A Study of the Feasibility of the Deployment of Solar Energy in a Factory of Yoghurt in the Zone of the Mata in the State of Minas Gerais

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Abstract

the *objective of this study was to determine the economic viability for the investment in a solar energy system in a factory of yoghurt, small businesses located in the interior of the state of Minas Gerais. A survey was done of spending by the company with power during the last 12 (twelve) months in order to assess the amount of kWh monthly expenditures, and consequently the amount disbursed by the organization.*

This project has a useful life of 25 years and has 10 years of guarantee of the company specializing in solar energy. However, through spreadsheets, it was found that the VPL shall be 4 years and 4 months, i.e., the entire investment made will be paid in this period, and after this phase, the project will start to provide profits. In short, the investment proved very beneficial, being feasible in the effectuation of the equipment and the use of solar energy.

Keywords: *Feasibility, investment, solar energy.*

I. INTRODUCTION

The progressive demand for optimization of the financial resources of an institution and the increase of competitiveness among the companies with which they seek different ways to reduce the cost of the final product that will be sold to the consumer, in order to increase your sales and maintain their products on the market. For this reason, the organization should always be innovating and seeking several mechanisms for this to occur.

According to Chiavenato [1], the investment of companies seeking to reduce costs are forwarding organizations to legitimise that administration of purchases is a methodology of productivity, where this control of costs is checking everything that is paid in everything that you purchase and use in production until the final product.

The general objective of the study, conducted in a factory of yoghurt, small businesses located in the interior of the state of Minas Gerais is to demonstrate the economic viability of the project for the installation of solar plates in this company. Were developed techniques for analysis of financial viability and potential market risks, to be able to reach a concrete position regarding the feasibility of technology deployment to capture Solar Energy in the company.

Therefore, an analysis was made to contemplate the profit margin of the company and also their respective operational costs in order to subsidise the implementation of technologies that can capture solar energy, in order to optimize the invoicing of the company over the long term.

II. LITERATURE REVIEW

According to ANEEL [2] Nearly all sources of energy including hydro, biomass, wind, fossil fuel and energy of the oceans, are indirect forms of solar energy.

According to Silva [3] photovoltaic panels are prepared by a composite of photovoltaic cells and can be connected in order to approve the preparation of modular structures which, in particleboard can expand the capacity of electric power generation.

A. Incentives for Solar Energy in Brazil

According to Silva[3] nationally to source of solar energy has in its production incentives, which could not be otherwise, because the country offers possibilities for clean energy cheaper. However, these incentives are not on the same scale of existing in other countries, which do not have many other options as sources of energy.

As evidenced EPE [4], the energy source countries of Europe, Australia, China, Japan and the United States is predominantly fossil fuels, resulting factor to increase aid to different possibilities of renewable energy as a way to minimise emissions and differentiate the array. Some incentives and benefits are offered to the generation of electrical energy through solar power, such as the Light for All Program (LPT), where it is made the installation of solar panels in some communities (depending on your characteristic) who do not have access to electricity. Also has the discount of 80% in the rate of use of transmission systems (TUST) and in the rate of use of distribution systems (TUSD) for companies in which the power introduced into the system of transmission or distribution is less than or equal to 30,000 kW.

This discount is 50% after the 11th year of operation of the solar plant or for companies that started its operations from 1st January of this year.

B. PhotovoltaicPanel

According to Pereira & Oliveira [5] photovoltaic panels are the main components of the photovoltaic system for power generation. They are formed by a set of photovoltaic cells that are associated, electrically, it can be in series and/or parallel. Photovoltaic generators are the first part of the system, i.e., are responsible in the process of capturing the solar irradiation and its transformation into electrical energy. With respect to the manufacture of panels, in accordance with Pine &galdino [6], the production of solar modules has suffered extensive government interference from tax incentives and environmental. However, with the increase in demand for production of these components, the cost for the realization of the system fell.

C. Autonomous Systems or Isolated (Off Grid)

The systems Off Grid, are those that do not depend on the conventional electrical network for your operation, it is possible its use in locations with limitations on electrical distribution network. There are two types of freelancers: with storage and without storage. As Villalva & gazoli [7], the system with storage, can be used for charging of batteries for electric vehicles, public lighting, and even in small portable devices. While those without storage, in addition to being often used in water pumps, have greater economic viability, since it does not use instruments for energy storage [5].

