NATURAL GAS AS A TRANSPORTATION FUEL

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Abstract
Environmental concerns relating to gaseous emissions from transport have led to growth in the use of Compressed Natural Gas (CNG) vehicles worldwide with an estimated 13 million Natural Gas Vehicles (NGVs) currently in operation. Across Europe, many countries are replacing traditional diesel oil in captive fleets such as buses used for public transport and heavy and light goods vehicles used for freight and logistics with CNG vehicles. Initially this was to reduce localised air pollution in urban environments. However, with the need to reduce greenhouse gas emissions, use of CNG is growing as it provides a cleaner more energy efficient and environmental friendly alternative. This paper briefly examines the growth of NGVs in Europe and worldwide. Then a case study on the introduction of CNG in Spain and Italy is presented. As part of the case study, policy interventions are examined. Finally, a statistical analysis of private and public refuelling stations in both countries is also provided. CNG can also be mixed with biogas. This study and the role of CNG is relevant because of the existing European Union Directive 2009/28/EC target, requiring that 10% of transport energy come from renewable sources, not alone biofuels such as biogas. CNG offers another alternative transport fuel.

Introduction
Driven by a desire for a sustainable transport model, increasing crude oil prices and a dependency on oil the global transport sector is in a state of transformation. Security and diversity of energy supply is also a key driver in addition to cost, energy balance and environmental performance. Across the world, policy makers and industry players are seeking to develop holistic policies and transport packages. At a recent European Union (EU) Russian conference in Brussels on innovative uses of gas, transport was high on the agenda and included the implementation of a ‘blue corridors’ concept to promote the use of natural gas in the transport sector as well as efforts to improve infrastructure and the regulatory framework [1]. Other policies and measures range from reducing the amount of carbon in traditional (petrol / diesel) vehicles; moving people away from cars to public transport, walking and cycling; integrating transport systems (road, rail and air) and developing alternative technologies. One alternative technology which has gained significant support in Europe, and worldwide, is the use of Compressed Natural Gas (CNG) as a transport fuel within Natural Gas Vehicles (NGV). CNG is natural gas that has been pressurised to elevated pressures (typically 200-250 bar). Its main application is within NGVs.

In this paper the growth of NGVs in Europe and worldwide is examined. Then some statistical data from the Spanish and Italian markets is examined. Policy interventions are briefly presented. This study and the role of CNG is relevant because of the existing EU Directive 2009/28/EC target and the more recently published EU White Paper called a Roadmap to a Single European Transport Area, as CNG offers another alternative transport fuel [2 and 3].

Growth in Europe
Data on the number of NGVs in Europe is available from the International Association for Natural Gas Vehicles [4] and Natural Gas Vehicle Association of Europe [5]. Table 1 shows that the number of NGVs in Europe grew from 360,000 in 2000 to 1,372,262 by the end of 2010. This is an average annual growth of over 14%.
Table 1 Growth in NGVs in Europe since 2000

A breakdown of the European NGV fleet is provided in Table 2 and Table 3 provides a breakdown of the NGV refuelling stations.

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<tbody>
<tr>
<td>NGV</td>
<td>1.372</td>
<td>1.250</td>
<td>1.093</td>
<td>0.861</td>
<td>0.744</td>
<td>0.600</td>
<td>0.585</td>
<td>0.547</td>
<td>0.454</td>
<td>0.418</td>
<td>0.360</td>
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<tr>
<td>%</td>
<td>9.7%</td>
<td>14.4%</td>
<td>27.0%</td>
<td>15.7%</td>
<td>23.9%</td>
<td>2.7%</td>
<td>6.9%</td>
<td>20.5%</td>
<td>8.6%</td>
<td>15.9%</td>
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Table 2 Number of NGVs in Europe

- Cars/Light Duty Vehicles: 1,133,091
- Buses: 144,428
- Trucks: 107,727
- Other (including forklifts & road sweepers): 16,293
- Total NGVs Europe: 1,401,539

