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Life cycle assessment integrated with thermodynamic analysis of bio-fuel options for solid oxide fuel cells

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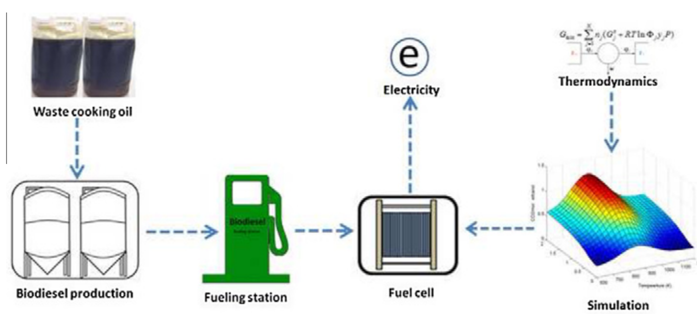
HIGHLIGHTS

- Feedstocks to produce bio-fuels for a solid oxide fuel cell auxiliary power unit.
- Energy and GHG emissions assessed through thermodynamic analysis and LCA.
- Optimal bio-fuel pathway in NY State is compressed natural gas from landfills.

GRAPHICAL ABSTRACT



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ABSTRACT

A methodology that integrates life cycle assessment (LCA) with thermodynamic analysis is developed and applied to evaluate the environmental impacts of producing biofuels from waste biomass, including biodiesel from waste cooking oil, ethanol from corn stover, and compressed natural gas from municipal solid wastes. Solid oxide fuel cell-based auxiliary power units using bio-fuel as the hydrogen precursor enable generation of auxiliary electricity for idling heavy-duty trucks. Thermodynamic analysis is applied to evaluate the fuel conversion efficiency and determine the amount of fuel feedstock needed to generate a unit of electrical power. These inputs feed into an LCA that compares energy consumption and greenhouse gas emissions of different fuel pathways. Results show that compressed natural gas from municipal solid wastes is an optimal bio-fuel option for SOFC-APU applications in New York State. However, this methodology can be regionalized within the U.S. or internationally to account for different fuel feedstock options.

1. Introduction

Heavy duty trucks (gross vehicle weight rating above 14,969 kg) serve as a common mode of long-distance product delivery within the United States. Conventionally, drivers tend to rest inside the truck cabin and keep the full diesel engine running to provide the auxiliary electricity. A recent report from the U.S. Environmental Protection Agency (U.S. EPA, 2010), however, indicates that trucks and locomotive engines idling for long durations consume over 4.55 billion liters of diesel fuel annually and release over 11 million metric tons of carbon dioxide as well as 150,000 metric tons of nitrogen oxides, which is equivalent to the greenhouse emission (GHG) from 2.3 million passenger vehicles on the road each year (U.S. EPA, 2005). Anti-idling legislation has been implemented in 31 states and prohibits running the diesel engine for long periods while the vehicle is at rest (U.S. EPA, 2006). A promising alternative technology is the solid oxide fuel cell auxiliary power unit (SOFC-APU) to provide power in the range of 2 to 20 kW for heavy duty trucks during rest intervals. The SOFC system

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