Social Bioclimatic Urban House Prototype in Arid Area Energy and Economic Assessment

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Abstract

The energetic and economic evaluation of an evolutionary bioclimatic social house prototype designed in the research unit, for urban arid zones, is presented, calculating their respective costs. The performance of passive systems is evaluated with the Optimix Program, using the Collector Load Rate Method (Los Álamos National Laboratory). The investment alternatives are adopted from the calculation from the Net Present and Marginal Value. The results quantify the use of passive solar systems to make more efficient the thermal and economic benefits of the executed prototypes. The winter thermal load, to which the homes are exposed, is reduced by 64.1%, with technics of energy conservation and the improvement of solar systems and variants applied. Energy savings result in 20% and 22% and the amortization of 2.4 years and 2.3 years, depending on the orientation of the prototype (azimuth 0° N and ± 15° N respectively.

Keywords: Bioclimatic architecture - Energy savings - Economic evaluation - Social house - Arid urban climate.

Introduction

Fossil generated energy is one of the basic pillars on which is based the current socio-economic model, both of the core countries as emerging. However, the main cause of the destruction of the physical environment is the extractive and productive procedure. Indeed, thermal electricity generation involves the emission into the atmosphere of gases responsible for the greenhouse and acid rain, as well as the generation of radioactive waste, in the case of nuclear generation. On the other hand, open-mining to obtain coal produces the complete degradation of large areas of the territory.

All these practices create with no doubt high unsustainable conditions that compromise the necessary ecosystemic balance of the planet, affecting first of all in the cities by their energy demand to meet their growing needs. In this regard, between 1997 and 2007 (OLADE, 2012), Argentina's carbon dioxide emissions increased by 57%.

The IEA (International Energy Agency) in its report for the year 2016 'World Energy Outlook', presented in London, showed that pollution has become the fourth risk factor for human health, behind blood pressure, bad food and the smoking cessation, with 6.5 million premature deaths. The research stressed that most of pollutions come from the energy sector, in particular from the burning of fuels in factories, cars and power plants and in particular kitchens.

According to the 2014annual report of the World Bank's world development indicators, Argentina is the second most polluting country in South America, after Venezuela. The publication determines that carbon emissions into the atmosphere in Argentina are 4.5 metric tons per capita by year. Some of the actions proposed by the IEA are: reduce polluting emissions by means of control technologies, substitute fuels by renewable energies, minimize costs of such reduction and ensure an effective implementation of these actions.

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In the framework of the Kyoto Protocol, Argentina is committed to not increase the greenhouse gasesemissions, promote energy efficiency in a continuous way, and develop the use of clean energies such as wind and solar ones. However, 68% of the electrical energy is produced through the use of fossil fuels (Ministry of energy and mining, 2015) highly pollutant and generators of carbon dioxide and other greenhouse gases.

The last national energy Balance (Ministry of energy and mining, 2016) indicates that by 2015 the 27% of the total energy consumption in the country (primary and secondary energy) corresponds to the residential sector, which in the past 30 years has been increasing: 1990, 22%; 2000: 24%; 2010: 25%).

The efficient use of energy through the bioclimatic design is also a source of energy and therefore savings in a sector and implies greater possibilities for use particularly in the productive sector, which cannot be replaced by other flow alternative resources. The concept of energy efficiency is associated with energy saving, but not necessarily equivalent. Worldwide estimations of the International Energy Agency (2007), indicate that optimizing buildings in relation to their requirements of refrigeration, heating, ventilation, lighting and water heating, the annual energy saving would be 500MTEP (million tons of equivalent petroleum), by the year 2030. International experience recognizes the efficient use of energy as the most effective decision in the short and medium term, to achieve a significant reduction of the dioxide of carbon emissions (CO_2) and other greenhouse gases.

A study on the energy consumption for thermal conditioning of houses in the Metropolitan Area of San Juan (Kurbán*et al*., 2016) indicates that, during the winter, about half of the electricity and gas (natural/liquefied) distributed by the respective entities of services is destined for this use. Duringsummer those percentage extents to 60% of the total electrical energy consumption. If house had been designed using energy efficient through the use of non-renewable energy, it would mean savings in electrical energy of about 43% in winter and 46% in summer. In the case of the natural/liquefied gas, the savings would reach 81%.

