WHAT IS REQUIRED TO DEVELOP A GASEOUS TRANSPORT INDUSTRY IN IRELAND?

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Abstract

The utilisation of gaseous transport fuel is currently being overlooked as a sustainable option to satisfying a proportion of the 10% renewable share in final transport energy demand by 2020 as mandated by the EU Renewables Directive (2009/28/EC). Compressed Natural Gas (CNG) and its renewable form biomethane, provide an alternative sustainable transport fuel to meet the 10% target; which the Irish Government aims to satisfy with biofuels (9%) and electric vehicles (1%). A blend of biomethane and CNG (bio-CNG) can bring diversity to Ireland's transport fuel portfolio as well as a number of benefits such as: indigenous production, emissions reduction in carbon dioxide, nitrogen oxide and particulate matter, economic savings and flexibility. Gaseous transport is an established industry across the globe with over 13.5 million natural gas vehicles (NGVs) in operation annually. However, it is still to be developed in Ireland. With such worldwide penetration, what is required to develop a gaseous transport industry in Ireland?

The development of a bio-CNG transport industry in Ireland requires strategic enterprise with a common purpose. Firstly, bio-CNG needs definite political support in terms of offering tax relief for a specified period to allow the industry to find its market. Such a scheme has seen the uptake of over 90,000 NGVs in Germany. Inclusion in strategic policy to satisfy a percentage of the Renewables Directive target would further strength the promotion of bio-CNG. A capital grant scheme to assist the development of anaerobic digestion focussed on biomethane production similar to the capital grant that was available for biogas to CHP is required. In terms, of injecting biomethane into the national gas grid, a specific injection policy is needed which defines parameters such as: gas quality specification, costs of connection, pressure requirements and commercial shipment of gas. Finally, application of bio-CNG to a niche market would ensure that a degree of certainty and demand is maintained once bio-CNG is economically competitive. Captive fleets can provide Ireland with a launch pad to a vibrant gaseous transport fuel industry.

Assuming tax relief is provided, bio-CNG can offer fleet operators circa 52% savings in comparison to diesel. Entry into a long term agreement between bio-CNG providers and fleet operators would ensure that the demand for bio-CNG is consistent and unlike electric vehicles; the development of a market is not dependent on private vehicle sales. Utilisation of the national gas grid will also increase; promoting new connections in the network which will increase the throughput of gas, thus reducing the sale tariff to the customer. The initiation of a bio-CNG industry through the captive fleet market could meet 1% renewable share in the final energy demand of the transport sector by 2020 through the fuelling of approximately 14,000 commercial vehicles in Ireland.

Global gaseous transport

Gaseous transport fuel can be delivered in the fossil fuel form of Compressed Natural Gas (CNG) and is a mature form of transport fuel. *Thamsiriroj, et al* offers an insight into the simplicity of CNG as a transport fuel; little processing from well to wheel, clean burning and worldwide utilisation [1]. The utilisation of CNG is a fully developed transport fuel technology throughout the globe with over 13.5M Natural Gas Vehicles (NGVs) operating worldwide consuming circa 3,7M Nm^3 of natural gas each month [2]. Europe currently fuels 21% of all NGV's worldwide, with Italy being the main contributor to NGV development in Europe as there were 790 public CNG stations fuelling over 0.7M NGVs in 2010 [3].

Gaseous transport fuel can also be renewable in the form of biomethane and has a similar composition as CNG. Anaerobic digestion is the process of converting organic matter into biogas energy in an oxygen free environment. Biogas typically consists of methane (55%), carbon dioxide (45%) and contains a number of trace impurities such as hydrogen sulphide and ammonia. When biogas is utilised in the natural gas grid or as a transport fuel, it must be upgraded through carbon dioxide removal to leave biomethane (>97% methane). Injection of biomethane into the national natural gas grid is a rapidly emerging technology in many countries throughout Europe. The German biomethane market has seen rapid growth since the first two biomethane injection plants were commissioned in 2006. In 2011, there are a total of 57 plants feeding into the natural gas network, with 900 CNG stations fuelling over 94,500 NGVs [4, 5]. The utilisation of biomethane as an admixing product with natural gas is known as bio-CNG. In Germany, bio-CNG mix proportions are usually in the range of 5-20% biomethane [4].

