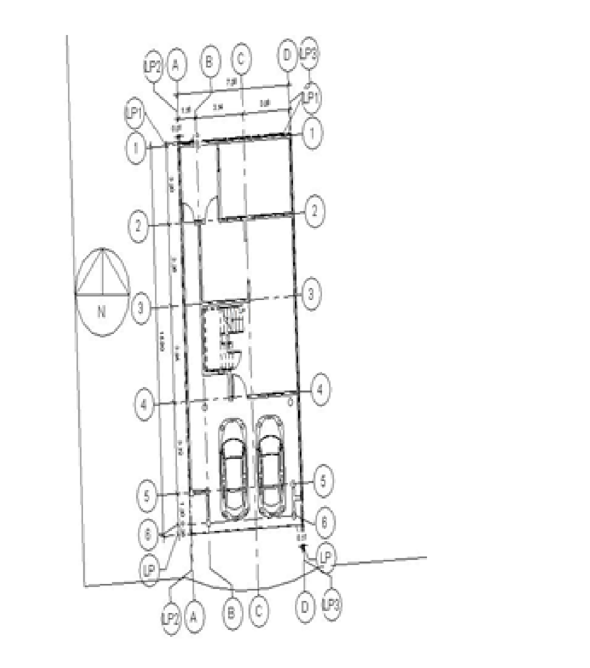


Figure 9. Architectural view of upper floor

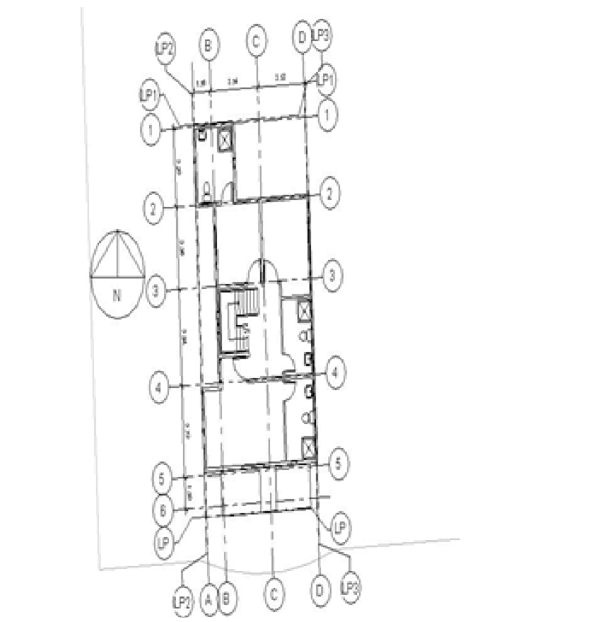
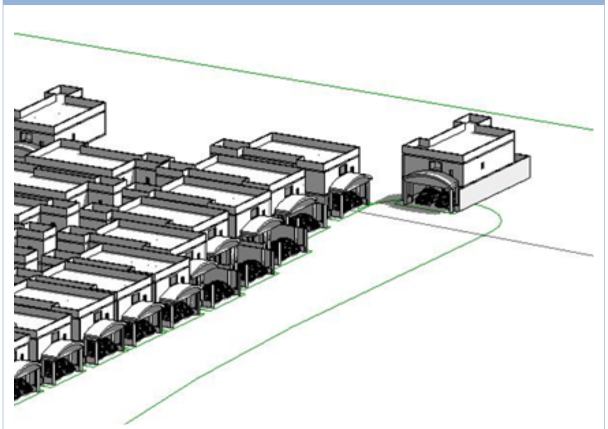


Figure 10. Perspective view of the whole.



## Solar radiation measured in the case studied area.

The measurements for solar radiation were taken in two stations belonging to the Integral Environmental Monitoring System of the State of Nuevo León (SIMA, 2013) closest to the study area, with data from the year 2012.The stations have pyranometers, instruments used to measure very precisely the incident solar radiation on the Earth's surface, they are sensors designed to measure the flux density of solar radiation (kilowatts per square meter) in the range of 180 degrees.