Considering that the AMSJ represents 0.14% of the provincial territory (127Km^2 of 89.651Km^2) and 67% of the population (458.230 inhabitants of 681.055 inhabitants) the contribution to energy savings that would provide the use of bioclimatic architecture in the house in the province, would be highly significant. If these energy savings are extrapolated to provinces with similar climatic conditions and urban development of San Juan such as Mendoza, La Rioja and Catamarca, the national global contribution that would make the use of bioclimatic architecture tools to the energy self-sufficiency would be substantial.

Also the contribution of bioclimatic architecture to the reduction of the carbon footprint should be added. In this sense, the use of teams of environmental conditioning for cooling and heating, using fossil fuels, constitutes another of the negative effects of urbanization on human health, since the CO_2 emitted, greenhouse effect, contributes to air pollution.

In Kurbán *et al* (2015a) the emission of $CO_2$is evaluated by comparing conventional house from the city of San Juan, with another designed using natural energies. It is concluded that, in the second case, there would be a decrease of 74% of CO_2 emissions. If this reduction were originated for electricity saving, it would be 84% and if it produced by savings in natural/liquefied gas, 56%. Quantifying the total San Juan’s houses and according to the energy used for each urban area, the decrease in the total carbon footprint would be 72%if bioclimatic design strategies are used,

The implementation of energy efficiency policies in a framework of environmental requirements, protection of natural resources and commitments to mitigate emissions of greenhouse gases responsible for global climate change, will contribute with no doubt to the establishment of conditions that favor the nation's sustainable development, employment growth and the increase in productivity.

In that context this article assesses energetic and economically a prototype of a bioclimatic social evolutionary house designed in the executing unit (Kurbán *et al*., 2015b) to provide quantitative information to thehouse management agencies in order to contribute to the adoption of decisions of sustainable use of energy resources, particularly to the most vulnerable people.

Social Evolutionary Bioclimatic House Prototype

Figure 1 (Center and right) shows two locations of the bioclimatic evolutionary social house prototype having two bedrooms (with extension to three bedrooms) designed by the executing unit (Kurbán*et al*., 2015b) depending on the orientation of the lots: N-S and E-W.

In the first case the major axis of the house is oriented with azimuth 90 degrees North (with access from the South or the North); in the second case the orientation of the axis is within ± 15 degrees North, with access from the West-Northwest and East-Southeast.

Figure 1: Left, IPV 2 bedrooms (with extension to 3 bedrooms)prototype. Center and right.INEAA two bedrooms (with extension to three bedrooms) bioclimatic prototype, with locations depending on lot orientation.

Meteorological Data Base of the Urban Climate in the Metropolitan Area of San Juan

Meteorological records entering as data in the OPTIMIX software, are constituted by the meteorological statistics of the Metropolitan Area of San Juan, in the period 1995-2015, with the data reported within the PROPAC framework (Permanent Program of Climatic-Urban update) from 1999 onwards (Papparelli, *et al*., 1999-2013; Kurbán, *et al*., 2014-2016) and statistical data for the period 1995 to 1998.

The meteorological records were obtained in two weather stations, located in the predominantly urban band of the city, on the Santa Fe and Sarmiento streets corner, at a distance of approximately 300m from the main city center, (25 de Mayo square).

Both Davis weather stations are connected to PC through Weather Monitor II interface with Weather link software. They have dry-bulb temperature, relative humidity, wind (direction and speed), atmospheric pressure, precipitation and radiation sensors. They are located at a height of 12m above the natural terrain level, without building obstruction, which guarantees a good exposure and uptake of atmospheric conditions of the urban area.

Economic Evaluation of the Ineaa Bioclimatic Prototypes

The economic evaluation is performed by comparing the INEAA prototype with that of the Provincial Housing Institute (IPV) which depends on the National Ministry of Housing, since the social characteristic of the buildings.

Since the IPV projects and builds mainly 2 bedroom houses, which may be expanded to 3 bedrooms, the prices of the INEAA passive solar 2 bedrooms house prototype are contrasted with the IPV type also of 2 bedrooms, which presents the following features:

a) The prototypehouse, designed and built by the Provincial House Institute (IPV) of San Juan (2016), consists of 2 bedrooms and has a total area of 55.87m^2 (Figure 1, left). The construction is traditional, with structure of reinforced concrete and walls of solid 18cm width bricks, revoked on both sides. The total cost per dwelling is U$S 20130 ($342168.02), price for the month of September 2016.

