

Perception of the Residents of Campina Grande (Brazil) of the Effects of Natural Gas Vehicles on Air Quality

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ABSTRACT

Natural gas has gained a good reputation as being one of the cleaner fuels. Several studies worldwide have shown that engines powered by compressed natural gas (CNG) produce the lowest emission levels compared to other fuels. This study aimed to determine the degree of public opinion about air quality, with a green vision, assessing attitudes about the use of natural gas vehicles (NGVs) as a possible way to mitigate the effects of air pollution in cities. The research was conducted with 100 NGV drivers, aged between 18 and 65. The instrument used was an anonymous questionnaire containing multiple-choice and fill-in-the-blank questions, administered between June and July of 2010. The results showed a possible improvement of air quality related to the use of CNG, frequency of car maintenance, safety check during refueling and adopted measures that contribute to mitigating the effects of air pollution in the city of Campina Grande. Most respondents believed that NGVs contribute directly and are efficient in improving air quality in urban areas, and half of those surveyed stated that they were concerned with safety and fuel prices. The concern most frequently shown during refueling at CNG stations was the Inmetro seal of quality control, while price was a minor factor. It was found that the respondents expressed the beginnings of environmental awareness, adopting the idea of preserving the environment, but were not giving up comfort and technology.

Keywords: air quality, CNG, NGV, pollution, Campina Grande

Abbreviations: CNG, compressed natural gas; NGV, natural gas vehicle

INTRODUCTION

The growing concern over global warming has pushed the automotive industry to reduce emissions of pollutants such as nitrogen oxide (NO_x), carbon dioxide (CO₂) and particulate matter (PM), due to their harmful effects on the environment, especially atmospheric air (Gellings 2011). At the same time, prices of conventional fuels such as gasoline and diesel are constantly increasing. These factors drive the development of environment-friendly fuels such as liquefied petroleum gas (LPG) and compressed natural gas (CNG) (Colombo 2004; Faria 2010).

Analysis of the global market for fuel conversion kits, which includes Brazil, reveals that the sale of these items in 2006 alone totaled 2.9 million units and is expected to increase, reaching 8 million by 2012. In Latin America, many countries are moving towards a large-scale use of vehicles adapted to CNG, with Brazil and Argentina being the largest buyers of conversion kits in the world. In these countries, the use of LPG as a vehicle fuel does not exist. However, the use of CNG is on the rise throughout the region (Frost and Sullivan 2007).

In Brazil, CNG was originally intended for use as a substitute for diesel fuel for the fleet of heavy vehicles in urban centers. This idea gave way to a greater widespread usage of CNG in the light vehicle fleet, due to difficulties inherent in the CNG market as a substitute for diesel, for example, the small price difference between diesel and CNG and the conversion cost of these vehicles (Pelliza 2003; Knight and Young 2010).

The CNG achieved a deserved reputation for being one of the cleaner fuels with respect to emissions generated by its use in the transportation sector, but also in its production process. Several studies worldwide have consistently shown that engines powered by CNG produce lower levels of

emissions compared to gasoline, diesel or LPG, despite the improvements achieved in the production of these fuels in recent years. Even when emissions are measured related to other clean fuels or methods, such as hybrid gasoline-electric, emissions from CNG are often lower. Besides producing lower emission levels, CNG also has lower environmental risks than other fuels (Brasil 2007; Vilela and Junior 2010).

Each year, there is a rise in environmental restrictions on emissions of motor vehicles, mainly in big cities, crowded with cars, buses and heavy trucks. The permissible levels of compounds in the exhaust will decrease in order to pollute less, encouraging research for alternatives and expanding the space for the penetration of clean fuels. Natural gas is an abundant energy source that is less harmful to the environment considering today's demands (Pelliza 2003; Pereira 2010; PCRJ 2011).

The discovery of oil reserves in the pre-salt layer in Brazil has been the subject of speculation in various branches of society, involving risks and rewards inherent in the exploration and production of oil and natural gas. The risks in the exploration of sedimentary basins in the country are considered high, but the size of reserves of oil and natural gas in the pre-salt is huge (Brasil 2009; Martins 2011).

The effects of air pollution are of great importance for future planning in order to avoid problems concerning the welfare of urban inhabitants, and also to raise ecological awareness, especially alerting young people and adults to the reality of global warming and the need for a better quality of life. Natural gas has gained a good reputation as being one of the cleaner fuels. Several studies worldwide have shown that engines powered by compressed natural gas (CNG) produce the lowest emission levels compared to other fuels. This study aimed to determine the degree of public opinion about air quality, with a green vision, asses-

sing attitudes about the use of natural gas vehicles (NGVs) as a possible way to mitigate the effects of air pollution in cities.