The position of these two stations is observed in Figure 2 (Marked as: 2 – Northwest Talleres and 3 – North Escobedo, circular figures). The North station in Escobedo is in the Santa Luz development, and the Northwest station is in the neighborhood of St. Bernabé, marked as the Talleres station. The measurements are shown in Figure 11.

As can be observed, the behavior of the radiation in these two stations is very similar, however northwest station (in front of the mountain of Topo Chico) receives more radiation in the summer than North station (behind the same mountain). The amounts of monthly solar radiation measured for both stations, as well as their averages, are shown in Table 2.

**Fig 11.** Solar radiation measurements (kWh/m2/month) in the year of 2012,for each one SIMA stations.
Source: Integral Environmental Monitoring System (SIMA).

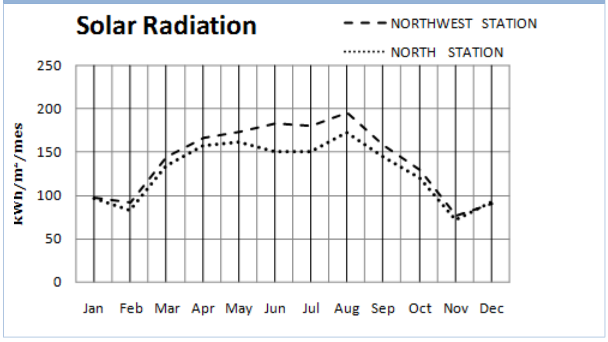



**Table 2.** Measured Solar Radiation for station and average. Source: Integral Environmental Monitoring System (SIMA).

| Months of the Year 2012 | NORTHWEST STATION (NO) | NORTH STATION (N) | AVERAGE |
|---|---|---|---|
| | kWh/m2/month | kWh/m2/month | kWh/m2/month |
| January | 96.942 | 96.901 | 96.92 |
| February | 91.855 | 82.833 | 87.34 |
| March | 144.402 | 134.185 | 139.29 |
| April | 166.509 | 156.871 | 161.69 |
| May | 172.524 | 160.511 | 166.52 |
| June | 183.244 | 150.742 | 166.99 |
| July | 179.903 | 149.871 | 164.89 |
| August | 195.151 | 172.101 | 183.63 |
| September | 157.749 | 144.504 | 151.13 |
| October | 129.128 | 119.141 | 124.13 |
| November | 76.542 | 71.59 | 74.07 |
| December | 90.049 | 92.779 | 91.41 |

## Electricity consumption in the Escobedo area

The following section describes the Electricity consumption in households that are taken as case studies in the area of Escobedo, within the metropolitan area of Monterrey, Nuevo León, Mexico.

To determine the consumption of the average homes in the development (Cases A and B), a survey was carried out which obtained the average monthly electrical expenses in two houses of each study area. Taking as a base the levels of consumption reported in the electrical utility's invoices, the average consumption per month in the year 2012 is presented in Table 3.

**Table 3.** Average consumption of electrical energy for each one home

| Month of consumption in 2012 | Case A. kWh/ month | Case B. kWh/ month |
|---|---|---|
| January | 132.50 | 363.25 |
| February | 145.00 | 306.50 |
| March | 145.00 | 310.25 |
| April | 125.50 | 314.00 |
| May | 125.50 | 329.25 |
| June | 163.00 | 344.50 |
| July | 163.00 | 388.00 |
| August | 246.50 | 431.50 |
| September | 246.50 | 369.00 |
| October | 192.50 | 306.50 |
| November | 192.50 | 363.25 |
| December | 132.50 | 420.00 |
| Total Annual | 2010.00 | 4246.00 |

## Photovoltaic panels, calculation of energy supplied.

When working with low power photovoltaic systems, as is the case in homes, one useful concept when working with solar paneling is the unit known as Peak Potency or Peak Watt (WP) (Hermosillo, 1995). The potency of every photovoltaic panel is marked in Wp, under what are known as Standard Test Conditions (STC). STC is a measurement standard that allows the comparison of different panels from different manufacturers under the same testing conditions (Style, 2012).