b) The passive solar prototype designed by the INEAA(Figure 1, centre and right) also consists of two bedrooms and has a total area of 60.45m^2, which represents 8% more than the IPV one. The final over-cost of the INEAA passive solar house is 17%. This results from its cost of U$S 23552 ($426454.18) for the same month, which is 25% more with respect to the basic house IPV in absolute values (considering 8% more area of the INEAA prototype)

Performance Evaluation of Heating Solar Systems Software Optimix Version 3.1

The Optimixsoftware, version 3.1 (Yarke and Castillo, 2006) is a calculation tool that uses for its economic assessment, the Solar Load Ratio (SLR) method (CCC - according to its acronym in Spanish)developed by Douglas J. Balcomb,*et al* (1982) from which also takes the method of guides for the recommendations previous to the design (Balcomb, 1980 and 1986). OPTIMIX is applied to the bioclimatic two bedroomsprototype, which was evaluated economically against the IPV house type. Then, the calculation of net loss coefficients (CNP), the solar savings fraction (FAS) and the net present value (VAN) and the marginal VANaredeveloped

a) Output data for houses located on North-South oriented lots: azimuth 0° North.

The OPTIMIX program calculates the best solution using the method of the Economic Feasibility and shows all combinations of solutions whose over costin relation to the total cost of the building, are below the maximum limits pre-established. Results for the economic feasibility (Table 1) shows the initial situation at the top and the best combination between all the improvements presentedat the bottom. This results screen also shows the identification of the combination of variants analyzed, and for each of them, the BLC (building loadcoefficient), CCC (coefficient load collector), FAS (annual solar savings fraction), conservation cost, total cost of improvements, and amortization time in years. In this way it identifies the best combination in terms of economic performance of up to 512 combinations of variants that can analyze.

Economic feasibility results

Solar System over cost 1264.08 **Total value in U$S**

Variants	BLC (w/°C)	CCC (w/m^2°C)	FAS %	Over costs (U$S) Conservat.	Over costs (U$S) Totals	Econom. Feasibility	Amortiz. Time
Project initial values with Solar System and without conservation improvements							
1 1 1 1 1	1500	153	8	0	1264.1	34	170
1 1 1 1 1	1500	153.00	8.00	0.0	1264.1	0.34	17.0
1 1 1 1 2	1480	151.00	8.00	0.0	1264.1	0.30	14.8
1 1 1 1 3	1461	149.00	8.00	1.5	1265.6	0.27	13.3
1 1 1 2 3	1454	148.00	8.00	1.5	1265.6	0.26	12.8
1 1 2 1 1	993	101.00	12.00	29.4	1293.4	0.07	3.7
1 1 2 1 2	973	99.00	12.00	29.4	1293.4	0.07	3.6
1 1 2 1 3	954	97.00	12.00	30.8	1294.9	0.07	3.5
1 1 2 2 3	947	97.00	12.00	30.8	1294.9	0.07	3.5
2 1 2 1 1	583	59.00	20.00	175.0	1439.1	0.05	2.5
2 1 2 1 2	564	58.00	21.00	175.0	1439.1	0.05	2.5
2 1 2 1 3	544	56.00	21.00	176.4	1440.5	0.05	2.4
2 1 2 2 3	538	55.00	22.00	176.4	1440.5	0.05	2.4
Best combination among the analyzed variants							
2 1 2 2 3	538	55.00	22.00	176.4	1440.5	5	2.4

Table 1: Economic feasibility results, 0° N - INEAA passive Solar house. Software OPTIMIX

Output data for houses located in E-W oriented lots: Azimuth ±15° North.

In the case of locations of the house prototypes on E-W oriented lots with access by East or West, the inclination of the house is ±15° N. In this case, Table 2 shows the economic feasibility results.

OPTIMIX Software Results with respect to the BLC

The effective level of energy conservation and built-in solar systems represented by the BLC coefficient (Building Load Coefficient) that results 538, according to Tables 1 and 2, indicates the reduction of thermal load to which is subject the house with improvements in its enclosure (insulation and masonry). This coefficient represents 35.9% of the original charge without improvements (equal to 1500 according to these tables). Therefore, designing bioclimatic ally such house as it has been conceived in the previous documentation, reduces three times the thermal load to which it is subject.

