GUIDE TO NEW AUTOGAS MARKETS

A STEP-BY-STEP APPROACH TO INTRODUCING LPG USE FOR TRANSPORT BASED ON LESSONS LEARNED FROM SUCCESSFUL MARKETS

DECEMBER 2021

WLPGA

LPG EXCEPTIONAL ENERGY

FOREWORD

*I am very pleased to provide a foreword to this revised and updated version of **WLPGA Guide to New Autogas Markets**. Autogas is the world's most popular alternative transport fuel to diesel and gasoline (petrol). Over 29 million vehicles are using Autogas today worldwide which is making a major contribution to improving air quality in urban cities. In Nigeria we recognise the important role that LPG can play in the total energy mix, and we are examining ways to maximise the utilisation of LPG to reduce flaring and further exploit our reserves. Autogas brings many benefits including cleaner urban air quality, reduced greenhouse gas emissions and an affordable alternative to petrol and diesel. This revised and updated version of **WLPG Guide to New Autogas Markets** is a valuable document for countries who are looking at introducing Autogas as it outlines a comprehensive step by step approach to developing Autogas markets. The government of Nigeria fully endorses this guide and will certainly be referring to it as we move towards introducing Autogas into our country.*

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ACKNOWLEDGEMENTS

This Guide was originally drafted in 2018 by Cecile Nourigat and David Tyler of the WLPGA and reviewed by the WLPGA Autogas Focus Group.

This latest update was completed in 2021 by David Tyler to coincide with the third Global Autogas Day event held in Dubai during LPG Week in December 2021. The final draft was reviewed by the WLPGA Autogas Focus Group.

Special thanks go to Angelique Berden – Westport Fuel Systems/Prins, Cinch Munson - Oberon Fuels (and previously PERC), Stuart Weidie – Blossman Gas, Andrzej Olechowski and Mateusz Piaścik – POGP, Pasquale de Marco and Giancarlo Cattini - Landi Renzo.

Rajeewa Sirisuriya, of Inzolutions, Australia, also made some valuable contributions.

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(Autonews - actualité automobile, essais, nouveautés, salon - Autonews)

LIST OF ACRONYMS

AEGPL/LGE	European LPG Association/Liquid Gas Europe
AFV	Alternative fuelled vehicles
BioLPG	Molecules of propane and butane produced from biological sources
CI	Carbon Intensity (grams of CO_2 released per megajoule of energy produced)
CNG	Compressed natural gas
CO_2	Carbon dioxide
ECU	Electronic control unit
EV	Electric vehicle
GHG	Greenhouse gas
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas (called Autogas when used as a transport fuel)
NOx	Nitrogen oxides
OEM	Original equipment manufacturer
PM	Particulate matter
PERC	Propane Education Research Council
WLPGA	World LPG Association

EXECUTIVE SUMMARY

Autogas – Liquefied Petroleum Gas (LPG) used as a transport fuel – is the most used and accepted alternative transport fuel in the world today.

'…THERE IS AN OPPORTUNITY FOR GOVERNMENTS TO TAKE ADVANTAGE OF USING AUTOGAS AS A TRANSPORT FUEL…WHY AREN'T MORE COUNTRIES USING AUTOGAS…?'

This Guide contains a 'toolbox' of information, drawn from the experience of successful markets, to present a one-stop-shop for those wishing to develop new Autogas markets. It is also a useful document for governments that are considering developing expansion plans for Autogas.

At the end of 2020 there were over 29 million Autogas vehicles in use around the world. They included cars, taxis, vans, minibuses, small trucks, and even two and three wheelers.

The restrictions on movement imposed by COVID-19 led to a dramatic downturn in global demand for all transport fuels. Gasoline and diesel consumption dropped by 12% and 6% respectively in 2020 compared to 2019. Autogas demand in 2020 fell by over 10% to 24.5mn t compared to the previous year. The last time it was at this level was in 2012.

Now more than ever, as the world emerges from the COVID-19 pandemic and strives towards a cleaner world, there is a need for strong and effective advocacy in support of Autogas as a clean transport fuel option.

While Autogas use is still concentrated in a small number of countries, it exists in all regions of the world. The top ten Autogas countries: Russia, Turkey, South Korea, Ukraine, Poland, Italy, Mexico, Kazakhstan, China, and Algeria, together accounted for over 70% of global Autogas consumption.

It is an exceptional engine fuel featuring strong performance and lower emissions of carbon dioxide (CO_2), and harmful pollutants, than conventional fuels. Recent tests conducted by the Indian Auto Coalition confirmed that (Emissions From LPG Vehicles Much Lower Than Newer BS-VI Grade Petrol, Says Study (news18.com)). So why aren't more countries using Autogas?

With countries targeting a net zero carbon future, there are opportunities for governments to promote Autogas to displace the traditional transport fuels - gasoline and diesel. This is especially true for diesel, which is reeling over the emissions scandal, and confirmation by the World Health Organization (WHO) in 2021 that diesel emissions are a group one carcinogen to humans.

The WLPGA is a strong advocate of Autogas and has overseen the publication of this update of *Guide to New Autogas Markets* to encourage new Autogas markets to develop around the world. An Autogas Focus Group, with representatives from some of the largest and most successful Autogas markets in the world, reviewed this publication.

The Autogas value proposition is strong (Charter-of-Benfeits-Autogas.pdf): LPG as a transport fuel is a mature technology, the fuel is convenient, easy to handle and demonstrates good performance in engine applications, and it is compatible with most type of vehicles and usages. What is more, LPG powered vehicles emit less CO_2 and less pollutants – nitrogen oxides (NOx) and particulate matter (PM) in particular – than conventional fuels. The environmental performance of Autogas is one of the main reasons why it is being incentivised by public authorities in order they can tackle worsening urban air quality and reduce greenhouse gas emissions.

For the motorist, the main attraction for using Autogas is the opportunity to reduce motoring costs. The financial attractiveness of Autogas over other fuels depends on the net cost of acquiring an Autogas vehicle – or converting to one – the pump price of Autogas relative to diesel and gasoline, as well as other tax benefits. All these are heavily influenced by government policy decisions.

SUCCESSFUL, SAFE AND SUSTAINABLE AUTOGAS MARKETS NEED:

- SUPPORTIVE LONG-TERM GOVERNMENT POLICY
- COMPREHENSIVE REFUELLING NETWORKS
- AVAILABILITY OF AUTOGAS VEHICLES, AND A SAFE AND EFFICIENT CONVERSION PROGRAMME
- POSITIVE CONSUMER PERCEPTION TOWARDS AUTOGAS

But non-financial elements also play an important role. Key success factors are considered in Chapter Four and are summarised here:

- A smart, long term, regulatory environment is necessary to grow Autogas by ensuring the continuous confidence of policymakers, investors, and consumers in the technology

- Recommendations are provided in this Guide for vehicle conversions to Autogas, the location and design of Autogas refuelling stations and associated Autogas equipment, including dispensers, to ensure the Autogas industry continues to grow in a sustainable manner

- While the commitment of vehicle manufacturers (OEM's) contributing to making Autogas a 'normal and accepted' technology, many new markets rely on the conversion of vehicles to LPG from gasoline (and sometimes diesel) to kick-start Autogas use

- Key standards and safety practices from established markets are provided as a benchmark for emerging Autogas markets, to ensure a positive perception from consumers'

There are a wide range of technologies to choose from depending on the characteristics of the target market - especially the type and age of the vehicle carpark - and the expectations of the consumers. This information needs to be considered before planning the development of LPG distributors and conversion kit manufacturers' market deployment strategy.

This Guide has been produced to promote the concept of Autogas, to provide recommendations and engender supportive policies to encourage governments, and other important stakeholders, to consider Autogas by creating a compelling proposition. It does not pretend to be exhaustive and contains links to further sources for additional information and knowledge enhancement.

A report published by the WLPGA addressing lobbying and advocacy in support of Autogas was first published in 2004. An extract from the first edition has been included in Appendix Three because it is still relevant today.

CHAPTER ONE – BACKGROUND

1.1 THE NEED FOR THIS DOCUMENT

The objective of this Guide is to leverage the knowledge and experience of the WLPGA and its members to support the emergence of new Autogas markets around the world. It provides recommendations on how to build and grow a safe and sustainable Autogas industry.

Although Autogas is used all over the world, over 70% of the global demand is concentrated in just ten countries. There is therefore an opportunity to grow the use of Autogas in other countries and to make its benefits available to a wider number of people.

While it is important to maintain and grow existing markets, there is a wealth of untapped potential in countries which are completely new to Autogas. There are several reasons for this:

- LPG use is increasing globally in the residential (domestic), industrial and commercial sectors, along with improved economic and human development, boosting the general awareness of, and familiarity with, the product

- Increasing urban air pollution, particularly in major cities, is forcing public authorities to look at alternatives to the most polluting transport fuels

- Global commitments on climate change mitigation are encouraging countries to look at ways to reduce greenhouse gas (GHG) emissions

- Decentralised LPG production, and tighter controls on gas flaring, is freeing up product for a wide range of uses, including transport

- Governments are looking at ways to minimise the imports of gasoline and diesel and become self-reliant for their transport fuel requirements

Autogas markets bring a new dynamic to the development of the global LPG industry. Unlike traditional heating demand, which is seasonal and influenced by ambient temperatures, demand in the transport sector is relatively steady throughout the year.

WLPGA staff, and members of the WLPGA, have gained extensive knowledge and accumulated considerable experience about how to make Autogas markets work.

Building on that, this Guide is designed to be the one-stop-shop, addressing questions from members and other stakeholders who are considering opportunities with Autogas in potential new markets, providing recommendations on how to grow and sustain Autogas use and pointing to relevant resources for further information.

1.2 WHO IS THE AUDIENCE?

There are three main target audiences for this Guide:

(i) LPG distributors in countries where Autogas:

- Does not yet exist, but where key stakeholders believe in its potential
- Has started to spread but in an unstructured manner

- Is developed but where key stakeholders believe there is room for improvement in the way the market functions

(ii) Public authorities in these countries, which have an essential role to play in setting the right conditions for Autogas to grow long term and enforce safety rules

(iii) Other interested parties such as vehicle and automotive component manufacturers, infrastructure managers, environmental NGOs etc.

1.3 GENERAL INTRODUCTION

This Guide has eight main Chapters. This first Chapter provides some background explaining the need for the document and the target audience.

Chapter Two introduces Autogas by describing what it is, where it comes from, and its key properties and characteristics as they relate to the safe storage, handling, distribution and use as a clean on-road engine fuel. Chapter Two also describes the history of Autogas and why it is such an attractive option to include in a country's transport energy policy.

Chapter Three sets out the statistics for Autogas use around the world with facts and figures - by country - on volumes, number of refuelling outlets and number of vehicles using Autogas. There is also a description by region of Autogas use, highlighting where the champions are. Taking the US as an example, the relative carbon intensity (CI) of Autogas (both fossil and renewable) compared to electricity is included to demonstrate to arguments of using Autogas over electric vehicles.

The key success factors for developing an Autogas industry are explained in Chapter Four. The need for an extensive refuelling network, the availability of Autogas vehicles (or the opportunity to convert Autogas vehicles), and long-term supportive government policy are each described, together with the need for a positive consumer perception of Autogas.

Chapter Five provides information about the key standards and good safety practices required for a safe and sustainable Autogas industry. The basic underlying principles for all Autogas installations and their safe operation are included here including the main components, sizing, and selecting the best location for the installation.

Chapter Six focuses on the conversion of vehicles to Autogas, including the main components. This Chapter is useful for developing a strategy of how to switch a vehicle fleet to Autogas and what resources are needed to do that.

Chapter Seven contains a collection of successful case studies of eight countries that have introduced Autogas illustrating some of the key factors that have contributed to the successful integration of LPG into the country's transport energy policy. This chapter includes some new stories from the earlier edition.

Chapter Eight contains a brief check list for developing Autogas with a summary of key recommendations.

Finally, there is an Appendix that contains information relating to the fuel system and refuelling infrastructure needed for an Autogas business, standards and good safety practices and an early reference document in support of Autogas lobbying.

2.1 LPG – AN EXCEPTIONAL ENERGY

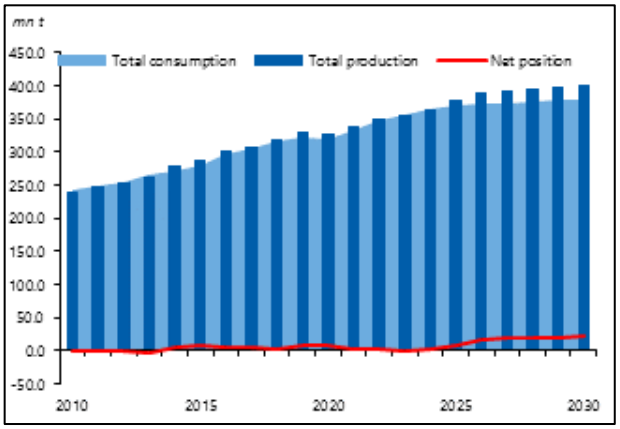
LPG used as a transportation fuel is called Autogas. LPG is a by-product of natural gas field extraction and crude oil refining. Its recovery and use therefore contributes to making the most of our energy resources. LPG has substantial reserves from its dual origins. The long-term forecast of LPG supplies is good, and the production is diversified.

With the discovery of large natural gas reserves, combined with the closure of refineries, LPG has increasingly been derived from natural gas production and today represents over 60% of the global production of LPG.

More recently, bioLPG, made from renewable crops grown from waste feed stocks, has become available from a wide range of production processes. In most cases bioLPG is a by-product of several technologies, many of which are in their early stages of development. This will make LPG a truly sustainable energy in the future.

The LPG industry is supply, rather than demand, driven. Nearly 330 million metric tonnes (m mt) of LPG were produced globally in 2020 and this is forecast to continue to grow over the next few years. Most forecasts suggest there are sufficient global reserves of LPG to last for many decades.

LPG is a clean-burning, sustainable and efficient fuel, and a vital source of energy for billions of people throughout the world today. It is a versatile, exceptional energy.



Forecast of LPG supply/demand until 2030 by Argus Media showing surplus towards the end of the decade

LPG has hundreds of applications in the residential, commercial, industrial, agricultural, chemical and transport sectors. When LPG is used in the transport sector as an engine fuel in on-road vehicles it is commonly called Autogas.

Because LPG is portable, it is easily stored and distributed virtually anywhere. It has a hot flame when burning and is most used as a cooking fuel. It is an extremely powerful form of energy.

Under ambient conditions LPG exists in a vapour form but converts to a liquid under moderate pressure. LPG is generally stored and transported in the distribution channel in the liquid phase. One unit of liquid LPG creates over 250 times the same volume in vapour form making it very efficient to store and distribute as a liquid. However, that same property means that a leak of liquid LPG is a far more serious event than a vapour leak.

LPG also has exceptional engine fuel properties. The octane number of LPG is higher than that of gasoline, and LPG has a relatively low carbon to hydrogen ratio.

The ability for LPG to be easily stored and distributed as a liquid, coupled with its excellent engine fuel properties, creates the opportunity for its use as a transport fuel. This has become particularly important with LPG creating very low emissions when burnt.

Propane, one of the two main components of LPG, boils at minus 42 degrees centigrade allowing it to be used in extremely cold climates. This enables propane to be easily vapourised at low temperatures if vehicles are operating in cold conditions. This property ensures that LPG, and especially propane, has good cold start engine properties.

Vehicles running on LPG are typically spark ignition engines that have either been converted to LPG, or are factory made with dedicated LPG tanks and systems. There is a storage tank, at the rear of the vehicle (often in the spare wheel compartment). The fuel is transferred to the engine where it is ignited. LPG vehicles often retain a small gasoline tank to enable them to be switched between gasoline and LPG, to provide added flexibility. These are called bi-fuel vehicles. But in other countries, typically in South Korea and Japan, mono-fuel LPG vehicles are common.

LPG is characterised by a smaller energy content per litre of fuel than gasoline. For the vehicle to cover the same distance, it is expected that 20% more LPG (in litres) is required compared to gasoline. However, it all depends on the vehicle that is being converted and the driving style. Consequently, the cost of LPG relative to gasoline (in dollars per litre at the dispenser) must be lower to deliver a financial incentive.

In 2021, according to a paper published by the World Health Organization (WHO) (Bulletin of the World Health Organization (who.int), $PM_{2.5}$ exposure caused 4.2 million deaths[1] and 92% of the world's population lived in places where air quality levels exceed WHO limits[2].

COMPARED TO GASOLINE, DRIVING ON AUTOGAS EMITS:
- 81% LESS PARTICULATE NUMBER (PN)
- 21% LESS CARBON DIOXIDE (CO_2)

COMPARED TO DIESEL, DRIVING ON AUTOGAS EMITS:
- 74% LESS NITROGEN OXIDES (NO_x)
- 81% LESS PARTICULATE MATTER (PM)

On average, compared to gasoline, driving on Autogas emits 81% less PN and 21% less CO_2 emissions calculated on a well-to-wheel basis[3].