A Wp represents the electrical potency delivered by the panel when the radiation over it is at 1000 W/m2 (standard or certified norm) with a specter or composition similar to solar radiation and with a temperature of 25°C (Sarmiento, 2003). The energy supplied by the photovoltaic panels will be determined as a function of the number of panels proposed and the availability of solar radiation as measured by both stations. Thus, equation (1) will calculate the energy supplied in kWh/year. Considering also the efficiency of the paneling previously mentioned (Hermosillo, op. cit.; Style, op. cit.; Sarmiento, op.cit.).

$$Ep = (ProR \cdot Pp \cdot Np \cdot (1-\phi) \cdot \alpha)/1000 \qquad (1)$$

Where:
Ep = Energy Supplied by the Panel, in kWh/year
ProR= Average solar radiation of both stations, in kWh/m2/year. (Table 2)
Pp= Potency supplied by the photovoltaic panel, in Wp
Np = Number of panels, Adim.
$\phi$ = Loss factor, Adim.
$\alpha$ = Panel Efficiency, Adim.

The losses in the photovoltaic system will be calculated via equation (2).

$$\phi = \omega + \theta + \mu + \beta \qquad (2)$$

Where:
$\omega$ = Losses due to shadows, dirt, and grime = 12% (Arenas & Zapata, 2011), (Likewise, 2008).
$\theta$ = Losses due to age of cables = 8% (Arenas & Zapata, 2011), (Likewise, 2008).
$\mu$ = Battery losses = 10% (Arenas & Zapata, 2011).
$\beta$ = Losses by inverter = 15% (Arenas & Zapata, 2011), (Likewise, 2008).

The photovoltaic panel proposed in this study are Polycrystalline with a width of 0.99 mts, a length of 1.74 mts, 1.719 m2 capture surface and supply capacity of 245 Wp in standard conditions STC (176 Wp under solar radiation of 800 W/m2). Thus this panel has energy efficiency $\alpha$ of 0.12, based on the characteristics supplied by the manufacturer. The costs considered for the system components were:
Panel 245 Wp ($Panel) = $ 6,500.00; Inverter 1500 Watts ($Inverter) = $ 850.00; Installation material* ($Mat) = $ 1,200.00.
* Structure and cables. Does not include labor costs (depends on place of installation as well as height, access conditions, among others).

## Calculation of the number of years

The following sections describes the calculation of the number of years required to recoup the costs of the installed system via compensation through the saving of electricity generated by photovoltaic panels in the consumption of an average house in Escobedo Nuevo León, México.

In the dictionary of the Spanish language of Royal Spanish Academy (Rae, 2001) the amortization term means: "Recover or compensate the funds invested in a company ".In the present study, the evaluation was carried out determining the number of years that were necessary to recover or compensate the initial investment in the solar paneling system, taking into account the following considerations:

1.-To calculate the number of Photovoltaic Panels in the installation, from 1 to 26.

2.- Because the tariffs for electrical energy consumption vary according to the geographic location and level of consumption besides also including a subsidy from the federal government (Government contribution), which aims to help the habitants of less economic resources, to pay less, the calculations were effected varying the cost of electricity supplied by the electric power company's grid from 0.50 to 6 $/kWh, to show a sufficient variability of values to place the range of tariffs in usual cases, including for industrial consumption (the maximum cost for residential consumption in CFE tariffs is of $4.085 for Baja California in the summer) (CFE, op. cit.),.
3.-For our calculations, we considered that the photovoltaic system is connected to the grid, that is under an interconnection contract (SENER S., 2012).Under this plan, the system is directly connected to the electric power company's grid (not requiring batteries to store the excess energy) and two meters are placed, one to quantify how much energy is consumed from the grid and needs to be paid to the electric power company, and another to quantify the energy that is supplied to the grid or sold to the electric power company(CFE, op. cit.).

