Economicfeasibility To Implant A Project of Energectical Efficiency In A Higher Education Institution In Cataguases Minas Gerais – Brazil

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Abstract - *This article presents a study about the economic feasibility of the energetic efficiency in a higher education institution, located in Minas Gerais, in view of the importance of optimizing the resources that are scarce. The use of energy through the use of economic light bulbs, substitution of equipments and of photovoltaics allows considerable savings that this work seeks to demonstrate. The research here developed is based on published articles in academic websites of scientific magazines, books and articles. The production of this article was motivated by the importance that this subject arouses, initiated through a study of a case, where the focus is to demonstrate through investment analysis tools that the economic use of energy resources makesthe project feasible. Started by an introduction of methodological character, the article follows with a brief conceptual discussion about the energy efficiency, analysis tool concepts and finishing with the research results and conclusion.*

Keywords:*Energy efficiency. Economic Feasibility. Energy saving.*

I. INTRODUCTION

Studies about our current national electrical system are realized in order to substantiate new investments compared to using existing demands [13]BRASIL, 2014. Such studies indicate the need for rapid national change with most efficient ways minimizing the impacts on the environment. The advent of these studies is a form of sustainability and economy found by the world industry, in which, consists in the energy use innovation using methods of energy efficiency.

[6]RIO DE JANEIRO, 2007, "An action policy regarding the Energy Efficiency has as objective to make use of techniques and practices capable of promoting the "intelligent" uses of energy, reducing costs and producing gains of productivity and profitability, in the sustainable development perspective".

The intelligent use of electricity becomes more and more necessary in today's society, since, unlike the population growth, the funds destinated to electricity production have been a smaller and smaller portion of the government investments.

The projects of energy efficiency also consist of the substitution of obsolete or outdated equipment for equipment with modern technologies and with better performance, for energy savings to occur.

The study has as justification the better use and exploitation of existing technologies to the clean power generation, reduction of costs and environmental impacts.

This work has as a general objective the study of technical and economic feasibility to implant a project of energy efficiency in ahigher education institution, located in Cataguases – Minas Gerais – Brazil. Specifically, calculations of monetary and energy saving,demonstrating the project feasibility.

II. LITERATURE REVISION

A. Energy efficiency

Efficiency means do more (or, at least, the same thing) with less, maintaining the comfort and the quality. When discussing energy, energy efficiency means generate the same quantity of energy with less natural resources or obtain the same service ("do work") with less energy.

Energy efficiency is an activity that seeks to improve the use of energy sources. The rational use of energy also simply called energy efficiency, consists of using efficiently the energy to obtain a certain result. By definition, the energy efficiency consists of the relationship between amount of energy used in an activity and the one made available for its realization,[14]ABCDENERGIA.

Energy Efficiency Program (EEP): The objective of the EEP is to promote the efficient use of electricity in all sectors of economy through projects that demonstrate the importance and the economic feasibility of the improvement of energy efficiency of equipment, processes and final use of energy. It seeks to maximize the public benefits of energy saved and of the demand avoided, promoting the transformation of the energy efficiency market, stimulating the development of new technologies and the creation of habits and rational practices of use of electricity[11]AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA – ANEEL 2015.

B. Economic viability

The energy efficiency must walk with the institution's strategic goals: "A company that wants to achieve a rational cost structure and becomes more competitive can't admit use the energy inefficiently and irresponsibly."(ELETROBRÁS, 2005, P.9).

With proper study, efficient energy management requires the replacement of old equipment for newer, better, economical and efficient models, as well as the modernization of use processes for better use.

To be deployed an energy efficiency project and the equipment acquisition it is necessary an economic feasibility study in which [5]Keelling (2006) defines as the most important step to the project success, besides becoming the main project monitoring indicator.

[1] ***Payback:***[4]KASSAI et al (2000), The payback is the elapsed period for the recovery of an investment, it is the identification of the deadline within which the amount entered in the project will be recovered through the cash flow. The investment value (negative flow) equals the cash value (positive flow). The simple payback calculation ignores the discount rate, that is, the value of the money over time, but the discounted payback method, considers the interest rate to make the calculation of the period spent.