METHODOLOGY

The study of air quality with regard to CNG use as a way to alleviate urban air pollution, assessed the views of drivers of both sexes, living in Campina Grande, PB, and who had converted their vehicles to gasoline/alcohol/CNG use.

According to IBGE (2008), the city of Campina Grande, located in Paraíba state, is the second most populous municipality in the state and is situated 520 m above sea level, where it is known as the queen of Borborema. Campina Grande is about 120 km from state capital, João Pessoa. It is bordered to north by the cities of Massaranduba, Lagoa Seca, Pocinhos and Puxinanã, to the south by Fagundes, Queimadas, Boqueirão and Caturité, to the east by Riachão de Bacamarte and Ingá and to the west by Boa Vista. Its population was 385,276 inhabitants in 2010 and it exerts a great political and economic influence on 57 other cities. It was estimated in 2009 to have 49,321 vehicles. Campina Grande has the second highest gross product of the state of Paraíba, and its main economic activities are mining, agriculture, ranching, manufacturing, software, retail, wholesale and services. It has a semi-arid climate with temperatures as high as 31°C on warmer days and as low as 15°C on the coldest nights of the year. The city's population in the last two decades has complained about the "climate behavior" of the city, especially the heat, even in months usually considered cold. The relative humidity in the urban area varies between 75 and 83%.

The survey was conducted with 100 drivers aged from 18 to 65 years, where 83 were men and 17 women. A total of 50 drivers were interviewed at the NGV refueling station located in the southern part of town and 50 at such a station located in the western part. The instrument used was a structured questionnaire composed of multiple-choice and fill-in-the-blank questions in the period between June and July 2010, **Appendix 1**. The sample used was not probabilistic (randomly chosen).

The questionnaire assessed the views on the possible improvement of air quality through the use of CNG, the reason that prompted drivers to convert their vehicles for CNG use, the maintenance of NGVs and regular control by inspection agencies, verification of driver's safety when refueling, and measures taken to reduce air pollution in the city.

RESULTS AND DISCUSSION

The majority of respondents (60%) believed that air quality in the city of Campina Grande-PB is influenced by the use of CNG, 38% disagreed with such influence, and 2% had no opinion (**Fig. 1**). This perception is in agreement with Pian and Schirmer (2008), who conducted a study of pollutants from the fleet of public transport vehicles in the city of Cascavel, Parana State, using diesel fuel, biodiesel and CNG. These authors concluded that the use of diesel fuel shows the highest amount of emission of all the compounds analyzed, and that biodiesel and CNG are less polluting, resulting in benefits in relation to urban air quality and effect on the health and well-being of the public. CNG has a great advantage over the two other fuels when it comes to particles, because CNG does not emit such pollutants.

Despite the views of most respondents that CNG is environmentally better, most respondents (70%) converted their vehicle to use CNG for economic reasons (lower cost of CNG), 6% for better air quality and 24% for lower cost and better air quality (mixed opinion) (**Fig. 2**), showing that economic reasons are the major reasons for using CNG. Our data corroborate the findings by Mizrahy (2003), who found that only a small percentage (6.1%) of CNG users in Curitiba considered this important in reducing pollution.

Society is faced with the continuous problem of air pollution in the cities, which is getting worse due to the growth of the population and industry. According to the NGV drivers surveyed, most of them (76%) believed that NGVs contribute to reducing air pollution (**Fig. 3**), while

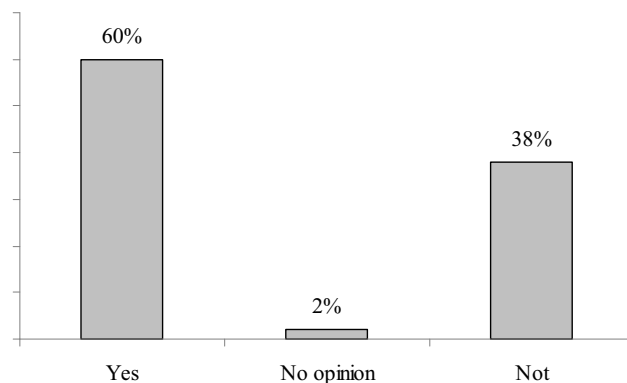


Fig. 1 Opinion of the owners of vehicles converted for CNG use in Campina Grande, about changing the city's air quality through the use of CNG.