D. Systems Connected to the Network (Grid)

Already On Grid systems, depend on a good network access to the distributor of electrical energy. Briefly, the photovoltaic panel generates electrical energy in continuous current, and injects in the network of electrical energy after converting it to alternating current. This conversion is given by the use of frequency inverter, which performs the interface between the panel and the electrical network [5].

E. Hybrid Systems

The association of photovoltaic systems with other sources of energy has foundation in the hybrid system. The biggest benefit is to provide electricity (stored in batteries), the scarcity of sun, i.e., in the days of low or no generation. However, it is pointed out as a system with a considerable degree of complexity, since we need to integrate various forms of production of electrical energy, such as diesel or gas engines or by wind generators [5].

III. METHODOLOGY

The study of this scientific article was developed through the literature review about the viability of the industrial deployment of solar energy and as support served as the foundation: scientific articles, websites, resolutions, budgets of companies supply of solar energy and technical visits in the company of study.

According to Neves *et al.* [8] constitute bibliographical research as inquiry of a given topic, established on the basis of national and international references from articles published in journals, theses and other documents, reaching - if solutions with parameters such as summaries of the files found and pattern of schemes with the basis of the information.

In correlate, we performed a case study and technical visits in the period from February to June 2018, investigating the values spent with power in the last 12 months of the yogurt factory located in the city of Santana from Cataguases - MG, with production line with only daytime Scale (8 hours per day). According to Gil [9], the case study is equivalent to the in-depth study of one or some of the purposes that provides extensive and detailed knowledge. The objective of this article was to transform and develop innovative and sustainable solutions for the enterprise in study and society, in addition to minimizing costs.

To classify the company profile analyzed and measure the proportion of the project of energy supply by means of photovoltaic panels was used the *software Excel* 2010 detailing the amounts spent on electric power and request the budget of a company specializing in solar energy and, with that, through monthly comparisons of the values spent with energy, with the purpose of analyzing the *payback*, i.e., what the return on investment of the project under consideration and their financial viability, minimizing the costs and expanding its profitability.

At the beginning of the study was carried out a budget for the implementation of Photovoltaic System through a specialized company, totaling an initial investment basis of R$ 122,005.06 (one hundred twenty and two thousand, five reais and six cents) included all equipment and services (Modules, Inverters, brackets and Installation Kit, Monitoring System, materials, design & Approval, labor of installation and *startup* of equipment). And with the analysis was observed and concluded that the company could save R$ 34,626.36 (Thirty-four thousand, six hundred twenty and six reais, thirty-six cents) on an annual average basis and that the account of light which before was the value of R$ 2,976.42 (two thousand, nine hundred and seventy-six reais and forty two cents) would spend for R$ 90.89 (90 reais and eighty nine cents) with a reduction of 96.89% and your discounted payback will be from 4 years and 4 months.

IV. RESULTS AND DISCUSSION

With the obtained data it was possible to generate a report with information of the current consumption and energy consumption through analysis and technical visit at the factory which is the study.

In Figure 1 is the comparisons of expenditures with the electrical energy in the period studied and as i would be with the use of solar energy and the sustainable environment, causing a reduction in the energy bill for the company and benefits for the environment.

Figure 1 - Values of Consumption Before and after the Implementation of the Solar System.

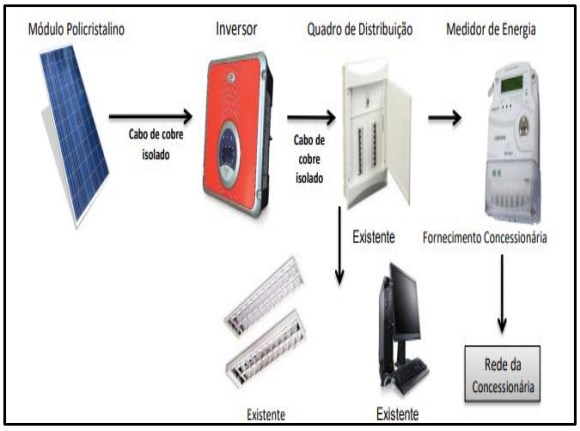
Consumo Mensal	
Energia Elétrica Antes	**Energia Elétrica Depois***
R$ 2.976,42	R$ 90,89
*Calculado em função do Custo de disponibilidade Elétrica cobrado pela concessionária	

Source: Author (2018)

