Autogas Incentive Policies

A Country-by-Country Analysis of Why and How Governments Encourage Autogas and What Works

2015 Update

WLPGA

The World LPG Association

The World LPG Association was established in 1987 in Dublin, Ireland, under the initial name of The World LPG Forum.

The World LPG unites the broad interests of the vast worldwide LPG industry in one organisation. It was granted Category II Consultative Status with the United Nations Economic and Social Council in 1989.

The World LPG Association exists to provide representation of LPG use through leadership of the industry worldwide.

Acknowledgements

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LPG EXCEPTIONAL ENERGY

Contents

Glossary

AFV	Alternative fuel vehicle
BEV	Battery electric vehicle
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbons
HDV	Heavy-duty vehicle
LDV	Light-duty vehicle
LPG	Liquid petroleum gas
NGV	Natural gas vehicle
NMHC	Non-methane hydrocarbons
NOx	Nitrous oxides
OEM	Original equipment manufacturer
PM	Particulate matter
THC	Total hydrocarbons
VAT	Value-added tax
WLPGA	World LPG Association

Executive summary

Autogas – LPG used as a transport fuel – is the second most widely used and accepted alternative automotive fuel in use in the world today after ethanol. Global consumption of Autogas has been rising rapidly in recent years, reaching 26.4 million tonnes in 2014 – an increase of 5.1 Mt, or 24%, over the 2009 level. There are now more than 25 million Autogas vehicles in use around the world. Yet Autogas use is still concentrated in a small number of countries: just five countries – Korea, Turkey, Russia, Poland and Italy – together accounted for half of global Autogas consumption in 2014. The 12 countries surveyed in this report accounted for 55%. The share of Autogas in total automotive-fuel consumption varies widely among those countries, ranging from a mere 0.1% in the United States to 18% in Turkey. The only country other than Turkey where Autogas makes up more than 10% of the automotive-fuel market is Korea, where the share is 14%. The enormous disparity in the success of Autogas in competing against the conventional automotive fuels, gasoline and diesel, is explained mainly by differences in government incentive policies.

The primary reason why governments in many countries actively encourage the use of Autogas and other alternative fuels is the environment. Autogas out-performs gasoline and diesel as well as some other alternative fuels in the majority of studies comparing environmental performance that have been conducted around the world. Autogas emissions are especially low with respect to noxious pollutants. With respect to greenhouse-gas emissions, Autogas performs better than gasoline and, according to some studies, out-performs diesel, when emissions are measured on a full fuel-cycle basis and when the LPG is sourced mainly from natural gas processing plants. Even so, the strength of actual policies and measures deployed does not always fully reflect the true environmental benefits of switching to Autogas from conventional automotive fuels.

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 on the net cost of converting an existing gasoline vehicle (or the extra cost of a factory-built Autogas vehicle compared with an equivalent gasoline or diesel vehicle) and the pump price of Autogas relative to diesel and gasoline. Since converting a vehicle to run on Autogas involves upfront capital expenditure and some minor inconvenience (including sacrificing some boot/trunk space), the owner needs to be compensated 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 average distance travelled monthly or annually. The payback period usually has to be less than two to three years to encourage commercial vehicle owners to switch; private individuals often demand a quicker return on their investment.

The payback period – or breakeven distance – is very sensitive to the extent to which government incentives lower fuel costs relative to the other fuels and to some extent also lower the upfront expenditure on the vehicle. Taxes on Autogas must be low enough relative to those on gasoline and diesel to compensate for the lower mileage of Autogas per litre (due to its lower energy-content-to-volume ratio) and to ensure that the pump price of Autogas is low enough to provide an incentive for motorists to switch fuels. In five of the 12 countries surveyed, Autogas pump prices per litre were less than half those of gasoline. The price of Autogas as a proportion of that of gasoline ranged from 32% in Thailand to 66% in Turkey, averaging 55% across all countries; the average share of the diesel price was 61%.

The wide variation in Autogas pump prices among the countries surveyed, both in absolute terms and relative to the prices of other fuels, mainly reflects differences in the way automotive fuels are taxed. Autogas taxes are lower than those on gasoline on a per-litre basis in all the countries surveyed. Autogas is totally exempt from excise taxes in India and Mexico. The ratio of Autogas taxes to gasoline taxes is by far the highest in the United States; in all the other countries, excise taxes on Autogas are less than a third of those on gasoline on a per-litre basis. The arithmetic average ratio across all the countries surveyed is 22%. For diesel, the ratio is 43%, because taxes on diesel are lower than on gasoline in all countries except the United States.

Financial incentives aimed at the vehicle, in the form of grants or tax credits, can also be effective in offsetting part or all of the cost of conversion or the incremental cost of buying an Autogas vehicle. Such incentives have become more important as the cost of conversion and installing dual-fuel systems has increased with the growing sophistication of fuel-injection engine technology. Despite this, fewer countries are making such subsidies available for conversions. Vehicle incentives are particularly important where fuel taxes generally are low, limiting the scope for savings on running costs.

The market penetration of Autogas is strongly correlated with the competitiveness of Autogas *vis-à-vis* diesel and to some extent gasoline. We have estimated, for each country, the distance at which an Autogas light-duty vehicle becomes competitive against gasoline and diesel in each country, based on 2014 data on pump prices and vehicle costs. The results show that Autogas use and rates of market growth are generally highest in countries where the breakeven distance is lowest. In half of the countries surveyed, the breakeven distance against gasoline is under 50 000 km – or about three years of driving. Autogas is most competitive in Thailand, where a converted Autogas vehicle breaks even with gasoline at just 26 000 km. At the other extreme, Autogas is never competitive with either gasoline or diesel in the United States, where Autogas accounts for a very small share of total automotive-fuel consumption.

But the competitiveness of Autogas is not the only factor that drives Autogas demand. For example, the breakeven distance for Autogas against gasoline in Italy, the Netherlands and Thailand is lower than that of Korea, yet the penetration of Autogas in those countries is much lower – even though Autogas is always competitive against diesel. Several factors explain these divergences:

- *Government policy commitment:* The Autogas market has tended to develop more quickly where the government has shown a strong, long-term policy commitment in favour Autogas.

- *Non-financial policies and measures:* In some cases, the use of non-financial incentives or other measures have helped either to boost or to hinder Autogas use. Public awareness and education campaigns to promote Autogas have certainly made a significant contribution to market growth in several countries. Mandates and public transport-fleet conversion programmes have also been very successful in several countries, including India and the United States. By contrast, traffic or parking restrictions discourage Autogas use in some countries.

- *Restrictions on diesel vehicles:* Local and central government environmental restrictions on the use of diesel vehicles have been an important factor behind the success of Autogas in Korea and Japan.

- *Availability of vehicles and fuel:* Autogas has sometimes struggled to penetrate the fuel market where car makers have been reluctant to market OEM models or where there is a limited number of refuelling sites selling Autogas.

- *Public attitudes to Autogas safety:* Worries about the safety and reliability of Autogas have clearly affected demand in several countries, including France and the Netherlands. Awkward refuelling facilities may also deter interest in using the fuel in some cases.

In countries where Autogas remains small, the role of the government in giving an initial strong impetus to kick-start the simultaneous development of demand and supply infrastructure is vital. Even where strong financial incentives exist, Autogas use will not necessarily take off until critical market mass is 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. Autogas must be widely available. And the market must be big enough to support a viable network or properly-trained mechanics to convert and maintain Autogas vehicles and ensure the availability of spare parts and equipment. In practice, achieving critical mass 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.

National circumstances affect the best approach to 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, the stage of development of the Autogas market and the prevailing barriers to fuel switching, including restrictive regulations and the local cost of vehicle conversions. Whatever the circumstances, however, experience in the countries surveyed in this study has clearly shown that the single most important measure – and a necessary condition – for making Autogas an attractive fuel to vehicle owners is favourable fuel-tax treatment *vis-à-vis* conventional fuels.

Policy stability and a strong, long-term commitment by the government to achieving environmental-policy objectives are also of crucial importance to efforts to promote the development of alternative-fuel markets. Stakeholders need to be given clear advance warning of any major shift in policy. Without policy stability, coherence and consistency, neither fuel suppliers, nor equipment manufacturers, nor consumers can be confident that they will be able to make a reasonable return on the investments required to switch fuels.

Introduction

Objectives of the study

Sales of Autogas – the most widely used alternative to conventional automotive fuels – have been growing quickly in some countries, thanks to government policies to encourage the use of alternative fuels on account of its inherent environmental, practical and cost advantages over other such fuels. But in some countries, Autogas-market development has been held back by ineffective or poorly-designed policies, such as unfavourable or contradictory tax rates and regulations that fail to account fully for the social benefits of switching to Autogas.

This study seeks to explain why governments encourage switching to Autogas and how they go about doing so based on an in-depth survey of some of the world's largest Autogas markets. It assesses what types of policies are most effective and why.

Approach and scope

The study involved a detailed survey of Autogas taxation and other incentive programmes covering 12 of the world's largest Autogas markets: Australia, France, Germany, India, Italy, Japan, Korea, Mexico, Netherlands, Thailand, Turkey and the United States. All of these countries have annual sales of more than 200 000 tonnes; collectively, they made up 55% of the global Autogas market in 2014. Historical data was compiled on pump prices, excise duties and sales taxes for Autogas and the conventional fuels, gasoline and diesel. In addition, we collated data on road-fuel consumption and vehicles fleets, as well as information on current tax and non-tax policies with regard to conventional and alternative fuels. The market data cover the period 2009 to 2014, while the price and tax data cover 2008-2014.

The data on Autogas prices and taxes were used to analyse quantitatively the competitiveness of Autogas *vis-à-vis* gasoline and diesel in all 12 national Autogas markets. This analysis takes account of fuel prices at the pump, differences in mileage per litre (due to differences in energy content per litre and vehicle-engine technology among the three fuels) and the relative costs of acquiring each type of vehicle and converting conventionally fuelled vehicles to Autogas. It also takes into account local market conditions and regulations. The results were then compared to the current penetration of Autogas in the overall automotive-fuel market and recent rates of Autogas-market growth.

The study also reviewed recent studies of the comparative environmental performance of Autogas in order to examine the rationale for promoting use of the fuel.

Structure of this report

Part A of this report presents the main findings of the study:

- Section 1 provides an overview of current global Autogas market trends and the main drivers of Autogas demand.
- Section 2 assesses the environmental performance of Autogas compared with conventional fuels and other alternative fuels.
- Section 3 sets out the principles of government policies and the different approaches available to policymakers to promote alternative fuels generally.
- Section 4 summarises and compares current Autogas incentive policies across the countries surveyed in the study, focusing on differences in taxes and subsidies.
- Section 5 analyses the impact of differences in policies on the competitiveness of Autogas compared with conventional fuels and the penetration of Autogas in the overall market for automotive fuels.
- Section 6 assesses the implications of this analysis and the lessons that can be drawn for policymaking.

