European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2011

Proposal for the use of solar heaters in small residences of Curitiba

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Summary. This article seeks to determine a proposal for the use of thermal solar heaters for small residences in Curitiba-PR, Brazil, being considered "small" residences of up to 100 m^2, what is equal, according to the Institute of Research and Urban Planning of Curitiba (IPPUC), to 26% of the total of all of the residences of the city. For the elaboration of the work, the averages of solar irradiation were considered in the city.
The factor of solar irradiation in this research is of addition importance, because it indicates us which is the participation of the solar energy in the generation of thermal energy through the system of solar heating.
Being known the total thermal energy necessary, energy generated by the system of solar heating and the energy generated by the auxiliary system, it was possible to relate data obtained with the values of the tariffs of electric power of the city, and in this way, it was possible to study the economical viability of the system. In this proposal we verified that the investment return will come in the 5th year of implantation.

Keywords

Solar energy, solar collector, thermal heating, solar irradiation, renewable energy, environmental effects.

1. Introduction

Approximately 6,7 billion existent people in the Earth are responsible so that the world energetic demand presents a scenery of growth dizzy and consequently preoccupying in the extent of shortage of energy. For this reason, the man should look for energy alternatives in the nature, in other words, to develop and to perfect renewable alternative sources of energy to aid in the supply of the world demand.
This article is limited to the study of the technical and economical viability of the use of the thermal solar energy in the residences of the city of Curitiba.
The current patterns of production and consumption of energy are based on the fossil sources, what generates emissions of pollutant, greenhouse effect gases and they put in risk the supply of long period of fossil fuels of the planet. It is necessary to change those patterns stimulating the use of the renewable energies, and, in that sense, Brazil presents a quite favorable condition in relation to the remaining of the world [1].
The main problem discussed in this article approaches the costs and incentives, especially in the Brazilian context, for productions centered in the reception and transformation of the solar energy, in compatible levels with the common use, in this case, in the heating of water, usual in the Brazilian homes.
This article presents a study where we verified if there is or no, technical and economical viability in the use of systems of solar collectors for heating of water, in residences in the city of Curitiba.
The article also analyzes the environmental degradation resulting from the energy generation originating from the installation of hydroelectric power stations, the main generating source of energy in Brazil, and the investigation need concerning themes as the environmental subject in confrontation with the pollution originating from of activities related with the production of energy and the new globalization context that demands clean energy activities.
With the technological progresses and with the need every time larger of production of energy to accompany those progresses is necessary mainly a larger use of alternatives of renewable energy sources to soften the concentration and dependence of the conventional sources of energy and that philosophy should be present in the daily of the people. Therefore, our proposal also fills out this requirement turning each residence a source producing of energy.

2. Energy Potential

The meaning of the word "energy" is linked to the innate potential for execution of any work or action, being used in different contexts.
The humanity, immersed in their crescents scientific, social, technological, economical, and productive needs, depends on energy (in their more varied forms) to stay in constant evolution. It happens, however, that the production of energy, fomented along the great human conquests, little observed on the "atmospheric and

environmental degradation" question, and that the activities of energy producing, frequently result in aggressions to the natural resources, pollution and devastation of the nature and of the ecosystems in it involved.

However, now the energy subject figures, with effect, and great expression, in the contemporary environmental lines, designating that the most varied sources of energy, are not able to and they should not cause harms to the alive species, to the environmental resources and the atmosphere. The satisfaction of the human needs, correlated to the consumption of energy cannot be harnessed to the emission of pollutant, to the release in great scale, of extremely poisonous and destructive elements to the planet.

Brazil is the country that possesses the largest world reservation of hydro energy. Fact that prevails due to the great amount of rivers that cover the country and for that reason it is the resource more used for the generation of electricity [2]. This hinders the incentive of the use of the renewable alternative energies. Even if the energy originating from the hydroelectric power stations is considered a type of clean energy it causes serious environmental consequences to the planet, be for flooding great areas, destroying the fauna and the flora, or for not being installed in an appropriate way, as for instance, the construction of a dam without the retreat of the wood of the land, causing this way the creation of a source of poisonous gases to the atmosphere.

According to the Energy Research Company (EPE), one of the most widely used forms of energy is hydro, and corresponds to approximately 16% of all energy consumed in the country.