IRR – Internal Rate of Return and MRA – Minimum Rate of Attractiveness: According to [4]KASSAI et al (2000) (2000), the IRR is the necessary rate needed to match the value of an investment (present value) with its respective future returns or cash balance generated in each period. Being used in investments analysis, means the rate of return of a project. The Internal Profitability Rate (IRR) is the rate of the project update that gives the NPV (Net Present Value) null. The IRR is the rate that the investor gets on average in each period (year, month, …) on capitals which keep invested in the project, while the initial investment is progressively recovered. Still according to [4]KASSAI et al (2000) (2000), it is considered economically attractive an IRR bigger or equal the MRA (Minimum Rate of Attractiveness). The MRA is a minimum rate that a project must reach, in which can be adopted by people having a civil status, if the project does not reach, it must be rejected.

$$\boldsymbol{IRR = \sum_{j=0}^{n} \frac{FC_j}{(1+i)^j} - FC_0}$$

FC_j: present value of cash inflows;
FC_0: Initial Investment;
i: Discount rate (equal to the capital cost of the company);
j: Discount time of each cash entry;
n: Last cash flow discount time.
j: It is the generic index representing the periods j: 1 a t.

NPV – Net Present Value: The measure of the Net Present Value (NPV) can be obtained through the difference between the present value of net cash benefits, scheduled to each period of the project duration horizon, and the investment present value [1]ASSAF NETO e LIMA, 2011. This way, the net present value of an investment project can be defined as the algebraic sum of the values discounted from the cash flow associated to it.

"The net present value (NPV) explicitly considers the value of money over time. It is considered a sophisticated technique of capital budget. All such techniques discount somehow discount the company cash flows at a specified rate. This rate commonly called discount, requiredreturn, cost of or opportunity cost, consists of the minimum return that a project needs to provide to keep unchanged the company market value" [3]GITMAN, 2010, p. 369.

$$\boldsymbol{NPV = \sum_{t=0}^{n} \frac{FC_t}{(1+i)^t} - I_0}$$

i: it is the discount rate;.
t: it is the generic period (t=0 at=n), running through all cash flow;
FC_t: it is a generic flow to t = (0... n) that can be positive (down payment) or negative (disbursement);
NVP: (i) it is the net present value discounted at a rate i;
n: it is the flow number of periods;
I_0: it is the initial investment.

C. Rated equipment

[1] ***Lighting:*** According to [15]INMETRO booklet, the LED technology light bulbs have greater durability and lower consumption, when compared to the existing ones, besides, they produce more lighting than the other light bulbs with less energy, that is, they are more economical.This way, to study the replacement of common light bulbs for LED light bulbs may impact on the reduction of

energy expenses. For example we have [9]Zanin et al. (2015) who developed a study about cost benefit, on a Community University Campus, about the replacement of conventional light bulbs for LED light bulbs. They conclude that the light bulbs replacement generated an economy of 448,49 MWh/year, consequently reducing the energy costs. According to INMETRO, depending on the model, the LED light bulbs can last at least twenty five times more than the incandescent ones and four times more than the compact fluorescent ones. But the time (in operating hours) estimated in packaging does not means the time that it will take to burn but the period that the light bulb will start working with more or less 70% of original luminous capacity. It also stands out the warranty, that is longer than the ordinary light bulbs. This way, if the product stops working or it has the lighting efficiency decreased within the warranty period stipulated by the supplier, setting a defect, the consumer can ask its replacement. But to have the use of this right it is necessary to keep the packaging and the invoice.

[2] ***Air conditioning:*** According to [12]ABESCO, every moment, new solutions and systems are presented to the air conditioning market. A retrofit (replacing an old system with a new one) of a system with 15 to 20 years of operation will bring to the final client an economy of 30 to 50% in the electricity cost (it depends on the system and as it was given the maintenance in this period), besides the reduction in the maintenance cost.

[3] ***Photovoltaics*****:** [2]Braga (2005) renewable sources are directly or indirectly linked to solar energy, that is, use of sources such as obtaining electricity through solar cells, having the sun as a supplier of this energy, guarantees a significant increase of the energy supply. The solar energy, dismiss extraction or transport of the place of generation, this way avoids the costs with the transmission in high voltage for using solar cells, which are responsible for generating energy, therefore it does not emit polluting gases or noises and with minimum necessity for maintenance [7]SHAYANI et al, 2006. According to Marinoski (2004) the photovoltaics is one of the best means for power generation, using an inexhaustible and non-polluting source, making economy available on energy bills through clean, sustainable energy, the photovoltaic system is increasingly being used by developed countries, not only for residential use, but also in commercial and industrial buildings. According to [10]AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA – ANEEL 2012. the system of power compensation, should be charged at least the amount related to availability cost, being able to take the option to install a photovoltaic system in an address and save in the energy bill of other address, since both properties are owned by the same owner.

III. METHODOLOGY

This search is classified, according to [8]Silva e Menezes (2001), from the point of view of its nature, as applied, because it objectifies the knowledge generation to solve specified problems.

In the form of the problem approach, as quantitative, because it will be demonstrated through numbers, obtained values and transformed into data for analysis.

Regarding the objective of this research classifies as descriptive, due to data collection and the relationship between the feasibility or not of the project.