Part B presents the detailed results of the survey and analysis of Autogas competitiveness by country. Detailed global Autogas market data, references and a note on data sources are included in the annexes.

Acknowledgements

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PART A: MAIN FINDINGS

1 The global Autogas market

1.1 Market trends

Autogas is the second-most widely used alternative to the conventional oil-based transport fuels, gasoline and diesel, after ethanol. A number of countries today have well-developed Autogas markets. Global consumption of Autogas reached 26.4 million tonnes in 2014 (Table A1.1), and is increasing rapidly. Demand increased by 5.1 Mt, or 24%, in the past five years to 2014, with growth coming from both established and emerging markets, though growth has slowed in recent years, in part because of improvements in fuel economy (Figure A1.1). Demand rose by 2.3% in 2014 alone. Nonetheless, trends differ markedly by country, with several markets contracting for several years in a row in 2014, while others exhibited growth.

Table A1.1: Top ten largest Autogas markets and the markets analysed in Part B, 2014

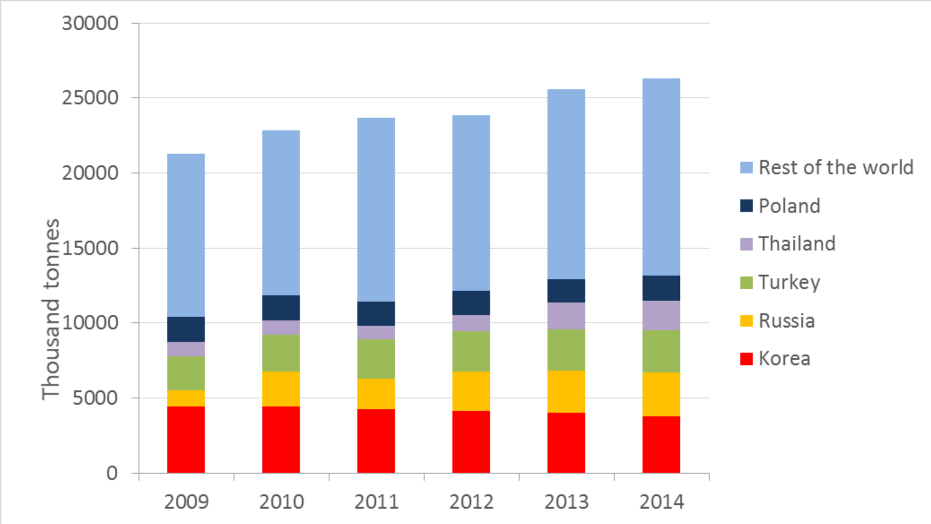
Country	Consumption (thousand tonnes)	Vehicles (thousands)	Refuelling sites
Korea	3780	2355011	2001
Russia	2900	3000000	4450
Turkey	2838	4076730	10397
Thailand	1974	1150000	2100
Poland	1645	2846000	5460
Italy	1570	1970000	3600
China	968	100000	310
Mexico	922	182000	2100
Japan	914	226339	1503
Ukraine	911	1600000	3500
Australia	725	490000	3700
US	559	148909	2931
Germany	498	494000	6850
India	310	2150000	1200
Netherlands	205	200150	1850
France	184	262000	1750

Source: WLPGA/Argus (2015).

Demand remains highly concentrated in a small number of markets: in 2014 the five largest countries accounted for exactly half of world consumption and the top ten for 56%. The 12 countries surveyed in this report together accounted for 55% of world Autogas use. Seven of the ten largest consumers saw large increases in consumption in absolute terms over last year. Worldwide, Autogas currently accounts for 1.2% of total road-transport-fuel consumption.

There are over 25 million Autogas vehicles in use around the world and almost 73 000 refuelling sites. Autogas accounted for 9.6% of global consumption of LPG, but this share varies considerably across countries. Among the countries surveyed, the share is highest in Turkey, where it is 74%, and is lowest in the United States at just 0.8%.

Figure A1.1: Global Autogas consumption, 2009-2014



Box A1.1: Autogas characteristics

Autogas is the abridged name for automotive liquefied petroleum gas (LPG, or LPG) – that is, LPG used as an automotive transport fuel. LPG is the generic name for mixtures of hydrocarbons that change from a gaseous to liquid state when compressed at moderate pressure or chilled. The chemical composition of LPG can vary, but is usually made up of predominantly propane and butane (normal butane and iso-butane). Autogas generally ranges from a 30% to 99% propane mix. In some countries, the mix varies according to the season as the physical characteristics of the two gases differ slightly according to ambient temperatures.

LPG is derived either as a product from crude-oil refining or from natural-gas or oil production. At present, more than 60% of global LPG supply comes from natural gas processing plants, but the share varies markedly among regions and countries. With both processes, LPG must be separated out from the oil-product or natural-gas streams. LPG is generally refrigerated for large-scale bulk storage and seaborne transportation as a liquid, but it is transported and stored locally in pressurised tanks or bottles (cylinders).

LPG has high energy content per tonne compared with most other oil products and burns readily in the presence of air. These characteristics have made LPG a popular fuel for domestic heating and cooking, for commercial use, for agricultural and industrial processes, including as a feedstock in the petrochemical industry, and increasingly as an alternative automotive fuel.

The make-up of the Autogas vehicle fleet by vehicle-type differs by country, reflecting mainly differences in government policies. In the two largest Asian markets, Korea and Japan, taxis and other fleet light-duty vehicles (LDVs) account for a large share of Autogas consumption. In both countries, the overwhelming majority of taxis run on Autogas as a result of a combination of incentives and government mandates requiring the use of alternative fuels. In Europe, private cars comprise the main market. In most countries, vehicles that run on Autogas are gasoline-powered vehicles that have been converted to use either Autogas or gasoline. An existing gasoline vehicle can usually be converted at moderate cost (see section 1.2.2). Korea and Japan, where most vehicles are Original Equipment Manufacturer (OEM) vehicles, i.e. factory-fitted, are the main exceptions.

At present, there are relatively few heavy-duty vehicles that run on Autogas, since converting diesel engines in an existing vehicle is technically more complex and less viable than gasoline engines. In recent years, however, a number of heavy-duty LPG 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, mainly in the United States, Korea and China.

1.2 Drivers of Autogas use

The emergence of Autogas as an alternative to gasoline and diesel is the direct result of government policies to address energy-security and/or environmental concerns. With the exception of ethanol, Autogas has been more successful than any other alternative automotive fuel because of its practical and cost advantages.

1.2.1 Alternative automotive-fuel policies

The oil-price shocks of the 1970s provided the initial impetus for the development of alternative automotive fuels, as countries sought to reduce their dependence on imports of crude oil and refined products. Environmental concerns have since overtaken energy security as the principal driver of government policies to promote such fuels, as they are generally less polluting.

The initial focus of policy action was air pollution in major cities, which is caused mainly by automotive fuels. Since the 1990s, attention has shifted to the threat of global climate change due to rising concentrations of greenhouse gases in the atmosphere resulting primarily from the burning of fossil fuels. As a result, governments are looking to fuels that emit less carbon dioxide (CO_2), methane (CH_4) and N_2O – the main energy-related greenhouse gases.

Research and development of alternative automotive-fuel technology in recent years has focused on fuels based on oil and natural gas, biofuels derived from vegetable matter such as ethanol or biodiesel, battery-electric vehicles (BEVs) and hydrogen-based fuel cells. BEVs are now starting to be commercialised, but their uptake is likely to remain small due to their high cost and limited mileage. The great promises this technology holds has distracted some governments from continuing a successful Autogas policy. The supply of ethanol and bio-diesel has risen sharply in recent years, but both fuels are usually blended with conventional gasoline and diesel for sale to end users. The scope for further increases in biofuel production using conventional technology will be limited by competition for land to grow food crops.

The main non-blended alternative fuels in use in the world today are Autogas and compressed natural gas (CNG). Autogas has established itself in many countries as by far the most important of these fuels, because of its favourable mix of inherent practical and cost advantages and environmental benefits. Air-borne emissions of regulated and unregulated toxic gases from Autogas use are among the lowest of all the automotive fuels commercially available today; in addition, greenhouse-gas emissions from Autogas are generally lower than those from gasoline, diesel and some alternative fuels (the comparative environmental performance of Autogas is discussed in more detail in the next section).

From an energy-security perspective too, Autogas has advantages over conventional fuels. There is an abundant supply of LPG from many sources around the world. In addition to proven reserves in oil and gas fields, the flexibility of modern refining processes offers considerable potential for expanding supply to meet demand from the transport sector. LPG supply has been rising briskly in the past few years with growing natural gas production and associated liquids extraction – already the primary source of LPG worldwide. And field and refinery supplies will also increase as wasteful flaring and venting practices, which are still common in many parts of the world, are eradicated. In addition, there is considerable scope for diverting supplies from relatively low-value petrochemical uses, where LPG can easily be replaced by other feedstock such as naphtha, ethane and distillate.

Autogas use has generally responded much better to government policies to promote alternative fuels than CNG, methanol or BEVs. Despite some environmental advantages over conventional fuels, the development of CNG has been slow in all but a few countries because of cost and practical considerations associated with the fuelling infrastructure. In contrast, the technology for installing Autogas systems in vehicles or converting existing vehicles is proven (see below), greatly reducing the financial risks to investors. The costs of establishing the distribution infrastructure and converting vehicles to run on Autogas are generally much less than for other alternative fuels.

1.2.2 Autogas fuel systems

In most cases, an existing vehicle running on a conventional fuel is converted to run on Autogas by installing a separate fuel system that allows the vehicle to switch between both fuels. This equipment can be installed at the time the car is manufactured (in which case, the car is known as an OEM). For mainly technical reasons, most LDV conversions involve gasoline-powered spark-ignition engines, which are particularly well-suited to run on Autogas.

There are four main types of Autogas system in use today – a conventional converter-and-mixer systems and three types of fuel-injection system:

- *Converter-and-mixer:* Also known as a venturi system or "single point" system, this is the oldest system, having existed since the 1940s, and is still widely used today. It uses a converter to change liquid fuel from the tank into vapour, which is then fed to the mixer where it is mixed with the intake air.

- *Vapour phase injection (VPI):* This system uses a converter like that in the converter-and-mixer system, but the gas exits the converter at a regulated pressure. The gas is then injected into the air intake manifold via a series of electrically controlled injectors, allowing for more accurate metering of fuel to the engine than is possible with mixers, improving fuel economy, increasing power and reducing emissions. The injector opening times are controlled by the Autogas control unit, which works in a similar way to a gasoline fuel-injection control unit. Most vehicles of recent vintage use this type of fuel system.