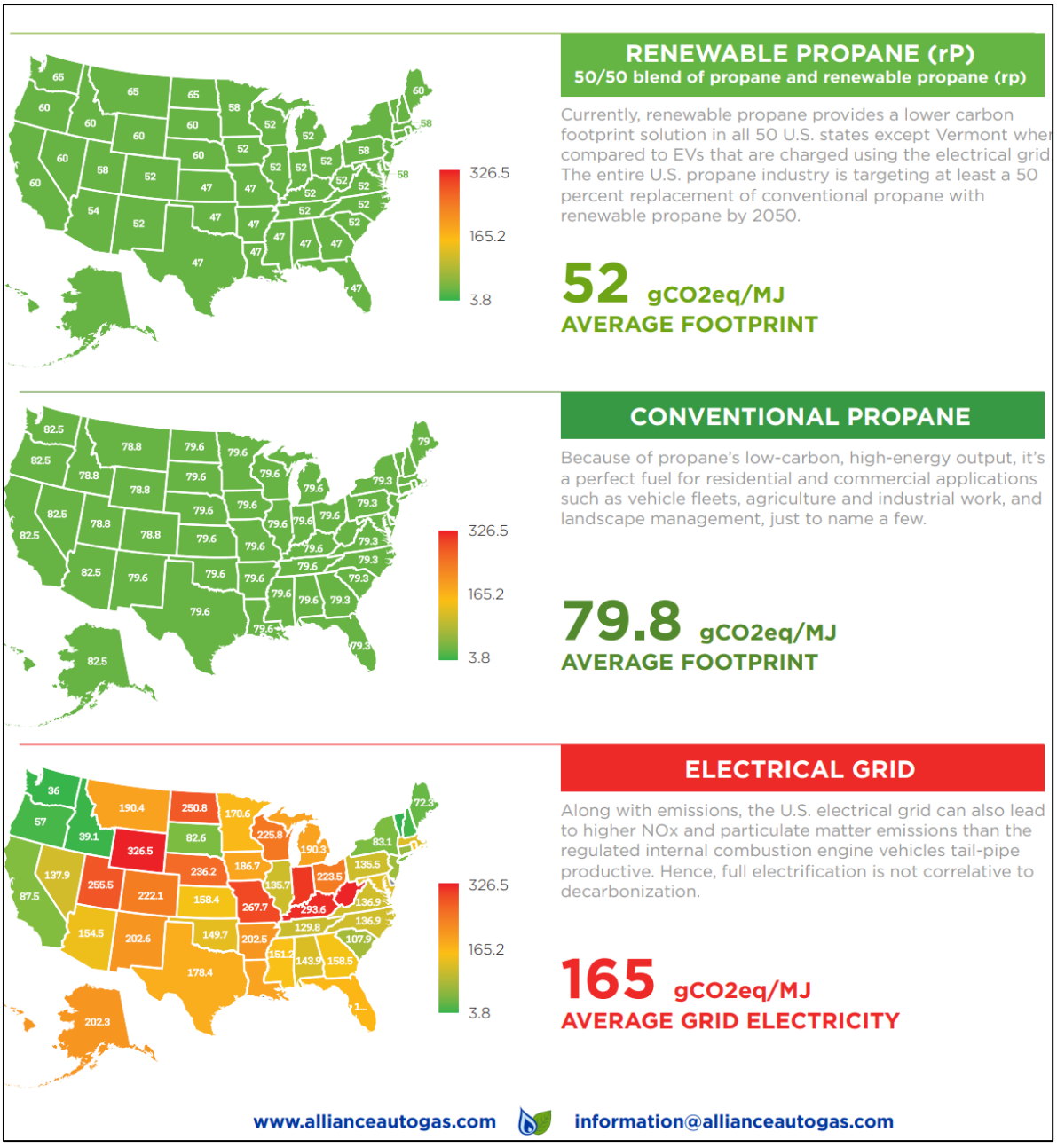
And on average, compared to diesel, driving on Autogas emits 74% less NOx and 81% less PM[4].

Over the years Autogas has demonstrated a proven track record of having a direct impact on reducing air pollution and this is a key reason why LPG has become the most popular alternative transport fuel to the two traditional ones, gasoline, and diesel.

[1] http://www.healthdata.org/gbd
[2] http://www.who.int/mediacentre/news/releases/2016/air-pollution-estimates/en/
[3] Emissions and Performance of Liquefied Petroleum Gas as a Transportation Fuel: A Review, Ross Ryskamp, Ph.D. Research Assistant Professor West Virginia University Center for Alternative Fuels, Engines, and Emissions: https://auto-gas.net/wp-content/uploads/2017/11/WLPGA-Literature-Review-FINAL.pdf
[4] Ibid.

There are arguments, using carbon intensity, for using Autogas vehicles instead of electric vehicles depending on how the electricity is generated, stored, transmitted, and consumed. In the US, the state average energy mix for electricity generation, and assuming a 10% charging loss, shows the carbon intensity of electricity compared to conventional and renewable propane (LPG).

Blossman & Alliance Autogas (www.allianceautogas.com) illustrate below the carbon Intensity of the electricity grid system in the US compared to propane (LPG) and a 50/50 blend of traditional LPG rLPG. This information is based white paper the Propane Education and Research Council (PERC) produced (www.propane.com). This analysis ignores the mining of battery materials and their production.



2.2 INTRODUCTION AND HISTORY OF LPG AS AN AUTOMOTIVE FUEL

Autogas is a proven technology. LPG has been successfully used as a transport fuel for over 70 years.

Autogas station in Japan in the 1950's

The first gasoline-fuelled four-stroke engine was built in Germany in 1876. The LPG industry was born several years later in the early 1900's but its early use was mainly as a burner fuel, especially for cooking use.

It was not long before it was discovered that LPG also had exceptional engine fuel properties. It was soon being used as an important gasoline blending component at the oil refineries, and this use continues today.

LPG was being used as an alternative to gasoline in the 1950's. The United States of America and Japan were two of the first countries to introduce it.


An early Autogas vehicle in Japan

Many countries, including Japan, South Korea, Hong Kong, and Australia, use LPG in their respective taxi fleets.

Hong Kong switched their entire taxi fleet of Toyota and Nissan diesel vehicles to Autogas in 1990-1992 to combat deteriorating urban air quality. Thirty years later Autogas represents over 75% of the total LPG demand in Hong Kong demonstrating the importance to the LPG industry of introducing Autogas as an alternative to diesel.

This switch was supported by the development of a comprehensive network of dedicated Autogas refuelling stations to meet the demand for the new transport fuel.


A large dedicated Autogas refuelling station in Hong Kong

Some of the dedicated Autogas stations in Hong Kong are the largest found anywhere in the world with over 20 dispensers on a single site.

The largest Autogas markets nowadays are in Europe and Asia, although new markets have emerged on several other continents in recent years.

Although the Autogas technology was first developed in the 1950's, the engine technology has continuously improved since then, in parallel with the development of the gasoline internal combustion engine. As a result, we are now benefitting from the sixth generation of LPG engines (see also Chapter 6.0).

2.3 THE AUTOGAS PROPOSITION

LPG is an attractive transportation fuel, compared not only to the two conventional petroleum transport fuels - gasoline and diesel - but also to other alternative fuels.

The gaseous properties of LPG promote improved air and fuel mixing compared to liquid fuels, while providing better energy density than other alternative fuels.

LPG has a higher-octane rating, and a lower hydrogen-to-carbon ratio, than conventional gasoline which helps to deliver improved performance and emissions benefits. LPG has a low carbon footprint and burns cleanly, resulting in low tailpipe, or exhaust, emissions. It is also a very clean fuel to have on the service station compared to diesel and gasoline.

Although diesel engines emit relatively low CO_2 – which is why some countries historically favoured diesel over other transport fuels – diesel emissions, unlike those from gasoline and Autogas engines, are now known to be carcinogenic to humans according to the WHO.

In addition, butane and propane are not greenhouse gases (GHG), and LPG cars emit no methane, which is listed as a GHG by the Kyoto Protocol.

Diesel engines produce harmful PM and NOx which are major contributors to respiratory problems in humans. This, coupled with the bad publicity from the Volkswagen emissions scandal, has led to many governments abandoning support for diesel engines, especially those operating in urban areas.

According to the largely recognised JEC Well-to-Wheel studies[5] conducted at the level of the European Union and used for laying down the calculation methods and reporting requirements of the Fuel Quality Directive[6], LPG vehicles emit 21% less CO_2 than gasoline equivalent vehicles on a life cycle basis.

The introduction of bioLPG further increases the potential for Autogas. The availability of bioLPG, made from renewable sources, grown and waste feed stocks, is increasing, from a wide range of production processes ensuring that Autogas has a long-term future in a net zero carbon world.

> '…BIOLPG CAN BE PROGRESSIVELY MIXED WITH LPG AS A DROP-IN RENEWABLE FUEL, USING THE SAME INFRASTRUCTURE AND VEHICLE TECHNOLOGY…'

BioLPG is identical in its use, and has the same properties, as conventional LPG, but in addition, bioLPG reduces greenhouse gas emissions by up to 90% over the life cycle of the fuel[7]. BioLPG can be progressively mixed with LPG as a drop-in renewable fuel, using the same infrastructure and vehicle technology.

Both LPG vehicle equipment and LPG refuelling equipment have a long track record of being safe and sustainable.

[5] https://iet.jrc.ec.europa.eu/about-jec/downloads (revised 2020)
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32015L0652 (retrieved on 20 July 2018)
[7] A survey of markets, feedstocks, process technologies, projects and environmental impact, Atlantic Consulting for AEGPL/WLPGA, June 2018

A common feature of traditional transport service stations is a stained forecourt resulting from diesel, and to a lesser extent, gasoline spillage. A benefit of using Autogas is that forecourts are not contaminated by accidental spillage of fuel by motorists when refuelling.

LPG engine technology has continuously improved over time. For example, LPG direct injection engines offer better fuel economy than previous systems and CO_2 savings (10-15% compared with a similar gasoline engine) with little to no emissions of particulates.

LPG vehicles are fully compliant to the latest emission standards (Euro 6 WLTP) and the industry is now working to be ready for Euro 7.

From a consumer perspective, there is a wide range of vehicle models available from car manufacturers. Drivers can choose their new LPG car among over 130 models, proposed by the biggest car brands (Renault, Ford, Dacia, Stellantis, Hyundai, Opel etc) with full manufacturer warranty and other benefits[8]. In addition, most gasoline vehicles in the market can be converted to LPG, which is a customer-friendly and cost-effective option for used vehicles.

Dedicated LPG Dacia Sandero

The incremental cost of purchasing a new LPG car from a dealer rather than a gasoline engine vehicle (out of 70 models available in Europe) is typically up to €2,000 but can be zero. The cost of conversions also varies between €500 and €3,000, depending on the vehicle and country undertaking the conversion.

Most importantly, driving on LPG can provide drivers with the opportunity of lower operating costs, which makes it an attraction option.

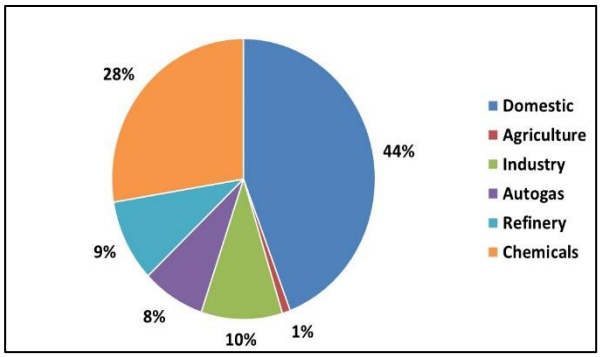
If the Autogas pump price per litre (including all taxes) are less than 80% of the gasoline price per litre, the running costs will be lower with Autogas. The bigger the price differential, the lower the running costs will be with Autogas, allowing to pay back the initial investment of switching fuel in a shorter period of time.

Research undertaken by Aygaz in Turkey (see also 7.1), shows that if the cost of Autogas compared to gasoline at the dispenser is between 50%-60% (in $/litre) there is a clear financial incentive for switching to Autogas. This fuel cost differential will typically generate savings to recover the cost of a conversion to Autogas within two years. The situation will be different in each case depending on the actual cost of conversion, mileage driven and behaviour.

[8] Autogas vehicle catalogue 2018: https://auto-gas.net/wp-content/uploads/2018/04/WLPGA-LPG_Vehicle_CATALOGUE_A4_V11_pbp_SMALL-2.pdf (retrieved on 20 July 2018)

Over the last decade, LPG use in the transport sector has grown steadily, to reach almost 8% of the total worldwide demand for LPG.

The latest figures available from the 2021 WLPGA Global Statistical Review indicates that over 29 million (mn) vehicles worldwide are running on Autogas as their main fuel, an increase of 1.6mn compared to 2019.



LPG consumption by sector, 2020

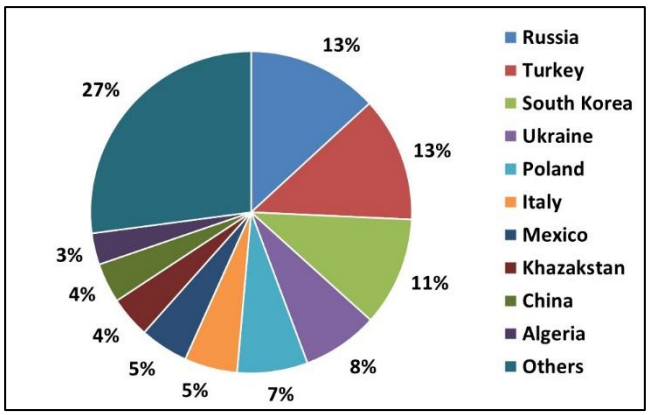
Over 24mn t of LPG was consumed globally as a transport fuel in 2020. A drop of 2.8mn MT compared to 2019. However, this percentage fall in demand is less than experienced by gasoline in 2020.

Autogas use is focused mainly in two regions: Europe & Eurasia and Asia-Pacific.

Russia has the largest Autogas market in volume terms with 3.22mn tonnes of demand in 2020 and 3.0mn vehicles.

Turkey hosts the largest Autogas fleet with 4.65mn vehicles currently on the roads, indicating there are over 40% of private cars powered by LPG.

The top ten Autogas countries by consumption are shown in the pie chart.

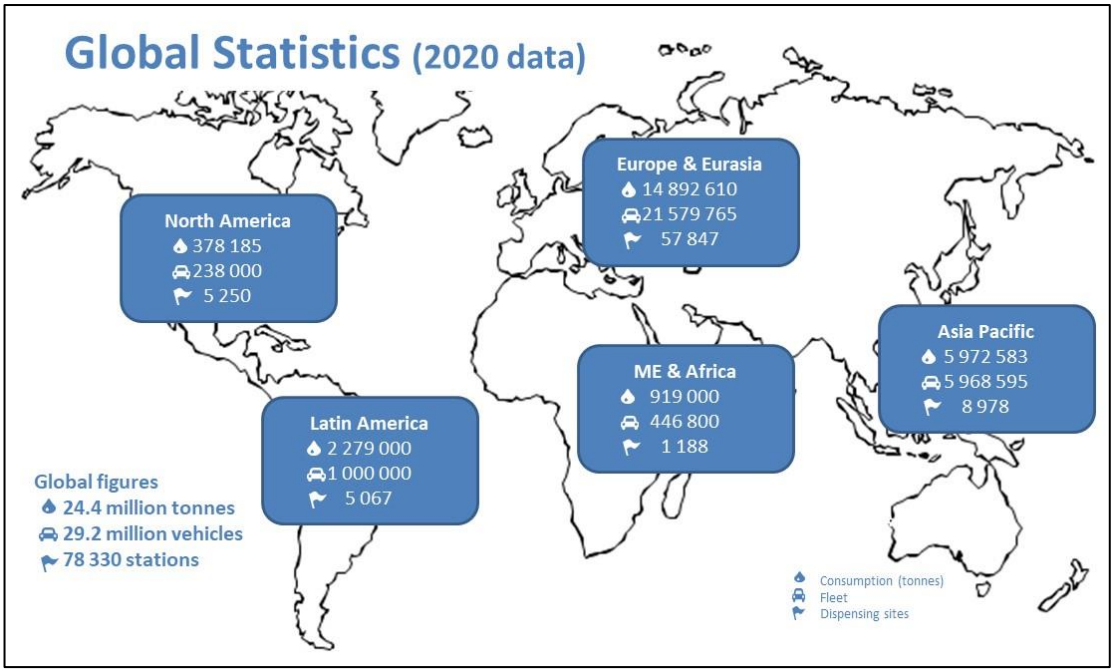


Autogas Demand in 2021 by country

Those top ten countries accounted for 73% of global Autogas demand in 2020.

More recently, some of the Southern and Eastern European countries have shown significant growth in Autogas demand, albeit from a small base.