And from the point of view of technical procedures: A case study, because it will involve a profound and detailed study to perform the analysis of the results.

For the elaboration of the present study, surveys of the characteristics of the equipment of lighting systems and air conditioning were performed, with theirrespectives utilization regimes, in a higher education institution, located in Minas Gerais, in the period from 08th to 19th April, 2019.

The data obtained were inserted into excel spreadsheet, separated by equipment type, aiming to calculate the consumption of existing equipment, according to its characteristics and operating regime. Then after analyzing each of them, it was proposed the replacement of those deemed inefficientby others more efficient and calculated again the new consumption with the efficient equipment. The difference between the two consumptions resulted in annual savings that could be obtained.

It was also scaled a photovoltaic generation system to reduce part of the remaining consumption.

After quotation of costs for the replacement of equipment and photovoltaic generation system installation, the total annual electricity expected savings to be obtained was valued based on the current electricity fares.

Based on the expected values for the investment and for the economy financial assessment was performed to verify the project feasibility.

IV. RESULTS AND DISCUSSION

The institution has an average consumption of 33.827 KWh off-peak hours and 1.510 KWh in peak hours, with a medium demand of 64,78 KW in off-peak hours and 58,59 in peak hours.

The project contemplated the replacement of obsolete equipment from the lighting and air conditioning system by more efficient technologies and systems sizing improvements, with the suitability of the lighting system, replacing 449 light bulbs that are not yet efficient, from a total of 741, by more efficient technologies and the replacing of 12 air conditioners with low efficiency, from a total of 28, by more efficient models.

Also contemplated the installation of a photovoltaic solar generator, with power of 16,08 KWp (kilowatt peak), connected to the distributor network, with an expected generation of 26,642 MWh/year, reducing the consumption in this amount of energy.

A. Financial Evaluation

[4] ***Investments and benefits:***In Table 1, are presented the involved costs and the expected savings for each final use, considering the energy fare of R$ 0,472810/KWh, in off-peak hours and R$ 2,457940/KWh, in peak hours and the demand fare of R$ 29,115750/KW, in off-peak hours.

Energy and Demand Costs and Savings					
Final Uses	Off-peak Energy Saved (MWh/year)	Peak Energy Saved (MWh/year)	DemandR eduction (kW)	Savings (R$/year)	Final Use Cost (R$)
Lighting	6,58	3,46	6,70	13.956,46	35.697,36
Air Conditioning	13,65	3,17	8,02	14.479,04	49.838,90
Photovoltaic Solar System	24,64	0,00	0,00	11.650,04	63.628,57
TOTAL	44,87	6,63	14,72	40.085,54	149.164,83

Table 1: Costs and obtained savings.

Table 1 shows the savings at peak hours (highest electricity usage) from 6:00 pm to 9:00 pm and off-peak hours, and the reduction in demand, generating an economy/year of R$ 40.085,54.

[5] ***Payback Calculation:***

Simple payback (years) = Investment value (R$) / Savings (R$/year)

Simple payback (years) = R$ 149.164,83 / R$ 40.085,54/year

Simple payback = 3 years and 9 months

[6] ***The NPV and IRR calculation:*** In Table 2 the NPV and IRR calculation was realized using an excel spreadsheet, considering a discount rate of 14% a year and a live cycle of 25 years for the project, that is the warranty time provided by solar module manufacturers.

PROJECT			
Fare adjustment:		8,5%	
Rate:		14,0%	
NPV:		R$ 411.905,11	
IRR:		37,6%	
INVESTMENT		-149.164,83	
SAVINGS			
YEAR 1	43.492,81	YEAR 14	125.604,17
YEAR 2	47.189,70	YEAR 15	136.280,53
YEAR 3	51.200,82	YEAR 16	147.864,37
YEAR 4	55.552,89	YEAR 17	160.432,85
YEAR 5	60.274,89	YEAR 18	174.069,64
YEAR 6	65.398,26	YEAR 19	188.865,56
YEAR 7	70.957,11	YEAR 20	204.919,13
YEAR 8	76.988,46	YEAR 21	222.337,26
YEAR 9	83.532,48	YEAR 22	241.235,92
YEAR 10	90.632,74	YEAR 23	261.740,98
YEAR 11	98.336,53	YEAR 24	283.988,96
YEAR 12	106.695,13	YEAR 25	308.128,02
YEAR 13	115.764,22		

Table 2: NPV – IRR Calculation.

In Table 2 besides showing the NPV and IRR results, it also exhibits thesavings year by year until the end of the project duration.