The calculations considered that the price of the Watts-hr sold is equal to the price of the Watts-hr bought. In this scheme, the photovoltaic system includes panels and an inverter.

4.-To calculate the number of years it takes to recoup the investment (Na, NaA y NaAVR) three contexts were taken into account:

***Context a***
Without considering a rate of investment (TI%) (Table 4.) Using the equation (3).

Na= (($Panel+$Mat) ·Np+$Inverter) / ($CFE·Ep) (3)

***Context b*** -
Considering a TI% = 4% per year.(Table 5.)Using the equation (4), which was obtained considering the influx of money as an investment that generates interest as time goes by (James, 1994; Ochoa, 2012). This is both for the initial investment as it is for the sum of money influx discounted from the initial investment. TI% = 4% corresponds to the rate of banking interest offered for investments to be paid in 28 days.

NaA= (ln (1/ (1(TI %·(( $Panel+$Mat) ·Np+$Inverter)) / ($CFE·Ep)))) / ln (1+TI%) (4)

***Context c -***
Considering a TI% = 4% per year and a Rescue Value (VR) of the Investment (Table 6). Using equation (5), obtained taking into account the influx of money as an investment that generates interest with the passage of time [context B] and a VR taking into account that the recovery would be 10% of the value invested in the sale of the photovoltaic system at the end of the period of returns of investment.

NaAVR= (ln ((TI%·(( $Panel+$Mat) ·Np+$Inverter) ·VR-$CFE·Ep) / (TI%·(( $Panel+$Mat) ·Np+$Inverter)-
$CFE·Ep (1+TI%)))) / ln (1+TI%) (5)

## Results

The results of calculating the number of years until recouping required to recover the costs of installing photovoltaic panels through the saving of electricity generated by the same, are shown in Table 4 for Context a), Table 5 for Context b), and Table 6 in Context c).

## Discussion

Government energy regulations (SENER S., 2012) does not allow private consumers to substitute the entire electrical energy of a home for solar energy, in said legislation it is established that "The Interconnection Contract for Renewable Energy Sources or Small Scale Co-generation System (CIFER-PE) can be applied by physical and moral persons.

The maximum capacity cannot exceed 10kW for users under residential tariffs and 30 kW for those under general low tension tariffs". For case studies A and B located in the suburb of Escobedo, Nuevo León, the analysis was carried out proposing the installation of 1 to 26 photovoltaic panels, resulting in a maximum capacity possible after installation of 6.4kW (245 W each). Therefore the present analysis is made within the limits of the Interconnection Contract.

From a survey on the payment invoices to the electric power company generated by the consumption in these homes, we can establish that the electrical energy paid was 0.70 $/Kw-h for Case A and 2.826$/kWh for Case B. These amounts correspond to the application of the corresponding tariff to the appropriate consumption levels generated by these homes, including the discount for Government subsidies, which reflect usage customs and climate among other factors.

Thus, from the results we can establish that:
n Table 4, if we do not consider a compensation for the depreciation of money as time goes by (without TI%), for an initial investment when installing 1 to 26 photovoltaic panels, the period until return of investment in (Na) Case A would be 44.9 to 58.3 years at an electricity cost of 0.70 $/kWh, and for Case B it would take from 11.4 to 14.8 years at a cost of 2.826 $/kWh.

From Table 5, we can establish that if we consider a compensation for monetary depreciation (TI%=4%) for Case A with an electricity cost of 0.70 $/kWh, the initial investment in photovoltaic panels would not be recoupable for some combinations of photovoltaic paneling, and for Case B the investment would be paid off in a period of 15.8 a 24.0 years for a cost of 2.826 $/kWh.

From Table 6, if we consider a compensation for depreciation (TI%=4%) and a final recovery as rescue value (VR=10%), for Case A in the same way that in Table 5 an energy cost of 0.70 $/kWh would not be recoverable for certain photovoltaic paneling combinations, and for Case B the investment would be recoverable in a period of 13.9 to 21.4 years for a cost of 2.826 $/kWh.