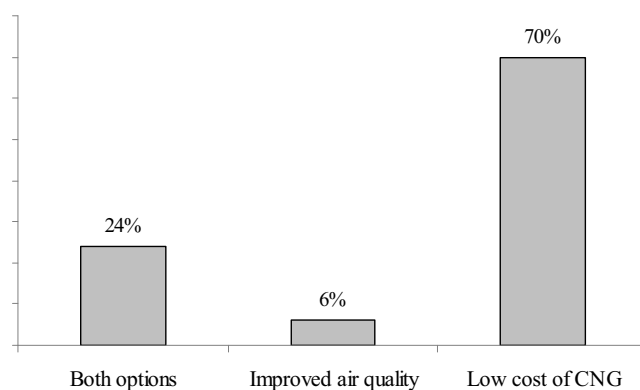


Fig. 2 Reasons for the conversion of vehicles for CNG use, according to owners living in the city of Campina Grande-PB.

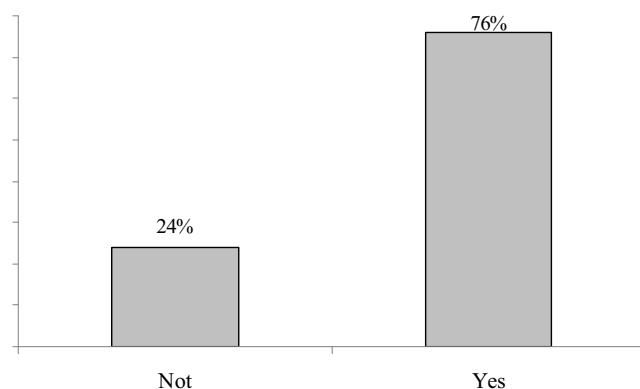


Fig. 3 Belief of the owners of vehicles converted for CNG use that this contributes to alleviating air pollution in the city of Campina Grande-PB.

23% did not agree with this association and 1% had no opinion. In fact, from an ecological perspective, the use of CNG is advantageous, resulting in less emission of polluting gases into the air, and CNG is a fuel that burns so clean that it not only produces scarce exhaust emissions, but hardly releases any combustion by-products (carbon particles and acids) into the engine oil (Brasil 2005).

The city of Campina Grande-PB has the second largest fleet of cars in the state, due to its importance and size. Failure to maintain vehicles can cause enormous damage to the environment and physical "health" of the city. According to the participants in the study (**Fig. 4**), 16% had regular maintenance on their vehicle at accredited stations and 84% did not. The respondents reported that this maintenance varied and involved replacement of parts, initial maintenance, inspection by accredited agencies, for example, inspection of emissions of certified vehicles (INSPE-VEC). In 2008, there were 3000 legal vehicles converted

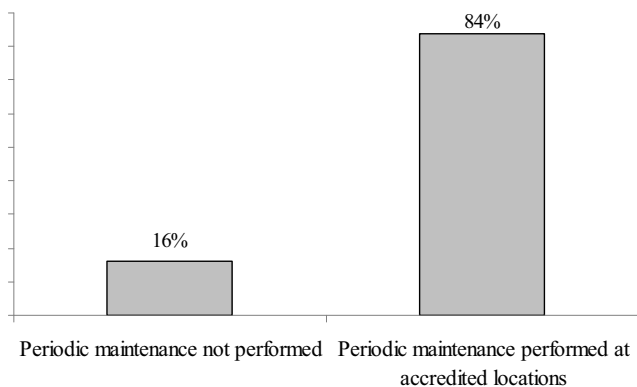


Fig. 4 Maintenance performed on CNG-powered vehicles according to owners in the city of Campina Grande-PB.

for GNV and registered only in the city of Campina Grande-PB, representing thus 6.57% of the registered vehicles in the city. It should be pointed out that there are vehicles on the city streets that are not approved and/or inspected by official agencies, making up an unknown percentage.

According to Azeredo and Rodrigues (2003), the process of licensing the vehicle to use CNG is a bureaucratic process that requires time and costs, since they are needed along with five-year check-ups, which is reflected in the finding that a minority of car owners interviewed had regular maintenance (Fig. 4). These results highlight the need to expand the inspection posts and maintenance stations, and to reduce the bureaucratic processes associated with the maintenance of CNG-powered vehicles.