For example, in Greece, Autogas was first introduced in the 1980s, but its use was initially limited to taxis. In 2010, the government imposed a sharp rise in excise duties on gasoline and diesel – bigger than that imposed on Autogas – to raise additional tax revenue in the wake of the financial and economic crisis, making Autogas the cheapest fuel option for Greek motorists. The Greek Autogas market has seen rapid growth since then, reaching 255,000MT in 2019, up from just 9,000MT in 2009. It fell back in 2020, along with the global trend in, to 205,000MT.



Data taken from the Statistical Review of Global LPG – 2021 (WLPGA/Argus Media)

Similarly, Spain has a very small Autogas market, but it is expanding rapidly in response to a substantial fiscal incentive and various national and local initiatives to promote the take-up of the fuel for environmental reasons. The number of Autogas vehicles was almost 100,000 in 2020, an increase of over 20% compared to 2019.

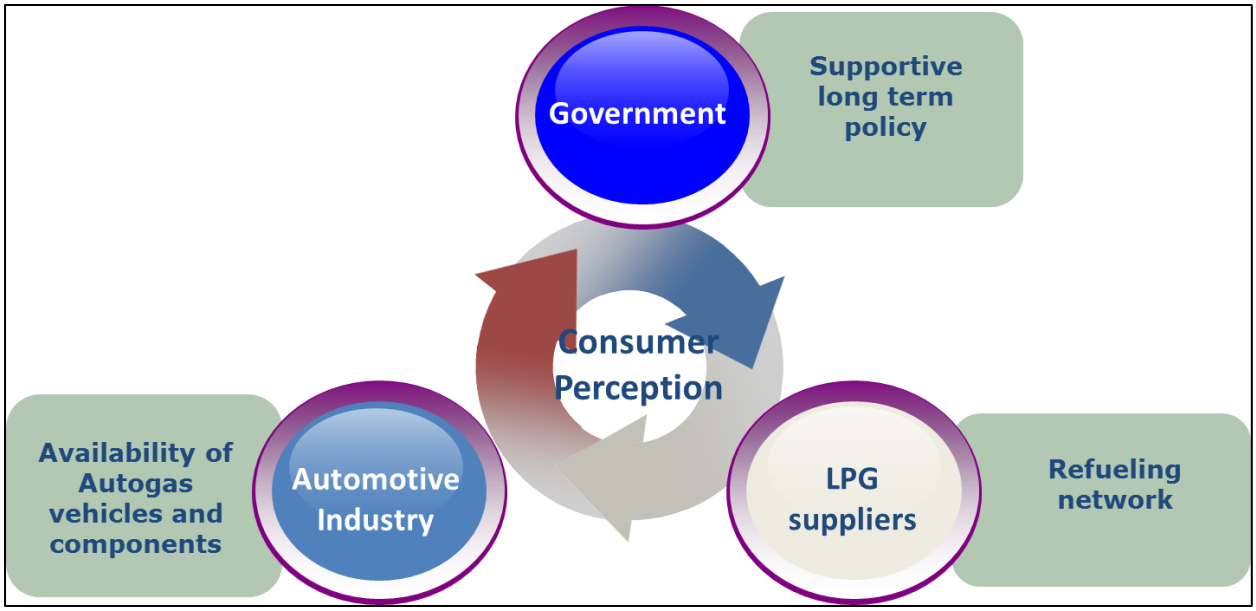
Some other countries are also showcased in Chapter Seven.

Autogas is suitable for all vehicle segments, from buses and heavy goods vehicles, to vans, passenger cars and even two and three wheelers.

A three-wheeler Autogas vehicle in Asia

While the bulk of the Autogas market in Europe is made up of passenger cars, LPG is becoming an increasingly successful option in North America for fleets of trucks, buses, and delivery vans. In India and Bangladesh two, and three wheelers using Autogas are common.

The key success factors for Autogas development are summarised in the diagram below:



The Main Autogas Stakeholders

All three stakeholder groups, government, automotive Industry, and LPG suppliers, contribute to improving the perception of Autogas among consumers.

This diagram is sometimes referred to as the 'three-legged stool'. If one of the legs is not there the stool will collapse. With all three legs in place, the task is then to ensure the stool has a good base, or strong consumer perception for Autogas.

When considering the potential for Autogas the first step is to develop an assessment of the market in a country/region/city. It is recommended to develop an analysis covering the following elements:

(i) Current LPG market and trends

- Main players
- Supply and distribution infrastructure
- Consumption patterns

(ii) Current automotive market and trends

- Main players
- Type, age, and number of vehicles in circulation

(iii) Current regulatory framework for LPG and Autogas (if any)

(iv) Local challenges: e.g., air pollution, energy security etc.

(v) Local strategy for sustainable development and other favourable policy commitment

This exercise aims to confirm whether the country/region/city is a promising market for Autogas, and if Autogas would assist in achieving the political objectives, address the existing challenges and deliver the projected benefits.

4.1 GOVERNMENT POLICY

Government support and encouraging policies for Autogas as an alternative transport fuel is a key success factor.

Government policy towards the long-term use of Autogas needs to be clarified before any serious investment is made in developing the business.

This is best determined through the development of an analysis where the role of LPG within the overall energy policy in the country is considered.

The primary reason why governments in many countries actively encourage the use of Autogas is because of the environmental benefits it brings. Autogas out-performs gasoline and diesel, as well as some other alternative fuels.

Asian Autogas vehicle

The most effective Autogas incentive policies are those that help to make the fuel more competitive against gasoline and diesel and give a strong financial incentive for an end user to switch to Autogas.

In practice, the financial attractiveness of Autogas over other fuels depends essentially on two factors: the net cost of converting an existing gasoline vehicle (or the extra cost of buying a factory built Autogas vehicle compared with an equivalent gasoline or diesel vehicle) and the pump price of Autogas relative to diesel and gasoline.

In summary, the vehicle owner needs to be compensated for the additional upfront cost through lower running costs, of which fuel is the most important. The time it takes for the savings in running costs to offset the capital cost – the payback period – depends on the usage of the vehicle, i.e., the distance travelled. The payback period is usually less than two to three years to encourage commercial vehicle owners to switch; private individuals often demand a quicker return on their investment.

A useful link to some questions regarding the decision to use Autogas can be found on the Elgas website here (LPG Australia Energy Security (Self-Sufficient in LPG) (elgas.com.au))

Taxes or excise duties on Autogas must be low enough, relative to those on gasoline and diesel, to provide an incentive for motorists to switch fuels.

Supportive taxation structures to help Autogas equipment importers/manufacturers - with reduced excise duties and other taxes of the fuel reflecting the environmental advantages of Autogas - is another key for achieving success.

Government incentives and grants for consumers to purchase Autogas vehicles/conversion kits will also have a positive effect on the demand, as they reduce the initial outlay, and payback period.

However, the success of Autogas in any specific country cannot only be justified by the costs of the fuel or the systems. Government support can also take other forms.

- Communication campaigns to raise consumers awareness of Autogas and its benefits, and to create a positive public attitude towards safety and reliability

- Mandates and public transport fleet conversion programmes

- Local and central government environmental restrictions on the use of diesel vehicles

- Exemptions from parking/road use charges and city driving restrictions (access to low emission zones)

- Availability of equipment and fuel

- Government consumer helpline to promote Autogas as a sustainable automotive fuel and to answer questions on conversions, safety standards, fuel pricing etc.

- Establishment of proper regulatory requirements, standards/codes for Autogas conversions and the construction and operation of Autogas stations, supported by strict enforcement measures and penalties for non-compliance

Whatever the form of government support, it is important to ensure long term policy stability, coherence, and consistency, for fuel suppliers, equipment manufacturers, and consumers to be confident that they can make a reasonable return on the investment required to switch fuels.

The WLPGA Autogas Incentives Policies document is an in-depth analysis of how and why governments promote LPG as an alternative fuel for transport and what works, supplemented by an extensive look at a selection of 23 countries around the world, and is freely available from the Autogas website (www.auto-gas.net) here.

4.2 REFUELLING NETWORK

Consumers need to have the confidence that when they travel, they can readily refuel their vehicle when they need to. They do not want to be concerned about running out of fuel.

This Autogas self-serve dispenser in Australia is fully integrated with the gasoline and diesel ones

An attendant operated Autogas station in Hong Kong

For a new market this is a challenge because investment in Autogas refuelling facilities will need to be made before the market has fully developed.

To develop Autogas in a country with no existing refuelling network will need careful planning that will include the following issues:

- Consider starting to service captive fleets such as taxis, delivery vans, which allows for high volumes over a limited number of refuelling points

- Identify the target cities/areas where the majority of Autogas vehicles are planned

- Identify locations where filling stations are to be established in those cities/areas to provide good geographic coverage in well sited location

- Particularly target larger cities with high volumes of vehicles and poor air quality

- Plan refuelling stations to cover all major routes and high-density suburbs in order that motorists have convenient and short drives to refill

- Plan refuelling stations in all major cities around the country in order that motorists can drive between major cities without concern for running out of fuel

- Provide good clear signage to indicate Autogas refuelling station locations (including the use of apps)

- Ideally, establish Autogas refuelling facilities within existing traditional (gasoline & diesel) fuel service stations. This will provide exposure to Autogas and give motorists the confidence to convert. Prospective Autogas users will see Autogas vehicles being refilled which will create interest to convert themselves. A key requirement will be available space to locate the LPG storage tank and comply with the necessary safety distances (see also Chapter 5)

- Plan for adequate Autogas storage at filling stations. It is always challenging to forecast daily/weekly throughput in a new service station network with limited cars being refuelled during the early stages. Providing space for adding storage later will make it easier to meet safety/regulatory requirements.

- Consider underground LPG storage on service stations as an option. This maximises forecourt space and storage volumes and makes it easier to meet safety and separation distances. In most international standards underground LPG tanks require far less separation distances compared to above ground tanks. Underground systems have limited above ground pipework however the investment is greater than for above ground systems. Underground systems will require submersible pumps, cathodic protection systems, remote fill points etc. But they are aesthetically pleasing and more likely to create the perception that Autogas is no different than gasoline or diesel.

- Safety at Autogas filling stations is paramount, just like at any other LPG installation. There will be a need for extensive training of personnel. Safety instructions will be needed on site (especially at the dispensers, forecourt, and tank/vent areas). Emergency management plans and emergency shutoff (ESD) buttons will also be required on the forecourt.

4.3 VEHICLES

Vehicles that run on Autogas have engine and fuel systems that are dedicated to run on LPG, developed by an OEM, or have been converted to run on LPG.

In most countries, vehicles that run on Autogas are gasoline powered vehicles that have been converted to use LPG by installing a separate fuel system that allows the vehicle to switch between Autogas and gasoline.

The converted vehicles will often retain the gasoline fuel system (i.e., bi-fuel vehicles) to provide extra flexibility, especially where the Autogas refuelling network is still being developed. This allows the motorist to switch seamlessly from one fuel to another through a flick of a switch on the dashboard of the vehicle. Where space restricts the option of retaining the original gasoline fuel tank in the vehicle, a smaller one can be installed.

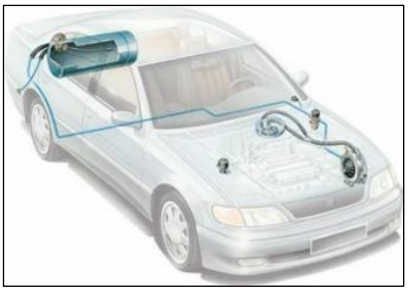
LPG Filler point

Dashboard switch

Most Autogas vehicles on the roads are bi-fuel, except in South Korea, Japan, and Hong Kong, where they are typically mono-fuel LPG, because the refuelling network is comprehensive and Autogas vehicles are often used as taxis.

For mainly technical reasons, most Autogas vehicle conversions involve gasoline-powered spark-ignition engines, which are particularly well-suited to run on Autogas.

Autogas fuel systems are a proven and mature technology. Specialist companies have developed and market standardised Autogas conversion kits (the front end), including a parallel fuel system and tank (the back end), with specialist garages and workshops carrying out the installations.



Schematic Autogas fuel system showing back end (left top) and front end (right)

The supply is diversified, with many firms selling conversion kits, though consolidation is occurring in Europe and the United States.

Many of them serve just their national markets (for example, in China), but a growing number of them now export to other countries.

Sales of OEM Autogas vehicles, incorporating conversion kits at the point of manufacture, have been growing in many established markets in recent years.

Worldwide, there are over twenty car brands currently marketing around 140 Autogas models. As Autogas has become more popular and widely available, some OEM vehicle manufacturers have become involved in the development, design, and manufacture of Autogas systems.

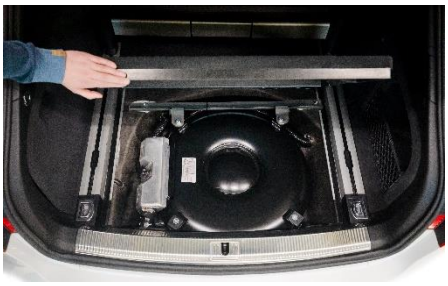
Most of the leading car manufacturers have introduced Autogas versions of their models, while others offer conversions at the time of sale, with the full manufacturer warranty. The latter is also called delayed OEM, or zero-kilometre conversion.

Toroidal Autogas fuel tank fitted to a private car

In France, the Renault group has increased its range of OEM models, both in the Renault brand (two models) and in the Dacia brand (three models - including one which is only available with an LPG engine).

A full list of available OEM vehicles worldwide is detailed in the *WLPGA Autogas vehicle catalogue* which is available from the Autogas website [Autogas Vehicles Catalogue 2018 - WLPGA]. There are plans for this publication to be updated in 2022.

These OEM models have under-floor fuel (LPG) tanks to save space in the boot. One common practice is to use toroidal LPG tanks in the place of the spare wheel.



LPG tank in the boot of the vehicle

LPG is fully compatible with electricity in hybrid configurations (mild hybrid, plug-in hybrid). The hybridisation of Autogas vehicles allows the combination of the benefits that electricity brings, together with a longer range provided by a cleaner fuel (Autogas).

For example, some taxis in Melbourne, Australia, and Madrid, Spain, are LPG hybrid vehicles. In 2017, Toyota, Japan, launched the JPN taxi combining an LPG engine with an electric motor, offering a 19.4 km/litre fuel consumption and sharply reduced CO_2 emissions. Suzuki in Italy makes its entire (mild) hybrid range available in LPG version. It is also possible to convert hybrid vehicles to LPG, expanding the application of LPG to almost all hybrid vehicles.

In comparison with light-duty vehicles, there are curently relatively few heavy-duty vehicles running on Autogas, due to the current dominance of diesel in this segment, in Europe in particular.

Converting a diesel engine to Autogas is technically possible by replacing the cylinder head. However, it is more complex and expensive than converting a gasoline engine because of the need to introduce spark ignition.

Autogas bus re-fuelling in the USA

In North America, the segment has always been different as almost all LPG powered vehicles are heavy duty. Many are used in fleet applications, such as school buses, shuttle, transit to para-transit buses, and law enforcement vehicles.

More recently however some heavy-duty Autogas spark-ignition engines (mostly adaptations of their diesel counterparts) have been commercialised by several of the larger engine manufacturers.

These engines are used mainly in buses and mid-sized trucks, notably in the United States, South Korea, and China.

Beyond the availability of LPG vehicles and conversion kits, it is important to establish an effective service and maintenance system to keep the Autogas vehicles on the roads and to maintain customers' satisfaction.

4.4 CONSUMER PERCEPTION

Consumers who are more familiar with gasoline and diesel will have questions, and maybe doubts and concerns, when considering converting their vehicle to run on Autogas, or buying a new dedicated Autogas vehicle.

Misperceptions about safety and reliability have affected the growth of Autogas in some markets. It is important to address these through effective communication based on facts and highlighting the benefits of switching to LPG.

Integrating Autogas with gasoline and diesel pumps will help consumer perception

Some of the benefits to highlight are:

- Cost benefits, daily/monthly savings running on Autogas
- Driving range is comparable to gasoline
- Bi-fuel advantage. Autogas conversions offer an additional fuel, not necessarily a permanent switch from gasoline to LPG
- No change to driving style, engine performance or maintenance (it can be argued that LPG is a better fuel than gasoline for engine maintenance)
- No special or costly maintenance required for converted vehicles
- Autogas is environmentally friendly, reduces air pollution, emits less CO_2
- The refuelling process is like refuelling with gasoline. The dispenser (pump) at the service station can be adjacent to the gasoline and diesel dispensers and refuelled using a similar nozzle. Refuelling time is comparable to gasoline, with some differences based on the nozzles and vehicle used
- The availability of trained technicians to repair/service Autogas vehicles
- Support from the automotive industry. Many leading vehicle manufacturers in the world produce Autogas vehicles
- The availability of a comprehensive refuelling network, to counter range anxiety and the perception that the infrastructure is limited

4.5 SUMMARY

National circumstances must be carefully reviewed as they can affect the best approach for designing and implementing Autogas incentive policies. These include budgetary considerations, which might limit available funds for subsidies, the seriousness of local pollution problems, fuel-supply and cost issues, reliance on imports for diesel and gasoline when LPG is available locally, the practice of flaring creating the opportunity of utilising waste gases (LPG), the stage of development of the Autogas market and the prevailing barriers to fuel switching.