- *Liquid phase injection (LPI):* This type of system does not use a converter, but instead delivers the liquid fuel directly into a fuel rail 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. LPI systems are still under development, but have the potential to achieve better fuel economy and power as well as lower emission than VPI systems.

- *Liquid phase direct injection (LPDI):* The most advanced system, LPDI uses the existing gasoline high-pressure pump and injectors to inject LPG in its liquid state directly into the combustion chamber. The fuel vaporises instantly, cooling the charge prior and during the compression stroke. This increases the anti-knock behaviour of the fuel, potentially yielding further efficiency and emissions gains.

The different Autogas fuel-systems generally use the same type of filler, lines and fittings but use different components in the engine bay (Figure A1.2). Unsurprisingly, injection systems make more use of electronic controls. Liquid injection systems use special tanks with circulation pumps and return lines similar to petrol fuel injection system. Normally, the tank is installed either in the boot (trunk) or in the spare tyre well (in which case, it is known as a toroidal tank), which is more ergonomic. The tank is usually fitted with an automatic fill limiter and a hydrostatic pressure relief valve for safety reasons.

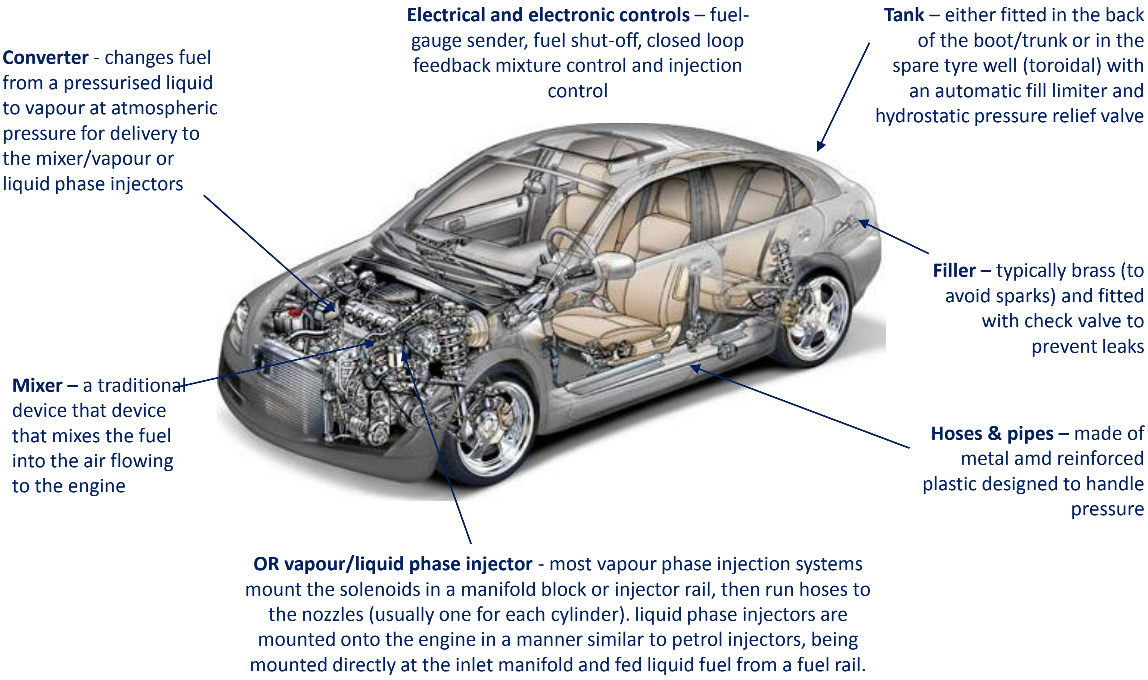


Figure A1.2: Autogas fuel-system components

Source: Menecon Consulting.

Autogas fuel systems are a proven and mature technology. Specialist companies have developed and market standardised Autogas conversion kits, including a parallel fuel system and tank, with specialist garages carrying out the installations. The market is fairly fragmented, with a large number of firms selling conversion kits; many of them serve just the national markets (for example, in China), but a growing number of them now export to other countries.

The bulk of Autogas vehicles on the world's roads today are after-market conversions, i.e. they were converted immediately or sometime after the original vehicle purchase. But sales of OEM Autogas vehicles, incorporating conversion kits at the point of manufacture, have been growing in most established markets in recent years. Most of the leading car manufacturers have introduced Autogas versions of at least one of their models, while others offer conversions at the time of sale, such that they are covered by their warranty (aftermarket conversions can invalidate the vehicle warranty). As Autogas has become more widespread, some OEM vehicle manufacturers have become involved in the development, design and manufacture of Autogas systems. Several OEMs are now producing and marketing dedicated Autogas vehicles with under-floor fuel tanks. For example, Ford and General Motors market a range of such Autogas cars in Australia, as does Hyundai/Kia in Korea.

1.2.3 Practical considerations

The performance and operational characteristics of Autogas vehicles compare favourably with other fuels. Autogas has a higher octane rating than gasoline, so converted gasoline-powered spark-ignition engines tend to run more smoothly. This reduces engine wear and maintenance requirements, including less frequent spark plug and oil changes. Autogas causes less soot formation than both gasoline and diesel, reducing abrasion and chemical degradation of the engine oil. In addition, Autogas does not dilute the lubricating film on the cylinder wall, which is a particular problem with gasoline engines in cold starts. The higher octane of Autogas also allows higher compression ratios, which can deliver increased engine-power output and better thermal efficiency, reducing fuel consumption and emissions. Acceleration and top speed using the latest generation of Autogas-fuel systems are comparable to gasoline or diesel. Autogas has a lower energy density than gasoline and diesel, which means that a larger volume of fuel and a bigger tank are required to achieve the same overall driving range, though this has no effect on engine performance.

In practice, however, converting a vehicle to be able to run on Autogas involves some operational inconveniences. The most important of these are the loss of boot/trunk space to accommodate the fuel tank and, in some cases (depending on the equipment installed), the marginal loss in acceleration and speed mainly due to the extra weight of the tank. The development of new technologies, including ring-tanks and lightweight composite tanks, has helped to alleviate these problems. This inconvenience is offset to some extent by the lower weight of the fuel compared with gasoline and the increased flexibility provided by the dual-fuel capability of converted vehicles. The refuelling process can also be a little trickier than for gasoline and diesel depending on pump facilities, which can be off-putting for some motorists. Nonetheless, practical experience has shown that vehicle owners are often willing to convert their vehicles to Autogas if the savings in running costs are sufficiently attractive. A modern refuelling connector system, with which almost no fuel is emitted when decoupling, has been developed for the European market and has already been introduced with great success in Spain. Other markets such as the US are also introducing this technology, which is currently being standardised internationally.

Safety concerns with regard to the handling and on-board storage of Autogas are a barrier to conversion in some cases. Yet many years of operation worldwide have amply demonstrated the integrity and safety of bulk LPG/Autogas transportation and storage containment systems, as well as on-board vehicle tanks. In fact, the safety record of Autogas use in practice is at least as good as, if not better than, gasoline or diesel. A good example is Hong Kong, where the Autogas taxi fleet has accumulated over 20 billion kilometres since 1990 without a single major accident. Autogas is fully contained under pressure in solid tanks, which limits the danger of leakage. Being stored in liquid form, gasoline is prone to leaks or vapour escapes. Nonetheless, widely-publicised accidents, often resulting from poor installation, the absence of a safety valve on the fuel-tank or the illegal use of cylinder gas, have undermined the safety image of Autogas in a few countries, such as France (see section 2 in Part B).

1.2.4 Cost factors

The cost of Autogas supply and infrastructure is generally lower than for other non-blended alternative fuels. On an energy-content basis, the cost of bulk LPG delivered to service stations is roughly the same as for gasoline (Section 4.1.2). Rising demand for Autogas is not expected to raise significantly the cost of LPG on the international spot market relative to gasoline given the abundance of supplies.

The costs incurred in establishing or expanding an Autogas distribution network essentially relate to investments in service-station storage and dispensing facilities. The plants and equipment that already exist to handle the importation, production, storage and bulk distribution of LPG for traditional uses are exactly the same as for Autogas, although some additional investment may be needed to cope with higher bulk throughput. Since Autogas generally makes use of the existing service-station infrastructure for distribution of conventional fuels, additional costs for Autogas dispensing are low relative to some other alternative fuels. For example, the cost of installing a standard tank, pump and metering equipment for Autogas alongside existing gasoline and diesel facilities is typically around a third that of installing dispensing facilities for CNG with the same capacity. This is because of the added cost of dedicated supply pipelines, high-pressure compression, storage cylinders and special dispensers for CNG. In addition, the fuelling rate for CNG is generally lower than for Autogas.

Vehicle-conversion costs vary considerably from one country to another, depending on the sophistication and quality of the equipment installed and local labour costs. Conversion costs for older cars with less sophisticated engines tend to be much lower. On average, the cost of conversions and the cost installation of dual-fuel systems in OEM vehicles has risen in recent years as fuel-injection engine technology has become more sophisticated, Worldwide, costs for an LDV vary from about $500 in developing countries to $4 000 in the United States. The premium for an OEM vehicle varies considerably: it is usually at least $1 000 in most countries and sometimes much more. But the premium has fallen sharply in some countries in the last couple of years, as some carmakers have cut the prices of their Autogas models. In France, for example, the Romanian carmaker (and wholly owned subsidiary of Renault), Dacia, currently sells the Autogas version of its popular Duster model at a price *below* that of the equivalent gasoline-powered version.

Among the various alternative fuels available today, CNG is probably the main alternative to Autogas on cost grounds (with the exception of biofuels in some locations, where production costs are particularly low, such as in Brazil, due to climate and soil). Both fuels have pros and cons, but Autogas is generally more cost-competitive for LDVs (if both fuels are taxed equally on an energy-content basis), whereas CNG in many cases may be a more viable option for heavy-duty vehicles, or HDVs (Table A2.2). The cost of installing refuelling infrastructure and converting LDVs is significantly lower for Autogas, in large part because of the extra cost of CNG tanks (which need to be bigger and stronger because of their higher operating pressures). Autogas also generally beats CNG on grounds of practicality, as refuelling is quicker.

Despite the favourable environmental attributes of Autogas compared to other alternative fuels, the rate of switching to Autogas and overall consumption is highly dependent on the financial benefits to end users. A publicly-owned bus company may take account of the local environmental benefits as well as relative costs of different fuel options in deciding whether to switch to Autogas. But for most private fleet operators, truckers and individual motorists, the sole factor is cost. As a result, private vehicle owners must be given an adequate financial incentive to switch to Autogas.