According to Teixeira *et al.* (2008), who conducted a study on emissions from vehicles in the metropolitan region of Porto Alegre (Rio Grande do Sul), the fleet of vehicles running on CNG with/without a flexible fuel system (alcohol/gasoline) should modify the picture of emissions today, promoting the improvement of air quality. The estimate of emissions can be enhanced when inspection posts and vehicle maintenance are implemented, because it will then be possible to obtain a more precise idea of the distance traveled by the fleet each year and more accurate control of these emissions.

Considering the safety aspect during refueling, it is clear that CNG is safe, because during this process the fuel does not come in contact with the air. The following guidelines must be observed during the refueling of natural gas vehicles: the vehicle must be parked in the space provided with the parking brake on and the engine turned off, as well as the headlights, radio and cell phone; all occupants of the vehicle must get out and stay in a safe place; all electrical and electronic equipment within the area should remain off during refueling; the driver must open the trunk and hood of the vehicle; the attendant should be grounded next to the supply valve; and during CNG refueling, smoking or use of lighters should be forbidden in the refueling area. After CNG refueling, one should make sure that the refueling hose is disconnected before restarting the vehicle. The refueling pressure must never exceed 220 kgf/cm². Pressures above that threshold can cause leaks in the system, shortening the life of the equipment, and may run the risk of causing accidents (Brasil 2007). However, most of these recommendations are not followed, which results in increased risk of accidents associated with CNG (Fig. 5). Reflecting this, 14% of those surveyed said they had experienced incidents involving problems with the supply nozzle or pump. Nevertheless, 86% of respondents claimed never to have witnessed any accidents during refueling with CNG (Fig. 6). It should be noted that there were no injuries as a result of the accidents mentioned.

According to Globo Brasil Gas (2008), human error has been identified as the major cause of accidents with CNG (Gas Globo Brasil 2008). This study shows that about 96% of accidents occur as a result of the following: the improper

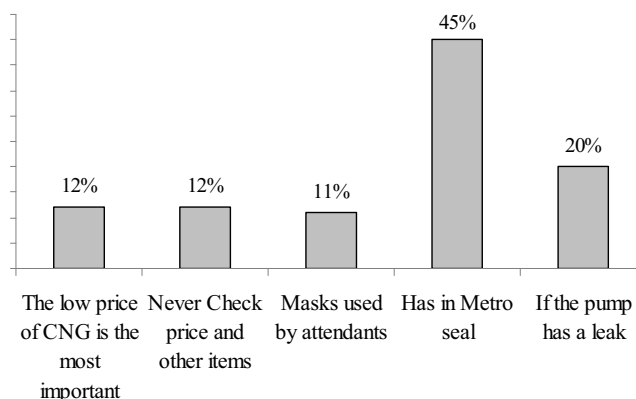


Fig. 5 Items checked by the consumer during refueling of CNG-powered vehicles in service stations.

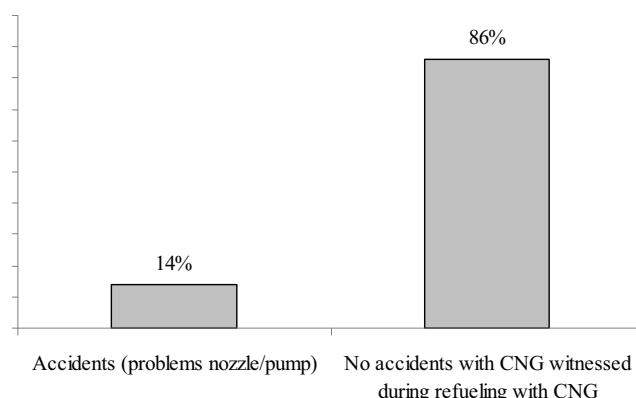


Fig. 6 Number of accidents with CNG witnessed.

use of components such as compressed air cylinder, Freon storage tank, high-pressure pipes made of copper, and CNG storage tanks that are welded and drilled; improper handling of components, such as obstruction or decalibration of pressure relief valve on the cylinder head; and lack of clarification regarding the use of natural gas systems (fire, caused by faulty electrical system). The other 4% of accidents occur due to failure of components not to specifications and leakage of CNG, poor maintenance of vehicle and natural gas system, and excessive pressure of CNG while refueling (above 220 kgf/cm²).

According to the site Gaspoint (2010), CNG is not toxic, has a high flammability point (very hard to keep flame; therefore safer than other fuels), has no impurities of any kind, cannot be adulterated, does not condense or drown the engine, and also disappears immediately after a leak.