These barriers might include restrictive regulations and the local cost of vehicle conversions.

A suggestion here is to first consider developing an Autogas Roadmap for the country that takes all the above issues into consideration by debating with all the relevant stakeholders. The outcome will be an agreed pathway forward for Autogas that all parties are bound to.

> '…DEVELOP AN AUTOGAS ROADMAP FOR THE COUNTRY THAT SETS OUT AN AGREED LONG-TERM PATHWAY FOR LPG…'

The next step might then be for government to run a pilot project, which will generate evidence on the feasibility and the benefits of using Autogas, while limiting the initial investment needed.

Vehicle fleets should be targeted, for which limited infrastructure development is necessary, and for which the cost/benefit analysis is relatively straightforward.

From this platform Autogas use should increase once a critical market mass has been achieved. The market needs to be large enough to demonstrate to potential Autogas users and fuel providers that the fuel is safe, reliable, easy to use and a cost-effective alternative to conventional fuels

Achieving critical mass and government support requires a concerted effort on the part of all stakeholders – vehicle manufacturers and converters, Autogas suppliers and the government – to promote the development of the market.

The involvement of these stakeholders in the development of an Autogas Roadmap will be helpful here.

Some success stories of Autogas, illustrating some of the above recommendations, can be found in Chapter Seven.

CHAPTER FIVE – KEY STANDARDS AND SAFETY PRACTICES

The safety track record of the LPG industry, which is over 100 years old, is very good.

LPG is a powerful fuel and requires strict standards in both the equipment and the installation in which it is being stored, handled, and distributed.

The application of LPG as a transport fuel demands the same rigorous approach to safety as the traditional LPG markets with the added challenge of having private individuals and vehicles involved in the final application.

The approach to ensuring the Autogas business remains safe centres on the design, location, and operation of the Autogas service station, the vehicle (conversion) and mechanics who install and maintain the vehicle, and the consumer (motorist).

The basic underlying principles for all Autogas service stations and their safe operation are:

- Sound design and construction, including easy and safe access
- Consideration of adjacent land use: adequately separated from residential accommodation, commercial and industrial development, vulnerable populations, etc. Open area with good ventilation (no cellars, open drains etc – LPG vapour is heavier than air and any leaks will fall to the ground)
- Non combustible construction materials
- Electrical equipment which is appropriate for hazardous areas
- Impact protection for equipment (especially from vehicles)
- Safeguarding and mitigation systems
- Emergency procedures and telephone numbers clearly displayed
- Clear visible hazard and warning notices and work instructions
- Appropriate fire-fighting equipment
- Trained and competent staff
- Good housekeeping – site clear of other flammable and combustible materials
- Control of ignition sources
- Good security (from vandalism and theft) and access for authorised personnel only
- All equipment used in Autogas service stations must be suitable for use with LPG and meet a recognised standard, preferably type approved

- Equipment must also be suitable for all the operating conditions likely to be encountered during the service life

- All fire safe, fail safe or electrical equipment and pipe work must be procured with relevant material certificates that should be kept as a matter of record.

Successful Autogas markets need trained personnel, operating in a well-controlled environment with fit for purpose workshops, which delivers safe and reliable vehicle conversions.

This infrastructure can also maintain the dedicated Autogas vehicles entering the market.

The LPG storage system at an Autogas service station resembles that found at a small industrial or commercial LPG facility.

An underground LPG tank being installed at an Autogas service station

The main difference is to be found in the way the product leaves the tank to the point of application.

Autogas is sold to the motorist in liquid volume form in the same way as diesel and gasoline. So, in an Autogas service station LPG is always transferred to a dispenser on a retail site in liquid form. Any liquid leak of LPG can be very hazardous (one unit of liquid LPG generates over 250 units of vapour) and so great care must be taken in the design of the facilities to prevent any leak occurring.

5.1 MAIN COMPONENTS OF AN AUTOGAS SERVICE STATION

Some typical layouts of Autogas facilities are shown in Appendix One with both above and below ground LPG storage systems.

Safety distances must be respected whenever dealing with LPG storage installations and equipment, including distances from tanks, pumps, dispensers, and LPG loading points. These may vary from country to country.

5.1.1 STORAGE TANKS

The LPG storage tank at an Autogas facility must be large enough to cope with periods of peak demand. This might be during a change of shift with taxi fleets when the vehicles are refuelled.

To meet the necessary safety distances storage tanks are often buried underground.

A 7.5kl above ground LPG tank servicing an Autogas site

Underground tanks and pipework also limit the risk of impact damage from moving vehicles between the tank and dispenser and gives the Autogas station a neater look.

In some countries the underground Autogas tank turret is covered with a lid, strong enough to be able to sustain a vehicle load, as found over the diesel and gasoline fuel tanks in a service station forecourt.

Underground Autogas tanks look no different to diesel and gasoline ones Source – D J Batchen, Australia

Typical sizes of above ground Autogas tanks are 5 kilolitres (kl), 7.5kl, 10kl & 14kl. Underground tanks come in sizes from 10kl to 30kl.

Some countries specify the maximum volume allowed in both above and underground tanks on filling station forecourts according to the relevant codes/standards.

Buried tanks must be protected against corrosion and it is good practice to locate them in concrete chambers, buried in dry washed sand, and with cathodic protection to minimise any corrosion risk.

Another important feature is that they must be secured to prevent them lifting off their foundations in the event of flooding as LPG is less dense than water in liquid form.

Above ground tanks will be subject to the risk of air and water corrosion and will also need protecting with an appropriate surface coating although they are a cheaper option to buried tanks and they are also more visible.

In a large Autogas facility the use of small, mounded tanks might be another alternative although this is not common.

Pumping equipment is fitted to move the product from the storage tanks to the dispensers. Examples are shown in Appendix Two.

Vents ensure any release of product, resulting from the relief valves activating, is done safely, away from the facility.

5.1.2 PIPE WORK

A series of pipework connects the storage tank to the dispenser(s) and this needs to be protected against impact, over pressure and corrosion.

Service stations are busy facilities with continuous traffic and pipework, and storage tanks, must be protected against impact from vehicles.

These barriers must be robust and strong enough to protect the pipework from damage which could cause product leakage.

Pipework will also be necessary between the fill point and tank to facilitate stock replenishment. This will be carrying liquid LPG

Pipe work (vents/relief valves) leading from underground pipe work

which must be protected from any volumetric expansion. The use of pressure relief valves where the liquid lines are exposed is another critical issue.

In a fully underground tank system, the only pipe work exposed will be the tank turret vents and the safety relief valve pipe work.

The pipe work connecting LPG tanks (above ground, mounded or underground) with the dispenser can be traditional carbon steel pipes or a flexible mechanically reinforced pipe system. The flexible pipes specially designed for LPG is becoming popular as they are quick and simple install, with no need for welding or x-ray tests. Just single compression connectors at the start and end of the entire pipeline.

5.1.3 DISPENSERS

The dispenser is the 'face' of Autogas on a refuelling site and is best incorporated on the traditional fuel service station where gasoline and diesel are available. This creates a feeling of acceptance for the consumer and presents Autogas as a natural alternative.

The dispenser can either be designed as a standalone Autogas dispenser or incorporated in a multiproduct dispenser also containing diesel and gasoline.

The Autogas dispenser is shown here on the left and has a delivery rate of 50 litres min

This decision will depend on the design and local standards requirements.

5.1.4 SAFETY FEATURES

Some of the key safety features on an Autogas refuelling station include:

- Installation complies to an accepted international standard (refer Appendix Two)

- Approved equipment for Autogas stations e.g., storage tanks, pumping equipment, dispensers etc. (valves and accessories for an LPG tank servicing a bulk facility and Autogas facility can be different due to safety requirements and operation)

- Adequate personnel training on Autogas service station equipment operations and maintenance

- On site personnel need to be trained to respond to such an emergency and notices should be displayed for consumers to understand how to react

In the event of an emergency there must be a facility to isolate the product in the storage tank by stopping the flow. This is done using emergency stop buttons or shut down devices (ESD's) strategically positioned around the station. They should be periodically checked to make sure they operate effectively. Avoid locating these in an area that is likely to be impacted in a fire.

It is important that a safety management system is prepared and implemented for service station operations, and that Autogas safety aspects are well covered in this.

5.2 SIZING THE INSTALLATION

Determining the size of installation to service a new market is a challenge. Estimating what the demand might be for the product is one key assumption.

For an Autogas installation there are other factors, especially relating to the safety distances required for the storage facility.

In urban areas, where the installation is most likely to be, the price of land will be a premium. Urban areas also bring with it higher population densities and the requirement to ensure a safe operation. It is also important that visually the installation does not create any cause for concern.

Underground storage for the LPG tanks in a congested urban area is probably the best option because it reduces the land required and conceals the LPG storage tanks. Traditional gasoline and diesel tanks are normally underground.

Underground LPG storage tanks at an Autogas station

The first step would be to estimate the daily or weekly volume throughput from the proposed location. Periods of peak demand would also need to be factored in to determine the storage requirement.

A review of the country's safety/regulatory requirements to determine what maximum storage is possible for a service station would also be required to decide tank sizing.

Another consideration is road tanker access and the safety requirements for unloading. There may be some onsite limitations for the access of road tankers, especially if they are fitted with semi-trailers.

If there are serious constraints with road tanker access, then the need for larger storage becomes less of a priority and small road tankers with small drop sizes will only be able to service these locations.

In such cases larger storage will not be an advantage and only add capital cost and the need for additional space. The station though will be reliant on frequent small deliveries putting up the delivered cost of LPG.

Adverse weather conditions (e.g., typhoons) may influence the decision to have larger storage to cater for possible delays in deliveries.

In some countries bulk deliveries of LPG are restricted at night even though the service station may be open 24 hours. Stock control will be important in these situations especially if there are periods of high demand at night e.g., the end of a taxi shift.

Whatever size storage is decided it is important to ensure there are at least two tanks. This allows for the occasion removal of one of the tanks from service to conduct maintenance and requalification tests without affecting the business.

5.3 SELECTING LOCATION FOR LPG INSTALLATION

Deciding on the location of the Autogas station may be driven by the existing gasoline/diesel station network. There are several other factors that will influence location if the decision is to create a new independent network.

The location is there to service the Autogas consumer, and having a good understanding of what routes the target consumer drives will be an important consideration.

The results of any risk assessment might force a decision on preferred location if the surrounding area creates a high perceived level of risk that cannot be mitigated by means other than moving.

Locating on a busy and popular route with heavy traffic would normally be an objective for capturing a wider audience, but if the target sector is operating on another defined route that might not be sensible.

If the Autogas dispensers are to be located on existing service stations, then having a good understanding of how busy those stations are, and whether there is space to accommodate Autogas, will be important.

Apart from having good coverage across the urban area it is also important to ensure refuelling facilities are strategically placed in peri-urban and rural areas too, so the consumer is reassured they will not run out of fuel wherever they drive.

Understanding where future developments might be is also useful in the long-term planning of networks.

Good visibility of the station from the road will be important for the consumer to see the facility as they approach, and well before they reach it.

On a busy highway/motorway it would be convenient to have service stations on both sides.

Mixed fuel station with Autogas integrated on the forecourt

Other factors to consider are multi-hose dispensers on multiple (dispenser) islands for busy locations and conversion workshops in service stations for servicing and to attract potential customers. A one-stop shop for Autogas.

5.4 EXAMPLES OF LPG INSTALLATIONS

LPG installations for Autogas cover the local LPG storage tank, the pipework feeding the dispenser, the dispenser where the consumer fills the vehicle, and all the associated equipment required to ensure a safe operation.

Autogas station designs vary greatly depending on size, throughput, government policy and regulations, market forces and other factors.

They can be simple skid mounted facilities that might be servicing a small fleet of taxis or a new market entry, or they can be very sophisticated and stylish constructions designed exclusively for high volume Autogas markets.

Autogas storage facility

There are others that sit somewhere between these two extremes where Autogas may exist alongside an existing gasoline/diesel service station.

Some examples of Autogas installations are included in Appendix One including a site layout.

The common feature of them all is that there is a storage tank supplying LPG by pipeline to a dispenser operated by the consumer (motorist) who buys the LPG by volume.

The storage installation resembles a typical bulk commercial or industrial facility but instead of an on-site point of consumption the product is transferred to a vehicle which leaves the site.

References to appropriate standards/codes of practice and Good Business Practices are available in Appendix Two of this guide.

Dedicated Autogas stations may be justified in fast growing markets

The commitment of vehicle manufacturers OEMs is critical to improve the perception of LPG and sustain Autogas markets in the longer term. For many new markets the conversion of vehicles from gasoline (and sometimes diesel) to LPG is the most popular way for kick-starting Autogas use.

Since the introduction of LPG conversion systems back in the 1950s, the technology has been continuously improving to keep pace with the advancement of vehicle engine technology.

The average age of vehicles on the roads will vary from country to country. Most of the developing countries will have an older average age of vehicle car park, in some cases up to 15-20 years.

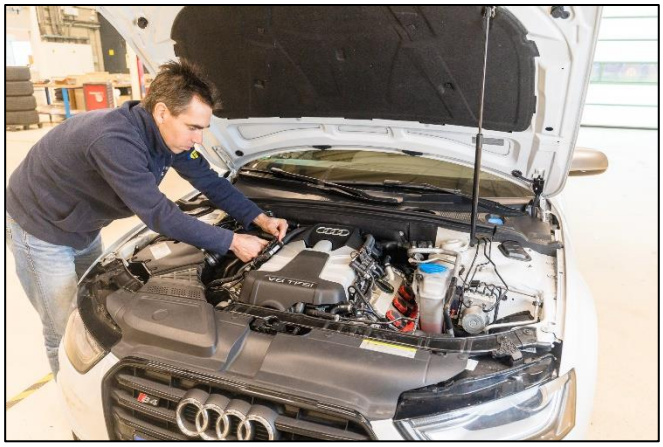
In Europe the average vehicle age is lower. In 2019 the average age of the European passenger cars was 11.5 years (source: Average age of the EU vehicle fleet, by country – ACEA – European Automobile Manufacturers' Association).

For new market entries, it is very important to carry out an assessment to determine the vehicle numbers by types, and by age. This will help to identify the types of conversion systems that will suit the target car population and to offer affordable and suitable conversions with greater savings and reduced payback period to the potential customers.

For most developing markets it is important to keep the cost of conversion down to encourage penetration of Autogas across as wide a market as possible.

Newer vehicles may benefit from a more advanced generation conversion system. An owner with the latest vehicle model will likely prefer an advanced conversion system to improve efficiency, and to add value to the vehicle, whilst saving fuel cost.

A motorist with an older car will focus mainly on a more affordable, fit for purpose, conversion kit to save daily running costs and have a quicker payback period.



Installing an LPG system (courtesy - Prins)

For new Autogas markets there should be a mix of early and latest generation systems on offer to give motorists the choice depending on the suitability for the car model/engine and budget. This approach will help new markets to attract customers quickly and improve the potential for growth. It will also aspire people to seek higher technology options as they upgrade their vehicle.

The lessons from the success stories of Autogas development in countries like Turkey, Sri Lanka and Bangladesh show that providing a choice of conversion system – which included a low-cost entry version – was a key factor for the Autogas industry growth.

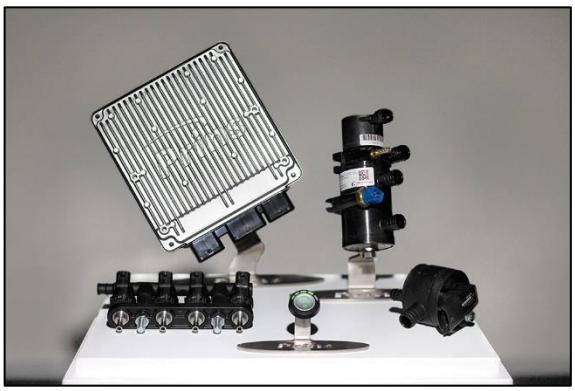
> '…A KEY SUCCESS FACTOR WAS TO HAVE A LOW-COST ENTRY CONVERSION SYSTEM…'

It is critical that the companies carrying out the conversion employ staff that are both knowledgeable and well-trained and able to advise motorists on conversion system selection, safety, and the installation process.

Many countries with mature Autogas markets have well established standards, codes, and regulations in place for Autogas conversions. The Australian and New Zealand standard AS/NZS 1425 - 'LP Gas fuel systems for vehicle engines' is a very detailed, globally recognised standard for Autogas conversions but there are others (also refer Appendix Two and ACEA – European Automobile Manufacturers' Association – Driving mobility for Europe]. Another good reference is UNECE Regulation R67.

6.1 MAIN COMPONENTS OF A VEHICLE GASEOUS FUEL SYSTEM

Conversion system technology was first developed in the 1950's. Since then, engine technology has continuously improved, in parallel with the development of the gasoline internal combustion engine, like single point injection, Multi point injection and Direct injection systems. LPG systems are fully controlled by an Electronic Control Unit (ECU). Before installing a system proper training by the system supplier is recommended due to safety regulations and quality perception.



