Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 12, Issue, 06, pp. 56980-56983, June, 2022
https://doi.org/10.37118/ijdr.24748.06.2022

ISSN: 2230-9926

RESEARCH ARTICLE OPEN ACCESS

TECHNICAL-ECONOMIC VIABILITY OF TUBULAR BIODIGESTER AND PHOTOVOLTAIC ENERGY FOR RURAL PROPERTY

Gabriela Feistauer Araújo[1], Armin Feiden[2] and Carlos Eduardo Camargo Nogueira[3]

[1] Master of the Postgraduate Program in Energy Engineering in Agriculture, State University of Western Parana UNIOESTE; [2]Doctor in Agronomics, State University Júlio de Mesquita Filho/UNESP; [3]Doctor in Electrical Engineering, Federal University of Santa Catarina / UFSC

ARTICLE INFO

Article History:
Received 20th March, 2022
Received in revised form
19th April, 2022
Accepted 23rd, May, 2022
Published online 28th June, 2022

Key Words:

Solar Energy, Renewable Energy, Biomass, Cattle Farming.

****Corresponding author:***
Gustavo Reis Araújo

ABSTRACT

Dairy cattle farming is an activity of great economic importance for Brazil, and the state of Parana has a relevant participation in national milk production. In order to reduce production costs, the generation of the electric energy in the distributed generation model appears as an alternative for the milk cattle farmer. Therefore, there are two possible options: The use of the property's animal waste for turning biomass into a biogas source, or the installation of photovoltaic panels. The objective of this work was to evaluate and compare through the use of economic engineering tools such as NPVand Payback, the feasibility of implementing these energy sources in a milk-producing property. The results demonstrated the economic viability of both forms of energy generation for a 25-year project horizon, considering a minimum attractiveness rate of 6,5%. Among the scenarios evaluated, the most financially interesting alternatives were those in which the cost of implementing the system was financed, since the considered interest rate of 3% per year is lower than the average inflation of 5,92% per year on the investment balances.

Citation: *Gabriela Feistauer Araújo, Armin Feiden and Carlos Eduardo Camargo Nogueira.* "Technical-economic viability of tubular biodigester and photovoltaic energy for rural property*", International Journal of Development Research*, 12, (06), 56980-56983.

INTRODUCTION

In 2018, Brazil was the world's fourth largest milk producer, behind India, the United States and Pakistan (FAO, 2019). The average worldwide growth in milk production between 2017 and 2018 was 2,2%, leaving Brazil, with 0,8% growth, below the world average. In this scenario, the Brazilian state of Parana has been outstanding in its participation in the national milk production according to preliminary data from the Brazilian Institute of Geography and Statistics (IBGE, 2017). In 2017, Brazil produced more than 30 billion liters of bovine milk, with Parana accounting for about 11,39% of this production. According to Pereira (2011), the need to reduce costs and increase food production in order to maintain competitiveness and meet international demands has as a consequence the constant increase in energy demand. In addition to the economic demands, which are pressing for a permanent increase in energy production, concern with environmental issues has also grown, causing the search for sustainable development to generate increasing interest in the use of renewable energy sources (SILVA, 2018). According to the Intergovernmental Panel on Climate Change (IPCC, 2014), about 25% of greenhouse gases are emitted in electricity and heat generation. Thus, increasing the use of renewable energy sources is an important strategy for reducing greenhouse gas emissions and thus combating global climate change (JENNICHES, 2018). In this scenario, photovoltaic panel systems and biodigesters stand out as sources of renewable energy and low carbon that provide alternatives for milk-producing properties to generate their own electric energy, making the comparative analysis of the technical-economic viability of the two forms of energy generation of paramount importance to assist in the decision-making of the milk producer. When a cost-benefit economic analysis is performed for an investment project, all costs and benefits assigned exclusively to the project are considered in a comparison between the scenario "with project" and the scenario "without project". Net present value (NPV), and *Payback* are used to determine the economic viability of a biogas plant (CHAKRABARTY *et al.*, 2013). The NPV consists in transforming into present value a series of revenues and disbursements of a given project; *Payback* is the time needed to recover the capital invested in the project. Morais (2012) demonstrated the technical and economic viability of the use of tubular biodigester with pig farming residues for the generation of electrical energy in a network connected system. The author used the NPV for economic evaluation.