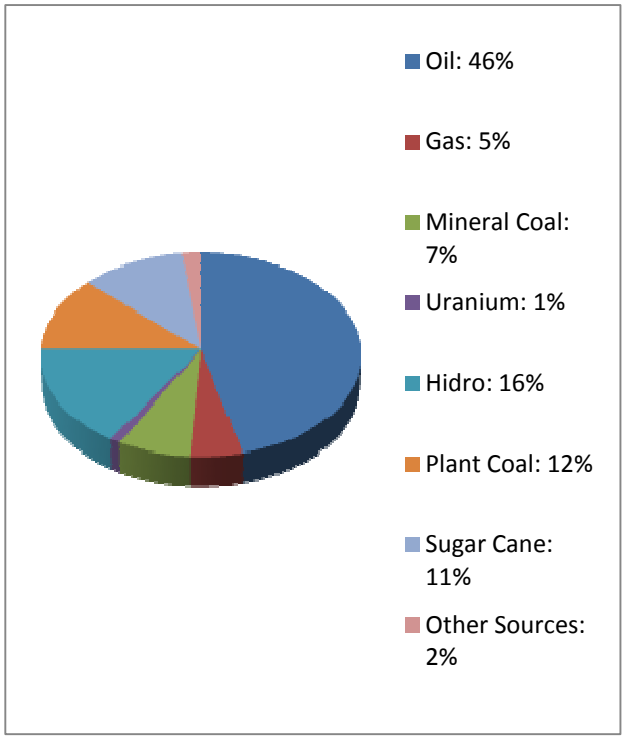

Fig. 1- Energy supply in Brazil - 2000

Given the growing worldwide concern with global climate change - particularly global warming - emissions of greenhouse gases become an issue increasingly relevante.Em compared to the rest of the world, Brazil has become known for show reduced rates of greenhouse gas in its energy production, which is basically due to the high share of renewables in energy supply inside.

3. Solar Irradiation

The Sun generates a great amount of energy, which a part is absorbed by the Earth maintaining its temperature, and the remaining is irradiated for the space [3]. However, that portion of energy that arrives to the atmosphere from the Sun is responsible for the production of all the other ways of energies, be with the cycle of the waters or even with the photosynthesis of the vegetables. The solar irradiation is of extreme importance for the study, because the efficiency of the system is directly related to the amount of energy that the solar collector can capture. Brazil, in its largest part, locates between the tropics of Cancer and Capricorn, place with the best solar indexes of solar irradiation in the Planet.

The solar energy is a form of clean energy, because its use doesn't generate pollution to the environment, and of the available renewable sources of energy now it is the one that better adapts to Brazil as source of primary use, because the country is placed at privileged place in relation to the incidence of luminous rays [4]. The availability of solar irradiation also depends on the local latitude and of the position in the time, in other words, hour of the day and day of the year. This is due to the inclination of the imaginary axis around which the Earth accomplishes the rotation movement and also due to elliptic path that it accomplishes during the movement of translation.

Curitiba is not located so close the line of the equator (place of larger solar incidence), however, it receives very more solar energy than Germany, country that uses this source of energy a lot. Comparing Curitiba with cities in countries that receive smaller solar irradiation during the year and that use this source of energy in very larger amount, we concluded that the city has potential to use and to develop new forms of use of the energy originating from the Sun.

4. Proposal of Implantation

The proposal for the use of solar heaters in small residences in Curitiba considers that the "small residence" doesn't cross the area of 100m^2 of construction and that the model used for the calculation of electricity consumption considers: four residents, daily consumption of 50 liters of hot water per resident, residence with approximate consumption of energy of 383,67 kWh a month, with an approximate value to R$ 179,21 of monthly bill. We have adopted approximated values due to the potency of an apparel to vary from manufacturer for other.

Because the system of solar heating proposed not to get to supply everyday of the year the demand of hot water for this residence type in Curitiba, we used a partial

substitution of the water heated up electrically by the water heated up via solar heater. In Brazil, the shower and the electric faucet have great prominence in the total electricity consumption of a residence, approximately 43% of the value to be paid, arriving up to 50% in some cases.

To simulate a model of economical and financial viability of systems of solar heating in residences of up to 100m^2 we should consider some data and to admit some presupposed. Therefore we have considered the medium and minimum temperatures monthly; temperature of the consumption water equal to 40^{o}C; necessary volume of monthly hot water; performance of heating systems with electric resistance equal to 0.95, in other words, 95%; performance of the system of solar heating equal to 0.60 or 60%; electric power tariff; estimate of evolution of the electric power tariff in function of the growth of the future inflation and of the cost of the system of solar heating. In the present proposal the medium values of the medium and minimum temperatures will be considered, having as base the data obtained by the Meteorological System of Paraná State (SIMEPAR) in 2009. The volume of hot water depends on the consumer type and of the type of the installation in a residence it is stipulated in the proposal 200 daily liters of hot water, having a monthly volume of 6,000liters of hot water. The value of the electric power tariff in Curitiba, 2009 year, for the residential consumer is of 0.44120 R$/kWh, value this obtained by COPEL (public dealer of electric power in Paraná State). This value will be used to measure in R$ (Real) the expense with the auxiliary system energy that uses the electric energy. The projection of readjustments of the electric power tariff is made by the General Index of Prices of the Market (IGP-M), being of 7.99% in 2010, 4.8% in 2011, 4.5% in 2012, and from 2013 to 2015 of 5% a year. The costs of the system of solar heating were accomplished for a system coupled with the solar plate and the thermal reservoir of 200 liters. The choice of the solar system was based in the one that offer the better performance and the better cost benefit. The model Transsen was purchased, with total cost, including installation, of R$ 1,850.00. The system has a boiler of 200 liters and a solar plate of area of 1.73m^2, allowing to warm up the total capacity of water inside of the boiler.