Economic feasibility results

Solar System over cost 1264.08 **Total value in U$S**

Variants	BLC (w/°C)	CCC (w/m^2°C)	FAS %	Over costs (U$S) Conservat.	Totals	Econom. Feasibility	Amortiz. Time
Project initial values with Solar System and without conservation improvements							
1 1 1 1 1	1500	167	8	0	1264.1	0.34	17
1 1 1 1 1	1500	167.00	7.00	0.0	1264.1	0.34	17.0
1 1 1 1 2	1480	164.00	7.00	0.0	1264.1	0.29	14.7
1 1 1 1 3	1461	162.00	7.00	1.5	1265.6	0.26	13.0
1 1 1 2 3	1454	162.00	7.00	1.5	1265.6	0.25	12.5
1 1 2 1 1	993	110.00	11.00	29.3	1293.4	0.07	3.5
1 1 2 1 2	973	108.00	11.00	29.3	1293.4	0.07	3.4
1 1 2 1 3	954	106.00	11.00	30.8	1294.9	0.07	3.3
1 1 2 2 3	947	105.00	12.00	30.8	1294.9	0.07	3.3
2 1 2 1 1	583	65.00	18.00	175.0	1439.1	0.05	2.4
2 1 2 1 2	564	63.00	19.00	175.0	1439.1	0.05	2.3
2 1 2 1 3	544	60.00	20.00	176.4	1440.5	0.05	2.3
2 1 2 2 3	538	60.00	20.00	176.4	1440.5	0.05	2.3
Best combination among the analyzed variants							
2 1 2 2 3	538	60.00	22.00	176.4	1440.5	0.05	2.3

Table 2: Economic Feasibility for the passive Solar INEAA house. Azimuth ±15 ° N. Software OPTIMIX

Results in energy savings for houses located on N-S oriented lots, Azimuth 0° N. Software OPTIMIX

Solar Saving Fraction for the INEAA passive solar house

The percentage of energy savings generated by the use of passive heating systems was calculated for the INEAA passive solar house using the OPTIMIX software. For N-S oriented lots, resulted 22% solar savings fraction. This fraction is the amount of energy obtained through solar technology used, divided by the total energy required. A fraction of 22% indicates the percentage of savings that the house provides, through its design with solar systems (Table 1).

Therefore, families living in the INEAA passive solar house will payin concept of building air conditioning, 78% of the amount they would pay living in the IPV type.

To the above, it must be added that a family cannot pay all the energy needed for its climatic conditioning, and this lack is paid with discomfort by its poor socioeconomic situation, in the majority of cases. Therefore, to live in the passive solar INEAA house, brings not only economic advantages in the energy aspect, but better conditions in thermal comfort. This savings, generated only by the utilization of passive solar systems, must be added those produced by: use of hot water generated by solar heaters and use of electrical energy generated by photovoltaic panels.

Energy amortization of the INEAA passive solar house over cost

Using the OPTIMIX software the amortization time of the over-cost of the INEAA passive solar house was calculated resulting that the amortization demands a period of 2.4 years (Table 1). This indicates that the investment will be recovered before the three years, but during this time and even the life of the house, the family will save at least 22% of energy for thermal conditioning, without considering the savings made in the heat of water and in the electric power used for lighting and appliances.

Results on energy savings for houses located on E-W oriented lots: Azimuth ±15° North. Software.

Solar saving fraction of the INEAA passive solar house

The solar saving fraction resulted 20%. This fraction is the amount of energy obtained through solar technology used, divided by the total energy required. A fraction of 20% indicates the percentage of savings that the house provides, through its design with solar systems. To the above, it must be added that a family cannot pay all the energy needed for thermal conditioning, and this lack is paid with discomfort due its socioeconomic situation, in the majority of cases. Therefore, inhabit the INEAA passive solar house, brings about not only economic advantages in the energy aspect, but better conditions of thermal comfort. Again, to this savings, generated only by the utilization of passive solar systems, must be added those produced by: use of hot water generated by solar heating and use of electrical energy generated by photovoltaic panels.

Energy amortization of the INEAA passive solar house over-cost.

With the software OPTIMIX was calculated the time of amortization of the INEAA passive solar houseover cost, resulting period of 2.3 years (Table 2). This indicates that investment is recovered before the three years, but during the same and even the life of the house, the family will save at least 20% of energy for thermal conditioning, without considering the savings made in the heat of water and in the electric power used for lighting and appliances.

Cost-Benefit Analysis of Solar Hot Water Systems and Power Generation

The analysis of determination of the advantages in the use of solar panels is subdivided into: collectors for water heating and photovoltaic solar panels for electricity generation. In each of the cases, it is distinguished what type of energy is being replaced. In this way, five cases of comparison are obtained.