In the case of photovoltaic solar energy, the economic analysis is simpler because there are no by-products of this form of energy generation (like the biofertilizer when using biodigesters), taking into account for economic analysis the initial disbursements for the installation of the system and the costs avoided with the production of energy. To Bai *et al*. (2019), the NPV is the main economic indicator for assessing the economic performance of a network connected photovoltaic solar system. Okoye *et al.* (2016) assessed the economic feasibility of using photovoltaic systems in Nigeria using NPV; the authors concluded that the use of this energy source is technically and economically feasible for use in urban residential areas in Nigeria. For Halder (2016), solar systems are economically viable even for local small-income businesses and homes. In Brazil, solar systems and biodigestors can be financedthe National Program for strengthening Family Agriculture– PRONAF - wich works with interest rates below inflation as an effort by the Brazilian government to foster economic and social development in agriculture and can, thus, increase the economic feasibility of such energy investments.

RESEARCH ELABORATIONS

The study property is located in the municipality of Brasilandia do Sul, in the state of Parana, in the northwestern mesoregion of the state, in the microregion of Umuarama. It is at latitude 24°13’32” S and longitude 53°31’51” and has an azimuthal deviation of 33°. When the study was carried out, the property worked with 68 cows of the pure Dutch cattle breed in lactation and confined to the free-stall production system . The cover of the shed where the animals are located has a total of 313,089 m², 14 ° slope and 33 ° azimuthal deviation. For the preparation of the photovoltaic project, the free software *Radiasol 2* was used to survey the daily solar radiation incident in the roof of the cattle shed. The software returned the values in kWh/m²/day for each month considered; the values were multiplied by the number of days in each month, resulting in a monthly average of solar radiation incident. After that, energy to be ideally generated by the system was calculated, in order to meet the energy demand of the study property. The monthly offset energy value was divided by 30 to obtain a daily value. The optimal system power was calculated by dividing the daily compensation energy value by the daily average solar radiation on the slope. A global performance factor (FP) of 0,70 (PINHO and GALDINO, 2014) was adopted in order to obtain the value of the system's real power.

A market survey was then conducted for the choice of the photovoltaic module and the interactive inverter. Dividing the actual power of the system by the power of the chosen photovoltaic module model, the number of modules required to meet the system was reached. By multiplying the monthly solar radiation on the slope with azimuthal deviation, FP and system power, the monthly generation potential of the system was found. The system voltage increase with the temperature drop on the surface of the photovoltaic panel was verified, as was the system voltage drop with the temperature increase on the surface of the photovoltaic panel. For the elaboration of the tubular biodigester project, the daily production of effluents (feces, urine from animals and washing water from the shed) was calculated by multiplying the value of the feces by EMBRAPA (2018) - equal to 93,7 $L.animal^{-1}.day^{-1}$ for milk cattle - by the number of animals in the property. The HRT was fixed at 30 days (ALVES, 2017). The amount of effluent produced per day and the HRT was determined, and the geometric project of the biodigester was developed according to the methodology proposed by Alves (2017). Having calculated the volume and other dimensions of the biodigester pit, daily biogas production was calculated on the basis of the value of milk cattle, which corresponds to 0,674 $m^3.animal^{-1}.day^{-1}$ (Medeiros *et al.* , 2019). Finally, the dimensions of the complementary elements were calculated (tarpaulin for waterproofing the pit, tarpaulin for the gasometer, input box and output box) according to the methodology proposed by Alves (2017). For the economic evaluation of each energy generation source, the 25-year design horizon and the 12-month energy consumption data (June 2018 to May 2019) of the property were considered. Equation 1 calculates the NPV, used in economic evaluation.

$$NPV = \sum_0^n Fn(1+i)^{-n} \qquad (1)$$

Where *n* represents the number of periods in each element of cash flow revenue and expense, *Fn*represents the values involved in net cash flow and *I* represents the minimum attractiveness rate (MAR) (BAI *et al*, 2019).