A useful aspect to mention is that in Article 32 fraction XXVI LISR (SHCP, 2005) "Support for the use of renewable energies, establishes that ISR contributors that invest in machinery and equipment for the generation of energy provided by renewable sources will be able to deduce 100% of the investment in a single tax filing, and with this favor the protection of the environment and the reduction of fossil fuel use."This allows any case where this article applies to reduce the initial expense and thus its time until return on investment.

On the other hand, the tables generated based on the results of the study are useful to evaluate installation of photovoltaic paneling under other conditions of consumption, as long as they are found within or close to the zone of influence in the monitoring stations that were used to measure solar radiation. Therefore, we only have to establish from the corresponding invoices the cost of electrical energy for each particular case, owing to the customs of consumption show through payment receipts.

## Conclusions

In this study, the objective of evaluating the use of solar radiation in urban development's was carried out using a financial analysis of the installation of a system of photovoltaic panels for two specific cases of study located in the area of the suburb of Escobedo within the metropolitan area of Monterrey, Nuevo León.

This is because the amount of solar radiation that reaches the ground depends on factors individual to the area such as latitude, cloud cover, humidity, dust, and smog, among others. Besides this, the harnessing of the solar resource to satisfy the electricity needs of a home also depends on the conditions of climate and customs of consumption of the inhabitants of the area.

Thus, owing to the large amount of factors involved and the variability of the same, which are so closely bound to climate, spatial, and social conditions of each geographic area, it was determined to evaluate all these factors carrying out a financial analysis that determines the number of years required to recoup the initial investment that was made in photovoltaic panels for two homes in a specific area.

From the study it was established that 1 to 26 photovoltaic panels would require at least 11.4 years to recoup the investment in the case of a home with high consumption (4246 kWh per year) within the area of Escobedo N.L., Cerradas de Anáhuac Residencial Complex and at least 44.9 years for a typical low-consumption home (2010 kWh per year), VIDA Development in the area of Escobedo, N.L.

The results allow us to establish as a conclusion that a photovoltaic system becomes progressively more efficient as consumption rises, owing to the higher tariff on consumption, making the investment more quickly recoupable.

Using our generated tables, it is feasible to financially evaluate the use of photovoltaic paneling that harness the solar resource in Urban Developments in that area, allowing us to make an economic and environmental comparison to substitute a part or the whole of consumption of renewable energy, amplifying the knowledge obtained about the application of these systems and their possible insertion as part of urban design projects in sustainable urban developments.

## References


Ahumada, E., López, M., Morgan, J., & Valle, M. (2010) El Papel de las Redes de Innovación y la Energía Renovable en la Competitividad Regional. In III Coloquio Nacional de Estudios Sobre Competitividad (pp. 82-94). Baja California, México: Universidad Autónoma de Baja California.

Arenas , D., & Zapata, H. (2011) Libro Interactivo sobre Energía Solar y sus Aplicaciones. Tesis de grado en Técnico en Electricidad. Universidad Tecnológica de Pereira, Colombia.

Bustamante, W. (2004) Estudio de comportamiento termico viviendas en diferentes ciudades de Chile. Bases para una zonificación climático-habitacional. Revista de la Construcción, 3 (1), 46-58.

Cabeza, L. F., Castell, A., Barreneche, C., De Garcia, A., & Fernández, A. I. (2014) Materials used as PCM in thermal energy storage in buildings: A review. Renewable and Sustainable Energy Reviews, 15(3), 1675-1695. http//doi:10.1016/j.rser.2010.11.018.

CFE (2013) Tarifas para el Suministro y Venta de Energía Eléctrica, Comisión Federal de Electricidad (CFE). Retrieved from http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/Tarifas/tarifas_industria.asp

CNA (2015) Estación Observatorio Monterrey: Latitud 25° 44' 01", Longitud 100° 18' 17", Altitud 515 msnm. Monterrey, N.L.: Gerencia Regional Río Bravo, Subgerencia Técnica. Estación Observatorio Monterrey.