Solar Collectors

Solar heaters vs. natural gas water heaters comparison

The amount of energy needed to boil 190 liters of water, corresponds to 100000KCal. 10.64m^3 of natural gas is required to take the temperature of 24° C up to 100° C. A solar water heater has a lifetime of about 20 years. With the level of insolation of the province of San Juan, it is estimated that a solar hot water tank of 200 liters would generate in that period, about 60.4 million kilocalories. Figure 2 presents a comparative graph of costs between a solar water heater and a gasone, with October/2016 values. The three resulting scenarios are described below.

Scenario A: Gas Cuyanaprices for June and July 2016

The 100000KCal necessary to boil the 190 lts of water had a value of U$S60, considering partially subsidized current prices of U$S0.01 per m^3. If it is added the price of a 150lts gas water heater U$S16.9 as average, results that in the next 20 years, the total operation would cost U$S577. The value of a solar hot water round the U$S545, whereupon the solar investment is recovered in 9.3 years, getting 10.7 years of free energy.

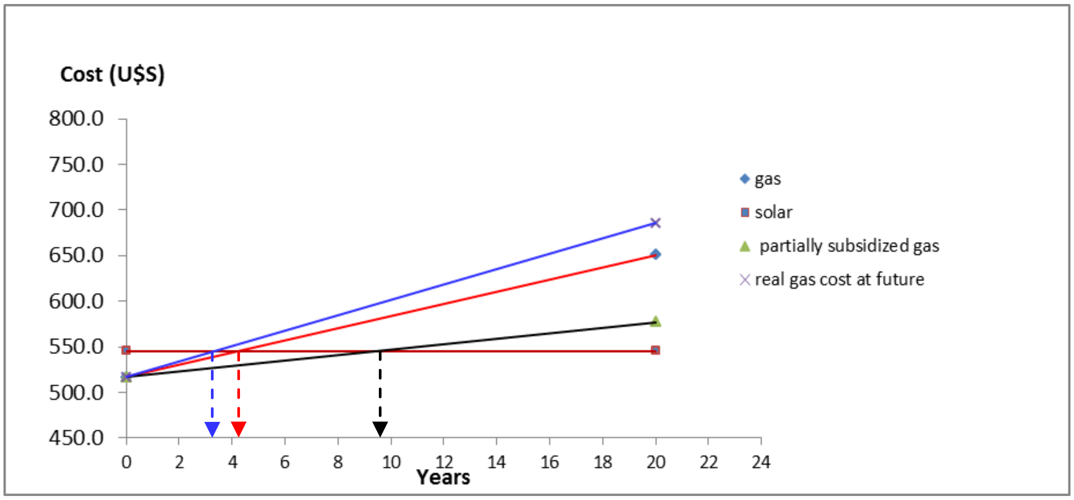

Figure 2: solar water heater vs. gas water heater cost comparative graph

Scenario B: Gas Cuyana prices for the last quarter of 2016.

Considering October 2016 partially subsidized prices (Gas Cuyana, 2016) of U$S0.22 per m^3, the 100.000KCal necessary to boil 190 liters of water, would have a value of U$S13.37. If it is added the price of the 150lts gas water heater, U$S517 as average in the commerce, in 20 years, the total operation would cost U$S651. The value of a solar water heater is around U$S545 whereupon the solar investment is recovered in 4 years, with 16 years of free energy.

Scenario C: Gas Cuyana not subsided prices.

The 100.000 Kcal needed to boil 190 liters of water today would cost U$S200.9 in line with prices without subsidies of U$S0.33 per m^3. If it is added the price of the gas water heater of 150lts of U$S517 as average in the commerce, in 20 years, the total operation would cost U$S718. The value of a solar water heater is around U$S545 whereupon the solar investment is recovered in 3.2 years, getting 16.8 years of free energy.

Solar photovoltaic panels

Solar panels generate electricity via the photovoltaic effect, resulting from the photoelectric effect. Its advantage in saving gives stability to the electricity avoiding spikes that can damage appliances.

National energetic balance

According to official statistics of the national energy balance (Ministry of energy and mining, 2016) Argentina consumes 56828 TEP; produces 74358 TEP and imports 18219 TEP. At the same time, of the total consumption, the residential is 15394TEP. Therefore, 32% of national consumption is imported and the residential energy use represents 27% of the total consumed (Table 3). Of the total energy consumption in the residential sector, 26% corresponds to electric power and 74% to Gas: 65% distributed gas and 9% (Table 4) liquefied gas.

