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Potential of climate change mitigation associated with the utilization of solar thermal energy in the ice cream industry

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INTRODUCTION

Concerns about excessive global warming due to anthropogenic activities have significantly increased interest in energy transition.

Energy decarbonization targets the use of low-carbon fuels or energy vectors to diversify the energy utility matrix, reduce dependence on fossil fuels, and mitigate climate change.

In terms of sustainability, Life Cycle Assessment (LCA) is one of the most modern methodologies of strategic environmental management, as it provides important information to decision making.

The use of solar thermal energy in industrial processes in Brazil still very timid compared to other countries in the world. The main sectors of the industry that require process heat are the food and beverage industry, especially dairy, processed meats and breweries.

An ice cream factory located in João Pessoa (Northeast Brazil) was selected to represent the case study: the existing system (LPG burner) was compared with a solar thermal energy system.

OBJECTIVE

Estimate the potential of climate change mitigation associated with the use of solar thermal energy in the ice cream industries of the state of Paraíba, Northeast of Brazil.

MATERIALS AND METHODS

The Annual Report of the Brazilian Ministry of Labor Information was consulted to obtain data on the number of ice cream industries in the Paraíba state (Northeast Brazil).

The LCA was developed with software SimaPro, utilizing two databases for the inventory: Ecoinvent 3 and Agri-footprint, and method IPCC 2013 GWP 100y for the environmental impact assessment (carbon footprint).

Table 1 shows the material and energy flows associated with the existing LPG system.

Table 1 – Material and energy composition of the current LPG system

Process	Material/ Energy Composition
Atmosferic Burner	5 kg tin-coated stainless steel, 10kg fiberglass, 160 kg hot-rolled stainless steel.
LPG combustion	71.522,68 MJ/kg LPG

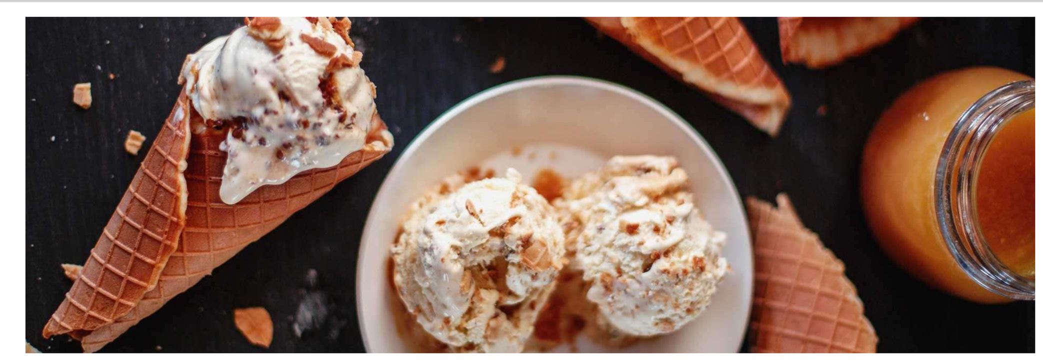
The average efficiency of the burner was considered to be 75%. After the end of its lifetime, the recyclable components of the equipment were recycled and the remainder was landfilled.

Table 2 shows the processes selected to compose the pasteurization process with solar collectors.

Table 2 – Material composition of the solar collector system

Process	Material
Hot water tank	47.04 kg aluminum 33.84 kg copper 109.32 kg solar glass 49.68 kg stainless steel 29.16 kg rock wool 8.88 kg rubber
Flat solar collectors (12m^2) Installation and connections	19.98 kg glass wool 2 kg PVC 220 kg low-alloy hot-rolled steel 40 kg stainless steel

RESULTS AND DISCUSSION



After the processes specified in Tables 1 and 2 were implemented in software Simapro using the Ecoinvent database. The IPCC 2013 GWP 100y method was selected and the figures 1 and 2 show the processes responsible for the higher shares of annual carbon footprints per system.

There is a considerable difference in the annual carbon footprint associated with the two systems: the use of solar thermal energy for the pasteurization process has approximately 95% less GHG emissions, resulting in avoided emissions of 2054 kg CO_2-eq/year.