In Campina Grande, according to 32% of respondents, the factor that most contributes to mitigating the effects of air pollution in the city was the maintenance, control and cleanup of landfills (Fig. 7); 24% chose the use of CNG and 24% noted the use of catalytic converters in vehicles powered by gasoline and ethanol, while 20% believed that the implementation of filters in city factories was the most important.

According to Pissinin (2002), the problem of waste management has been worsening, especially in metropolitan areas and in large and medium-sized cities, as a result of population growth, industrial development and the creation and/or change in consumption habits. With regard to filters in factories, measures can be taken to avoid or minimize industrial pollution, especially in cities through the use of technologies and appropriate filters, and recovery and use of some gaseous pollutants such as for raw material in making other products.

The opinion of respondents also corroborates the findings of Rangel and Carvalho (2003), who conducted a study on the impact of automobile catalytic converters on the control of air quality, and found that the converter coup-

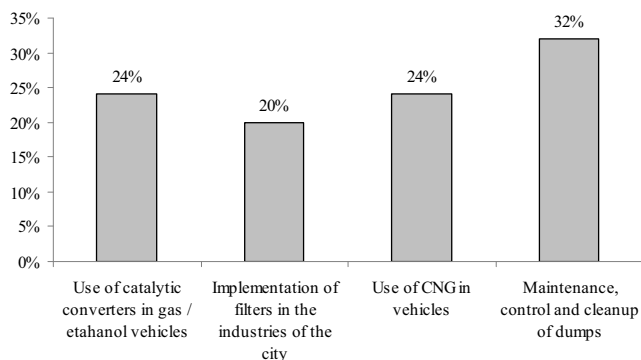


Fig. 7 Factors that affect the improvement of air quality, according to the opinion of NGV drivers.

led with changes in the design of cars, effectively achieved its proposed function and is regarded as an indispensable component of automobiles. Currently, the three-way converters represent the most competitive technology to meet the standards required to improve air quality.

According to Biesemeyer (2004), CNG is the best fuel for use in urban areas, where pollution controls are getting tighter, and it contributes significantly to improving the quality of life and environment through reducing emissions and improving air quality, while also providing major economic advantages to its user.

CONCLUSION

It was found that although the respondents were aware of pollution and air quality, global warming, and the need for vehicle maintenance, this was not enough to determine if there truly was an environmental consciousness among them, because economic factors had a preponderant influence. The use of NGVs can be very beneficial to metropolitan areas, since the replacement of diesel oil- and gasoline-powered vehicles would substantially reduce pollution in these areas. There is therefore a need to publicize the various efficient technologies for better utilization of the potential of natural gas and to make CNG more accessible to drivers. Our case study reveals that urban dwellers understand the need for environmental preservation and that the recognition of this need seems to be already displaying a great improvement in the ecological sense. However, this view has not been sufficient for the adoption of attitudes aimed at environmental conservation, which are tied to economic values. It is necessary to encourage energy efficiency programs targeted at urban populations to promote the spread of a new environmental awareness, which will provide economic benefits and improved quality of life, in addition to preserving the environment.

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APPENDIX 1 – QUESTIONNAIRE

Perception of the residents of Campina Grande (Brazil) of the effects of natural gas vehicles on air quality

Age: _____ Sex: M () F () Neighborhood where you reside: _____

QUESTIONNAIRE

1. In your opinion, did air quality improve in the last years with the use of compressed natural gas (CNG) use in vehicles in the city of Campina Grande-PB?
() YES () NO () DID NOT SENSE ANY CHANGE
 2. What motivated you most to convert your vehicle for CNG use?
 3. Do you believe that the use of CNG truly contributes to diminishing air pollution in the cities?
() YES () NO () NO OPINION
 4. Global warming is a reality that mostly affects the quality of life in large and medium-sized cities, and Campina Grande-PB has seen an increase in climatic temperature in the last 10 years. What are you doing to help improve air quality, in relation to the utilization and maintenance of your vehicle.
 5. When refueling with CNG at the service station (a), what did you note?
 - () Attendants use masks.
 - () Service station has an Inmetro seal.
 - () Pump appeared to have some type of leak.
 - () Price of CNG, which is most important to me.
 - () Never noted any of the above concerns.
 6. Have you experienced any type of incident while refueling with CNG? If so, describe.
 7. Based on your point of view, which of the items below contributes more to reducing the effects of air pollution in the city of Campina Grande-PB?
 - () Implementation of filters in city factories.
 - () Utilization of CNG
 - () Maintenance, control and cleaning of dumps.
 - () Utilization of catalytic converters in gasoline/alcohol-powered vehicles.
-