Table A1.2: Competitiveness of Autogas against compressed natural gas (CNG)

	Autogas	CNG
Price of fuel	Driven by the international LPG price (which follows other oil prices but is generally lower than those of gasoline and diesel)	Driven by bulk cost of delivered natural gas to major demand centres (low now in United States, but high in importing regions where the price is linked to that of oil)
Cost of refuelling infrastructure	Comparable to conventional fuels	Generally higher than for conventional fuels and Autogas as higher compression is needed; home refuelling costs are typically in excess of $10 000
Cost of vehicle conversion (LDV)	Ranges from around $500 to $4 000 depending on the type of car, type of conversion and local market conditions	Generally more expensive, partly because a bigger tank is needed (in the United States, the cost ranges from $12 000 to $18 000 due to licensing requirements)
Ease of refuelling	Refuelling is quick and the fuel is generally widely available as it is easy to transport by road	Refuelling takes longer; the fuel is not always available in all areas as it must be piped

Source: Menecon Consulting analysis.

2 Comparative environmental performance

2.1 Environmental benefits of Autogas

Road-transport vehicles are an important source of both air pollutants and climate-destabilising greenhouse gases. There is clear evidence of the harmful impact on human health of exposure to vehicle pollutants. As a result, local air quality has become a major policy issue in almost all countries. Most industrialised countries have made substantial progress in reducing pollution caused by cars and trucks through improvements in fuel economy, fuel quality and the installation of emission-control equipment in vehicles. Increasingly, these improvements have been driven by a combination of emission and fuel-efficiency standards. However, rising road traffic has offset in most countries at least part of the improvements in vehicle-emissions performance. Less progress has been made in developing countries, where local pollution in many major cities and towns has reached catastrophic proportions.

The European Union and the United States have been the main driving forces behind vehicle-emissions standards. Every developed country and most developing countries have progressively introduced EU, US or similar standards for new vehicles. The international nature of vehicle manufacturing and trade has prompted increasing harmonisation of standards and regulation. The most broadly implemented standards, generally referred to as Euro regulations, are those developed by the United Nations Economic Commission for Europe (UNECE), which are uniformly applied across the European Union and in many other parts of the world. Different standards are applied to LDVs (essentially passenger cars and vans, in most cases with a maximum gross weight of less than 3.5 tonnes) and HDVs (trucks and buses). These standards have been tightened periodically, typically every four to five years, since they were first introduced in 1992. Euro 6 regulations came into force in September 2014 for LDVs, covering emissions of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM), and in December 2013 for HDVs (also covering smoke). The European Union and several countries, including China and Japan, have also introduced and tightened fuel-efficiency standards in recent years. The United States – the first country to introduced fuel-efficiency standards in the 1970s – has its own emission and efficiency regulations.

Governments are also looking increasingly at ways of encouraging a shift in fuel use to alternative fuels that can yield a reduction in emissions of greenhouse-gases at least cost. Globally, road transport has become the second-largest source of emissions of carbon dioxide (CO_2) – the leading greenhouse gas – after power generation, accounting for well over one-fifth of total emissions. Emission standards for CO_2 have not yet been applied anywhere as yet.

Autogas out-performs gasoline and diesel and most alternative fuels in the majority of studies comparing the environmental performance of conventional and alternative fuels that have been conducted around the world in recent years. Autogas emissions are especially low with respect to noxious pollutants. With regard to greenhouse-gas emissions, Autogas performs better than gasoline and, according to some studies, out-performs diesel, when emissions are measured on a full fuel-cycle, or well-to-wheels, basis and when the LPG is sourced mainly from natural gas processing plants (see below).

The results of these studies vary to some degree, according to the types of vehicles selected, the quality of the fuel, the types of emissions measured and the conditions under which they were carried out vary: actual vehicle emissions are highly dependent on vehicle technology and driving behaviour. The rest of this section summarises the results of recent studies for LDVs and HDVs.

2.2 Light-duty vehicle (LDV) emissions

2.2.1 Regulated pollutant emissions

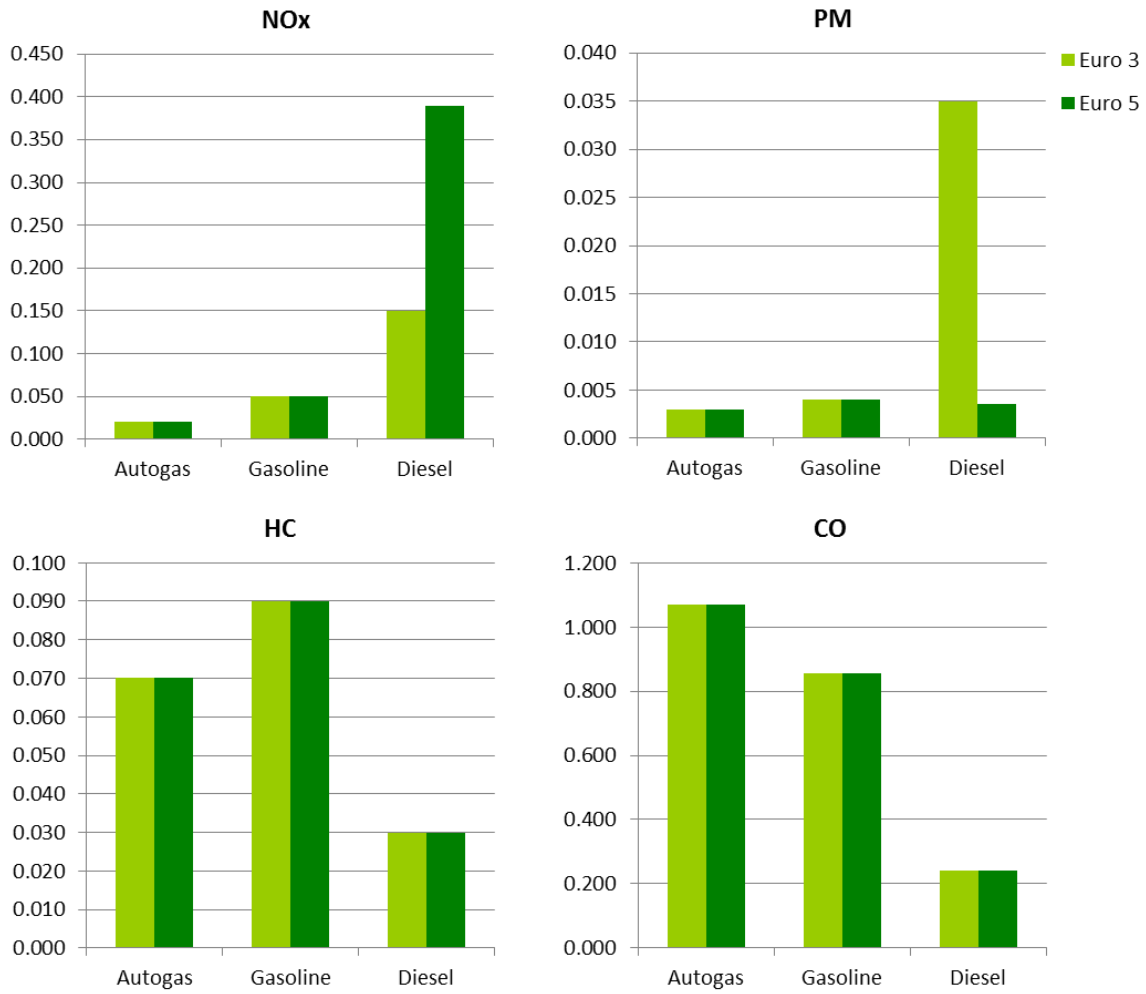
The main regulated emissions for LDVs are the following:

- Nitrogen oxides (NO and NO_2, or NO_x).
- Particulate matter (PM).
- Hydrocarbons (HC), measured as total hydrocarbons (THC) or non-methane hydrocarbons (NMHC).
- Carbon monoxide (CO).

CO, NO_x and HC emissions contribute to the creation of ground-level ozone and photochemical smog, while PM is a known carcinogen and contributor to respiratory problems. NO_x also impairs the lung function in humans, increasing the incidence of asthma attacks. Because these emissions are detrimental to local or regional air quality, most studies of this type of vehicle emissions have focused on tail-pipe emissions.

Autogas performs well in comparison with gasoline and diesel with respect to regulated emissions because propane and butane are chemically simpler and purer forms of hydrocarbons that mix easily with air, allowing almost complete combustion. Data compiled principally from the results of the European Emissions Test Programme (EETP) completed in 2004, the most recent major comparative study of LDV emissions, show that emissions of NO_x – the most important of the regulated toxic gases – from Autogas are much lower than from gasoline and diesel, especially for Euro-5 compliant vehicles (Figure A2.1). Autogas emissions are comparatively even lower for cold starts, since gasoline needs to be enriched when the engine is cold due to its poor vaporisation characteristics at low temperatures.

Figure A2.1: Regulated emissions from LDVs by fuel (g/km)



Note: Euro-5 results are based on vehicles equipped with diesel particulate filters; NO_x emissions for Euro-5 vehicles were adjusted to reflect current vehicle tehnology. Average emissions of the other pollutants were already low for Euro-3 vehicles, so were not adjusted.
Source: WLPGA (2009).

PM emissions are negligible for Autogas and very low for gasoline vehicles, but remain a major problem for diesel vehicles, especially those built to Euro-3 or earlier standards. Although Autogas performs less well than diesel and gasoline with respect to CO emissions, and less well on HC emissions with respect to diesel, the differences on a full fuel-cycle, or well-to-wheel, basis do not influence significantly the overall comparison of the environmental impact of the different fuels.

A more recent study by Atlantic Consulting reinforces the overall findings of the EETP. The Atlantic Consulting study draws on a database of actual test data of cars and vans that are available for sale in Germany compiled by the KBA (Kraftfahrtbundesamt), Germany's Federal Agency for Motor Transport

(Atlantic Consulting, 2014). It compares five fuels – petrol, diesel, Autogas, CNG and ethanol – with respect to their regulated pollutants for similar models of different brands all of which have power ratings within + 5%, similar weights, compliance with Euro 5 or Euro 6 emission standards, manufacturing dates of 2011 or later and current commercial availability.

The study finds that, compared with Autogas-fuelled vehicles (bi-fuelled Autogas-gasoline vehicles operating in Autogas mode),:

- Gasoline-fuelled vehicles emit slightly more NOx and NMHC, slightly less CO and more than 20% less methane. Gasoline also emits some PM (Autogas vehicles emit none).
- Diesel vehicles emits about one-third less CO and THC, but five times as much NOx. They also emit significant amounts of PM.
- CNG vehicles emits about three to four times more methane and about 50% more CO, but less methane and NOx in bi-fuel mode (in mono-fuel mode, emissions of CO are lower and NOx much higher).
- Ethanol (E85) emits more of all pollutants, but 7% less NOx.