Main components of a DI system (courtesy - Prins)

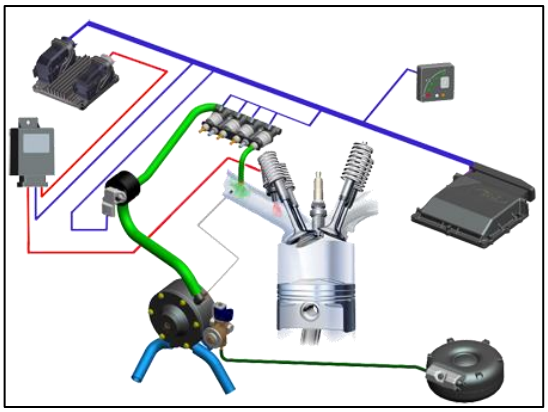
An LPG system consists of several components that are connected with the ECU depending on the type of the LPG system. The switch mounted in the dashboard can be operated by the driver. Other components like the LPG regulator, LPG injectors, LPG filter are mounted in the engine compartment. The LPG tank can be mounted in the spare wheel compartment, in the trunk or under the rear of the car. A trained installer can advise what option is most suitable.

The LPG regulator, also known as an 'LPG converter', 'LPG vaporiser' or an 'LPG vaporiser/regulator', converts the liquid LPG to vapour, and delivers the LPG vapour to the engine.

This VW Golf has been converted to LPG

The LPG injectors are solenoid operated valves that are controlled by the LPG electronic control unit (ECU). They are connected to the inlet manifold with hoses to direct the LPG into the engine.

There are two types of LPG injection systems: vapour LPG injection and liquid LPG injection. With these the LPG is injected into the engine in its gaseous form in vapour injection and in its liquid form in liquid injection.



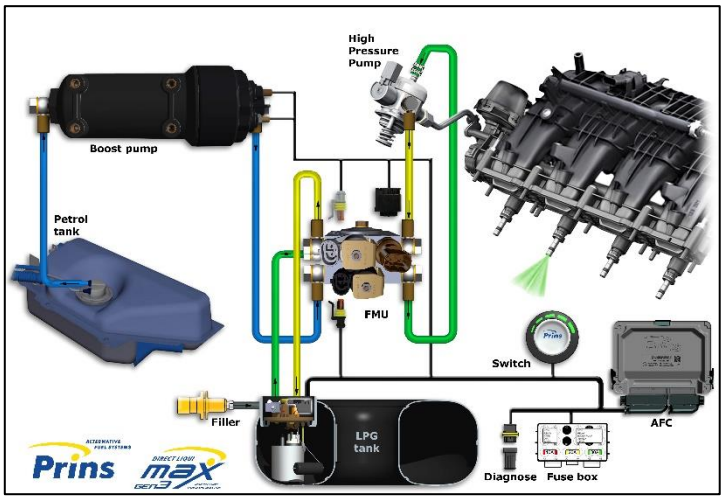
Main components and operation of an LPG vapour injection system

Vapour phase injection: Also known as a gaseous phase sequential injection. This system still relies on a converter to vaporise the gas like the old systems, but the injection takes place via a series of electrically controlled injectors. This allows for more accurate metering of fuel to the engine than was possible with previous generations. As a result, fuel economy, power and emissions are much improved.

The injector opening times are controlled by the original gasoline control unit, which the Autogas electronics then translate into the correct values considering the different fuel behaviour and injector construction. It is still the most widely available type and most often used for retrofits.

Liquid phase injection: This type of system injects the LPG in a liquid state in much the same manner as a gasoline-injection system. Because the fuel vaporises in the intake, the air around it is cooled substantially. This increases the density of the intake air and can potentially lead to substantial increases in engine power output.

Liquid phase direct injection is one of the most advanced systems available, much like gasoline direct injection. It utilises a high-pressure pump and injectors inject LPG in liquid-phase directly into the combustion chamber. The fuel vaporises instantly, increasing the anti-knock behaviour of the fuel, unlocking the true potential of the engine design while at the same time reducing emissions.



Prins Direct LiquiMax LPG system for DI engines ***(Prins)***

LPG direct injection engines offer fuel economy and CO_2 savings (10-15% compared with a similar gasoline engine) with little to no emissions of particles, which were declared as harmful for human health by the WHO.

In all systems, a switch on the dashboard of the vehicle, added during the conversion, allows the engine to run either on LPG or gasoline at the flick of a switch (or the push of a button). It often incorporates an LPG fuel gauge.

All these systems are fed with LPG from a tank that is mounted to the vehicle, in the boot and sometimes underneath.

The LPG is stored in liquid form in the tank under pressure. The tank is fully sealed and has safety systems to prevent over-pressurising or over-filling. It can only be filled to 80% of its capacity to allow for liquid expansion (LPG liquid expands with temperature several times greater than water).

Autogas tank in boot of vehicle

There are many different sizes and configurations of tank available.

6.2 STANDARDS AND SAFETY PRACTICES

There are several key safety features built into an LPG conversion system on a vehicle.

The LPG storage tank is normally fitted either in the boot of the vehicle or is located underneath the rear of the vehicle.

The tank is obviously vulnerable to any rear end collision – as is the gasoline/diesel tank – and constructed to withstand pressures many times more than the working pressure, as well as to provide protection against accidental impact damage.

The LPG tank is manufactured from heavy gauge carbon steel (between 3mm - 6mm thickness) and welded. It is designed to contain LPG for car conversions.

Some of the key features of an LPG tank fitted to a vehicle include:

- Pressure relief valve in the tank
- Gas tight compartment for tank valves with vents connected to the outside of the vehicle preventing LPG from entering the vehicle's interior in the event of a leakage
- Electronically controlled shut off solenoid valves to control gas flow and stop gas flow to the engine, if the engine stops for some reason
- Gas refuelling through a safety check valve to prevent backflow when filling
- Automatic overfill protection designed to limit filling only up to 80% of the tanks water capacity

Internationally recognised standards and codes must be used for Autogas tanks. Most recommend regular inspection and testing every ten years as a part of an Autogas maintenance programme.

Independent tests by TNO[9] in Holland concluded that LPG vehicles were safer in an accident than gasoline.

In fire service tests conducted in the UK it was demonstrated that in the event of a serious fire occupants in a vehicle have three times longer to evacuate with LPG than with gasoline.

[9] https://www.tno.nl/en/

CHAPTER SEVEN – CASE STUDIES ON SUCCESSFUL INITIATIVES

The following case studies focus on countries that have successfully introduced Autogas.

7.1 TURKEY – WORK ON PERCEPTIONS

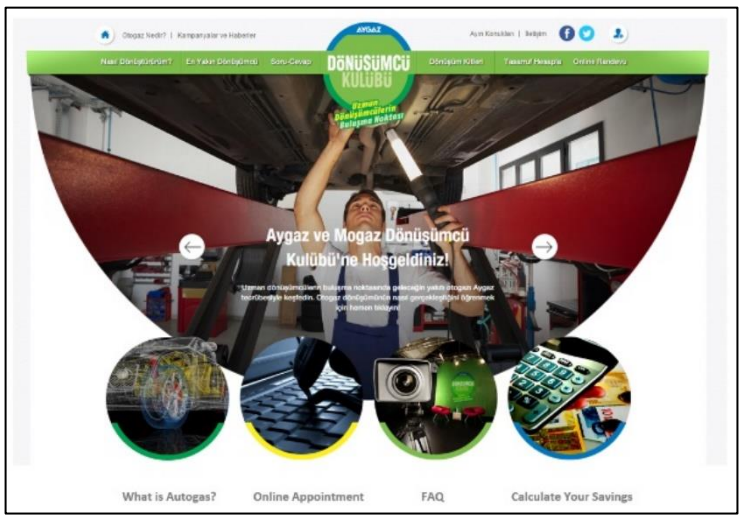
Turkey today has the second-largest Autogas market in the world after Russia – the result of spectacular growth in consumption since the end of the 1990's, when a ban on Autogas vehicles was lifted, and especially since 2003.

Consumption of Autogas overtook that of gasoline consumption in 2009, making Turkey the only country in the world where Autogas sales are larger than those of gasoline.

'…LAUNCHED AN INFORMATION CAMPAIGN TO HIGHLIGHT THE BENEFITS OF AUTOGAS…'

Autogas consumption has more than doubled since 2010, reaching 3.06 million tonnes in 2020. Autogas meets an estimated 14% of the country's total demand for automotive fuels and accounts for three-quarters of Turkey's total LPG consumption, 74% of which is met by imports.

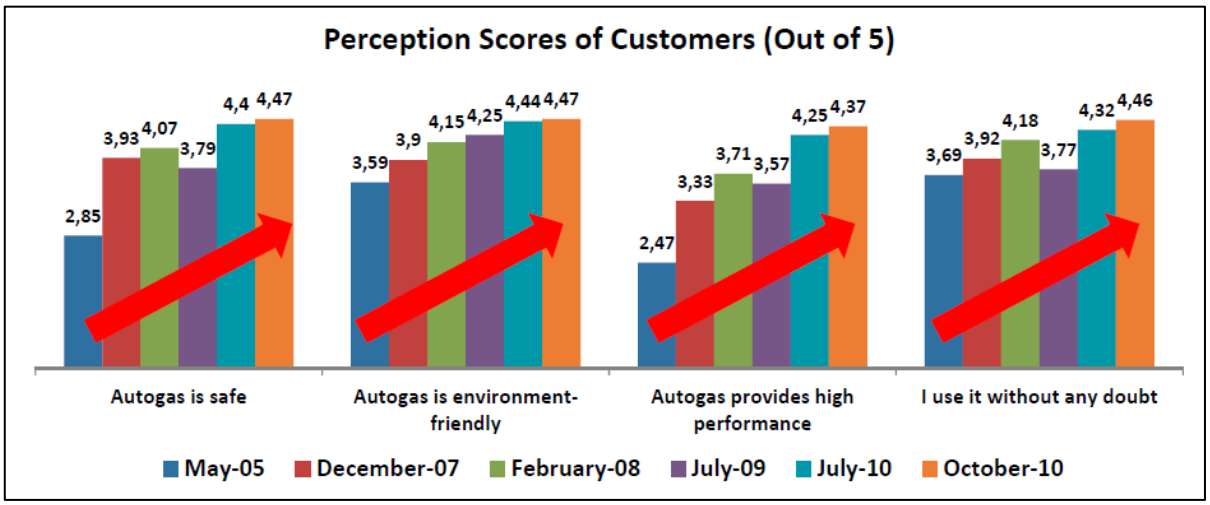
The LPG industry stimulated the growth of Autogas with several effective communication campaigns.



Support to the conversion workshops – source Aygaz

In 2007, Aygaz conducted an information raising campaign, highlighting the following three elements about Autogas:

- Clean, environmentally friendly
- Safe
- High performance



Source: Aygaz

Aygaz managed to change the poor reputation of LPG in the minds of Autogas users.

Several other advertising campaigns followed, which led to an improvement in the reputation of Autogas. This is essential for ensuring the sustainable growth of the fuel.

7.2 UNITED STATES – FOCUS ON VEHICLE FLEETS

There are very few private non-commercial Autogas vehicles in the United States. Despite Autogas being competitively priced compared to gasoline and diesel, the fact that there are only 3,000 LPG refuelling stations on such a vast territory of 9,834 million km², is probably the main reason, coupled with the cost to certify fuel systems to the Environmental Protection Agency (EPA) and California Air Resources Board standards.

'…FOCUSING ON FLEETS IS ONE OF THE MOST EFFECTIVE WAYS TO LAUNCH AUTOGAS…'

Most Autogas vehicles in the United States are in the medium duty commercial and public fleets, such as school buses, shuttles, delivery trucks and police vehicles. Market penetration is highest in the school-bus segment, with almost 5% of all school buses running on Autogas.

Over 1,000 public and private operators in 49 states currently operate a total of 22,000 buses nationwide, over 1,700 of them in Texas, over 1,400 in California, 1,185 in Pennsylvania, 1,070 in Georgia and over 1,000 in Wisconsin.

The availability of new light, and medium-duty propane vehicles has surged in recent years, especially for fleet use[10].

Broward County Transit, Florida

Paratransit Fleet saved US$8 million in five Years with Autogas. When deciding on the right energy solution for Florida's Broward County Transit, Paul Strobis, the director of paratransit, had several factors to consider. First, the vehicle range. With a 471 square-mile county, Broward County Transit provides more than 900,000 trips a year across 11.5 million miles. Second, the environment. Broward is nestled between the fragile Everglades and coral reefs, so the energy source had to reduce emissions. Finally, the cost. The energy solution couldn't drive up the cost of achieving a high-volume, near-zero emissions fleet.

The only energy source that could achieve all these goals was Autogas. Not only has Broward County been able to easily keep up with the volume of passengers, but the fleet has saved $8m and reduced CO_2 emissions by thousands of metric tonnes a year.

Broward County prioritises alternative energy solutions to protect the fragile environment it encompasses. It's why Mr Strobis chose Autogas engines, which are 90% cleaner than the most stringent Environmental Protection Agency (EPA) standards. Since making the switch from gasoline to Autogas, Broward County has reduced its CO_2 emissions by 60.5 metric tonnes per bus. Or for the full fleet, 11,975 metric tons in five years.

With lower maintenance and fuel costs, Broward County has saved $5.2 million in the five years that it has operated on a mostly Autogas fleet. Broward's average net cost-per-gallon for Autogas is $0.86, and the average maintenance cost-per-mile is $0.20 less than gasoline.

Mr Strobis was also able to take advantage of state and federal grants, like the Alternative Fuel Tax Credit, which has amounted to an additional $2.9 million in savings over five years. That is over $8

[10] https://www.afdc.energy.gov/vehicles/propane.html

million saved and put back into the fleet.

"…If you're looking at ways to trim operational costs through efficiencies, I urge you to consider looking at Autogas…," Mr Strobis said. "…when you consider the small amount of capital outlay and the immediate return on investment, it makes it easy to build Autogas into your programme…"

During the hurricane season, Broward County Paratransit is tasked with evacuating its vulnerable population who cannot evacuate themselves. For Mr Strobis, that meant he needed a reliable energy solution that could keep running for hundreds of miles even when gasoline stations closed or ran out of fuel. Autogas was the mobile energy source he needed.

When a hurricane hit Florida, Broward County worked with its Autogas supplier to have two Autogas delivery trucks on site to provide fuel for the vehicles. While the gasoline-powered vehicles were grounded, the Autogas buses were able to continue evacuations. Broward's Autogas vehicles have a range of over 300 miles, allowing the fleet to keep going when it was needed most.

Since implementing Autogas, Mr Strobis has been able to demonstrate significant environmental, financial, and operational efficiencies, allowing him to check off each of these goals for his fleet.

Fleet Profile - 73% of the fleet uses Autogas:

- 124 Ford E-450 DRW Cutaways
- 44 Ford Taurus's
- 102 Ford Transit Cutaway
- 6 Autogas re-fuelling Stations

Summary

- 11,975 metric tonnes of CO_2 reduced from the fleet over five years
- $8 million in cost savings over five years
- 73% of the fleet currently operates on Autogas with plans to transition more vehicles as they are retired
- 300 mile range for each vehicle
- 20 cents - the amount of money saved per mile on Autogas maintenance costs compared to gasoline

Source: PERC

There are several federal programmes, regulations, and incentives in place to encourage alternative fuels, including Autogas.[11] Under the Energy Policy Act of 1992, 75% of new LDVs acquired by certain federal fleets must be alternative fuel vehicles (AFV).

Executive Order 13514, issued in October 2009, and the Energy Independence and Security Act of 2007, introduced additional requirements for federal fleets to acquire vehicles with low greenhouse-gas emissions, favouring Autogas and other AFV. The Federal government also runs several programmes that encourage the use of alternative fuels. One of the most important is the Clean Cities

[11] A full list of current programmes and incentives can be found at https://www.afdc.energy.gov/fuels/laws/LPG/US.

Program, which supports local public/private initiatives to promote the deployment of AFVs and reduce conventional fuel consumption in urban areas.[12]

In 2011, President Obama announced the creation of a National Clean Fleets Partnership, run by the DOE, under which more than 20,000 advanced technology vehicles, including Autogas vehicles, are to be deployed.[13]

Clean School Bus USA provides funding for projects designed to retrofit and/or replace older diesel school buses with AFV; Autogas accounts for many the buses that have been converted under this programme.[14]

Autogas fuelled school buses in the USA

Focusing on fleets is one of the most effective way to launch Autogas. It:

- Requires limited infrastructure
- Allows for economies of scale for both users and LPG industry players
- Guarantees a quick return on investment to both users and LPG distributors thanks to big volumes
- Raises the awareness of Autogas of a broader public using/seeing these vehicles

Funding for alternative fuels, including Autogas, has grown significantly over the last ten years, with hundreds of local state and federal programmes, regulations, and incentives. The Volkswagen (VW) settlement is one of the largest funding sources for alternative fuels vehicles and infrastructure.