It was chosen the cash flow method to present an economical-financial analysis of the implantation of the system. This method considers the obtained economy of electric power for a period monthly or annual in function of the thermal energy generated by the system of solar heating, as well as, the evolution of the price of the electric energy along the time, being considered a tax of estimated inflation. It is also considered the useful life of the equipment and the initial investment.

In this way, considering the data previously described, as well as their validations through the suitable exit data to the consumption of a family with four people, we obtained the following data for an economical and financial analysis: the amount of necessary energy for the consumption of hot water in the residence proposed in kWh (Qn); the amount of monthly energy generated by the system of solar heating (Qs); the amount of necessary monthly energy of the electric auxiliary system (Qae); the economy in R$ (Real) generated by the system of solar heating and the monthly cost of the electric energy in accordance with the use need as an auxiliary energy; the total annual of the monthly data regarding the economy of energy and the expenses with the auxiliary energy and the value of the investment for the implantation of a coupled system of residential solar heating. Those data can be verified in the Table 1.

Table 1 – Amount of solar and auxiliary monthly energy - Tmed - (vol. 200 liter/day)

Month	Tmed	Qn	Qs	Qa	Qae
	ºC	(kWh)	(kWh)	Qn-Qs	(kWh)
Jan	21.3	130.48	147.10	-16.6	--------
Feb	21.6	128.39	129.46	-1.06	--------
Mar	21.3	130.48	109.30	21.18	22.29
Apr	18.9	147.23	96.39	50.84	53.52
May	14.9	175.47	79.69	95.45	100.47
Jun	14.8	175.84	77.80	98.04	103.20
Jul	13.6	184.21	97.96	86.25	90.79
Aug	15.1	173.75	104.26	69.48	73.14
Sep	15.8	168.86	115.60	53.26	56.06
Oct	17.9	154.21	132.93	21.28	22.40
Nov	19.2	145.14	155.61	-10.4	--------
Dec	20.2	138.16	159.39	-21.2	--------
Total			**1,405.5**		**521.89**

The data presented in the Table 1 are important, because through them, it can be quantified in Real (R$) the monthly economy that a system of solar heating generates for the residence in study, as it can be observed by the Table 2. Besides that monthly economy, we can make a projection of future economy to validate the viability of the implantation of the system.

Table 2 – Amount of solar and auxiliary energy converted in R$/kWh – Tmed

Mês	Qs		Qa	
	kWh	R$/kWh	Qae(kWh)	R$/kWh
Jan	130.48	57.57	----	----
Feb	128.39	56.64	----	----
Mar	109.30	48.22	22.28	9.83
Apr	96.39	42.52	53.52	23.61
May	79.69	35.16	100.47	44.33
Jun	77.80	34.32	103.20	45.53
Jul	97.96	43.22	90.79	40.05
Aug	104.26	46.00	73.14	32.27
Sep	115.60	51.00	56.06	24.73
Oct	132.93	58.64	22.40	9.88
Nov	145.14	64.03	----	----
Dec	138.16	60.95	----	----
Total	**1,356.15**	**598.33**	**521.89**	**230.26**

The Table 2 is to elucidate the amount of energy used for consumption of hot water by the system and the amount that was used by the electric resistance. For the six year-old future projection, shown by the Table 3, where the first year is 2010, it was used the annual economy of Qs and the annual expense of Qae, coming from the Table 2.

Table 3 – The return of the investment in relation to the electric energy – Tmed

Year	Annual Economy of the solar system (kWh)	Annual expenses with the auxiliary system (kWh)	Annual Economy (kWh)	Price of the kWh	Total (R$)	IGPM (%)
1	1356.15	521.89	834.25	0.44	368.0	7.9
2	1356.15	521.89	834.25	0.47	397.4	4.8
3	1356.15	521.89	834.25	0.49	416.1	4.5
4	1356.15	521.89	834.25	0.52	435.1	5.0
5	1356.15	521.89	834.25	0.54	456.8	5.0
6	1356.15	521.89	834.25	0.57	479.6	5.0
Total					**2553**	

With base in the Table 3 we can see that the investment return will be obtained along the 5th year of the system installation, with the acquisition value and installation of the system of solar heating being of R$ 1,850.00. In this article the medium temperatures of the city of Curitiba were considered, in the year of 2009.

5. Conclusion

Besides, other very important reason is the minimization of the degradation of the atmosphere, because with the use of the energy originating from the sun, any pollution type won't be generated in the reception process and conversion of that energy. As larger is the electric and thermal energy use originating from of solar collectors, as larger will be the preservation of the environment. The people that use the electric energy from photovoltaic origin are avoiding the consumption of fossil fuels and in a more advanced analysis, they are contributing to the decrease of the need of flooding provoked by hydroelectric plants [5] and decrease of greenhouse effect gases produced by the consumption of fossil fuels.

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