Equation 2 calculates *Payback*, also used in the economic evaluation.

$$\sum_j^N \frac{FCj}{((1+MAR)\times(1+I))^j} \geq |FC_0| \qquad (2)$$

Where, *N* represents the planning horizon of the project, *FC0* represents cash flow in the zero period, *FCj*expresses cash flow in the period of recovery of investments in the enterprise, *MAR* represents the minimum attractiveness rate, and *I* represents inflation (HALDER, 2016). The values presented in this study considered the exchange rate conversion of the year 2019, when 1,00 US dollars were equivalent to 4,00 Brazilian reais (R$) in average. For the photovoltaic project, both the costs of periodic deployment and maintenance and the costs avoided with the generation of energy in the property were considered; for the biodigester project, the costs of periodic implantation and maintenance were considered, as were the costs avoided with the application of the biofertilizer and with the generation of energy in the property. The costs of the equipment for the implementation of each project were quoted with companies in the market in 2019. For the photovoltaic project, the deployment costs included the value of photovoltaic modules, interactive inverter, fixation materials, project labor and installation. For the biodigester project, the implementation costs included the digesting pit value, the tarpaulin for covering the pit, the tarpaulin for gas storage, the materials for construction of the input and output box, and the motor-generator assembly. Two economic scenarios were considered for each of the projects: one in which the initial investment would be paid in full, and another in which the initial investment would be 100% financed under the conditions offered in 2019 by the National Program for strengthening Family Agriculture - PRONAF - in 10 years at an annual interest rate of 3%. In projects for individuals in Brazil, the minimum attractiveness rate (MAR) is generally equal to the profitability of a savings account; in the case of projects for companies, the MAR depends on factors such as time periods or strategic importance of alternatives (CASAROTTO FILHO and KOPITTKE, 1996). In this work, we chose to use 6,5% for the value of MAR, referencing the SELIC rate (Special System of Clearance and Custody) for June 2019. In addition to the MAR, the impact of inflation was taken into consideration for the analyzes, using a value equal to the average of the last 10 years (WORLD WIDE INFLATION, 2021). Since there is 53ha of corn planting for silage in the property, the cost avoided in mineral fertilizers with the production of biofertilizer was considered. For calculating the cost avoided with the production of the biofertilizer, an estimate was made for the amounts of nutrients present, relating them to the values found in industrialized mineral fertilizers. With nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) as primary macronutrients, required in larger quantities by plants, the equivalent concentration of these nutrients was considered as shown in Table 1, according to (Kunz et al., 2019).

Table 1. Amount of nutrients in residues of bovine milk ($kg.animal^{-1}.year^{-1}$)

Nutrient		
N	P_2O_5	K_2O
65,6	36,8	61,8

Source: Own authorship with data from Kunz *et al.* (2019)

Therefore, to estimate the biodigester’s annual nutrient potential in $kg.year^{-1}$, the values in Table 5 were multiplied by the number of animals in the property. After that, the value in kg of mineral fertilizers available on the market (urea, triple superphosphate and potassium chloride) was calculated to supply the same amount of nutrients present in the effluent of the biodigester. Finally, the price in

R$ (Brazilian reais) for the ton of mineral fertilizers was quoted - urea, potassium chloride and triple superphosphate - (INDEX MUNDI, 2021) to estimate the cost avoided by the production of the biofertilizer. The values were quoted for the month of May 2019, which was the last month of energy consumption considered in the study. To calculate the cost to be avoided annually by using biogas for electricity generation, the conversion factor considered was of 1 m 3 of biogas equivalent to 1,43 kWh (FERRAZ and MARIEL, 1980; SGANZERLA,1983) . The average value of the fee applied by the concessionaire during the evaluated period was R$ 0,41 per kWh. Thus, the annual cost avoided in electrical energy (CEN) is calculated by means of equation (3).

$$CEN = PB \times 1{,}43 \times 0{,}41 \times 12 \quad (3)$$

Where PB corresponds to monthly biogas production in m^3.month^{-1}. The value of the initial investment for the implantation of the biodigester was based on the volume of the biodigester pit, which once calculated was multiplied by an investment factor, according to Alves (2017). Thus, the total investment was equal to R$ 519,80 for each m^3 of biodigester pit. In addition, costs with annualized periodic maintenance were considered according to Alves (2017). According to Kohler (2017 *apud* ALVES, 2017), annual periodic maintenance costs are equivalent to 5% of the initial investment. Thus, this value was calculated using equation (4):

$$CMP = CINV \times 0{,}05 \quad (4)$$

Where CMP corresponds to the cost with periodic maintenance and CINV to the cost with initial investments. Maintenance costs for each five-year period were considered to be the equivalent of 10% of the initial investment (ALVES, 2017). According to the author, maintenance expenses every five years should be annualized by a correction factor equal to 1,3945.