Table 3 Number of Existing & Planned NGV Refuelling Stations in Europe

- Public: 2,618
- Private: 1,102
- Planned: 398
- Total No. Stations: 3,720

Benefits of CNG as a Transport Fuel

Substantial fuel savings can be gained by moving from diesel to CNG. CNG across Europe is typically 30-60% cheaper than petrol or diesel. Research by the International Energy Agency (IEA) established that the average end-user price for CNG was 44% cheaper than diesel [6 and 7]. Air pollution is also responsible for around 100,000 premature adult deaths in Europe each year, with road traffic emissions accounting for a significant portion of this [8]. Urban air pollution is of particular concern with large volumes of slow moving vehicles / traffic in concentrated, localised areas. Climate change, health and the need to reduce emissions has become a key driver of change across almost all areas of European policy in recent years. Policies to reduce emissions focus on two main emission categories are greenhouse gas (GHG) and carbon dioxide (CO2); and local emissions specifically nitrogen oxides (NOx) and Particulate Matters (PM). European Union directives have placed great importance on the reduction of vehicle tailpipe emissions specifically PM, NOx, and CO2. A number of EU directives have been put in place to reduce these emissions which affect health – causing respiratory troubles, heart problems and premature deaths. Two of the main directives which seek to reduce PM and NOx are the National Emission Ceilings and Thematic Strategy on Air Pollution directives. The transport sector, principally road vehicles, is responsible for 28% of EU emissions of CO2, the main greenhouse gas. In Ireland, transport contributes 21.1% to overall GHG emissions in 2009 [9]. Emissions in 2009 were 156% higher than the 1990 transport emissions.
The specific CO₂ emission of methane expressed in gCO₂/MJ is some 25% lower compared with petrol and diesel [10]. A number of international studies demonstrate that CNG can reduce emissions in transport. In a study on refuse collection vehicles, it was concluded that CNG refuse collection vehicles are those that emit the lowest emissions of CO₂ during well-to-wheel, which means that their global environmental impact (greenhouse effect) is lower [11]. In this study CNG also demonstrated 13% lower tank-to-wheel GHG emissions (gCO₂-eq/km) than diesel. Turrio-Baldassarri et al (2006) [12], reported that “toxic emissions of a heavy-duty engine used for urban busses fuelled with CNG were measured and compared to what was emitted in identical conditions by an equivalent diesel engine fuelled with diesel oil… The results obtained show that the CNG engine emissions, with respect to the diesel engine fuelled with diesel), were nearly 50 times lower for carcinogenic PAHs, 20 times lower for formaldehyde, and more than 30 times lower for PM. A 20- to 30-fold reduction of genotoxic activity was estimated. A very high reduction of NOX was also measured. Based on the results obtained and on literature studies, it can be concluded that the use of CNG in public transportation can contribute the improvement of urban air, reduce adverse health effects and social costs of air pollution.”
followed. In Sweden, 65% of gas used in transport comes from biomethane. In Germany, at the end of 2009, 12% of 850 CNG refuelling stations had 10% biomethane at the dispenser [5]. Finally, the introduction of CNG as a transport fuel creates fuel diversity. By including a further option – natural gas has different sources with a completely different infrastructure in place – it reduces the dependency on foreign oil and reduces the risk of potential shocks in the oil market affecting the transport sector as a whole. This has been recognised by the EU in this year’s transport White Paper [3].

Case Studies
With a long history in CNG, Italy is Europe’s NGV leader, with 730,000 NGVs. The market has an active retrofit conversion industry, along with an increasing number of off-the-production-line vehicles and models from vehicle manufacturers especially Fiat. For the 10 year period since 2000 there has been an average annual growth of NGVs in Italy of 9%. Italy has 730,000 NGVs out of which 2,300 are buses and 1,200 are trucks. Figure 3 shows the growth in CNG vehicles in Italy. There are a total of 837 refuelling stations in Italy, of which 790 are public and 47 are private [5]. There has been strong support for NGVs from the Government and the gas industry in Italy. Along with their history of using natural gas as far back as early 1900’s, the Italian government has also used CNG to help improve air quality through the ‘the establishment of prevention rules instead of having to face the problem of pollution’ [13].

In 2006, the Italian government authorised the expenditure of €50 million for each of the years 2007, 2008 and 2009 [14]. In addition, Italian regions are given the autonomy to exempt new or converted cars; and NGVs within the M1 and N1 categories; from paying vehicle tax for up to 5 years. Other examples of CNG support and incentives include grants of up to €2,000 to purchase new NGVs; and grants of up to €650 for converting a vehicle (until 2009) [15].

There are over 2,900 NGVs in Spain which is primarily focused within the bus and truck sectors. The market has an increasing number of off-the-production-line vehicles and models from vehicle manufacturers, notably Iveco. For the 10 year period since 2000 there has been an average annual growth of NGVs in Spain of 129%. As of February 2011, Spain has 2,985 NGVs, out of which 1,374 are buses and 1,018 are trucks. There are a total of 44 refuelling stations in Spain, of which 3 are public and 41 are private [5].