NPV = R$ 411.905,11

IRR = 37,6 %

B. Evaluation result

The Payback was of 3 years and 9 months, in a 25 years project, we have a positive NPV worth R$ 411.905,11, besides an IRR of 37,6 %, far above the minimum rate of attractiveness that is of 14 %. The project proved financially feasible in all verified analyzes.

V. CONCLUSIONS

This article had as an objective the economic feasibility of the use of electricity with replacement of light bulbs for LED ones and air conditioning equipment and photovoltaic energy in a Higher Education Institution, using tools that allow to demonstrate that the project was feasible from the amount invested and from the result obtained over 25 year project duration and with 3 years and 9 months return. The theme related to the energy efficiency arouses countless possibilities in the form of surveys and publications because, not only Brazil, like the rest of the world, faces difficulties in establishing an efficient way to use the energy matrix, even taking into consideration the technological difference that some countries have in relation to Brazil. This way, this theme always presents updated and lacking in new publications, because the worry with the efficient use of energy is fairly recent and increased a lot in Brazil when there was the necessity to do power rationing in 2001.

REFERENCES

[1] ASSAF NETO, Alexandre; LIMA, Fabiano Guasti. Curso de administração financeira. São Paulo: Atlas, 2011. Pag. 350 a 380.

[2] BRAGA, B. et al. Introdução à engenharia ambiental. 2. ed. São Paulo: Pearson Prentice Hall, 2005.

[3] GITMAN, Lawrence J. Princípios da administração financeira. São Paulo: Pearson, 2010. Pag 369

[4] KASSAI, José Roberto; KASSAI, Silvia; SANTOS; Ariovaldo dos; ASSAF NETO, Alexandre. Retorno de investimento: Abordagem Retorno: abordagem matemática e contábil do lucro empresarial. São Paulo: Atlas, 2000. Pag. 58 a 90.

[5] KEELLING, RALPH. Gestão de Projetos: uma abordagem global. Tradução de Cid Knipel Moreira. Revisão Técnica de Orlando Cattini Junior. São Paulo: Editora saraiva, 2006. p.45.

[6] RIO DE JANEIRO (ESTADO). Política de ação: eficiência energética. 10/2007. Governo do Estado do Rio de Janeiro. Secretaria de Estado de Planejamento e Gestão.

[7] SHAYANI Rafael Amaral. et al. Comparação do Custo entre Energia Solar Fotovoltaica e Fontes Convencionais. V Congresso Brasileiro do Planejamento Energético. Brasília, 2006.

[8] SILVA, E. L. & MENEZES, E. M. - Metodologia da pesquisa e elaboração de dissertação, 3ª Ed. revisada e

atualizada, 2001. - Laboratório de Ensino a Distância da UFSC, Florianópolis, 2001, pag 121.

[9] ZANIN, A.; BAGATINI, F. M.; BARICHELLO, R.; TIBOLA, A. Análise do Custo x Benefício na troca de Lâmpadas Convencionais por Lâmpadas LED: O Caso de uma Universidade Comunitária do Sul do Brasil. Anais... XXII Congresso Brasileiro de Custos, Foz do Iguaçu, PR, 2015. p. 1-13.

[10] AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA – ANEEL. Resolução Nº 482, de 17 de abril de 2012. Biblioteca virtual. Disponível em < http://www2.aneel.gov.br/arquivos/PDF/Resolu%C3%A7%C3%A3o%20Normativa%20482,%20de%202012%20-%20bip-junho-2012.pdf>. Acesso em 31 de outubro 2019.

[11] AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA – ANEEL. Programa de Eficiência Energética. Disponível em <https://www.aneel.gov.br/programa-eficiencia-energetica>. Acesso em 31 de outubro 2019.

[12] ABESCO – Associação Brasileira das Empresas de Serviços de Conservação de Energia - O que é Eficiência Energética? (EE) – Disponível em <http://www.abesco.com.br/pt/o-que-e-eficiencia-energetica-ee/ >. Acesso em 31 de outubro 2019.

[13] BRASIL. Balanço Energético Nacional. Relatório final – 2014. Disponível em https://ben.epe.gov.br/downloads/Relatorio_Final_BEN_2014.pdf. Acesso em 01 setembro. 2019.

[14] EMPRESA DE PESQUISA ENERGÉTICA – ABCDENERGIA – Eficiência Energética. Disponível em <http://www.epe.gov.br/pt/abcdenergia/eficiencia-energetica>. Acessoem 31 de outubro 2019.

[15] INMETRO- Instituto Nacional de Metrologia, Qualidade e Tecnologia – LÂMPADA LED . Disponível em<http://www.inmetro.gov.br/inovacao/publicacoes/cartilhas/lampada-led/lampadaled.pdf> Acesso em 31 de outubro 2019.