$$CMQ = CINV \times 0{,}1 \times 1{,}3945 \quad (5)$$

Where CMP corresponds to the cost with five-year maintenance. Finally, the costs of environmental licensing for the biodigester were considered, the values of which are shown in Table 2:

Table 2. Taxes and charges applied

Rates and taxes	Value (U$D)
Prior license	33.228,78
Installation license	34.976,24
Operating license	25.719,00
Total cost	93.924,02

Source: Own authorship with data from (Gonçalves et al., 2018)

The average solar radiation value on the slope with azimuthal deviation returned by *the Radiasol software* was equal to 5,43 kWh/m²/day; the average monthly solar radiation value on the slope with azimuthal deviation was equal to 165,17 kWh/m²/month. The ideal energy value to be generated by the photovoltaic system in order to meet the energy needs of the study property, discounted the monthly 100 kWh of the three-phase network availability rate, was calculated at 5.313,42 kWh/month; the daily value was equal to 177,11 kWh/day. The system was scaled in 144 photovoltaic modules arranged in 8 strings of 18 modules each. To accommodate the system, a coverage area of 285,70 m² would be required - the north facing part of the roof of the shed, which has a more favorable solar position, has an area equal to 313,10 m², making it possible to have the whole system in the roof water, which provides a better usage of the solar potential. Since Brazil is located entirely in the southern hemisphere of the planet, it is advantageous that the photovoltaic system is set toward the geographic north. In the inverter chosen for the project, which has 4 maximum power point tracker (SPMP) inputs, 2 strings were connected per SPMP. The process of choosing the modules and the inverter proved iterative, as the modules needed to be arranged in a system compatible with the voltage range and operating current of the inverter – thus, even with modules of higher power or lower price in the market, these could not be arranged in a system that, at the same time, met the energy demand of the property and could be connected to the available inverters in the market working within its operating range. The total cost of the photovoltaic system was calculated in U$D 686.748,40, of which U$D 414.720,00 refers to the 144 photovoltaic modules; U$D 113.548,00 refers to the iterative inverter; U$D 52.826,80 refers to the hiring of labor for installation; U$D 79.240,2 refers to the costs of fixation and cabling structure and U$D 26.413,4 refers to the design costs. Taking into account the average annual increase in the energy fee, inflation, and MAR in the first scenario - in which the system would be paid in full and the interactive inverter would be replaced every 10 years - the *Payback* of the project was equal to 8 years and the NPV of the project was equal to U$D 1.097.678, showing that the project is economically viable.

In the second scenario (in which the impact of inflation, the increase in the energy fee, the MAR, and the replacement of the inverter every 10 years were also taken into account), where the cost of the initial investment for the system would be paid by means of financing in 10 fixed installments of U$D 80.507,88, there has been financial return since the first year. This was due to the fact that the value of the annual portion of the financing was lower than the annual revenue provided by the system's energy generation, with the accumulated balance already positive since the first year. For this scenario, the NPV was equal to U$D 3.185.918,72. In both cash flows, the income values (from the costs avoided by generating the energy through the system) were increasing, since an annual increase of 9,56% in the energy tariff was considered. Thus, taking into account a future scenario in which energy fees grow annually at the rate considered, costs avoided through the project are also increasing. The value of 9,56% for the energy tariff annual increase was set by calculating an average of the annual variations in the concessionaire's fee over the last 9 years (ANEEL, 2021). Since the NPV greater than zero indicates that the investment brings higher yields than the costs (MORENO, 2015), both scenarios were economically viable. However, the scenario with the largest NPV, and therefore most interesting from the financial point of view, was the one in which the initial costs of the project were paid out through financing - this indicates that even if the producer had capital available to pay for the project in full, under the conditions presented it would be more profitable in the long term to get the financing. The results showing the economic viability of the photovoltaic system confirm the data of Halder (2016) and Okoye *et al*. (2016).