Rising transport fuel prices

Ireland is an island country which is heavily dependent on imports, especially in the transport sector. In 2010, circa 97.9% of the Irish transport sector energy demand was satisfied by traditional fossil fuels such as petrol and diesel relating to motor vehicle fuel and kerosene relating to aviation fuel; equating to a 120.7% growth rate in fossil fuel usage in transport since 1990 [6].

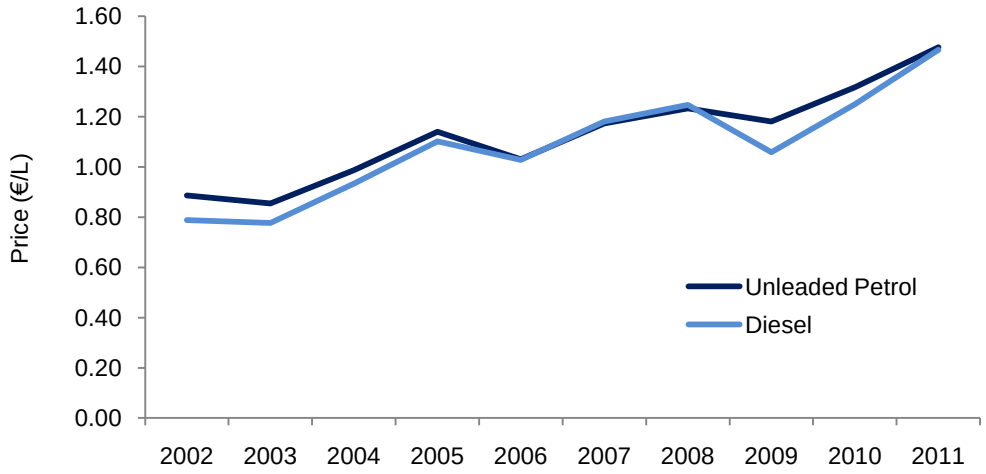

Figure 1: Fossil fuel transport prices at the pump in Ireland [7].

Rising international crude oil prices coupled with a higher cost of living have seen Irish motorists paying all time high prices at the pump. Figure 1 illustrates the rapidly rising increase in petrol and diesel prices for Irish motorists since 2002 [7]. During the last decade, petrol has traditional been slightly more expensive than diesel. Petrol prices have increased

by 81.6% since 2000 retailing at €1.48/L in December 2011, while diesel prices experienced an increase of 91.9% over the same period, retailing at €1.47/L in December 2011.

Focus of paper

Gaseous transport is an undeveloped form of transport energy in Ireland. There are currently no commercial CNG facilities and although a few anaerobic digesters are in operation, biomethane injection to the national grid is proving intangible to develop. Although, there are significant advantages to gaseous transport fuel over petrol and diesel, there are a number of commercial, technical and regulatory barriers facing the development of a bio-CNG industry in Ireland. This paper highlights the key advantages of bio-CNG while also outlining the key requirements and possible solutions to effective bio-CNG development. The potential of a bio-CNG industry is also realised with respect to the Renewables Directive (2009/28/EC) and recommendations are given to assist the development of such an industry.

Advantages of bio-CNG

Price:

