Replacing diesel with liquefied natural leads to a fuel economy of up to 60%

May 28 2019

Credit: CC0 Public Domain

The substitution of diesel oil with liquefied natural gas (LNG) for cargo transportation in São Paulo would possibly lead to a significant reduction in fuel costs and greenhouse gas (GHG) emissions—as well as other

pollutants—in São Paulo State, Brazil. This was presented in a study by the Research Centre for Gas Innovation (RCGI) supported by the São Paulo Research Foundation—FAPESP—and Shell.

Hosted at the Engineering School of the University of São Paulo (Poli-USP), the RCGI is one of the Engineering Research Centers (ERCs) financed by FAPESP in partnership with large companies.

"The biggest benefits, both in terms of pollution reductions and in prices of the fuels being discussed herein, are perceived in São Paulo and Campinas, which are regions with greater potential for substituting diesel oil with LNG and where diesel oil is more expensive than it is in the rest of the State. Our results show that in São Paulo, LNG can be up to 60% cheaper than diesel oil," said Dominique Mouette, Professor in the School of Arts, Sciences, and Humanities at the University of São Paulo (EACH-USP), in an RCGI press communiqué. Mouette is principal author of the article and leader of the RCGI project focusing on the viability of a Blue Corridor in São Paulo State.

The objective of the study, which resulted in an article published in *Science of The Total Environment*, was to evaluate the economic and environmental benefits of substituting diesel oil with LNG for the purpose of establishing a Blue Corridor in the state. This concept appears in Russia and designates routes on which trucks use LNG instead of diesel oil.

LNG is obtained by cooling natural gas to minus 163 °C. Gas is condensed so that its volume is reduced up to 600 times, making it possible to be transported using cryogenic carts to places located far from oil ducts.

To analyze the substitution of diesel with LNG, the investigation considered four scenarios. "Within the best scenario, the use of LNG

would reduce fuel costs by up to 40%; equivalent CO_2 emissions [a measure used to compare the potential heating effect among several greenhouse gases (GHGs), also known as CO_2-eq] by 5.2%; particulate materials by 88%; nitrogen oxides (NOx) by 75%; and would eliminate hydrocarbon emissions," states Pedro Gerber Machado, a researcher at the University of São Paulo's Institute of Energy and Environment and coauthor of the article.

"The methodology initially considered two contexts: one for the geographical regions served by gas pipelines, called the Restricted Scenario (RS), and another covering the 16 administrative regions of the state, called the State Scenario (SS). Both scenarios had different versions of the Blue Corridor, with 3,100 and 8,900 kilometers of roads, respectively," Machado explained.

According to Machado, in the case of each scenario, two forms of LNG distribution were considered: the first one considered a centralized liquefaction with road distribution and generated two subscenarios, a State Scenario with Centralized Liquefaction (SSCL) and a Restricted Scenario with Centralized Liquefaction (RSCL). The second would perform the liquefaction locally in the region where it would be used, which would eliminate the need for distributing LNG on highways. From this scenario, two more subscenarios were derived: the State Scenario with Hybrid Local and Central Liquefaction (SSHL) and the Restricted Scenario with Local Liquefaction (RSLL).

Cost comparison

"The RSLL scenario presents the lowest average price difference for the consumer between LNG and diesel, which means that, in this case, the delivery process of LNG is more expensive, as influenced by the scale factor and greater operating costs," Machado explains.

He continues, "The RSCL scenario offers the lowest gas price for the consumer, that is, 12 dollars per MMBTU (million British thermal units), whereas diesel, in this same scenario, would cost 22.01 dollars per MMBTU. The difference in price between LNG and diesel, in this scenario, is also the largest: 10.01 dollars per MMBTU."

However, the RSLL scenario was designed within the context of a shorter corridor, where the investment would be US$ 243.40 per meter. This contrasts with the SSHL scenario, which has the lowest investment per meter of the four scenarios (US$ 122.10 per meter).

Emissions avoided

Machado explains that to calculate the GHG and pollutant emissions, only the two macroscenarios were considered: SS and RS. "When using LNG, the GHG emissions are different from diesel oil emissions due to CH_4 and N_2O, which are greenhouse gases with potential for global warming. If the fuel used is diesel, CO_2 is responsible for 99% of the emissions of CO_2-eq, and if the fuel used is LNG, it represents 82% of the CO_2-eq emissions, while CH_4 is responsible for 10% and N_2O for 8%," he states.

Regarding the GHG emissions generated by the logistics of transporting LNG, the worst-case scenario refers to the SSCL and corresponds to 1% of the total CO_2-eq emitted with the use of trucks. In the SCHL, the logistics represent 0.34% of the emissions, and in the RSCL, the logistics correspond to 0.28% of the emissions.

As for pollutants, in the RS scenario, 119,129 tons of emissions from particulate matter (PM) would be avoided: 7.3 million tons of NOx and 209,230 tons of hydrocarbon (HC). In the SS scenario, the benefits are even greater, with reductions of 163,000 tons of MP, 10 million tons of NOx, and 286,000 tons of HC.

When one compares the burning of natural gas and diesel oil, the reduction of 5.2% in GHG emissions, which was observed in the State Scenario, might not be so great, but there are considerable reductions in local pollutants—NOx, PM, and HC saw reductions of 75%, 88%, and 100%, respectively.

However, despite the economic and environmental advantages presented, LNG still faces regulatory barriers to its general use in the transportation sector. "It is not regulated to be used as a fuel for vehicles in Brazil. Most of the LNG used here is compressed natural gas (CNG)," states Professor Mouette.

More information: Dominique Mouette et al, Costs and emissions assessment of a Blue Corridor in a Brazilian reality: The use of liquefied natural gas in the transport sector, *Science of The Total Environment* (2019). DOI: 10.1016/j.scitotenv.2019.02.255

Provided by FAPESP