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Environmental Comparison of the Origin of Electric Power Consumed in Breweries

Daniel de Paula Diniz[1], Monica Carvalho[2,*]

[1] Graduate Program in Mechanical Engineering, Federal University of Paraíba.
[2] Department of Renewable Energy Engineering, Center of Alternative and Renewable Energy, Federal University of Paraíba.

*** Corresponding author: monica@cear.ufpb.br**

UFPB
Federal University of Paraiba

CEAR
Center of Alternative and Renewable Energy

INTRODUCTION

Beer is the most consumed alcoholic beverage in the world and its global consumption reached 2.5 billion hectoliters (hL) in 2016 (Statista, 2018). Brazil has a large share of this market, according to the Brazilian Beer Industry Association – CervBrasil (2016) , recently the country reached the level of 140 x 106 hL of beer produced, placing the country in the third position in the world rank, behind only China (460 x 106 hL) and the United States (221 x 106 hL), but in front of traditional brewing countries such as Germany (95 x 106 hL) and Russia (78 x 106 hL).

However, the large scale of beer production has resulted in substantial environmental impacts due to resource-intensive use. Alcoholic beverages, including beer, are estimated to account for 0.7% of global greenhouse gas (GHG) emissions when the life cycle is considered (Cimini & Moresi, 2016).

Electricity consumption by the Brazilian industrial sector represents 37.7% of all electricity generated in the country, and 9.2% of this consumption refers to the food and beverage industry, making this industry the largest consumer of electricity in the country.

OBJECTIVE

The aim of this study is to apply the Life Cycle Assessment (LCA) methodology to quantify the carbon footprint associated with the consumption of electricity in the beer industry, using as a case study a brewery located in the city of João Pessoa, Paraíba, Brazil. Northeast Brazil.

MATERIALS AND METHODS

The Life Cycle Assessment (LCA) methodology can quantify the potential environmental impacts associated with a product, process or service throughout its life cycle (or part of it).

The LCA is internationally validated and consolidated, being standardized by the International Organization for Standardization (ISO) in ISO 14040 (2006) and ISO 14044 (2006).

Simapro 9.0.0.49 software (2019) with the Ecoinvent database (2019) was used for the development of Life Cycle Assessment. The environmental impact assessment method selected was IPCC 2013 GWP 100y (IPCC, 2013), which groups GHGs emitted over a 100-year horizon, expressing the results in terms of a common metric, kg CO_2-eq.

For the consumption of electricity from the national grid, the methodology reported by Carvalho and Delgado (2017) was used to estimate the GHG emissions associated with the consumption of 1 kWh of electricity from the grid in Brazil in 2018, which used the National Electric System Operator data (ONS, 2018) for the period, dividing the sources of power generation into: hydroelectric 71.80%, thermal 16.70%, wind 8.30%, nuclear 2.70% and solar 0.50%.

For the electricity consumption from photovoltaic panels, a 3kWp slanted-roof installation, multi-Si, panel, mounted process was selected. The attributional approach is employed, where environmental burdens are allocated in proportion to the causative processes.

The Brazilian process comprises the generation of electricity (low voltage) in a 3 kWp system installed on a sloping roof with 30-year service life. Includes the manufacture and installation of multi-crystalline silicon panel (mc-Si, with 13.5% efficiency and 270-300μm cell thickness), ancillary equipment, cabling, and maintenance (cleaning) water.

Table 1 shows the electricity consumption of the brewery, obtained from a quantitative survey.

Table 1. Electricity Consumption at the Brewery

Month	Consumption (kWh)
December	4519
January	6218
February	5860
March	6350
April	5857
May	6252

RESULTS AND DISCUSSION

The carbon footprint associated with the electricity consumption of the Brazilian national grid in 2018 was 0.259 kg CO_2-eq/kWh. For the electricity obtained from photovoltaic panels, the carbon footprint was 0.076 kg CO_2-eq/kWh.

The factory production averages 50 hL/month, which corresponds to 116.85 kWh/hl of beer.

Table 2 presents the results of GHG emissions associated with the progressive substitution of electricity from the Brazilian electric mix by photovoltaic solar energy, for the brewery installed in João Pessoa - PB.

RESULTS AND DISCUSSION

Table 2. GHG Emissions associated with meeting the electricity demands of the brewery.

Partial replacement by solar energy (kg CO_2-eq)	
0% (Reference case)	1513
20%	1300
40%	1087
60%	874
80%	661
100%	448

With the total replacement of the energy source, using photovoltaic panels for power generation, the brewery emits about 448 kg CO_2-eq/month. This is much lower than the Business as Usual scenario, employing only the Brazilian electric mix, which emits 1513 kg CO_2-eq/month.

In a more realistic case, partial substitution is already very effective, representing about -213 kg CO_2-eq/month for each 20% substitution. Over the course of the year, considering the 12 months of operation, these values are quite significant: 2556 kg CO_2-eq/year when 20% of the electricity is substituted by photovoltaic.

Although the Brazilian electric mix is considered a low-carbon mix, in terms of significant hydroelectric contribution, it still presents an important share of fossil fuels. The partial introduction of solar photovoltaic electricity is quite beneficial in terms of GHG, as seen herein. The introduction of renewable sources, in general, is always beneficial when comparing with the utilization of fossil fuels.

A small brewery that produces about 50 hL per month was used herein as a reference. Considering the overall Brazilian reality, with a production of 12 x 10^6 hL per month, potential avoided emissions reach 613 x 103 t CO_2-eq per year with only 20% energy substitution. Even the partial replacement of electricity from the Brazilian grid with photovoltaic solar energy has significant potential for mitigating climate change.

CONCLUSIONS

This work quantified the carbon footprint associated with the consumption of 1 kWh of electricity to a brewery using electricity from the national electric mix (grid) and then simulated the progressive substitution by photovoltaic electricity generation. The partial substitution has been demonstrated to be an environmentally viable alternative.

The results can help inform how to diminish the negative effects associated with brewery activities. Applying similar research to food and beverage companies could mitigate the intensification of the greenhouse effect, as the sum of avoided emissions in different sectors is potentially high. Through such research and paradigm shifts, it will be possible in the near future to establish a low carbon economy.

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