The study applies an environmental impact assessment (EIA) method, known as ReCiPe, which allows impacts to be characterised, normalised, weighted and evaluated by a single-score of 'ecopoints'. The fewer ecopoints registered by a product or a process, the less environmental impact it creates. The overall environmental impact is compared for seven car/van models which are available in versions that run on gasoline, diesel, Autogas and CNG. Autogas ranks first in four of seven brands: (Ford C-Max, Ford Focus, Fiat Panda and Piaggio Porter (Table A2.1). In those cases where Autogas is relegated to engines of significantly older technologies the ranking is naturally influenced and Autogas ranks low.

Table A2.1: Ecoimpact rankings for the seven brands available in 4-fuels

Brand	Gasoline	Diesel	Autogas	CNG (bi-fuelled)	CNG (mono-fuelled)
Caddy	2	1	4	NA	3
C-Max	3	2	1	NA	NA
Focus	4	2	1	3	NA
Golf	3	2	4	1	NA
Panda	3	4	1	2	NA
Porter	4	2	1	3	NA
Zafira	4	2	3	NA	1

Note: The highest ranking indicates the lowest overall environmental impact covering acidification, climate change/global warming, smog and toxicity, human and ecological effects. Autogas is bi-fuelled operating in Autogas mode. NA means not available.
Source: Atlantic Consulting (2014).

One of the key environmental advantages of Autogas over gasoline and, especially diesel, is the near-absence of PM emissions. The importance of this factor has increased greatly with the announcement on 12 June by the International Agency for Research on Cancer (IARC) – part of the World Health Organization (WHO) – that diesel-engine exhaust causes cancer. For more than two decades, the IARC had classified diesel engine exhaust as a "probable" carcinogen – a cancer-causing agent – but there has been no clear evidence linking it to higher cancer rates up to now. But based on the evidence presented in two papers published by the National Cancer Institute and the National Institute for Occupational Safety and Health that found an increase in lung cancer rates among workers exposed to diesel exhaust underground, with greater exposure linked to steadily higher cancer rates, the WHO has decided to name diesel fume a grade-1 cancer-causing substance. It claims that diesel fumes could potentially be as big a public health threat as second-hand smoke, increasing the chances of lung cancer and bladder cancer.[1]

2.2.2 Non-regulated pollutant emissions

The environmental advantages of Autogas over conventional and other alternative fuels are even greater with respect to non-regulated emissions. These include air toxics such as benzene, acetaldehyde, formaldehyde and 1,3 butadiene. As the hazards at different concentrations of these pollutants in the air are not yet fully understood, their emissions are not yet regulated.

A major study of non-regulated toxic emissions carried out by the US Argonne National Laboratory found that Autogas emissions are lower than for all of the conventional and alternative fuels, with the exception of CNG which yields lower benzene and butadiene emissions but higher emissions of acetaldehyde and much higher emissions of formaldehyde and methanol (Argonne, 2000a). Autogas emissions of benzene, linked with various cancers, and butadiene are particularly low compared with gasoline and diesel.

Evaporative and fugitive emissions of hydrocarbons from motor vehicles and refuelling facilities are known to make a substantial contribution to total HC emissions. This is a particular problem with gasoline, due to its volatility. Because they have completely sealed fuel systems, Autogas vehicles and pumps have virtually zero evaporative emissions and fugitive emissions are normally limited to the small release of gas when the fuelling coupling is attached and removed.

2.2.3 Greenhouse-gas emissions

Greenhouse-gas emissions for any given fuel are almost directly proportional to the amount of fuel consumed. Thus the main factors affecting emissions are the energy and carbon content of the fuel. Autogas has an intrinsic advantage over gasoline and diesel with respect to CO_2 emissions because of its lower carbon content, although this is largely offset by the higher fuel consumption of Autogas vehicles *vis-à-vis* diesel vehicles.

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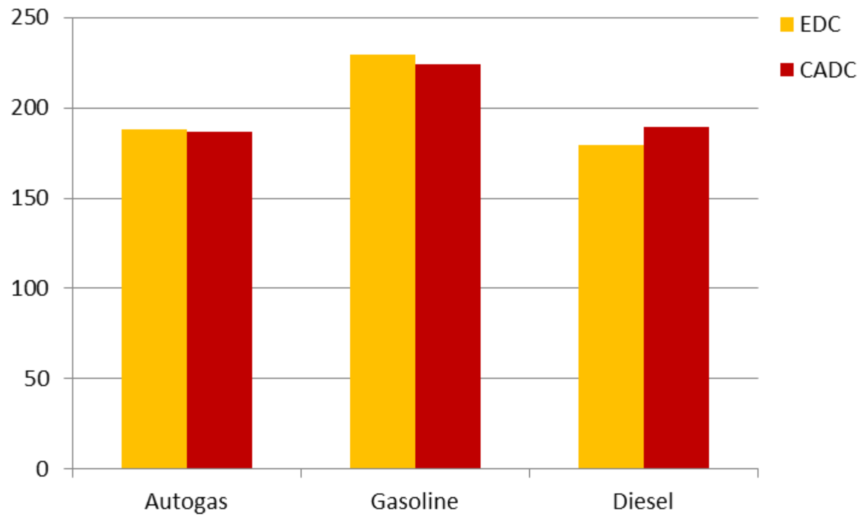
[1] http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf

Several studies compare emissions of CO_2 and other greenhouse gases from different fuels and vehicles over the full life cycle, including emissions incurred during the production and supply of the fuel. In general, these studies show that Autogas yields lower emissions compared with gasoline and similar emissions to diesel. Results vary somewhat among the various studies that have been conducted, partly because of differences in assumptions about the source of LPG: emissions from LPG production from natural gas processing plants are considerably lower than from refineries. Results for CO_2 emissions from the 2004 EETP study are shown in Figure A2.2. Autogas emissions are lower than diesel and gasoline in the Artemis driving cycle (CADC), which simulates actual driving conditions, but are marginally higher than diesel in the standard European driving cycle.

Figure A2.2: CO_2 emissions from LDVs by fuel on a well-to-wheels basis (g/km)



Note: EDC = European driving cycle; CADC = Artmis cycle, which simulates actual driving conditions.
Source: WLPGA/Menecon Consulting (2005).

The 2014 Atlantic Consulting study also finds that, on average, Autogas emits less CO_2 than gasoline, but more than diesel, though the ranges of emissions are broad and their rankings do not always hold. For bi-fuelled Autogas-gasoline cars, emissions in Autogas mode are about 11% lower than in gasoline mode.

Most studies that involve comparisons of CO_2 tailpipe emissions from Autogas and CNG cars suggest that the reductions in emissions compared with gasoline and diesel are typically about 50% higher for CNG than for Autogas. But a recent study suggests that well-to-wheel emissions are generally quite similar for both fuels because of the much higher emissions associated with the processing and transportation of natural gas (Heinze and Ortmayr, 2012).

Biofuels, when blended into conventional fuels, produce similar emissions to the petroleum-based equivalents, but, in principle, can achieve significantly lower greenhouse-gas emissions on a well-to-wheels basis. However, in practice, these reductions can be minimal, depending on the type of feedstock and the process used to produce the fuel. As a result, Autogas emissions are often no higher than those from ethanol or biodiesel. Ethanol derived from sugar cane in places like Brazil certainly results in far lower CO_2 emissions than either conventional fuels or Autogas as relatively little energy is required to produce the fuel. But the emissions savings associated with ethanol derived from corn and other starchy crops are much smaller. A 2007 study by the US energy laboratory at Argonne shows that CO_2 emissions for corn-based ethanol in the United States – the world's biggest ethanol producer – are just 19% lower than from gasoline and barely less than those from Autogas (Wang *et al.*, 2007). The emissions savings from biodiesel, which is the leading biofuel in Europe, are generally bigger than from corn-based ethanol, but not necessarily much bigger than those from Autogas (EUCAR/JRC/Concawe, 2006).

Plug-in hybrids generally produce significantly lower tailpipe emissions of greenhouse gases, while BEVs produce no emissions at all. But well-to-wheel emissions, and those of other pollutants, can be higher than those of petroleum-based fuels, including Autogas. A recent study by researchers at Norwegian University of Science and Technology found that electric cars might actually pollute much more even than conventional gasoline or diesel-powered cars, especially if coal is used to produce the electricity (Hawkins *et al.*, 2013). Only where renewables or nuclear power accounts for a large share of generation do electric vehicles deliver any significant reduction in greenhouse-gas emissions. Electric car factories also emit more toxic waste than conventional car factories as producing batteries and electric motors requires a lot of toxic minerals such as nickel, copper and aluminium. And across the other impacts considered in their analysis, including the potential for effects related to acid rain, airborne particulate matter, smog, human toxicity, ecosystem toxicity and depletion of fossil fuel and mineral resources, electric vehicles consistently perform worse or on a par with modern internal combustion engine vehicles, despite virtually zero direct emissions during operation.