The price of bio-CNG comprises of two elements; biomethane production price and natural gas commodity price. *Browne, et al* state that the energy content of one cubic metre of bio-CNG ($1m^3$) has an energy content equivalent to a litre of diesel equivalent ($1L_{DE}$) and can be compared on a sound basis [8]. *Browne, et al* derives the price of biomethane produced in a 50,000tpa facility utilising grass silage and pig slurry as €1.406/L_{DE} [8]. In terms of CNG commodity, the price of natural gas is strongly linked with continental oil indexed prices and is constantly changing in a vibrant trading market. Irish energy utility Bord Gáis Energy (BGES) prices suggest that industrial and commercial natural gas prices deviate from €0.045/ L_{DE} to €0.35/L_{DE} depending on demand requirements and market conditions [9]. *Browne, et al* states that the cost of CNG compression is €0.244/ L_{DE} [8] and therefore the analysis in this paper concludes that the price of CNG is circa €0.602/L_{DE}. Figure 2 highlights the price at the pump of bio-CNG dependant on the blend of the admixture. It is important to note, that biomethane blending cannot be physically measured, and thus is determined on the notional balancing of biomethane entering and exiting the grid. This paper assumes that excise duty is excluded. Bio-CNG with an 80% blend of CNG will cost €0.76/L_{DE} in comparison to price of diesel at €1.47/L, equating to a 52%. As CNG is the cheaper element in the bio-CNG, the greater the volume of CNG in the blend, the lower the price of bio-CNG at the pump. Bio-CNG favours significantly in comparison to traditional diesel and petrol once excise duty is excluded and assuming that improving NGV engine efficiency can compete with petrol and diesel engines.

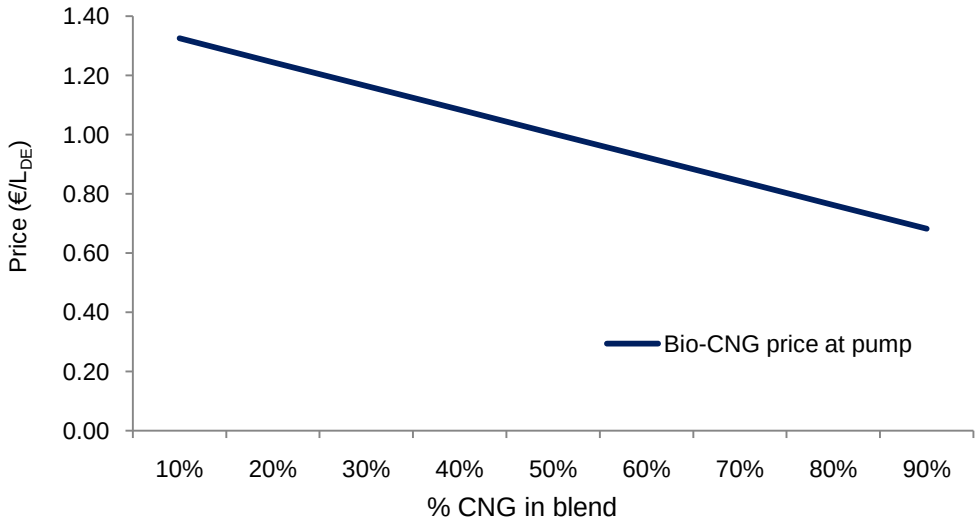

Figure 2: Bio-CNG transport prices at the pump dependant on admixture blend.

Renewable targets:

The Renewables Directive of 2009 has pressed the Irish government to develop renewable transport infrastructure to achieve a 10% renewables share in final transport energy demand (RES-T) by 2020 [10]. The Irish government aim to achieve this mandatory target in the form of mixing biofuels (mainly imported) with traditional petrol and diesel and also the introduction of electric vehicles (EVs), satisfying 9% and 1%, respectively. The introduction of a bio-CNG industry will bring diversity to Ireland's RES-T portfolio, with the added advantage of biomethane receiving double credits for renewable production in achieving the mandatory targets [10].

Greenhouse gas emissions:

CNG provides a more environmental friendly alternative to fossil fuels with *Thamsiriroj, et al* finding that CNG saves up to 38% and 21% in greenhouse gas emissions in comparison to petrol and diesel, respectively [1]. *Ryan and Caulfield* found that the utilisation of bio-CNG instead of just CNG can reduce greenhouse gas emissions by a further 63% [11].

Rapid development:

As seen in Germany, a bio-CNG industry was developed over a six year period resulting in 55 biomethane injection facilities being commissioned between 2006 and 2011 [4, 5]. Like Germany, Ireland has the necessary infrastructure available in terms of the natural gas grid. Bord Gáis Networks (BGN) is the owner of the natural gas network in Ireland which it operates via an operating agreement on behalf of Gaslink - the Independent System Operator (ISO). In 2010, BGN owned a total transmission network length of 2,373km and another 10,856km of distribution network throughout the country which transported 79,500GWh of gas [12]. The network has the capabilities to facilitate the injection of biomethane in rural Ireland and provide bio-CNG distribution in all the main cities of Ireland.