Ministerio de Energía y Minería

NATIONAL ENERGETIC BALANCE

ARGENTINA

2016 year - Millions in TEP unit (Tons of Equivalent Petroleum)

ACTIVITIES	OIL	PETROLEUM DERIVATIVES	NATURAL GAS	MINERAL CARBON	NUCLEAR ENERGY	HYDRAULIC ENERGY	OTHER PRIMARIES	OTHER SECONDARY	ELECTRICITY	TOTAL
PRODUCTION	26,440	-	39,557	14	-	3,283	5,065	-	-	74,358
IMPORT	790	3,993	9,143	1,154	2,224	-	-	68	847	18,219
VAR.STOCK	64	-4	-8	11	-	-	-	11	-	74
EXPORT	-2,332	-1,715	-50	-7	-	-	-	-1,582	-28	-5,714
BUNKER	-	-1,657	-	-	-	-	-	-	-	-1,657
NOT ACCEPTED	-	-	-136	-	-	-	-	-	-	-136
TOTAL OFFER	**24,962**	**617**	**48,505**	**1,172**	**2,224**	**3,283**	**5,065**	**-1,504**	**819**	**85,143**
CENTRAL S.PUB.	-	-4,649	-13,282	-393	-2,224	-3,248	-48	-0	11,480	-12,364
CENTRAL AUTOP.	-	-241	-1,560	-12	-	-2	-576	-150	1,178	-1,363
REFINERIES	-25,501	23,854	-	-	-	-	-	407	-	-1,240
GAS TRANSFER	-	2,637	-3,703	-	-	-	-	1,067	-	0
DISTILLERY AND ACETERY	-	-	-	-	-	-	-2,932	2,818	-	-114
OTHERS	-	-	-	-617	-	-	-445	819	-	-242
OWN CONSUMPTION	-90	-1,462	-5,486	-	-	-	-	-483	-375	-7,897
LOSSES	-	-	-2,791	-	-	-33	-	-	-1,757	-4,580
ADJUSTMENTS	629	-71	-997	-124	-	-	-	14	-	-549
FINAL CONSUMPTION	**-**	**20,721**	**20,685**	**26**	**-**	**-**	**1,064**	**2,986**	**11,345**	**56,828**
RESIDENTIAL	-	1,381	9,898	-	-	-	84	180	3,851	15,394
COMMERCIAL AND SERVICES	-	369	1,136	-	-	-	42	120	2,944	4,611
TRANSPORT	-	14,453	2,346	-	-	-	-	-	47	16,846
AGRICULTURAL	-	3,754	-	-	-	-	129	-	79	3,962
INDUSTRIAL	-	403	7,306	26	-	-	810	-	4,424	12,968
NO ENERGY	-	361	-	-	-	-	-	2,686	-	3,047

Table 3: Synthesis of the National Energetic Balance table – 2016

ACTIVITIES	ELECTRICITY	DISTRIBUTED GAS	LIQUIFYED GAS	KEROSENE	DISESL OIL Y GASOIL	FUELOIL	NATURAL OIL	OTHER OILS	MOTO NAPHTHA	NO ENERGETIC	REFINERY GAS	COKE GAS	HIGH OVEN GAS	COKE	CARBON	BIOETHANOL	BIODIESEL	SECUNDARIES TOTAL	TOTAL
RESIDENTIAL	3,851	9,898	1,366	15	-	-	-	-	-	-		-	-	-	180	-	-	15,311	15,394
COMMERCIAL AND SERVICES	2,944	1,136	228	-	113	28	-	-	-	-		-	-	-	120	-	-	4,569	4,611
TRANSPORT	47	2,346	-	523	7,434	39	-	-	6,457	-		-	-	-	-	-	-	16,846	16,846
AGRICULTURAL	79	-	95	-	3,604	55	-	-	-	-		-	-	-	-	-	-	3,833	3,962
INDUSTRIAL	4,424	7,306	209	-	113	81	-	-	-	-		-	-	-	-	-	-	12,132	12,968
ENERGETIC CONSUMPTION	11,345	20,685	1,898	538	11,264	204	-	-	6,457	-	-	-	-	-	301	-	-	52,691	53,781

Table 4: Incidence of the EE in the national total energy consumes - 2016.