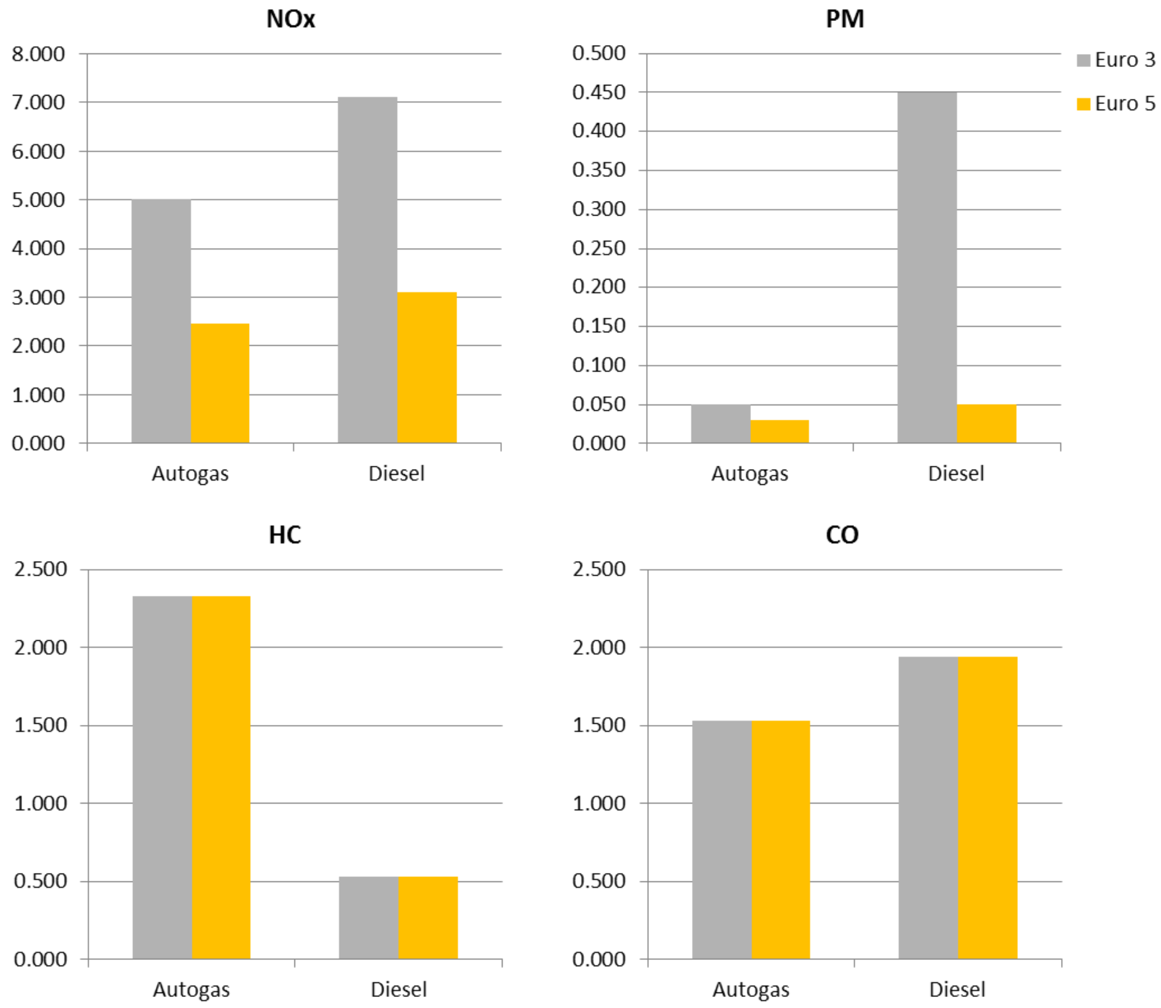
2.3 Heavy-duty vehicle emissions

Almost all heavy-duty vehicles (HDVs) in use today around the world are diesel-fuelled. The main environmental advantage of Autogas over diesel for HDVs relates to emissions of PM, which are zero for Autogas, and NO_x, which are significantly lower – especially for older vehicles. Although a considerable body of test data exists for HDV engines, many different test cycles have been used, with different speed profiles and energy content, which make comparisons extremely difficult.

A 2009 WLPGA report compiled data on emissions drawing on the results of comprehensive series of test programmes commissioned by the Australian government and carried out over the period 2000-2005. These tests involved almost 900 vehicles, including a number of Autogas-fuelled HDVs. Data from this testing and from other sources was distilled into a comprehensive set of speed-related on-road emission factors (in g/km) by the Queensland state government for all regulated pollutants. As for LDVs, the data was adjusted to take account of Euro-5 standards.

The results shows that Autogas beats diesel on all the regulated emissions except HC (Figure A2.3). In the case of PM, the difference is particularly marked for Euro-3 vehicles. The filters that are required to meet Euro-5 standards greatly reduce PM emissions from diesel-fuelled HDVs.

Figure A2.3: Regulated emissions from HDVs by fuel (g/km)



Note: Euro-5 results are based on vehicles equipped with diesel particulate filters; NO_x emissions for Euro-5 vehicles were adjusted to reflect current vechile tehnology. Average emissions of the other pollutants were already low for Euro-3 vehicles, so were not adjusted.
Source: WLPGA (2009).

3 Government policies to promote alternative fuels

3.1 Principles of alternative-fuel policies

Reducing the environmental impact of transport activities is the main justification for governments to promote the use of Autogas and other alternative fuels. Pollution and global warming caused by rising concentrations of greenhouse gases in the atmosphere are prime examples of *market failure*, since the market fails to put a financial value or penalty on the cost of emissions generated by individuals or organisations. Air quality and the climate are, in economists' parlance, public goods, from which everyone benefits. Damage done to the environment is known as an external cost or externality. Governments have a responsibility to correct these failures, to discourage activities that emit noxious or greenhouse gases and to make sure that each polluter pays for the harm he causes to public goods.

Levying charges on polluting activities is effectively a way of internalising these environmental externalities, although placing an exact financial value on them is extremely difficult and inevitably involves a large degree of judgment. A large number of studies have attempted to assess the health and economic costs of different types of emissions, including greenhouse gases. The social cost of carbon (SCC), for example, is the marginal cost of emitting one extra tonne of carbon (as CO_2) at any point in time. Estimates vary widely according to the assumptions made and methodological approaches used. For example, the SCC currently used by the US Environmental Protection Agency to analyse the CO_2 impacts of various rulemakings rises from $61/tonne in 2015 to $104 in 2050 at an average 2.5% social discount rate.[1]

In principle, the most economically efficient approach to internalising external costs is one that relies mainly on financial incentives, i.e. a market-based approach. In other words, the effective market price of the activity that gives rise to an environmental externality should be adjusted through the application of a tax and/or subsidy large enough to reflect the value or cost of that externality. Once an appropriate fiscal framework is in place, consumers and producers are free to make informed economic choices according to their own preferences. In the case of road transport, that involves taxing or subsidising transportation in such a way that the financial costs to end users of the different fuel and vehicle options reflect their associated environmental costs.

In practice, developing effective transport and energy policies that take account of environmental externalities is extremely complex – even if reliable quantitative estimates of external costs can be obtained. It is impractical to apply taxes and subsidies exactly according to actual vehicle usage and the

[1] http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

actual emissions produced during use. And emission-trading schemes are similarly impractical for fuel use in the transport sector given the large number of users. Financial incentives have, thus, generally focused on fuel-based taxes, as they are simpler and politically less sensitive than measures that impact vehicle use directly, such as road pricing – even though evidence suggests that pricing vehicle use can be very effective. The earliest widespread experience of differential taxation to support environmental goals was the introduction of unleaded gasoline, where lower taxes relative to leaded fuel were extremely effective in accelerating its uptake. More recently, similar incentives have been focused on encouraging the use of low-sulphur diesel and alternative fuels. The case for differential fuel taxes for to achieve environmental objectives is well established, though effective tax rates are rarely consistent with stated policy goals (OECD, 2013). In principle, economic efficiency demands that the excise taxes levied on any given fuel should be applied at the same rate to all users, commercial and non-commercial.

Most governments deploy other complementary approaches that target vehicle use and modal choices rather than just the prices of transport fuels, as such broader approaches tend to be more effective in practice in reducing emissions – especially of greenhouse gases – from road vehicles. Such approaches seek to internalise implicitly the external environmental costs of road transportation. They may be aimed specifically at encouraging the use of clean fuels, including Autogas and other alternative fuels, or discouraging the use of more polluting fuels.

3.2 Typology of policies to promote alternative fuels

In practice, there is wide range of options at the disposal of policymakers within the normal policy-toolbox to promote the supply and use of alternative fuels, including Autogas. The main approaches that governments could or do deploy are financial incentives and regulatory measures. Other measures include support for technology development and public awareness programmes. These are summarised in Table A3.1 and are discussed below.

3.2.1 Financial incentives

Financial incentives can be directed at the fuels themselves or vehicles that are able to use them. Fuel incentives – the main measure that the countries surveyed in this report use to promote Autogas – can take the form of a lower rate of excise duty (and/or sales tax) or its complete exemption. In some cases, commercial vehicles may enjoy a rebate on fuel taxes. These measures directly reduce the cost of running an alternative fuel vehicle (AFV) *vis-à-vis* gasoline and diesel vehicles, and shorten the payback period on converting or acquiring the AFV. Since differences in excise duty show up in prices at the pump, the measure is also highly visible, raising public awareness of the potential cost savings from using alternative fuels. The lower the rates of duties and taxes relative to other fuels, the bigger the financial incentive to switch.

Table A3.1: Typology of government policies and measures to promote alternative fuels

Fiscal/financial	Regulatory	Other
Excise-duty exemption or rebate Road/registration-tax exemption or rebate Vehicle sales-tax exemption or income/profit tax credit (purchasers and OEMs) Tax credits for investment in distribution infrastructure and R&D Grants/tax credits for AFV conversion/acquisition. Rapid depreciation for commercial purchasers of Autogas vehicles and owners of distribution infrastructure Exemption from parking/road-use charges	Mandatory sales/purchase requirements for public and/or private fleets (with enforcement) Standards to harmonise refuelling facilities Vehicle-conversion standards Coherent and appropriate health and safety regulations Exemptions from city-driving restrictions	Government own-use of AFVs Information dissemination and public awareness campaigns Voluntary agreements with OEMs to develop and market AFV technologies Direct funding for research, development, demonstration and deployment of AFVs

Source: Based on WLPGA (2001).

The main way of providing incentives for AFV themselves is to subsidise the higher cost of buying an OEM vehicle or the cost of converting an existing conventional fuel vehicle. Subsidies are most easily provided through grants or tax credits. Eligibility can be made dependent on the emission performance of the vehicle being converted. Governments can also encourage AFV purchases or conversions directly through partial or complete sales or consumption-tax exemptions. Favourable rates or exemptions from vehicle registration and/or annual road taxes are another approach. Such incentives may be restricted to a pre-determined number of years to limit the loss of tax revenue and the free-rider problem (where the financial benefit to some end users from the tax incentive is greater than is necessary for them to switch to using an alternative fuel).

The measures cited above are demand-side fiscal incentive measures aimed directly at reducing the cost to the end user of switching to an alternative fuel. Supply-side fiscal measures that reduce the tax liability of fuel providers and/or AFV manufacturers can also help to lower these costs in an indirect way. For example, profit-tax credits can be used to encourage OEMs to develop and market dedicated AFVs, or to encourage fuel providers to invest in distribution infrastructure.

3.2.2 Regulatory policies and measures

Governments can strongly influence how quickly alternative fuels and technologies are adopted through the design of the regulatory framework. There is a wide range of policies and measures that governments currently employ to promote the use of alternative fuels.

The most direct form of regulatory measure involves the use of legal mandates on public or private organisations to purchase a fixed number of

AFVs. Traffic-control regulations can be also be used to favour such vehicles. For example, AFVs may be granted enjoy exemptions from city or highway-driving restrictions, such as those imposed on peak-pollution days. They may also be exempt from on-street parking charges and road-pricing schemes. Government can also facilitate the development of coherent standards, in partnership with industry, covering vehicle conversions, refuelling facilities and health and safety aspects of alternative fuel supply and use.

3.2.3 Other measures

Governments can support the research, development, demonstration and deployment of alternative-fuel technology either through voluntary agreements with OEMs and fuel providers or through direct funding of such activities. Voluntary agreements or collaborative partnerships with industry are usually seen as an alternative to stringent, mandatory regulations and punitive fiscal measures.

Other measures include the use of voluntary agreements and programmes between government and fuel providers and fleet operators. The aim is to advance public understanding and awareness of the benefits of switching away from conventional fuels and of the various incentives available to them. The deployment of AFVs by the government itself can also expand the market for alternative fuels and set an example to other end users.

