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Greenhouse Gas Analysis of Energy Transition in Breweries

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INTRODUCTION

With population growth, technological development, and improvement in the living conditions of society, global energy demand has grown considerably and this has had negative impacts on the environment as most of this energy derives from fossil fuels.

Solar energy technologies have been increasingly employed as an alternative to reduce the environmental impacts associated with climate change and dependence on fossil fuels – however, in Brazil, despite the considerable solar potential, solar technology encouragement is still incipient.

Solar energy technologies have been demonstrated to mitigate climate change through reducing energy-related emissions, and can be divided into photovoltaic solar technologies and solar thermal technologies.

In the food and beverage industry, there are low (under 150ºC) and medium (between 150ºC and 400ºC) temperature thermal processes that can benefit from the use of well-established solar energy technologies

OBJECTIVE

The objective of the study presented herein is to apply the LCA methodology to quantify the greenhouse gas (GHG) emissions associated with providing process heat to a brewery located in Northeast Brazil.

Utilization of electricity (electric grid) and diesel is compared with solar thermal energy. The hypothesis is that even a partial replacement of traditional thermal energy sources presents environmental advantages.

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 (2018) 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. The functional unit considered herein was the consumption of 1 kWh of process heat.

For electricity consumption, the methodology of Carvalho and Delgado (2017) was used to quantify GHG emissions associated with the consumption of 1 kWh of electricity in Brazil. The most recent data available are for 2019: hydroelectric 66.67%, natural gas 9.28%, oil 1.55%, coal 1.62%, nuclear 2.79%, biomass 8.25%, wind 9.15%, solar 0.69%. An electric boiler with 90% efficiency was considered.

For diesel, the process considered the utilization of heavy fuel oil, in an industrial furnace, considering a 95% efficiency in this boiler. For the use of solar collectors, the process considered a solar collector system, with copper flat plate collectors, for hot water, which has an efficiency of 85%. The heat demand was utilized herein: for a microbrewery that consumes 950L of water daily, for approximately 44.23 kWh/day of heat is required.

RESULTS AND DISCUSSION

Initially, GHG emissions associated with the consumption of 1 kWh of the electricity from the grid were calculated, which totalled 0.2760 kg CO_2-eq per kWh consumed from the grid (low voltage).

Considering the efficiencies associated with each heat production process, the results for obtaining 1 kWh_{th} of process heat are presented in Table 1.

Table 1. GHG Emissions associated with the supply of 1kWh of heat.

Power Supply	GHG Emissions (kg CO_2-eq)
Solar Collectors	0.0144
Diesel	0.3490
Eletricity	0.2760

Table 1 shows that the utilization of electricity emits almost 21% less GHG emissions to the atmosphere than diesel, and solar collectors emit 96% less than diesel. The environmental advantage of solar collectors over electricity from the Brazilian electric grid for the production of heat yields 94% less emissions.

Considering that the annual heat demand for the microbrewery is 11,500 kWh (operating 252 days per year), Table 2 presents the results of GHG emissions associated with progressive thermal energy substitutions, based on this microbrewery.

RESULTS AND DISCUSSION

Table 2. GHG Emissions associated with the supply of 11,500 kWh of heat to a Microbrewery.

Partial replacement by solar energy (kg CO_2-eq)		
	Diesel + Solar	Eletricity + Solar
0% (Reference case)	4013	3174
20%	3243	2572
40%	2474	1970
60%	1704	1368
80%	935	767
100%	165	165

With the total replacement of the energy source, using solar collectors for water heating, the microbrewery analyzed emits to the atmosphere 165 kg CO_2-eq/year, much lower than if only diesel used to feed the heat generator boiler (4013 kg CO_2-eq/year) or electricity (3174 kg CO_2-eq/year). These are the *Business As Usual* scenarios.

In a more realistic case, partial substitution is already quite effective, representing -770 kg CO_2-eq/year for every 20% diesel replaced and -602 kg CO_2-eq/year for electricity replaced. There is an important potential for climate change mitigation associated with energy substitution.

Analysis of the results obtained herein confirm the hypothesis that even a partial replacement of traditional thermal energy sources presents numerous environmental advantages, with significant potential for climate change mitigation associated with the energy substitution of the heat source used in beer production processes.

CONCLUSIONS

The use of LCA concepts can inform the environmental benefit associated with energy source substitution, demonstrating that the introduction of solar thermal energy is an environmentally viable alternative, from the viewpoint of GHG emissions.

With total replacement of the energy source for heat production, the use of solar collectors for water heating emitted 165 kg CO_2-eq/year, much lower than if only diesel was used to power the hot water boiler (4,013 kg CO_2-eq/year) or electricity (3,174 kg CO_2-eq/year). In a more realistic case, partial substitution is already quite effective, representing -770 kg CO_2-eq/year for every 20% of diesel replaced and -602 kg CO_2-eq/year for electricity.

The results obtained in this work, added to future research in other sectors, can help reduce the negative effects of industrial activities. Applying similar research to different industries could mitigate the intensification of the greenhouse effect, as all GHG emissions are emitted into the atmosphere and the global sum of avoided emissions could be high, opening the path to establish a low carbon economy.

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