[12] For more information, go to https://cleancities.energy.gov/.
[13] For more information, go to http://www.afdc.energy.gov/uploads/publication/60619.pdf
[14] https://www.epa.gov/cleandiesel/clean-school-bus

7.3 SOUTH KOREA – USE AIR QUALITY POLICIES

The Republic of South Korea was one of the first countries to promote the widespread use of Autogas and, for many years, has had one of the largest Autogas market in the world.

Demand took off in the 1970's as taxis started to adopt the fuel and surged in the 1990's in response to strong government support for the fuel's use in taxis, other fleet vehicles and public buses.

'…MANY YEARS OF HIGHLY SUPPORTIVE GOVERNMENT POLICIES, INCLUDING FAVOURABLE TAXATION…'

The exceptional size of the South Korean Autogas market today, despite the recent contraction in demand, is primarily the result of many years of highly supportive government policies, including favourable taxation of Autogas.

Environmental restrictions on diesel vehicles also helped encourage Autogas use by high-mileage vehicles.

Regulations concerning the use of diesel vehicles as taxis has been a critical issue to Autogas growth in South Korea. While since 2015 diesel taxis are theoretically allowed, the government has tightened the regulations on emissions, due to concerns about the environmental and health risks associated with diesel.

Autogas car at South Korean Motor Show

Further changes are imminent; for example, the government plans to introduce extra NOx emission compliance tests during car inspections, which are thought to be very challenging for diesel vehicles.

As a result, LPG still powers more than 95% of the taxis in South Korea. Although this is still significant it was close to 100% in 2010. Fuel diversification such as hydrogen fuel cells and diesel etc., are the reasons for the decreasing Autogas market share.

7.4 SPAIN – ENSURE STRONG GOVERNMENT SUPPORT

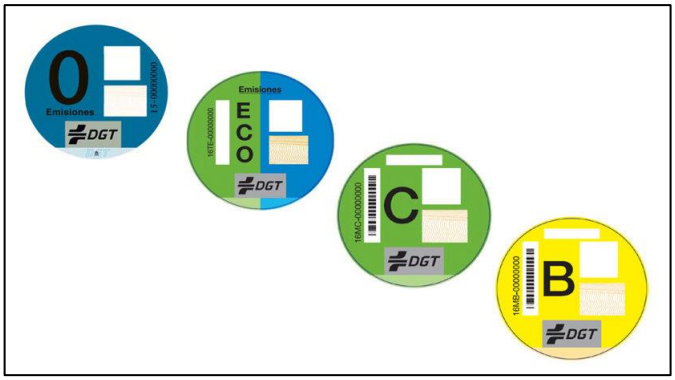
> '…NON-FINANCIAL INCENTIVES ALSO HAVE A ROLE TO PLAY IN THE PROMOTION OF AUTOGAS…'

Spain has a small Autogas market, but it is expanding rapidly in response to a substantial fiscal incentive and various national and local initiatives to promote the take-up of the fuel for environmental reasons.

The government, since the adoption of the plan MOVEA in 2016[15], has regularly allocated funds for the purchase of alternative fuels vehicles such as Autogas. A fund of 16.6 million Euros was announced in 2018, with a new grant scheme to be launched in June.

Another important measure that increasingly favours Autogas concerns traffic restrictions.

In early 2017, the General Transit Authority (DGT) started to implement a vehicle-labelling system based on emissions, which provides a legal basis for local traffic regulations related to air quality.



Spain's vehicle labelling system

Under the system, battery electric vehicles (EV) are classified in "zero emissions" category. Autogas, hybrids, Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) vehicles are classified in the "ECO" category, and vehicles that meet Euro-6 standards to a "C" category.

Some municipal authorities may restrict or prohibit the entry in densely populated areas of certain vehicles according to their emissions category.

This shows that non-financial incentives also have a role to play in the promotion of Autogas.

Active government involvement in Autogas promotion

In this context, the Spanish government states: "…it is estimated that the increase in the number of vehicles to LPG due to the market evolution given the measures contained in both the 2014-2020 Strategy for Driving the Vehicle with Alternative Energies (VEA) in Spain and in this National Action Framework will reach 200,000-250,000 vehicles by 2020 (for 800-1000 filling stations)"[16].

[15] http://www.mincotur.gob.es/industria/es-ES/Servicios/plan-movea/2016/Paginas/ayudas-movea.aspx
[16] Spanish National action framework for alternative energy in transport: http://www.mincotur.gob.es/industria/es-ES/Servicios/Documents/national-action-framework.pdf (retrieved on 20 July 2018)

7.5 ITALY – DEVELOP THE RIGHT TECHNOLOGY

Autogas is the most important alternative fuel in Italy, fuelling over 2.7 million vehicles. Retrofitting was the main market until 2008 - 2009 when OEMs started to propose new cars directly equipped with LPG fuelling systems.

'…OEMS PLAY A CRITICAL ROLE IN THE EVOLUTION OF AUTOGAS…'

The support from national government that incentivised purchasing of Autogas cars when scrapping old vehicles, completely reshaped the market. Since 2009 most of the registrations are with OEM vehicles. Retrofit numbers are stable at lower levels when compared to the first decade of this century.

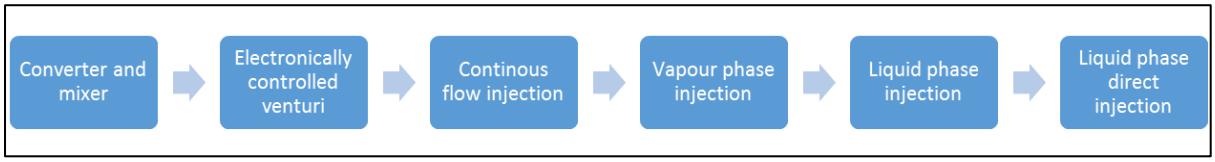
The Italian industry has an historical commitment with Autogas, and the consistency of the stations (more than 4,300) give a clear indication of the interest of LPG distributors to invest in this market. A clear set of norms and legislations on safety, together with a favourable taxation compared to liquid fuels, increase customers' confidence to the product and guide their choice also when buying new cars.

Green emissions of Autogas are well understood by local governments providing exemption for Autogas vehicles from environmental traffic bans.

Italy is home to several Autogas engine and conversion-kit manufacturers, with a well-established network of installers.

These companies have played a critical role in the evolution of the Autogas technology.

The technology was first developed in the 1950's. Since then, the engine technology has continuously improved, in parallel with the development of the gasoline internal combustion engine.
Currently the sixth generation of LPG engines is being used.



LPG direct injection engines offer fuel economy and CO_2 savings (10-15%, compared to a similar gasoline engine) with little to no emissions of particles.

7.6 ALGERIA – IMPLEMENT CONVERSION PROGRAMMES

The Algerian government has pursued a policy of promoting Autogas since the 1980's, to take advantage of its large production of LPG from refining and natural-gas processing. The policy also contributes to the reduction of diesel fuel imports and helps to tackle urban pollution.

Autogas consumption grew rapidly in the early 2000's, to reach 352,000mt in 2016.

'…PROMOTING AUTOGAS CONTRIBUTES TO THE REDUCTION OF DIESEL FUEL IMPORTS AND TACKLES URBAN POLLUTION…'

The Algerian government actively promotes the use of Autogas. The National Agency for the Promotion and Rationalisation of Energy Use (APRUE) targeted in 2011 the fuel to reach 20% of total road-fuel sales by 2020.

The principal measure is a substantial price differential to gasoline and diesel (the government fixes both the wholesale and retail prices of all automotive fuels).

In 2018, APRUE launched a 2018-2021 conversion programme to transform about 500,000 vehicles to LPG by 2020, allowing a net saving of $2.19 billion over the period 2018-2030. In 2020 there were an estimated 355,500 vehicles running on Autogas, serviced by 800 filling stations.

The State funded 50% of the costs of the import of 50,000 conversion kits during 2018. APRUE will also run a communication and awareness campaign to support the conversion programme.

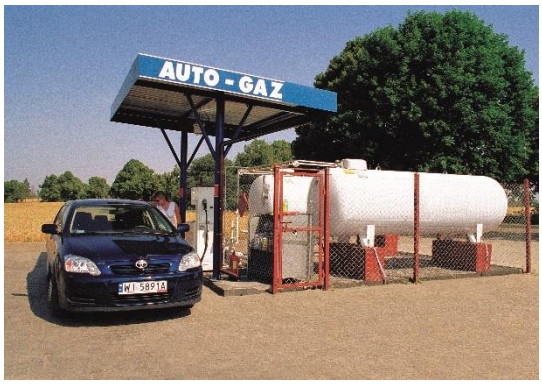
7.7 POLAND – INVEST IN INFRASTRUCTURE DEVELOPMENT

Poland has the largest Autogas market in the European Union today. There are over 7,400 retail sites across the territory where LPG is available.

> '…AUTOGAS TOOK OFF FOLLOWING INDEPENDENT INVESTMENT IN INFRASTRUCTURE …'

Furthermore, it is easy to convert gasoline-powered vehicles to LPG because of the high number of conversion points and the relatively low conversion prices. According to the latest data, there are about 100,000 vehicles being converted to LPG each year. In 2020 there were over 3.3 million Autogas vehicles in Poland.

There is no government-led support programme for Autogas, beyond the lower rate of excise duty applied to Autogas compared with conventional fuels. Consumers really made the popularity of Autogas, mainly due to its lower price.



Simple Autogas station

The development of the filling infrastructure has been spontaneous, without any financial support from authorities.

Small and independent (dedicated) LPG filling stations emerged first, and only when that fuel became more popular, the stations run by major fuel companies began to offer that fuel to consumers.[17]

Poland is a good example of a market which kicked off thanks to independent investments in the fuel infrastructure to become the leader in Europe.

[17] Krajowe ramy polityki rozwoju infrastruktury paliw alternatywnych http://bip.me.gov.pl/files/upload/26450/Krajowe_ramy%20_ver2_6_18012017.pdf

7.8 CHILE – STRONG ADVOCACY PROGRAMME

This case study describes the challenge facing the LPG industry to introduce Autogas (LPG) into a country where private vehicles were previously banned from using it, despite government support for Autogas in other sectors such as taxis, and commercial vehicles. It sets out how the industry persuaded the government to change policy and support Autogas use in private vehicles.

The global COVID-19 pandemic made the Environment one of the primary concerns for both Chile, and the rest of the world. The Chilean government recently authorised the conversion of private vehicles from gasoline and diesel to LPG (Autogas), to promote cleaner fuels. Getting to this point required several years of discussion; but at the same time the industry continued to develop this technology for commercial vehicles, taxis and high-displacement vans, which were all already authorised to use Autogas.

Gasco filling station in Chile supplying Autogas

In the years prior to this regulatory change, Chilean LPG distributors, principally Gasco, held several meetings with the Ministries of Finance, Energy and Transportation to propose changes in the Specific Fuel Tax (IEC), with the aim of promoting competition between more types of (cleaner) fuels - avoiding a fleet of 'diesel-only' vehicles - which would provide both economic and environmental benefits for users.

These meetings were the first instances in which the Government of Chile was informed on the benefits of Autogas and the importance of making changes to regulations in order to promote its use.

Before this, the public sector had only looked at electrification to promote emission reductions as part of public policy, without having considered Autogas as a transition fuel for which the technology was already available, and at competitive prices

In addition to meeting with Government, distributors continued to play a key role in developing this measure through:

- Promotion of meaningful investments to encourage conversions
- Sealing partnerships with automotive brands to bring this technology closer to the consumer
- Improving the network of service stations and workshops

In 2018, Gasco and Renault worked together to officially approve the sale of the first factory-manufactured, private use Autogas car in Chile: the Symbol sedan. After extensive work between Gasco and Renault, around 100 units of the Renault Symbol were sold in the first year of commercialisation. In 2019, Gasco presented its new fleet of light distribution vehicles with 100% gas technology as well as dual gas-diesel and gas-petrol options. They also unveiled a new bulk distribution truck for Latin America with a dedicated LPG engine for industrial and residential use

An important milestone in this process, which had great implications in bringing this measure to fruition, was the first Autogas seminar in Chile, held in August 2018. At the seminar, 'Gas Vehicles in Transport: Available Energy Today, Ready for Tomorrow', organised by Gasco in conjunction with the Society for Manufacturing Development (SOFOFA) and the WLPGA, the legislative framework of the industry was addressed, as well as the socio-economic and environmental benefits that come from its use. The seminar presented proposals on how to promote the use of this efficient energy resource in the automotive industry. The important participation of the WLPGA was key in advocating Autogas

within the government's agenda. The WLPGA took the opportunity to hold meetings with government authorities from the energy and transportation sectors, in order to reinforce the importance that.

Autogas vehicles have had in other countries around the world, and the benefits that promoting such a measure would have for Chile. Subsequently, several working groups, studies and meetings promoted by the WLPGA, unions and other organisations continued until September 2019, when The Ministry of Economy launched the Economic Recovery Agenda with 40 measures that aimed to accelerate the pace of growth, provide new jobs, and improve the quality of life for Chileans. Included in the package was deregulation on the conversion of private vehicles to Autogas and LNG. However, the measure that would reduce the cost of fuel for consumers by approximately 35%, not to mention a significant reduction in CO2 emissions and pollutants, was delayed as a result of the social crisis that broke out in October 2019 and the subsequent global pandemic of COVID-19

Despite the current health crisis, on the 12th of June 2020, the Chilean government published a new law decree that allows private vehicles, not exceeding five years of age, to convert from petrol to LPG. The conversions must be carried out in one of the 41 workshops accredited by the Vehicle Certification and Control Center (3CV) operating in the country.

'…As the Ministry of Transport and Telecommunications (MTT), we are working on modifying the regulations that provide greater benefits to people and contribute to the environment ... From now on, private vehicles may also opt for conversion to replace petrol by gas, which allows for a savings on fuel of about 35%...', said Undersecretary of Transportation José Luis Domínguez.


AUTOMÓVILES, CLASIFICADOS, ACCESORIOS Y SERVICIOS

GAS LICUADO DE PETRÓLEO [AUTOS PARTICULARES]

El GLP quiere abrirse paso en Chile

Newspaper coverage of the campaign '…Autogas wants to break through in Chile…'

The industry is expected to convert around 100,000 private vehicles to LPG. This figure is based on the experience from other countries that have undertaken similar processes and that only vehicles five years' old or less are eligible for conversion. After the conversion of the vehicle, the owner receives a certificate to present at the Technical Inspection Plant authorised to inspect cars that use gas. Once compliance with all regulations is verified, a new Certificate of Technical Review or Individual Homologation is granted, renewable every six months. This protocol seeks to ensure that the conversions are carried out in accordance with all safety standards.

Acknowledgement - Gasco, Chile.

Lessons from established Autogas markets and success stories, but also failures and mistakes, have created the opportunity to develop this *Guide to New Autogas Markets*.

The following checklist has been developed to summarise the key elements of this report and should be used by all stakeholders.