Information dissemination and education can also form a key element of government-incentive programmes for alternative fuels. They may take the form of regular communications, such as websites or newsletters, to inform the public of market and technology developments and to indicate how to apply for subsidies if available.

4 International comparison of Autogas incentive policies

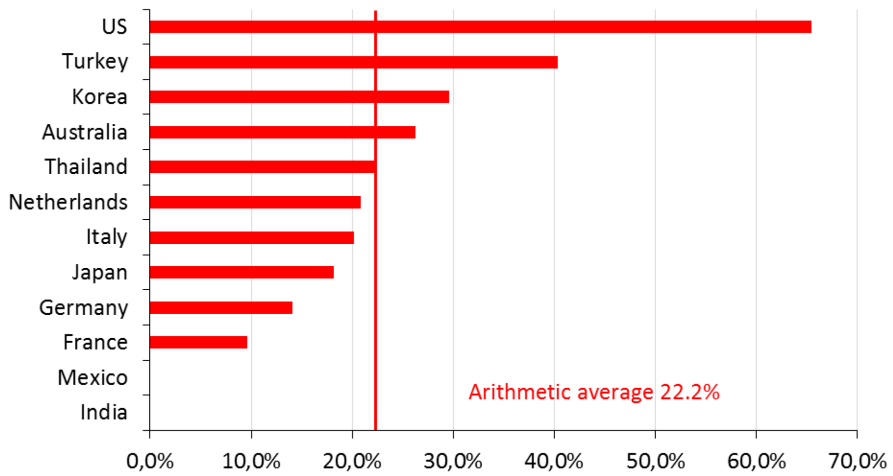
4.1 Fuel taxation and pricing

4.1.1 Comparative taxation of Autogas

Rates of excise taxes and duties on road-transport fuels vary markedly across countries, both in nominal terms and relative to each other. In no country among those surveyed in this report is the same rate of excise duty applied uniformly across all fuels, either on a mass or volume basis. Rates of value-added tax (VAT) or sales taxes also vary substantially, ranging from 5% in Japan and some US states to 21.3% in Italy. And the rules governing the recovery of VAT, consumption and sales tax by commercial users also vary. In practice, the absolute level of tax on Autogas matters less than the how high it is in absolute terms relative to conventional fuels, as that is what helps determine the size of the financial saving that can be made from switching to Autogas.

On a per-litre basis, Autogas taxes are usually lower than for both diesel and gasoline, but the extent of the tax advantage varies significantly. Autogas taxes are lower than those on gasoline on a per-litre basis in all the countries surveyed. Autogas is totally exempt from excise taxes in India and Mexico (Figure A4.1). The ratio of Autogas taxes to gasoline taxes is by far the highest in the United States; in all the other countries, excise taxes on Autogas are less than a third of those on gasoline on a per-litre basis. The arithmetic average ratio across all the countries surveyed is 22.2%.

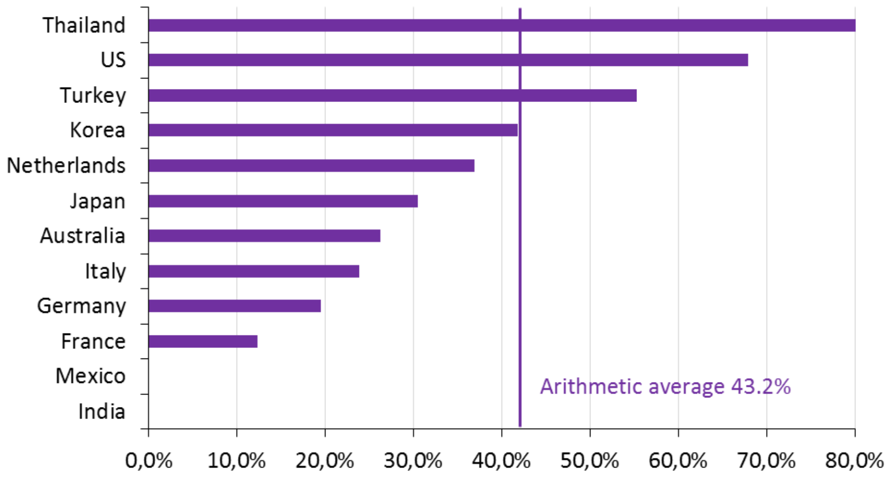
Figure A4.1: Autogas excise taxes as % of taxes on gasoline per litre, 2014



Excise taxes on diesel are lower than on gasoline in all countries except Australia (where they are the same) and the United States. As a result, Autogas generally enjoys a smaller tax advantage over diesel than gasoline.

The ratio of excise-tax rates on Autogas to diesel is highest in Thailand, at over 200% (though the rates on both fuels are very low) and in the United States, at 67.9% (Figure A4.2). Autogas taxes as a proportion of diesel taxes average 43.2% for all 12 countries, though the average is distorted by the exceptionally high figure for Thailand: in all other countries, the share is below 70%.

Figure A4.2: Autogas excise taxes as % of taxes on diesel per litre, 2014



Note: The share in Thailand is over 200%, though taxes on both fuels are low.

Because the calorific value of each fuel varies, the tax advantage of Autogas is in reality smaller – especially over diesel, which has the highest calorific value per litre. If all three fuels were taxed equally on an energy-content basis, taxes *per litre* on Autogas would on average be 22% lower than on gasoline and 29% lower than on diesel.

There is no environmental justification for taxing diesel less than gasoline – even less Autogas – either on a volume or energy-content basis (see Section A3). The favourable treatment usually given to diesel *vis-à-vis* gasoline reflects lobbying by road hauliers and industry generally to minimise commercial fuel costs, especially in countries where trucks can easily refuel in a neighbouring country where duties and therefore pump prices are lower. Many European countries come into this category. It is impractical as well as economically inefficient to levy different rates of duty on different categories of end users. No country currently reimburses excise duties on diesel to commercial users.

4.1.2 Comparative pricing of Autogas

Retail or pump prices of Autogas also vary considerably across the countries surveyed both in absolute terms and relative to the prices of other fuels. This is largely because of differences in the way automotive fuels are taxed. But differences in the bulk price (import, ex-refinery or ex-processing plant) of LPG and the distribution and retail mark-up (including costs and profit margins) also contribute to price differences at the pump. Generally, wholesale pre-tax prices are lowest in countries that export LPG. Margins differ among countries and regions according to the degree of competition between distributors and, in some cases, government margin or price controls. Autogas prices are controlled in India, Mexico, Thailand and, to some degree, in Turkey. In all the other countries surveyed, the government is no longer directly involved in setting wholesale or retail prices.

In 2014, pre-tax pump prices converted to US dollars were on average highest in Turkey. Despite this, due to fiscal measures such as differential taxation, the Turkish government has been able to establish Autogas as a strong alternative. Thanks to large subsidies, pre-tax prices are lowest in Thailand and Mexico. Pre-tax Autogas prices in per-litre terms were lower than for both diesel and gasoline in all countries except Turkey and France. Pre-tax prices change over time in line with fluctuations in international-market prices (Box A4.1); international butane and propane prices have fallen relative to gasoline and diesel prices in recent years due to strong growth in supply with rising natural gas and associated liquids production.

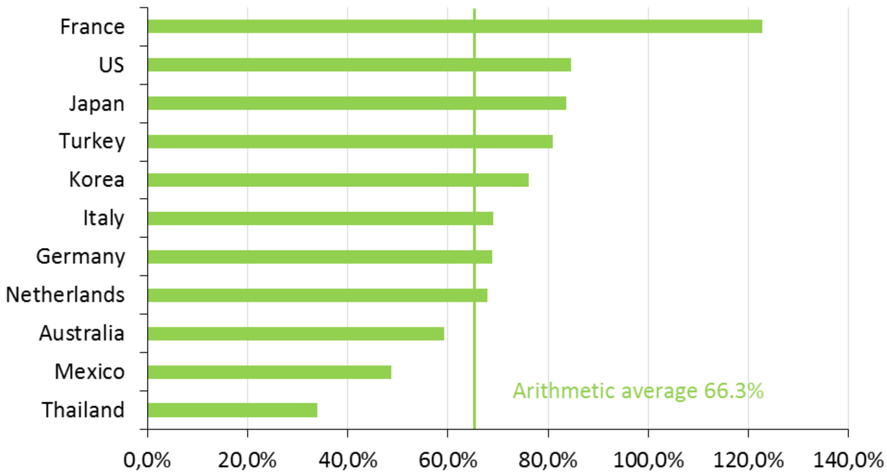


Figure A4.3: Pre-tax pump price of Autogas as % of pre-tax diesel price, 2014

Note: Pre-tax Autogas prices are in relation to pre-tax diesel prices. Pre-tax prices are not available for India.

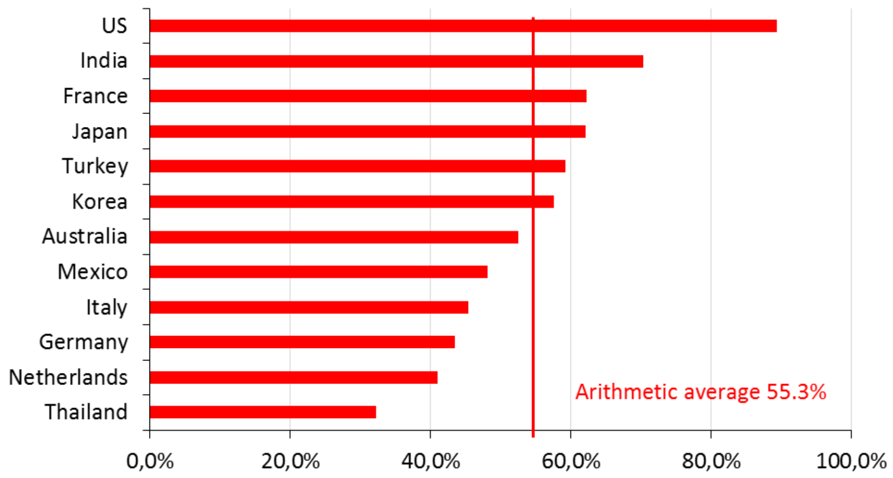
In 2014, the per-litre pump price of Autogas for non-commercial users (including all taxes) was lower than that of both conventional fuels in all countries. In five of the 12 countries surveyed, Autogas pump prices per litre were less than half those of gasoline. After peaking in 2011, the price of Autogas relative to gasoline has fallen in the United States. 2014 saw again an increase in average prices. This is due to the critical supply situation in the winter of 2013/'14 and does not reflect the general trend. The pre-tax price of Autogas as a proportion of that of diesel ranged from 34% in Thailand to 123% in France, averaging 66.3% across all countries (Figure A4.3).