CONAE ( 2007) Energía Solar: Estado Actual en México. Secretaría de Energía. México:Comisión Nacional para el Desarrollo de Energía. Retrieved from http://www.inecc.gob.mx/descargas/cclimatico/taller_ener_ren_08.pdf

Hatt T., S. G. (2012) Alto confort interior con mínimo consumo energético a partir de la implementación del estándar "Passivahus" en Chile. Revista de la Construcción, 12 (22), 123-134.

Hermosillo, J. (1995) Notas del Curso: Energía Solar. (Ed.) Dpto. Proc.Tecnológicos Ind. Div. Ingeniería. Tlaquepaque, Jalisco: Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO). Retrieved from http://www.catalogosolar.mx/download/curso_iteso.pdf

Igual, E. (2008) Instalación Fotovoltáica de 100KW Conectada a Red Sobre Cubierta de Nave en Cáceres. Escuela Técnica Superior de Ingeniería. Universidad Pontificia Comillas. Madrid, España.

INEGI. (Ed.). (1981) Synthesis Geographic of Mexico. México, D.f.: Coordinación General de los Servicios Nacionales de Estadística Geografía e Informática Secretaría de Programación y Presupuesto.

IVNL (2008) Boletín Informativo del Instituto de la Vivienda de Nuevo León. Monterrey, N.L.: Instituto de la vivienda de Nuevo Leon. Retrieved from http://es.scribd.com/doc/5438657/Nuestro-Espacio-1

James, O. (1994) Análisis Financiero. México: Iberoamérica, Grupo Editorial. ISBN: 9789706250728.

Mendes, N., Lamberts, R., & Philippi, P. C. (2002) Conducción Sensible y Latente en Paredes Porosas de Edificaciones, Sometidas a Altos Gradientes de Temperatura y Humedad. Revista de la Construcción, 1 (1), pp. 1-7.

Nahle Sabag, N. (2011) Radiación Solar en la Capa Exterior de la Atmósfera Terrestre y Sobre la Superficie Terrestre (Suelo y Océano). Biology Cabinet. Retrieved from http://www.biocab.org/Radiaci_n_Solar_en_la_Capa_exterior_de_la_Atm_sfera_Terrestre_y_sobre_la_Superficie_Terrestre.pdf

Ochoa, U. (2012) Matemáticas Financieras II; Primera Edición. Estado de México: Red Tercer Milenio S.C.

PECAN. (2012) Plan Energético de Canarias (PECAN). Revisión 2006-2015. Canarias, España.: Conserjería de Empleo Industria y Comercio, Gobierno de Canarias, España.

RAE (2001) Diccionario de la Lengua Española 22ª Ed. 2001. Barcelona, España: Espasa-Calpe, Planeta de libros.com, ISBN:9788423968145. Retrieved from http//rae.es/

Sarmiento , A. (2003) La Hora Pico.CUBASOLAR: Energía y Tu. Conciencia Energetica Respeto Ambiental, 1(22), 5-8.

Schiller, S. de, & Evans, J. M. (2005) Rol de la Envolvente en la Edificación Sustentable. Revista de la Construcción, 4 (1), 5-12.

SENER (2009) Energías Renovables para el Desarrollo Sustentable de México 2009. Retrieved from http://www.energia.gob.mx/res/0/ER_para_Desarrollo_Sustentable_Mx_2009.pdf

SENER, S. (2012) Modelos de Contratos Energías Renovables. Retrieved from http://www.renovables.gob.mx/renovables/portal/Default.aspx?id=1657

Seong, Y. B., & Lim, J. H. (2013) Energy Saving Potentials of Phase Change Materials applied to Lightweight Builfing Envelopes. Energies, 6(10), 5219-5230. http://doi:10.3390/en6105219.