A. Installation of Photovoltaic System Proposed.

The photovoltaic system composed of polycrystalline solar panels connected to the inverter to the system connected to the public network, supported by aluminum profiles for mounting of modules as shown in figure 2 below**.**

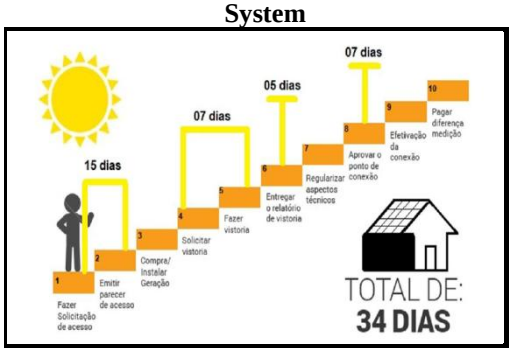
Figure 2 - Diagram of the Photovoltaic System



Source: Author (2018)

This photovoltaic system full of 30.53 kW, generating 3,588 kwh month is composed by 111 CANADIAN 275W modules and 1 inverter. The value of the complete system was budgeted at R$ 122,005.06 (one hundred twenty and two thousand, five reais and six cents) and the yield after 1 (one) month installed will provide a monthly average of R$ 2,885.53 (two thousand, eight hundred and eighty-five reais, fifty-three cents). The photovoltaic panels and aluminum structure must guarantee of 10 years, the inverters has a warranty of 5 years and the installation of 1 year, this system has its useful life for at least 25 years.

Figure 3 - Flowchart for the Installation of the System



Source: Author (2018)

(*) The deadline for issuing the opinion of access is 15 days for MICROGENERATION and 30 days for Minigeneration, after receipt of the request for access containing all the documentation foreseen in the standard.

(**) from the formal request for inspection by the acessante and if there are any pending technique.

(***), provided that all the possible pending items noted in the inspection have been remedied by the acessante, including commercial if.

(****) This term until 34 days runs in parallel from the beginning of the process and, unless there are details or pending commercial solve (as the forecast for the conclusion of contracts, for example), there is no impediment in connection technical approval in accordance with that demonstrates in figure 3.

In accordance with the rules laid down for the electric sector (ANEEL) [2], where the consumption recorded by the reading on the measuring equipment is less than the minimum set by legislation, the distributor must make the recovery of the cost of system availability, which is the minimum value of monthly billable consumption of consumer units of 'Group B'. In accordance with the rules of the electric sector, depending on the stage of the installation link, are charged the following minimum consumption of the concessionaire:

- Phase 30 kWh for the value of R$ 24.67;
- 50 kWh to biphase the value of R$ 41.11;
- 3-phase 100 kWh, if the value of R$ 82.22.

For consumers in the "Group", the cost of system availability is tied to the cost of contracted demand.

B. Power Generation Capacity of the System.

The system budgeted for this venture has a generating capacity of 120 kWh per day, since each card produces 1.08 kWh/day. In one month, this system will be able to generate 3,588 kWh, and with it will cover all the energy needed in the production process of the company in analysis.

C. Analysis of the Economic and Financial Viability of the Project.

To investigate the economic viability of the project of solar energy was done Discounted Payback in order to see how long the project will pay the

investment made, i.e., from which period the same begins to produce a profit for the organization. With the NPV (Net Present Value) was determined as the project provided profit for the company after the withdrawal of the investment done and taking into account the useful life of the equipment purchased.

Below figure 4 with the Discounted Payback on investment in the solar system.

Figure 4 - Estimate of Return on Investment (Discounted Payback).