Preparatory phase

- ✓ Establish a focused industry voice (e.g., LPG Association) to concentrate effort
- ✓ Conduct research to confirm market potential and interest level
- ✓ Identify where LPG sits in the country's energy portfolio
- ✓ Develop the Autogas value proposition tailored to the specific market

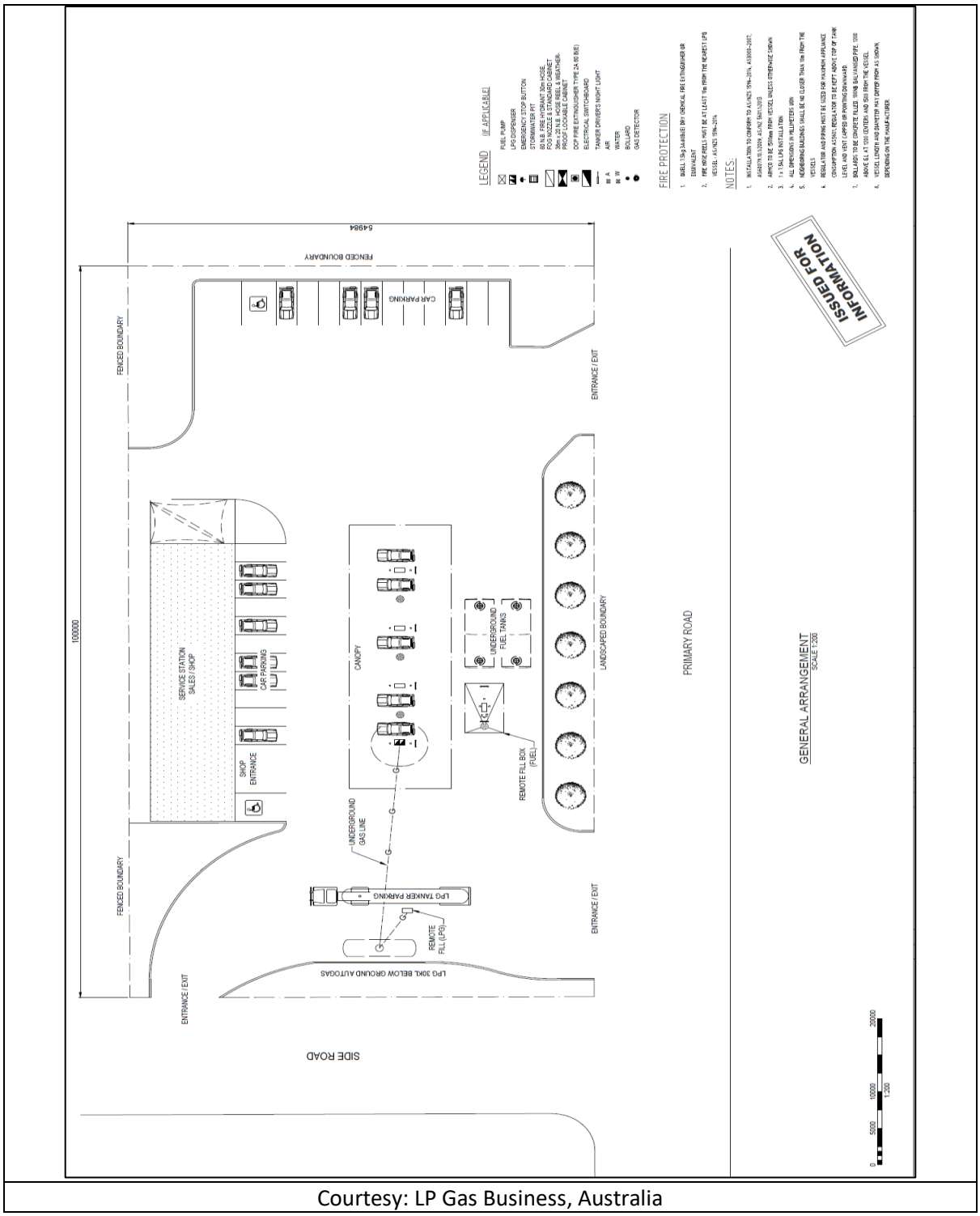
Engagement phase

- ✓ Assemble the industry and other partners together, including car manufacturers/importers, conversion kit manufacturers/importer, LPG component suppliers, environmental groups etc
- ✓ Develop a common roadmap for Autogas development covering all aspects
- ✓ Work with the government to ensure favourable long term taxation policy
- ✓ Explore with the government the possibility to establish other (financial and non-financial) incentives
- ✓ Kick-off Autogas use with a pilot project to demonstrate benefits

Deployment phase

- ✓ Define key targets, e.g., fleets, and develop an outreach plan
- ✓ Launch communication activities to raise awareness of Autogas among targeted audiences (include motor shows, automobile sessions/conferences, point of sale – display converted cars)
- ✓ Organise demonstrations for target groups (policymakers [health, transport, energy, environment], universities, vehicle dealerships, fleet operators)
- ✓ Provide vehicles for events to promote Autogas (sporting, races, rallies, charities)
- ✓ Utilise Autogas vehicles within inhouse fleets (staff cars)
- ✓ Establish refuelling points/workshops with relevance to the type and location of targeted consumers and promote locations (e.g. using Apps)
- ✓ Work with OEMs to ensure vehicles are correctly and safely fitted with 'fit for purpose' equipment – both on the vehicle production line and in the aftermarket
- ✓ Ensure quality and safety of conversions and re-fuelling operations
- ✓ Refer to recognised international standards when developing the Autogas infrastructure for both vehicles and refuelling network
- ✓ Ensure the availability of maintenance through properly trained personnel using OEMs to keep training updated
- ✓ Maintain the relationship with partners and governmental authorities to maintain favourable conditions
- ✓ Handle complaints swiftly and ensure resolution

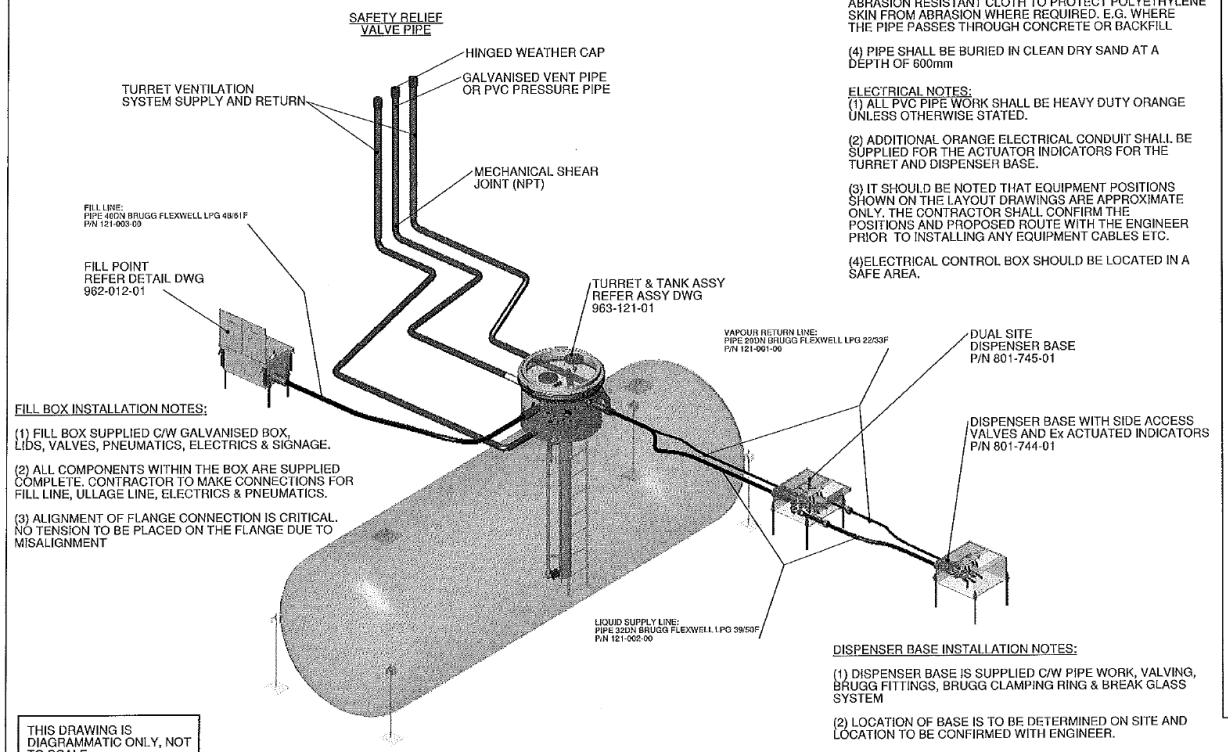
APPENDIX ONE – TYPICAL AUTOGAS STATION LAYOUTS



Courtesy: LP Gas Business, Australia

Courtesy: PSG Dover (Ebray)

REFERENCE DRAWINGS	DESCRIPTION
963-121-01	TURRET & TANK ASSEMBLY WITH ACTUATED INDICATORS
962-012-01	FILL BOX
801-744-01	DISPENSER BASE WITH ACTUATED INDICATORS
801-745-01	DUAL DISPENSER BASE WITH ACTUATED INDICATORS



FILL BOX INSTALLATION NOTES:

(1) FILL BOX SUPPLIED C/W GALVANISED BOX, LIDS, VALVES, PNEUMATICS, ELECTRICS & SIGNAGE.

(2) ALL COMPONENTS WITHIN THE BOX ARE SUPPLIED COMPLETE. CONTRACTOR TO MAKE CONNECTIONS FOR FILL LINE, ULLAGE LINE, ELECTRICS & PNEUMATICS.

(3) ALIGNMENT OF FLANGE CONNECTION IS CRITICAL. NO TENSION TO BE PLACED ON THE FLANGE DUE TO MISALIGNMENT

MECHANICAL NOTES:
(1) THE USE OF BRUGG FLEXWELL PIPE DOESN'T REQUIRE THE USE OF CATHODIC PROTECTION.

(2) NO JOINTS SHALL BE BURIED FLANGED OR SCREWED.

(3) BRUGG PIPE SHALL BE WRAPPED WITH ABRASION RESISTANT CLOTH TO PROTECT POLYETHYLENE SKIN FROM ABRASION WHERE REQUIRED. E.G. WHERE THE PIPE PASSES THROUGH CONCRETE OR BACKFILL

(4) PIPE SHALL BE BURIED IN CLEAN DRY SAND AT A DEPTH OF 600mm

ELECTRICAL NOTES:
(1) ALL PVC PIPE WORK SHALL BE HEAVY DUTY ORANGE UNLESS OTHERWISE STATED.

(2) ADDITIONAL ORANGE ELECTRICAL CONDUIT SHALL BE SUPPLIED FOR THE ACTUATOR INDICATORS FOR THE TURRET AND DISPENSER BASE.

(3) IT SHOULD BE NOTED THAT EQUIPMENT POSITIONS SHOWN ON THE LAYOUT DRAWINGS ARE APPROXIMATE ONLY. THE CONTRACTOR SHALL CONFIRM THE POSITIONS AND PROPOSED ROUTE WITH THE ENGINEER PRIOR TO INSTALLING ANY EQUIPMENT CABLES ETC.

(4)ELECTRICAL CONTROL BOX SHOULD BE LOCATED IN A SAFE AREA.

GENERAL NOTES:

1) THESE DRAWINGS HAVE BEEN PREPARED IN ACCORDANCE WITH AUSTRALIAN STANDARDS.

2) ALL MATERIAL AND WORKMANSHIP SHALL CONFORM TO THE LAST EDITIONS OF AUSTRALIAN STANDARDS AND DANGEROUS GOODS ACTS. ALL WORK SHALL BE TO THE SATISFACTION OF THE SUPERINTENDENT.

3) ALL WORK SHALL BE UNDERTAKEN IN ACCORDANCE WITH SAFETY REQUIREMENTS (REFER COMPANY STANDARD TECHNICAL SPECIFICATION STD-D905, SECTION 1) ALL EMPLOYEES ARE TO BE FAMILIAR WITH, AND OBEY THESE REQUIREMENTS.

4) ALL DIMENSIONS SHOWN ON DRAWINGS ARE IN MILLIMETRES UNLESS NOTES OTHERWISE.

5) ALL STANDARD DRAWINGS SHALL BE READ IN CONJUNCTION WITH PROJECT SPECIFIC DRAWINGS.

6) THE CONTRACTOR SHALL PROVIDE ALL NECESSARY MATERIALS AND LABOUR, WHETHER OR NOT DETAILED ON THE DRAWINGS, TO SATISFACTORILY COMPLETE THE INSTALLATION.

7) IN SOME STATES, STATUTORY REGULATIONS MAY REQUIRE MODIFICATIONS AND/OR ADDITIONAL WORK TO BE UNDERTAKEN TO THAT SPECIFIED ON THESE DRAWINGS. IN SUCH CASES ALL WORK SHALL BE CARRIED OUT IN STRICT ACCORDANCE WITH THE REQUIRED LOCAL REGULATIONS.

8) IN ADDITION TO ANY STATUTORY AND THE COMPANY SPECIFIED REQUIREMENTS, ALL WORK SHALL COMPLY WITH THE REQUIREMENTS OF THE FLEXIBLE PIPE OR COMPONENT MANUFACTURER. IN THE EVENT OF ANY CONTRADICTION OR INCOMPATIBILITY BETWEEN THE MANUFACTURERS REQUIREMENTS AND THE COMPANY/STATUTORY REQUIREMENT, THE SUPERINTENDENT SHALL DETERMINE PRECEDENCE.

DISPENSER BASE INSTALLATION NOTES:

(1) DISPENSER BASE IS SUPPLIED C/W PIPE WORK, VALVING, BRUGG FITTINGS, BRUGG CLAMPING RING & BREAK GLASS SYSTEM

(2) LOCATION OF BASE IS TO BE DETERMINED ON SITE AND LOCATION TO BE CONFIRMED WITH ENGINEER.

(3) DISPENSER PIPE WORK TO BE SUPPLIED WITH SHEAR POINTS LOCATED AS CLOSE AS POSSIBLE TO THE BALL VALVES. P/N 800-423-01 FOR SHEAR GROOVE SPOOL.

THIS DRAWING IS DIAGRAMMATIC ONLY, NOT TO SCALE

TOLERANCE TABLE	
LINEAR	
0 TO 6	±0.1
6 TO 30	±0.2
30 TO 120	±0.3
120 TO 315	±0.5
315 TO 1,000	±1.5
OVER 1,000	±3
ANGULAR	±0.1°
FLATNESS & STRAIGHTNESS	±0.2
RUNOUT	±0.2
SCREW THREADS AS1275	
REF PROCEDURE QWI-0022	

REV.	DESCRIPTION	DATE	DRAWN	APPROVED
B	UPDATED COMPONENT DRG NOS AND MODIFIED DRG LAYOUT	11/02/2014	MA	SOP
A	INITIAL RELEASE	2/11/2012	SOP	JRB

REVISIONS

MATERIAL: N/A

FINISH: N/A

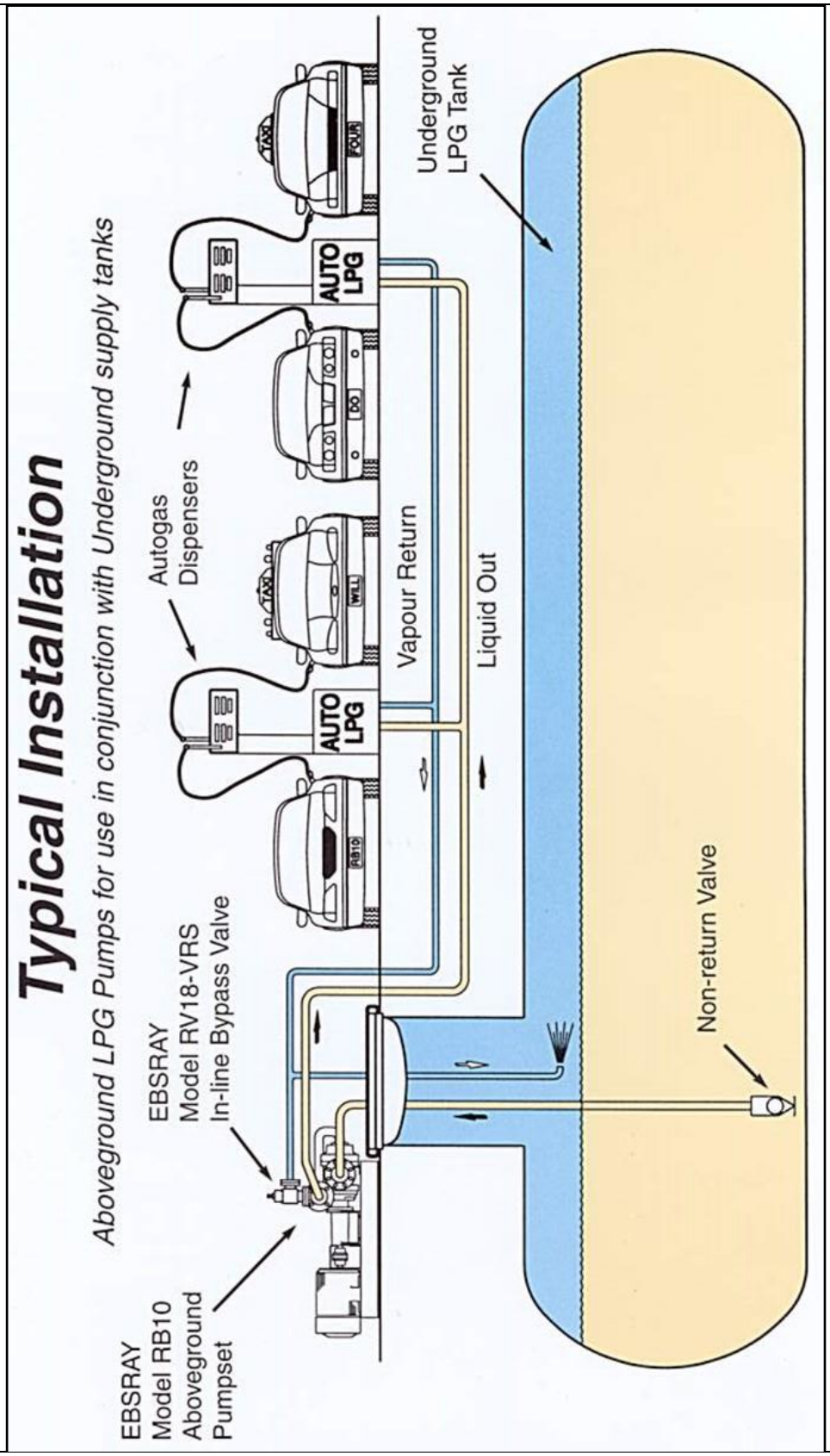
DRAWN TO AS 1100.101
ALL DIMENSIONS IN MILLIMETERS

BATCHEN
2-6 Raglan Road Auburn 2144, Australia
Ph:61-2-9644 7444 - Fax: 61-2-9645 1665
www.batchen.com.au