Solar panels vs. network electricity.

Energy Cost

In the province of San Juan, on average, the kilowatt-hour is paid U$S0.034 according to the 2016 September bills. The energy cost is U$S40per MWh. Values differ if the sources consider the real production and distributioncosts. In this regard according to an analysis of the Agency of environmental protection of the city of Buenos Aires (APRA), each MWh added to the country (from sources of thermal power plants) costs U$D 344, distributed as follows:

- Fuel (diesel oil): U$D 266.

- Operation and maintenance: U$D 16.
- Losses due to transport and distribution: U$D 37.
- Distribution: U$D 25.

Cost of thesolar panels

For a small solar battery connected to the network with four panels of 240W, turnkey installation cost about U$S 5700. For the isolation level of San Juan, this system would generate over 30 years, about 51.8MWh. That is to say that each solar MWh would cost U$S 110.

Analysis of the PS - EE relationship

If the price of the MWh in the province coincide with the production one, i.e. U$S 344, the cost of the photovoltaic electricity production(U$S110) would constitute 30% of that. Therefore, the use of this renewable energy source would be highly profitable in economic terms, and sustainable in environmental terms. In this way, the investment in the solar system receivership in 10 years, 20 years of free electricity and a saving of more than U$S 800 along the lifetime (30 years) of the photovoltaic panels.

Results and Discussion

A climatic seasonal and annual database for the climate of San Juan metropolitan area was obtained of the 1995-2015 period (Table 5).

Season	Dry Bulb Temperature (ºC)			Relative Humidity (%)			Solar Radiation (W/m^2)	
	Average	Maximum Average	Minimum Average	Average	Maximum Average	Minimum Average	Global	Diffuse
Summer	27.18	33.15	21.27	37.35	53.79	24.22	612.48	132.00
Fall	19.42	24.82	14.46	49.86	64.99	35.48	412.70	132.83
Winter	11.92	17.77	6.50	43.69	57.52	29.48	324.60	101.06
Spring	20.96	27.32	14.80	35.13	50.65	22.51	520.66	151.49
January - December	**19.88**	**25.77**	**14.27**	**41.48**	**56.75**	**27.91**	**467.62**	**128.50**

Table 5: climatic statistics 1995-2015 period for the AMSJ

The BLC coefficient (Building Load Coefficient) that indicates the reduction of the thermal load of the housewith improvements in its envelope (brickwork and insulation) is the 35.9% of the original load without improvements. Therefore, the winter thermal load of a house is reduced by 64.1%, with the procedures for the energy conservation and with the solar and improvement variants applied.

The solar savings fraction obtained by designing houses with solar systems, was between 20 and 22 per cent in accordance with their orientation. This indicates the percentage of savings that the house provides, therefore, the families who live in the INEAA solar passive house, only will pay in concept of building air-conditioning, between 78-80% with respect to an IPV house.

For houses located in streets with E-W direction, i.e. oriented with an azimuth of ±0 ° North the amortization is performed in a period of 2.4 years. Located in streets with N-S direction, i.e. oriented with an azimuth of ±15° North, in E-W oriented lots, the amortization becomes is 2.3 years. Replacing the natural/liquefied gas as energy for heating the water by solar radiation, two scenarios are presented for twenty years in relation to the two values in the cost of fuel by readjustment of prices: one in the first half of 2016 and the other in the second half. In the first case, the solar investment is recovered in 4 years, with 16 years of free energy.

In the second solar investment is recovered in 3.2 years, getting 16.8 years of free energy. During the 30 years of useful life of photovoltaic panels and making matching the consumption and production prices of the MWh of electricity, the investment in the solar system would amortize in 10 years, getting 20 years of free electricity.

Conclusions

To design the habitat of the population further disadvantaged, which in Argentina is the third of its population, in a bioclimatic way, constitutes a decision that widely contributes to the improvement of their living conditions. This improvement not only involves hydrothermal comfort, but also significant savings in the consumption of conventional energy, values more representative given the gradual accommodation of domestic prices in relation with the international ones. In this regard, in September 2016 a family that inhabited the passive solar house INEAA, might have paid in concept of building air conditioning, between 78 and 80% of what they would pay inhabiting an IPV house. Although the cost of the INEAA bioclimatic house exceeds 17% of the IPV house cost, energy savings mentioned above, implies that the over expenditure is amortized in little more than 2 years.

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