Ano	Rendimento	Geração anual de Energia kWh/ano consid. perda do rend. dos painéis	Geração Acumulada de Energia (kWh)	Custo do kWh (R$)	Economia Gerada/ano Descontada (R$)	Economia Descontada acumulada (R$)	Retorno do Investimento (R$)	Custo Anual da Energia sem o Sist. Fotovolt. (R$)
0							-122.005,06	
1	97,5%	41.982	41.981,94	0,756	29.922,81	29.922,81	-92.082,25	32.176,07
2	96,8%	41.681	83.662,47	0,786	29.147,45	59.070,26	-62.934,80	65.639,18
3	96,1%	41.379	125.041,59	0,817	28.390,70	87.460,96	-34.544,10	100.440,81
4	95,4%	41.078	166.119,31	0,850	27.652,13	115.113,09	-6.891,98	136.634,51
5	94,7%	40.776	206.895,61	0,884	26.931,32	142.044,40	20.039,34	174.275,96
6	94,0%	40.475	247.370,51	0,919	26.227,87	168.272,27	46.267,21	213.423,07
7	93,3%	40.173	287.544,00	0,956	25.541,37	193.813,64	71.808,58	254.136,06
8	92,6%	39.872	327.416,07	0,994	24.871,45	218.685,09	96.680,03	296.477,57
9	91,9%	39.571	366.986,74	1,034	24.217,71	242.902,80	120.897,74	340.512,74
10	91,2%	39.269	406.256,00	1,075	23.579,79	266.482,59	144.477,52	386.309,32
11	90,5%	38.968	445.223,86	1,118	22.957,31	289.439,90	167.434,84	433.937,76
12	89,8%	38.666	483.890,30	1,163	22.349,94	311.789,84	189.784,77	483.471,34
13	89,1%	38.365	522.255,33	1,210	21.757,31	333.547,14	211.542,08	534.986,26
14	88,4%	38.064	560.318,96	1,258	21.179,08	354.726,23	232.721,16	588.561,78
15	87,7%	37.762	598.081,18	1,308	20.614,94	375.341,16	253.336,10	644.280,31
16	87,0%	37.461	635.541,98	1,361	20.064,54	395.405,70	273.400,63	702.227,60
17	86,3%	37.159	672.701,38	1,415	19.527,57	414.933,26	292.928,20	762.492,77
18	85,6%	36.858	709.559,37	1,472	19.003,72	433.936,98	311.931,92	825.168,55
19	84,9%	36.557	746.115,96	1,531	18.492,68	452.429,67	330.424,60	890.351,36
20	84,2%	36.255	782.371,13	1,592	17.994,17	470.423,84	348.418,78	958.141,48
21	83,5%	35.954	818.324,89	1,655	17.507,89	487.931,72	365.926,66	1.028.643,20
22	82,8%	35.652	853.977,25	1,722	17.033,54	504.965,27	382.960,21	1.101.965,00
23	82,1%	35.351	889.328,19	1,791	16.570,87	521.536,14	399.531,08	1.178.219,67
24	81,4%	35.050	924.377,73	1,862	16.119,59	537.655,73	415.650,67	1.257.524,52
25	80,7%	34.748	959.125,86	1,937	15.679,44	553.335,18	431.330,11	1.340.001,57

Source: Author (2018)

For the preparation of Table 4 in what was considered the kWh currently paid by the client with the taxes the value of R$ 0.82 (eighty-two cents), the average monthly consumption of 3,549 kWh client, generating a monthly average of 3,588 kWh, customer's investment of R$ 122.005.06 (one hundred twenty and two thousand, five reais and six cents), net cost of kWh the value of R$ 0.76 (seventy-six cents). The indices and aliquots were analyzed for 18% of I.C.M.S, PIS-COFINS tax of 1.48%, 6.63%, annual adjustment of 4% and the Selic rate of 6% and from the instrument drawn up it was determined that the Discounted Payback will be approximately 4 years and 4 months. And, the VPL will be R$ 431,330.11 (Four Hundred Thirty-one thousand, three hundred and thirty reais and eleven cents) after the period of useful life of the system.

V. CONCLUSION

The research done has great relevance in the reduction of resources disbursed with electrical power by the company analysis, where a proposal was drawn up to an organization specialized in solar energy, informing it that the monthly current consumption in kWh.

Through the tables mentioned above, the results were observed in the reduction of costs that the company would have with the inclusion of this system for supplying energy to meet their needs and facilitate the reduction of spending power, optimizing the resources proposed as solar energy. The amount of energy consumed is constant, based on the average provided for this proposal, since the energy generated varies in accordance with the income of the panels, decreasing over the years.

In this way, with the customer's investment of R$ 122,005.06 (one hundred twenty and two thousand, five reais and six cents), the institution shall have an economy with electrical power monthly average of R$ 2,885.53 (two thousand, eight hundred and eighty-five reais, fifty-three cents) and, with this, pay all the investment in 4 years and 4 months, remembered that the useful life of the system are 25 years old, consequently be able to obtain a VPL approximately R$ 431,330.11 (four hundred and thirty-one thousand, three hundred and thirty reais, eleven cents).

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