Barriers to development

The development of a bio-CNG industry in Ireland is dependent on a number of requirements being satisfied. Such key requirements and potential solutions to overcome these issues are discussed in Table 1.

Type:	Requirement:	Solution:
Commercial	Successful market penetration	In Sweden, biomethane penetrated the transport industry by focussing on the captive fleet. Bio-CNG can offer urban fleet companies value for money and the consistency of refuelling on-site.
	Commercial route to market	Utilities suppliers need to provide gas trading agreements with biomethane producers to ensure commercial validity of injection.
	Biomethane transportation tariffs	The network operator will need to derive exit, entry and commodity tariffs for biomethane as is currently the case with natural gas.
Technical	Biomethane quality specification	Part G, Appendix A of the Gaslink Code of Operations details the quality specification for all natural gas entering the grid [13]. A similar specification is required for biomethane or at least a modification to the code to allow biomethane injection under the current specification.

	Natural gas network capacity	Ideally, a biomethane facility should be developed near a point in the distribution network where a significant consistent demand is required even through low demand seasons [14].
	Natural gas network pressure requirements	The pressure of natural gas is typically between 25 mbarg and 4 barg for the distribution network and is between 19 barg and 85 barg for the transmission network [14]. For a biomethane facility to inject successfully into the grid, a compressor unit is required to modify the gas to above the operating pressure of the network at the point of entry. Injecting into the low pressure distribution network will be more cost effective in terms of compression costs as the degree of pressure change is less.
	Connection agreement between the network operator and the biomethane producer	A connection agreement is required between the two parties detailing all the technical requirements of the network operator, as there is with all natural gas entry connection points [14].
Regulatory	Excise relief	A long term guarantee for excise duty relief from the Irish government is required to provide certainty for biomethane developers, bio-CNG fuelling stations, and fleet operators.
	Capital grant programme	In 2008, the Sustainable Energy Authority of Ireland (SEAI) introduced a capital grant programme for anaerobic digestion to CHP providing up to €1.5M per facility. That programme has now ended but should be renewed to facilitate biomethane development as a transport fuel.
	Regulatory support for biomethane injection	The common rules for internal natural gas markets are laid down in EU Directive 2009/73/EC and states that renewable gas products like biomethane cannot be discriminated against when seeking grid injection [1, 15].
	Animal-by-Products certainty	The Animal-by-Product Regulations define how feedstocks and digestate by products are handled and treated in the EU. *Thamsiriroj, et al* outline that Animal-by-Product Regulations in Ireland are interoperated much more severely by the Irish government than other EU countries [1]. This disadvantages biomethane developers in Ireland as much more expensive methods of treating feedstock such as pasteurisation are required; increasing capital costs of the facility [1]. The implementation of the Animal-by-Product Regulations in Ireland needs to be adapted to the standard of other EU countries to assist biomethane developers

		while ensuring that biomethane feedstock is treated effectively.
	Incentives for bio-CNG consumers	The provision of government incentives such as a capital grant for the purchase of NGV's for fleet operators similar to the capital grants of €2,500 for electric vehicles is required. This will incentivise fleet operators to purchase NGV fleets and close the gap between the capital cost of NGV's and traditional fossil fuel vehicles. Motor tax relief and free motor certificate testing should also be provided.

Table 1: Requirements and possible solutions to initiate a bio-CNG industry in Ireland.

