

## **Small-scale natural gas liquefaction for trucks: the use of LNG in the transport sector in Brazil**

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### **Overview**

The use of natural gas as a fuel has many benefits, such as cleaner combustion, low-noise, fuel cost savings, reduction of greenhouse gas emissions throughout its life-cycle by 20 per cent to 25 per cent in comparison to diesel fuel. International experiences indicate natural gas as sustainable energy resource to replace diesel oil, especially when seen as a transitional fuel for a less polluting and renewable source (Yeh, 2007). Thus, Blue Corridors are routes for road transport (usually trucks) that use compressed (CNG) or liquefied (LNG) natural gas as a motor fuel. The main feasibility factor for the Blue Corridor is the existence of gas stations, which encourage the use of natural gas vehicles. In this study, only LNG will be analyzed.

### **Methods**

The objective of this study is to establish different possibilities for a blue corridor in the State of São Paulo based on the drawing of maps. It also analyzes the possibilities of the Blue Corridor in the São Paulo State, routes for heavy road vehicles that run on natural gas, considering its economic aspects. Generally, the methodology of this work is based on the application of the cartographic method (geoprocessing techniques such Geographic Information System (GIS)). For the maps preparation, it uses the geoprocessing software ArcGIS developed by ESRI, as well as secondary data acquired by public and private organizations which hold the necessary data for the present work. All the maps were made based on the Brazilian Regional Division (Divisão Regional do Brasil), determined by the transformation of concrete elements, such as the urban network, the hierarchical classification of the urban centers, the detection of the management flows, among others, which are capable to distinguish regional spaces in suitable scales. For economic analysis, natural gas was compared to diesel in different regions to identify where it is most viable, economically.

### **Results**

Two blue corridors were designed for the state of São Paulo, with 3.1 and 8.9 thousand kilometers each. The restricted scenario are limited to gas pipelines, which reduces the length of the blue corridor. On the other hand, the state scenarios SSCL and SSSL do not require natural gas delivery through pipelines, since liquefaction is done offsite and LNG is delivered through truck transportation. Results show that LNG is an affordable fuel choice when compared to diesel fuel. Even though regional differences are present in the state of São Paulo, no region show

disadvantages for LNG. Price differences range from 9.7 USD/MMBTU in Araçatuba in and 15.2 USD/MMBTU in Santos.

Environmentally speaking, reduction in GHG emissions of 5% is observed in CO<sub>2</sub> equivalent, due to greater CH<sub>4</sub> and N<sub>2</sub>O emissions in natural gas combustion compared to diesel. However, local pollutant emissions of NO<sub>x</sub>, PM and HC have considerable reductions of 75, 88 and 100%. The Highest reductions in overall pollution are perceived in São Paulo and Campinas, the regions with higher LNG substitution.

## **Conclusions**

The future implementation of such infrastructure depends on the viability of investments. In this sense, it is recommended to begin distribution with a centralized liquefaction with a road transportation of LNG that would supply LNG for the regions with the highest concentration of start and/or ending of trips and refueling (regions also with natural gas pipelines).

## **References**

Yeh, S. (2007) 'An empirical analysis on the adoption of alternative fuel vehicles: The case of natural gas vehicles', *Energy Policy*, 35(11), pp. 5865–5875. doi: 10.1016/j.enpol.2007.06.012.