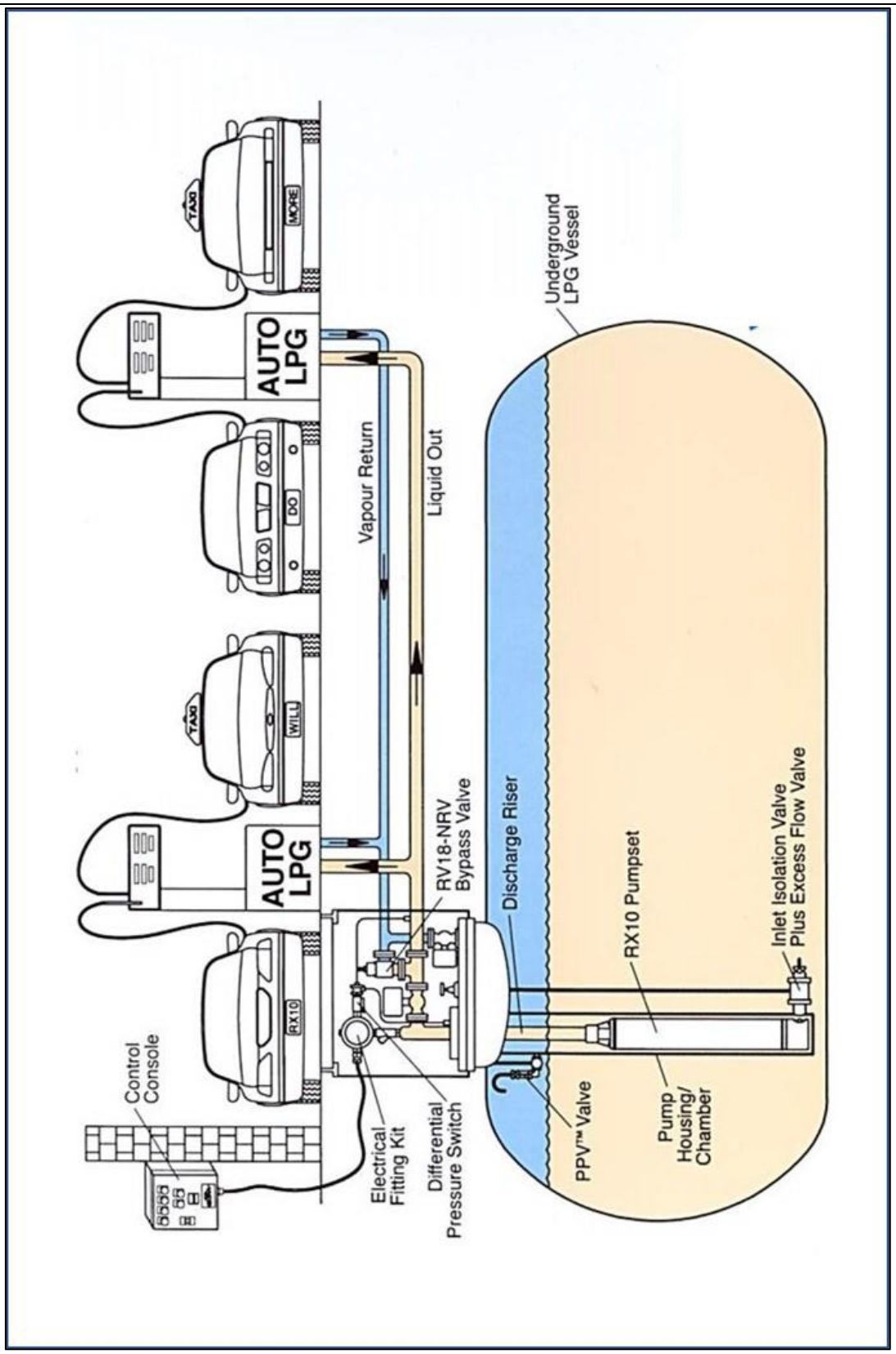
DRAWN: SOP CHECKED JRB
DATE: 02-11-2012 APPROVED JRB
SCALE SCALE

Title: SITE LAYOUT SPECIFICATION - BRUGG

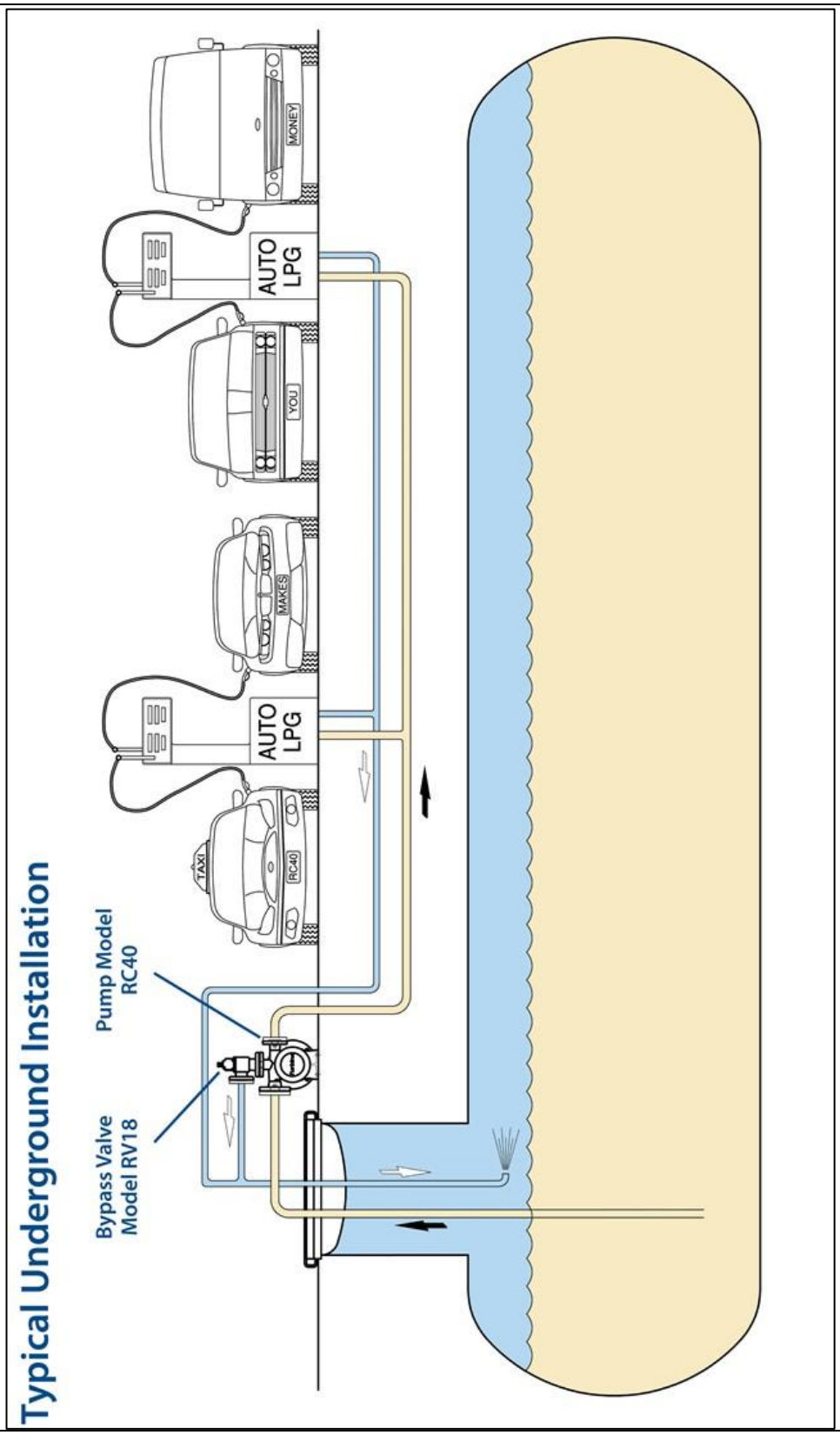
DRG. NUMBER: 800-116-01 REV B A3



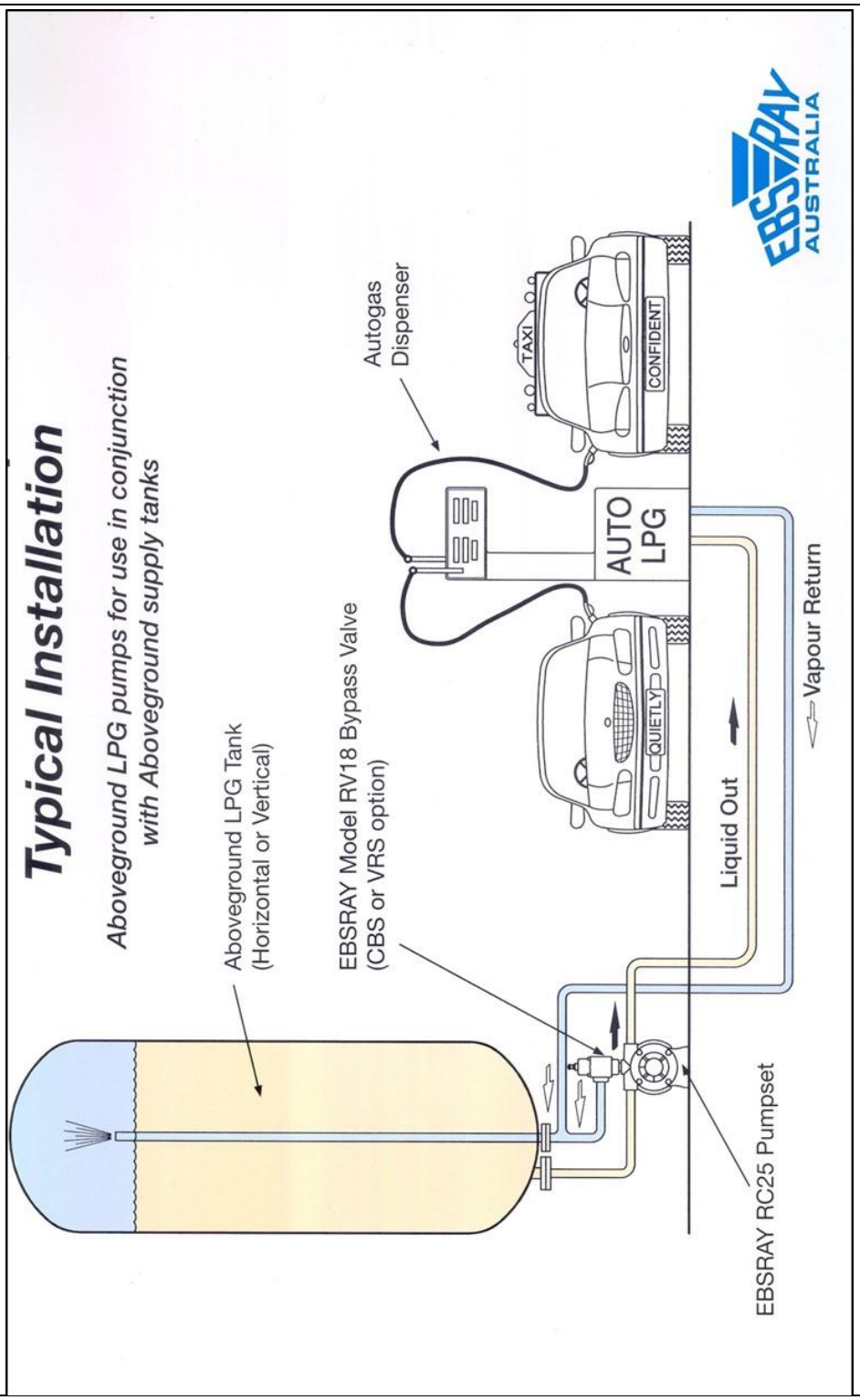
Courtesy: PSG Dover (Ebray)



Courtesy: PSG Dover (Ebray)



Courtesy: PSG Dover (Ebray)



Courtesy: PSG Dover (Ebray)

Appendix Two – Relevant standards and good safety practices

Fuel quality Standards

Europe:

CEN - EN 589: Automotive fuels - LPG - Requirements and test methods

LPG operations and systems safety standards and good practices

Liquefied Petroleum Gas Code – United States - NFPA 54 and NFPA 58
The industry benchmark for safe LP-Gas storage, handling, transportation, and use

Technical Standard for the design, construction and Operation of LPG filling stations for motor vehicles – NTGPL – 2015

UKLPG code of practice 11 – Autogas installation
This Code covers Autogas fuel systems for both light and heavy-duty vehicles and is particularly aimed at the aftermarket conversion business.
https://www.uklpg.org/shop/codes-of-practice/code-of-practice-11

Autogas systems regulations

Europe:

UNECE Regulation No. 67 Concerning The Adoption Of Uniform Technical Prescriptions For Wheeled Vehicles, Equipment And Parts Which Can Be Fitted And/Or Be Used On Wheeled Vehicles And The Conditions For Reciprocal Recognition Of Approvals Granted On The Basis Of These Prescriptions

https://www.unece.org/?id=39144

UNECE Regulation No. 115 Concerning LPG and CNG Retrofit Systems

https://www.unece.org/?id=39146

Australia and New Zealand:

Australian and New Zealand standard AS / NZS 1425 - LP gas fuel systems for vehicle engines

APPENDIX THREE – EXTRACT FROM WLPG GLOBAL AUTOGAS INDUSTRY NETWORK – A Guidebook for – Lobbying and Advocacy; First Edition published September 2004

Executive Summary

There are significant market differences and diverse challenges facing the Liquefied Petroleum Gas (LPG) industry in different countries throughout the world. One factor, however, is common to the global LPG industry, particularly in its automotive or transport fuel form (Autogas): that is, it is extremely vulnerable to the vagaries of public policy decisions. Whether it is to deliver benefits in terms of the environment, energy security or economic development, Autogas requires policy interventions to address market barriers. This is the industry's greatest challenge.

It is possible to develop an effective, ongoing lobbying campaign, which accommodates individual markets and circumstances, as well as different political structures. This can be achieved while simultaneously addressing the essential, common issue of how to engineer the most favourable public policy settings for the preservation, or indeed, growth and development of the Autogas industry.

Lobbying and advocacy involves a conscious attempt to influence government policy, both at the political and bureaucratic level. It is a methodical and strategic process of analysing the strengths and weaknesses of the existing situation; working out what is a desirable outcome; planning a communication programme, and taking steps to achieve the industry objectives. Such a strategy also requires a strong commitment by industry to resource its implementation.

There are four steps to achieving a successful lobbying and advocacy program:

- ***A comprehensive audit** of policies and positions (the current policy settings in the particular country and what is required to achieve the desired policy settings; together with an objective analysis of the attitudes of all the potential interested parties)*
- ***Planning and resource allocation for the programme**, where policy goals and themes for the campaign are decided; and the management team, processes, working program and resourcing needs are established*
- ***Establishing a communications plan**, both within the industry and externally in order to create awareness and outline the industry needs and policy benefits delivered; and*
- ***Influencing**, by transforming awareness to a supportive policy position, undertaking specific offensive or defensive campaigns and at all times maintaining credibility and consistency*

Progress needs to be monitored and assessed throughout each stage of the process and any adjustments made as necessary. The industry representatives and spokespeople should maintain credibility and build relationships with policy makers over time.

The platform for influence is built when there is awareness and understanding. Plausible policy positions should be advocated, backed by consistent and straightforward communication with reliable and verifiable information.

Autogas is an inherently good product, with demonstrable benefits. This Guidebook provides an organised framework for building knowledge of, and respect for Autogas, communicating its benefits, and engendering supportive policies.

References

WWW.PRINSAUSTRALIA.COM.AU/

AUTOGAS INCENTIVE POLICIES REPORTS: HTTPS://AUTO-GAS.NET/GOVERNMENT-POLICIES/AUTOGAS-INCENTIVE-POLICIES/

AUTOGAS CHARTER OF BENEFITS: HTTPS://AUTO-GAS.NET/WP-CONTENT/UPLOADS/2018/01/WLPGA-AUTOGAS-CHARTER-OF-BENEFITS_03-002.PDF

EMISSIONS AND PERFORMANCE OF LIQUEFIED PETROLEUM GAS AS A TRANSPORTATION FUEL: A REVIEW, ROSS RYSKAMP, PH.D. RESEARCH ASSISTANT PROFESSOR WEST VIRGINIA UNIVERSITY CENTER FOR ALTERNATIVE FUELS, ENGINES, AND EMISSIONS: https://auto-gas.net/wp-content/uploads/2017/11/WLPGA-Literature-Review-FINAL.pdf

AVAILABLE TO WLPGA MEMBERS ONLY:

AUTOGAS MARKET IN MOROCCO, AUGUST 2017
A GOOD EXAMPLE OF A STUDY OF THE MARKET POTENTIAL FOR AUTOGAS:
HTTPS://EXTRANET.WLPGA.ORG/WP-CONTENT/UPLOADS/2017/09/11092017-INFOMINEO-WLPGA-LPG-AUTOGAS-MARKET-IN-MOROCCO-VF-ENG.PDF

WLPGA GLOBAL AUTOGAS INDUSTRY NETWORK – A GUIDEBOOK FOR – LOBBYING AND ADVOCACY FIRST EDITION SEPTEMBER 2004

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