Potential for a bio-CNG industry

The satisfying of the requirements in Table 1 would leverage significant potential to develop a gaseous transport industry in Ireland in the form of bio-CNG. Based on analytical works of *Browne, et al*, a 50,000tpa agricultural digestion facility can produce circa 2.1Mm^3/a of biomethane equating to 77,000TJ/a of transport energy [8]. To achieve the RES-T target by 2020, the inclusion of gaseous transport can bring diversity to Ireland's green transport portfolio. The SEAI currently forecast that Ireland's total transport energy demand will be 167.7PJ in 2020 [6]. With electric vehicles sales currently struggling, a bio-CNG industry can assist the shortfall. Figure 3 illustrates that 11 such agricultural biomethane facilities are required to achieve 1% of RES-T in a phase development process from 2014 to 2020. Assuming an indicative blend of CNG of 80%; this results in the production of approximately 23M L_{DE} and 115M L_{DE} of biomethane and CNG each year, respectively.

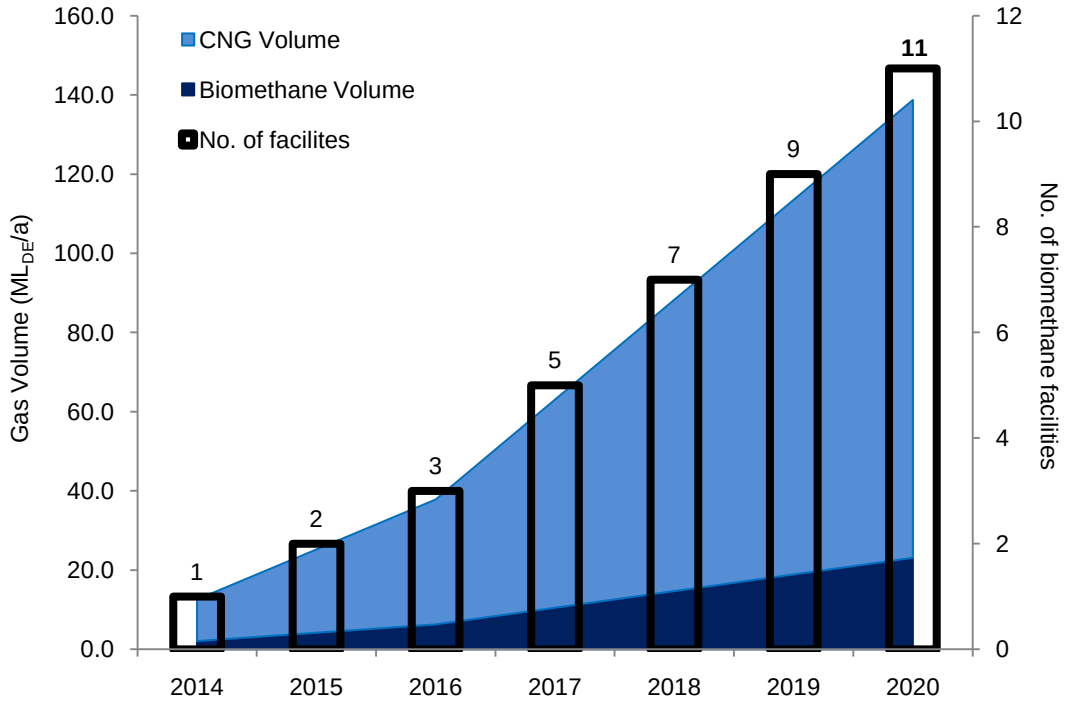

Figure 3: Biomethane facilities and bio-CNG output with 80% CNG blend.

Such a quantity of gas will displace vehicles currently operating on traditional fossil fuels. From applying the Swedish model, this paper suggests to focus on captive fleets such as bus companies, light goods vehicles (large vans) and taxi services. Figure 4 depicts the number of vehicles required to achieve a 1% RES-T, based on 50% of the produced volume of bio-CNG being attributed to light goods vehicles, 30% to buses and 20% to taxis. Based on NGV vehicle efficiencies from industry and assumed distances travelled per annum [16], 11 biomethane facilities deploying a 80% blend of CNG can achieve a market share (based on 2010 government data [17]) of 5.0% (5,839 vehicles), 7.5% (754 vehicles) and 29.1% (7,556 vehicles) in the light goods, bus fleet and taxi services sectors, respectively. The aggregate of such penetration equates to a market share of 9.3% (14,149 vehicles) by 2020.