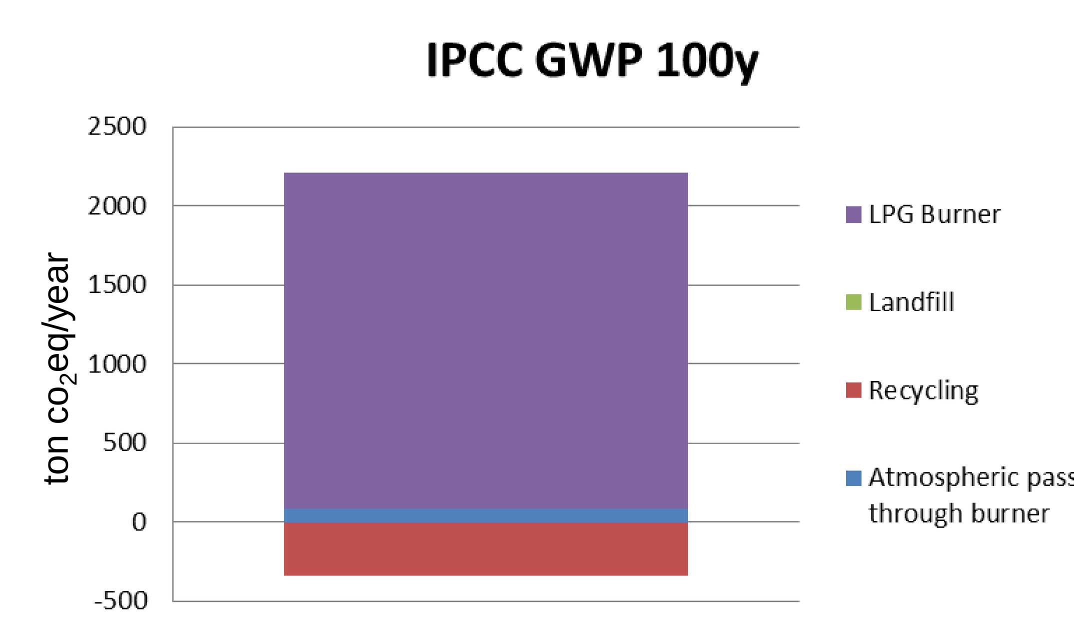


Figure 1 – Composition of the annual carbon footprint for the LPG system.

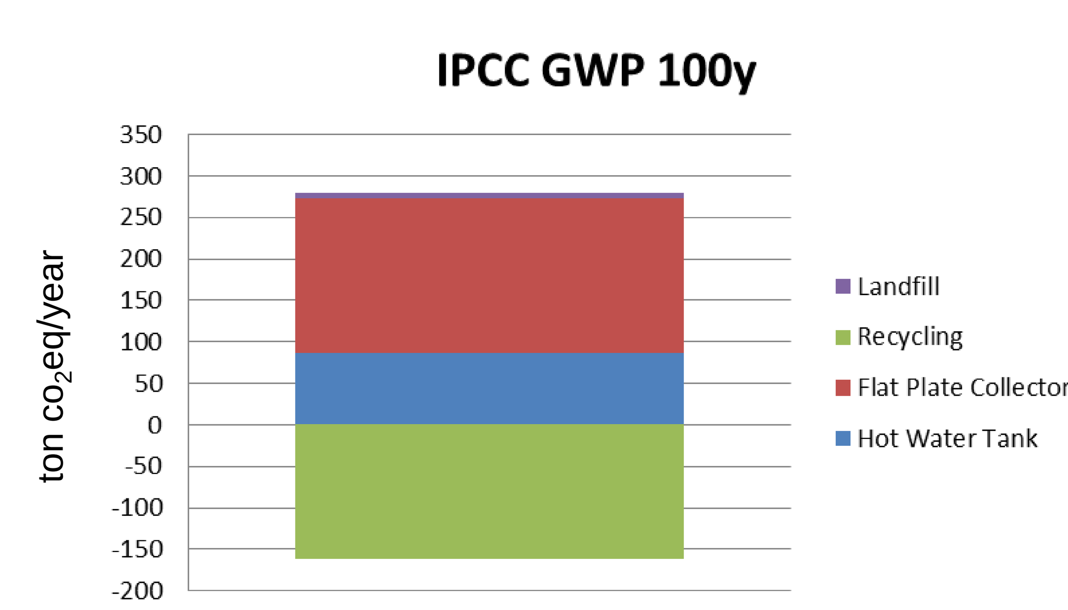


Figure 2 – Composition of the annual carbon footprint for the flat collector system.

CONCLUSIONS

A case study demonstrated the relevance of LCA when comparing the existing system for pasteurization, based on the burning of LPG, with a system based on solar thermal energy.

The carbon footprint associated with the existing system was 2,172 kg CO_2-eq/year, while that of the solar thermal system was only 117.9 kg CO_2-eq/year. An approximately 95% reduction in GHG emissions was observed, resulting in -2054 kg CO_2-eq/year.

Future work by the authors include LCA of other thermal processes (cooking, bleaching and cleaning) within the different branches of the Brazilian food industry.

ACKNOWLEDGMENTS

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