SHCP (2005) Artículo 32 fracción XXVI LISR. Impulso al uso de energía proveniente de fuentes renovables . Retrieved from http://www.sat.gob.mx/fiscal/leyes/rf05/113_4998.html

SIMA (2013) Agencia de Protección al Medio Ambiente y Recursos Naturales. Gobierno de Nuevo León, México. Retrieved from http://www.nl.gob.mx/?P=med_amb_mej_amb_sima

Stoffel, T., Renné, D., Myers, D., & Wilcox, S. (2010) CONCENTRATING SOLAR POWER: Best Practices Handbook for the Collection and Use of Solar Resource Data. http://doi.org/NREL/TP-550-47465

Style , O. (2012) *Energía Solar Autónoma.* (1a ed.). ITACA (Innovación en Tecnología Aplicada Comunitaria y Autónoma): Madrid. ISBN:978-84-615-7887-0.

Vera, S., & Ordenes, M. (2002) Evaluación del desempeño energi-termico de una vivienda social en Chile, utilizando un programa de simulación energetica de edificios. Revista Ingeniería de Construcción, 17(3), 133-142.

Table 1

| Title | Author | Journal | Description |
|---|---|---|---|
| Energy Saving Potentials of Phase Change Materials Applied to Lightweight Building Envelopes. | Seong, Y. B., & Lim, J. H. (2013) | Energies, 6(10), 5219-5230. ISSN 1996-1073 doi:10.3390/en6105219 | Study which investigated the potentials of energy saving in buildings when several materials with different temperatures of phase change are applied to an envelope of a building, through the thermal load characteristics analysis. |
| Alto confort interior con mínimo consumo Energético a partir de la im-plementación del Estándar " Passivahus" en Chile. | Hatt T., Saelzer G., Hempel R.,& Gerber A. (2012) | Revista de la Construcción ISSN: 0717-7925, 12 (22), 123 - 134. | Study where it is shown that in the Center-South of Chile is possible save 80% of energy in air conditioning with constructions that meet energy standard, called standard "Passivhaus". |
| Materials used as PCM in thermal energy storage in buildings: a review. Renewable and Sustainable Energy Reviews, | Cabeza, L. F., Castell, A., Barreneche, C., De Gracia, A., & Fernández, A. I. (2013) | Renewable and Sustainable Energy Reviews, 15(3), 1675-1695. ISSN 1364-0321 doi:10.1016/j. rser.2010.11.018 | Study of the use of materials of phase change thermal in the construction of buildings, which are able to store and release large amounts of energy. |
| Rol de la Envolvente en la Edificación Sustentable. | Schiller & Evans (2005) | Revista de la Construcción ISSN: 0717-7925, 4 (1), 5-12. | Evaluates the design of envelopes in the construction of buildings, presenting examples of buildings that incorporate 'green' strategies and energy efficiency studies to optimize the behavior of facades and the environmental quality of sustainable interiors. |
| Estudio de Comporta-miento Termico Viviendas en Diferentes Ciudades de Chile. Bases para una Zonificación Climático-Habi-tacional. | Bustamante (2004) | Revista de la Construcción ISSN: 0717-7925, 3 (1), 1-13. | Develops a methodology for the definition of a climate zoning for housing using criteria of comfort for the users and energy efficiency for thermal conditioning of dwellings, determining that for hot periods does not need artificial cooling to achieve comfort conditions in the Interior of the houses in the area that lies to the North of La Serena Ovalle shaft, in Chile. |
| Conducción Sensible y Latente en Paredes Porosas de Edificaciones, Sometidas a Altos Gradientes de Temperatura y Humedad. | Mendes, Lamberts, & Philippi, (2002) | Revista de la Construcción ISSN: 0717-7925, 1 (1), 1 - 7 | Study on heat conduction in walls of buildings located in extreme climatic environments. |
| Evaluación del desempeño energi-termico de una vivienda social en Chile, utilizando un programa de simulación energetica de edificios. Revista Ingeniería de Construcción | Vera & Ordenes (2002) | Revista Ingeniería de Construcción, Vol.17 num 3. , 133-142. | Research studying the effect of the strategies of passive control of thermal control over loads of heating and cooling in homes of Santiago and Punta Arenas in Chile. |