In the tubular biodigester project, the volume of the calculated digestion pit was equal to 191,15 m^3, enough to receive the daily load of 6,37 m^3.day^{-1} of dejects. As for the allocation of the biodigester, there would be enough area to allocate it in the vicinity of the shed, which would optimize the costs with the inlet piping of the droppings in the digestion pit. The total cost of the project was calculated in U$D 565.572,96, of which U$D 397.434,92 referred to the construction of the biodigester (materials and labor); U$D 19.871,76 referred to the periodic maintenance; U$D 55.422,28 referred to the five-year maintenance and U$D 92.844,00 referred to the environmental licensing. The monthly biogas production calculated was equal to 20,22 m^3.animal^{-1}, less than the 28,50 m^3.animal^{-1} adopted by Alves (2017), which leads to a more conservative estimate of the cost of energy production through biogas. The system, therefore, would be able to produce 1.374,96 m^3 of biogas monthly, generating 1.966,19 kWh of electrical energy each month - a value lower than the average monthly consumption of electrical energy of the property. The cost avoided annually with biogas energy generation was calculated at R$ 9.673,67; the cost avoided annually with the use of biofertilizer at the property was calculated at R$ 23.750,00. Currently, the property has a manure maker that receives animal dejects, which are later used without any additional treatment as fertilizer for corn crops used for silage. Thus, taking into account the average annual increase in the energy tariff, inflation and MAR, 4 possible scenarios were outlined for the verification of the system's economic viability:

- System 100% financed under the conditions of PRONAF and using the biofertilizer in the property. In this scenario, the NPV was equal to U$D 1.019.506,28, with accumulated balance in positive value present since the first year;
- System paid in full and using the biofertilizer in the property. In this scenario, the NPV was equal to U$D 816.530,54, with accumulated balance in positive value present from year 6;
- System 100% financed under the conditions of PRONAF and without the use of biofertilizer. In this scenario, the NPV was equal to U$D 314.085,96, with accumulated balance in positive value present from year 12.
- System paid in full and without the use of the biofertilizer. In this scenario, the NPV was equal to U$D 111.110,028, with accumulated balance in positive value present from year 20.

In all the scenarios considered, the revenues had increasing values, since the average annual increase in the energy fee was considered, an increase which fell on the cost avoided by generating electricity from biogas.

CONCLUSION

The analyzes developed in this study demonstrate the technical and economic feasibility of implementing photovoltaic and tubular biodigester systems for the generation of electricity in the distributed generation model in the study property. However, the most financially interesting alternatives were those in which the cost of implementing the system was financed, since the interest rate of 3% per year considered is lower than the average inflation of 5,92% per year on the investment balances. Of all the options presented, the financing of the installation of a photovoltaic panels system connected to the network was what proved to be economically more advantageous, since the value of the annual installment was equal to U$D 80.507,88, While the cost avoided by the system already in the first year was equal to U$D 114.564,76; this alternative was also the one that presented the highest NPV, equal to U$D 3.185.918,72 on a 25-year project horizon. The biodigester project proved feasible, even if it did not fully meet the energy demand of the property and even when the revenues from the use of the biofertilizer in the property were not taken into account, because of the average increase of 9,56% per year in the electricity rate of the concessionaire considered in this study.

REFERENCES

ALVES, Anelisiane Maria. Desenvolvimento de um aplicativo computacional para dimensionamento técnico e econômico de biodigestores tipo tubular. 2017. 105 f. Dissertação (Mestrado) - Curso de Pós-graduação em Engenharia Energia na Agricultura, Centro de Ciências Exatas e Tecnológicas, Universidade Estadual do Oeste do Paraná, Cascavel 2017.

ANNEL – Agência Nacional de Energia Elétrica, 2021. Tarifa residencial – Evolução TUSD/TE. Availabe: https://app.powerbi.com/view?r=eyJrIjoiOTY0NWQzOGItMmQ3ZS00MWUzLTllNmMMWUz5NTYxODdhYTkzIiwidCI6IjQwZDZmOWI4LWVjYTctNDZhMi05MmQ0LWVhNGL5YzAxNzBlMSIsImMiOjR9&.

BAI, Bo et al. Economic analysis of distributed solar photovoltaics with reused electric vehicle batteries as energy storage systems in China. Renewable and Sustainable Energy Reviews, v. 109, Ago 2018, p. 213–229, 2019.

CASAROTTO FILHO, N.; KOPITTKE, B. H.. Análise de Investimentos: matemática financeira, engenharia econômica, tomada de decisão e estratégia empresarial. 7ª ed. São Paulo: Atlas, 1996.