CNG support and incentives include up to €2,000 for a new buses or refuse trucks; lower tax on natural gas as vehicle fuel (approx. 6.5 times lower than diesel); and grants of up to €60,000 for filling stations. Government support through Department of Commerce, Industry and Energy and within the Estrategia de Ahorro y Eficiencia Energética en España 2004-2012 E4 (Strategy for Savings and Efficiency) [16 and 17]. The E4 strategy includes e.g. plans for urban mobility; fleet management; efficient trucks and buses; and renewal of fleets. Large Spanish cities are encouraged to introduce such NGV e.g. the Municipal Company of Transportations Madrid have a fleet of over 500 CNG vehicles; 300 in the Metropolitan
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Company of Transportations of Barcelona, and approximately 160 in Tussam (public transportation in Seville) [18]. The transport strategy in Spain is further supported through the Strategic Plan of Infrastructures and Transportation, PEIT (2005-2020) and the Spanish Strategy of Sustainable Development (2007) [19]. Figure 4 shows the growth in CNG vehicles in Spain over the last 10 years [5].

![Figure 4: Growth in CNG Vehicles in Italy](image)

**Market Comparison**

The Italian market is a much more mature market and with 730,000 NGVs has a greater number of NGVs than the youthful Spanish market with 2,985 NGVs. This can be further emphasised when looking at the NGV statistics between the periods 1995 to 2010. Table 4 outlines the relatively ‘mature’ Italian market has 290,000 NGVs in 1995, whereas Spain only has 4 [5].

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<th>1995</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
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<tr>
<td>Italy</td>
<td>290,000</td>
<td>320,000</td>
<td>382,000</td>
<td>730,000</td>
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<tr>
<td>Spain</td>
<td>4</td>
<td>22</td>
<td>912</td>
<td>2,539</td>
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**Table 3 Comparison of NGV Markets in Spain and Italy**

From Italy's 730,000, 726,500 are categorised as ‘LD Cars and Commercial vehicles’, whereas Spain only has 550 in this category. This suggests a considerable difference in strategy and market development in each country. In Italy, as above, incentives and supports are offered to all NGVs including private cars. However, in Spain, incentives are focused predominantly on buses and trucks (especially refuse trucks). In addition, Italy offers grants for converting a vehicle to CNG, whereas in Spain the focus is on OEM NGVs.

<table>
<thead>
<tr>
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<th>LD Cars and Commercial vehicles</th>
<th>MD+HD Buses</th>
<th>MD+ HD Trucks</th>
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<tr>
<td>Italy - NGVs</td>
<td>726,500</td>
<td>2,300</td>
<td>1,200</td>
</tr>
<tr>
<td>Spain - NGVs</td>
<td>550</td>
<td>1,374</td>
<td>1,018</td>
</tr>
<tr>
<td>Spain as a % of Italy</td>
<td>0.1%</td>
<td>59.7%</td>
<td>84.8%</td>
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</table>

**Table 4 Comparison of NGV Markets in Spain and Italy**

Table 4 shows that over a relatively short period of time, with a clear focus on buses and trucks, Spain has grown these NGVs to related levels as found within the much more mature Italian market [5]. Of course, in parallel with a strategy of developing private vehicles along with buses & trucks, it is not surprising to find a relatively strong, well distributed refuelling network in Italy. From a total of 837 refuelling stations, the vast majority i.e. 790, are accessible to the public and 47 are private. However, in Spain, where the strategy is targeted at buses and trucks, 93% of the stations are private.
Table 5 Comparison of NGV Markets in Spain and Italy

Table 5 also shows that in a relatively short period of time, Spain has developed a similar number of private refuelling stations as there are in Italy [5].

Stakeholders in Ireland

Janssen et al (2006) outline that the stakeholders in NGV market development can be divided into three main categories, which include the policy making stakeholders, the external stakeholders and the interdependent stakeholders [20]. Using this model, the key stakeholders in Ireland include those identified in Figure 4.

Figure 4: Potential Partners in Growth in CNG Vehicles in Ireland

Discussion & Conclusion

This paper showed that NGVs in Europe and worldwide is growing. An analysis of data from the Spanish and Italian markets is examined. This investigation demonstrated that a country like Spain can achieve very high levels of success and development over short period of time in the CNG market place to Italy, for example, a country comparable in size, but with a much longer history in NGV. The key potential stakeholders in the Irish market are identified. Finally, this study is relevant because of the existing EU Directive 2009/28/EC target and the more recently published EU White Paper called a Roadmap to a Single European Transport Area, as CNG offers another alternative transport fuel.

Acknowledgement

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