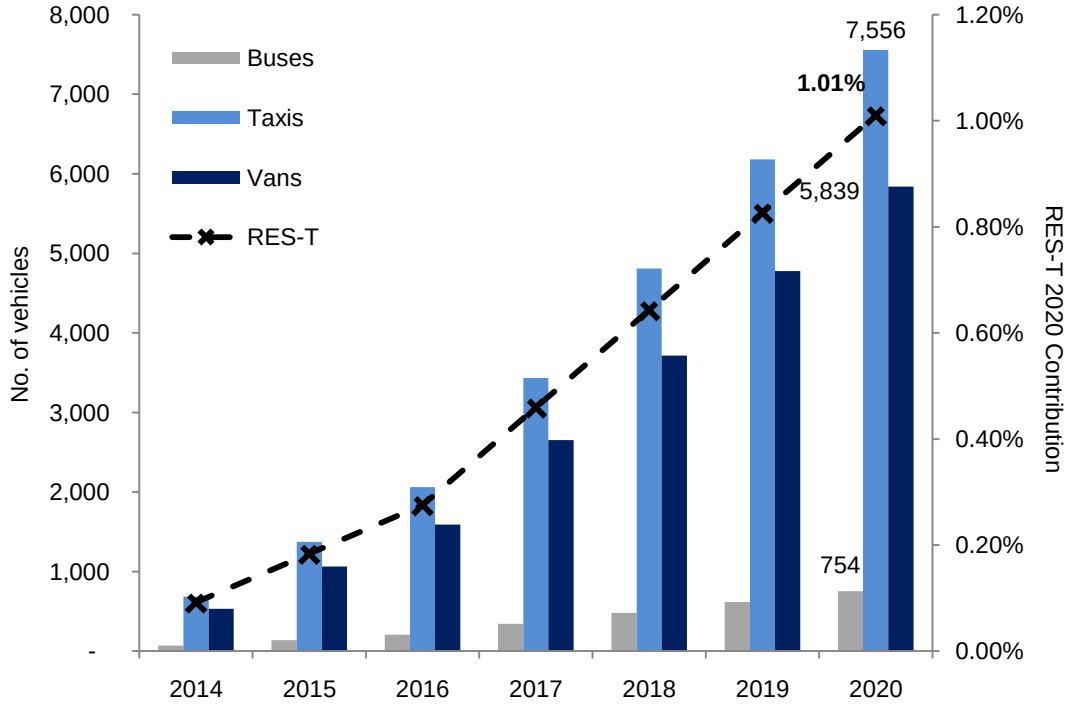

Figure 4: Biomethane facilities and bio-CNG output with 80% CNG blend.

Conclusions

When looking at other European countries that have successful gaseous transport industries such as Germany and Sweden, there is a strategic relationship between all commercial, technical and regulatory aspects of their development and operations. This paper highlights the requirements and solutions needed to deliver a suitable bio-CNG industry in Ireland with key concerns flagged such as finding suitable market penetration, technical requirements of the natural gas grid and strategic regulatory policy commitment and incentives. The delivery of such support tools will encourage fleet operators to look at alternatives to rising fossil fuel prices in the form of petrol and diesel, with a bio-CNG blend of 80% offering 52% saving in terms of price. The production of biomethane as a transport fuel offers a number of significant advantages over fossil fuels; it provides a renewable form of energy, it is indigenously produced, and it can contribute to Ireland's RES-T target of 10%.

To achieve a 1% share of RES-T from biomethane, 11 agricultural biomethane facilities should be commissioned in a laddered approach from 2014 to 2020. If devising a bio-CNG fuel product with an 80% blend of CNG, over 14,000 captive fleet vehicles (light goods vehicles, buses and taxis) can be fuelled in Ireland by 2020. This equates to an aggregate market share of 9.3% for the respective vehicle sectors. To allow such an industry to develop, a long term commitment to excise duty relief and a capital grant programme for biomethane facilities is required to give confidence to potential developers. The inclusion of

excise duty element on bio-CNG can be introduces once bio-CNG becomes competitive in the market.

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