CHAKRABARTY, Sayan; et al. Economic viability of biogas and green self-employment opportunities. Renewable and Sustainable Energy Reviews, v. 28, pp. 757–766, 2013.

EMBRAPA - EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. Metodologia para estimar o potencial de biogás e biometano a partir de plantéis suínos e bovinos no Brasil. 2018. FERRAZ, J. M. G., MARIEL, I. E. Biogás uma fonte alternativa de energia, Brasil, 1980. 27 p.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO), 2019. Dairy Production and Products – Milk Production.

GONÇALVES, A. D. et al. Dimensionamento e análise da viabilidade técnica e econômica de um biodigestor tubular. Revista Agrogeoambiental,v.4, pp 1-6, 2018.

HALDER, P. K. Potential and economic feasibility of solar home systems implementation in Bangladesh. Renewable and Sustainable Energy Reviews, v. 65, pp. 568–576, 2016.

IBGE. Censo agropecuário 2017. Instituto Brasileiro de Geografia e Estatística, v. 7, n. 01036157, p. 1–180, 2017.

INDEX MUNDI, 2021. Cloreto de potássio Preço mensal. Available: https://www.indexmundi.com/pt/pre%C3%A7os-de-mercado/?mercadoria=cloreto-de-pot%c3%a1ssio&meses=60&moeda=brl.

INDEX MUNDI, 2021. Superfosfato triplo Preço Mensal. Available: https://www.indexmundi.com/pt/pre%C3%A7os-de-mercado/?mercadoria=superfosfato-triplo&meses=60&moeda=brl.

INDEX MUNDI, 2021.Ureia Preço mensal. Available: https://www.indexmundi.com/pt/pre%C3%A7os-de-mercado/?mercadoria=ureia&meses=60&moeda=brl.

IPCC, editor. Climate Change 2014 – Mitigation of Climate Change Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

JENNICHES, Simon. Assessing the regional economic impacts of renewable energy sources - A literature review. Renewable and Sustainable Energy Reviews, v. 93, n. May, p. 35–51, 2018.

MEDEIROS, S. A. F. DE (COORD. .; SAMPAIO, F. G. (COORD. .; SOTTA, E. D. (COORD. . Diagnóstico da expansão da adoção da tecnologia de Tratamento de Dejetos Animais (TDA) no território brasileiro entre 2010 e 2019. Nota Técnica, p. 50, 2019.

MORAIS, Marcelo Antônio. Estudo experimental e avaliação econômica da operação de biodigestores tubulares para a produção de biogás a partir de resíduos da suinocultura. 2012. 92 f. Dissertação (Mestrado) - Curso de Mestrado em Engenharia de Energia, Universidade Federal de Itajubá, Itajubá, 2012.

MORENO, A. C. S. Avaliação técnico-econômica do uso de baterias para a racionalização de energia elétrica em aviários de frango de corte, 2015. Universidade Estadual do Oeste do Paraná.

OKOYE, Chiemeka Onyeka; et al. Solar energy potentials in strategically located cities in Nigeria: Review, resource assessment and PV system design. Renewable and Sustainable Energy Reviews, v. 55, p. 550–566, 2016.

PEREIRA, Gilberto. Viabilidade econômica da instalação de um biodigestor em propriedades rurais. 2011. 78 f. Dissertação (Mestrado) - Curso de Pós-graduação em Modelagem Matemática, Universidade Regional do Noroeste do Estado do Rio Grande do Sul, Ijuí, 2011.

PINHO, J. T.; GALDINO, M. A. Manual de Engenharia para Sistemas Fotovoltaicos. Rio de janeiro, 2014.

SGANZERLA, E. Biodigestor: uma solução. Porto Alegre: Agropecuária, 1983.

SILVA, Danieli Sanderson. Análise do custo e consumo em energia elétrica na cadeia produtiva de carne de suínos no Oeste do Paraná. 2018. 50 f. Dissertação (Mestrado) - Curso de Pós-graduação em Engenharia de Energia na Agricultura, Centro de Ciências Exatas e Tecnológicas, Universidade Estadual do Oeste do Paraná, Cascavel, 2018.

WORLD WIDE INFLATION. Inflação Histórica do Brasil – IPC, 2021. Available: https://www.inflation.eu/pt/taxas-de-inflacao/brasil/inflacao-historica/ipc-inflacao-brasil.aspx.

****