Box A4.1: International LPG pricing

Propane and butane are traded internationally and within the large North American market on a spot basis (cargo by cargo) and under term contracts that cover a specified number of cargoes over a specified period. Contract prices are typically indexed to published spot-price quotations for LPG and other oil products. Spot prices and the base prices in term contracts are determined by market conditions at the time the deal is struck. The primary determinants of propane and butane prices are crude oil, natural gas and naphtha prices, the local supply and demand balance, the proximity of the market to supply sources and the types of uses to which LPG are put.

Because of the large share of petrochemical demand in total world LPG demand and because of the volatility of demand from this sector, LPG prices tend to fluctuate more sharply in the short term than those of oil or natural gas. In particular, LPG prices tend to increase in the summer in the northern hemisphere, when petrochemical and refinery demand is highest because of increased demand for gasoline. Propane and butane replace naphtha as feedstock in ethylene plants, as larger volumes of naphtha are diverted to gasoline production in refineries. However, over the longer term, the bulk prices of LPG, crude oil and naphtha tend to move closely in line with each other. Propane and butane prices are usually very close and also tend to move in parallel.

Figure A4.4: Autogas pump price including all taxes as % of gasoline price per litre, 2014



Because diesel is taxed less than gasoline everywhere except in the United States, the pump-price differential between Autogas and diesel is generally lower than that between Autogas and gasoline. The per-litre price of Autogas was on average 61.5% that of diesel in 2014. The ratio was highest in India and, as for gasoline, lowest in Thailand (Figure A4.5). The share of total taxes in the per-litre pump price of each fuel and the ratio of Autogas pump prices including all taxes to those of diesel and gasoline are detailed in Table A4.1.

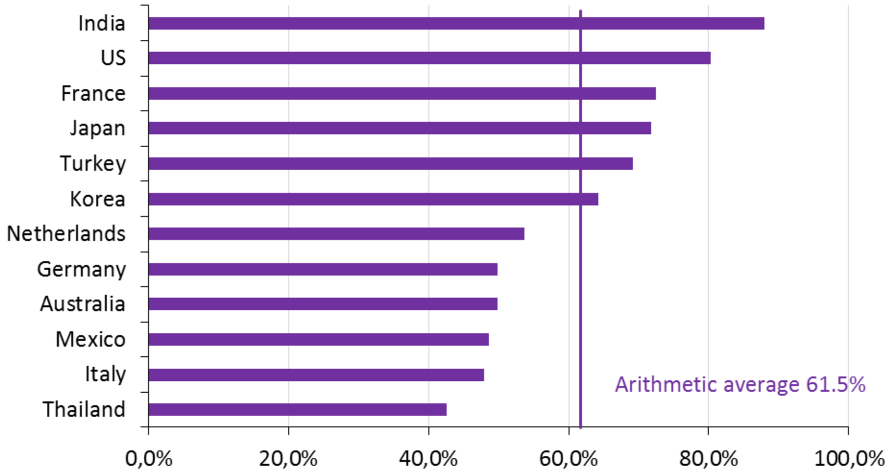


Figure A4.5: Autogas pump price including all taxes as % of diesel price per litre, 2014

Table A4.1: Automotive-fuel taxes and prices, 2014

	Share of total taxes in price			Autogas pump price as % of prices of other fuels (including tax)	
	Autogas	Diesel	Gasoline	Diesel	Gasoline
Australia	21,9%	34,3%	35,6%	49,8%	52,5%
France	23,9%	55,0%	62,5%	72,5%	62,3%
Germany	28,7%	48,4%	55,5%	49,8%	43,5%
India	n.a.	n.a.	n.a.	87,9%	70,3%
Italy	36,9%	56,2%	60,7%	48,0%	45,4%
Japan	17,4%	29,1%	41,5%	71,7%	62,2%
Korea	30,2%	41,4%	49,9%	64,2%	57,5%
Mexico	13,7%	13,8%	13,8%	48,7%	48,1%
Netherlands	43,5%	55,4%	68,7%	53,7%	40,9%
Thailand	36,0%	19,8%	43,1%	42,6%	32,2%
Turkey	47,1%	55,6%	59,7%	69,2%	59,2%
United States	9,8%	14,3%	14,2%	80,3%	89,4%
Average	**25,8%**	**35,3%**	**42,1%**	**61,5%**	**55,3%**

Note: Percentages are calculated on a volume basis. n.a. is not available.

Effective pump prices can also differ between commercial and non-commercial users. In most countries, commercial (business) users are able to recover VAT on fuel purchases but usually not excise duties. In most cases, the rules governing VAT refunds are the same for all fuels and all types of vehicles.[1] Where this is the case, the relative competitiveness of the different fuels is not affected, although the absolute savings on running costs from switching to cheaper fuel/vehicle options differ between commercial and non-commercial users.

4.2 Autogas vehicle subsidies

The most effective measure other than favourable fuel taxation in encouraging switching to Autogas is subsidies to the vehicle itself. They usually take the form of grants or tax credits for converting gasoline vehicles to run on Autogas or for purchasing OEM Autogas vehicles. Among the countries surveyed, the central government and/or local authorities subsidised gasoline-vehicle conversions or OEM purchases in 2014 in Australia (the subsidy scheme there ended in July 2014), Italy, Japan and the United States. In some cases, subsidies effectively covered the entire cost of conversion or the additional OEM cost. Other countries, including France, ran similar schemes until recently.

Discounts on annual road taxes and initial vehicle registration taxes compared with those levied on gasoline or diesel vehicles are less common. In 2013, France and the Netherlands used this approach (though annual road taxes in the Netherlands are higher for Autogas vehicles than for diesel or gasoline powered ones).

4.3 Other incentives

Supply-side fiscal or subsidy measures that reduce the tax liability, investment cost or running costs of fuel providers and/or vehicle converters or OEMs are used in only two countries. Some US states have introduced profit-tax credits for part of the construction cost of refuelling stations or improvements to existing stations so they can provide Autogas or other alternative fuels. The Japanese government also ran a programme to promote Autogas distribution, through grants covering 50% of both the cost of building and the cost of running Autogas refuelling stations up to a fixed ceiling; the programme ended in March 2012.

Fleet-vehicle purchase mandates or Autogas-fuelled public transport programmes are used in four of the countries surveyed countries: India, Italy, Korea and the United States. Mandates for AFVs, including those using Autogas, have been widely used in the United States. Under the Energy Policy Act of 1992, 75% of new LDVs acquired by certain federal fleets must be alternative fuel vehicles (AFVs). A minimum share of certain state government and alternative fuel-provider fleet vehicle purchases must also be AFVs. Additional requirements for federal fleets were included in the Energy Independence and Security Act of 2007, including requirements to acquire low-emitting vehicles.

Autogas vehicles – along with other with other clean AFVs – enjoy exemptions from city or highway-driving restrictions imposed on peak-

[1] France is an exception: 100% of VAT can be recovered in the case of Autogas and 80% for diesel; VAT is not recoverable for gasoline.

pollution days in several European cities, including Rome (in Italy) and Paris (in France). In some US cities, Autogas vehicles are given access to dedicated lanes. Most industrialised countries directly fund and manage transportation and automotive fuel R&D programmes, which sometimes benefit Autogas.

Other measures that have been or are being used by governments to promote Autogas use include the use of voluntary agreements and programmes between governments and fuel providers and fleet operators. For example, the US Clean Cities Program, run by the Federal Department of Energy, is aimed at helping city authorities seek voluntary commitments from fuel providers to expand the distribution network and fleet operators to increase their purchases of alternative fuel vehicles. The deployment of Autogas vehicles by the government itself is also used to expand the market for Autogas and set an example to other end users. Information dissemination and education programmes for Autogas and other alternative fuels are used in several other countries.

Table A4.2 summarises the principal measures deployed in the countries surveyed in this report. The most commonly used measure to support Autogas is a tax exemption or large rebate relative to conventional fuels.

Table A4.2: Summary of Autogas incentive policies in countries surveyed, 2014

	Fuel tax exemption or large rebate[1]	Vehicle tax exemption or rebate[2]	Grants/tax credits for conversions or OEM purchases[3]	Autogas fleet vehicle purchase mandates[3]
Australia	✓			
France	✓	✓		
Germany	✓			
India	✓			✓
Italy	✓		✓	✓
Japan	✓		✓	
Korea	✓			✓
Mexico	✓			
Netherlands	✓			
Thailand	✓			
Turkey				
United States	✓		✓	✓

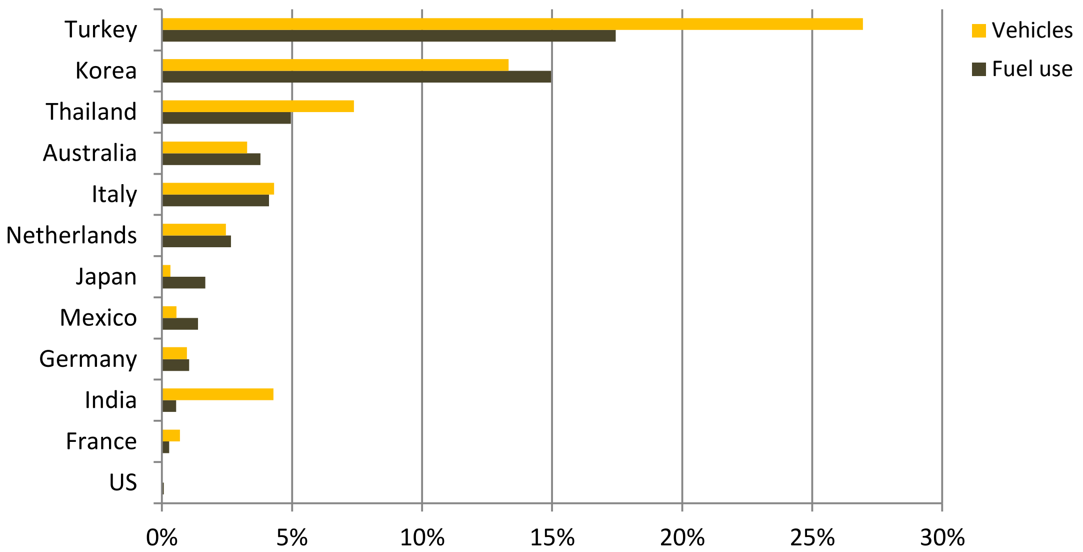
[1] Excise duty less than half that levied on diesel and gasoline, calculated on a per-litre equivalent basis. [2] Compared with gasoline. Includes taxes on vehicle conversion/acqusition, initial vehcile registartion charges and annual road/registration charges. [3] Central and state governments. Includes public transport.

5 Effectiveness of Autogas incentive policies

5.1 Autogas share of the automotive-fuel market

The effectiveness of Autogas incentive policies varies considerably among the countries surveyed in this report. The share of Autogas in total automotive-fuel consumption ranges from a mere 0.1% in the United States to over 17% in Turkey based on 2012 data[1] (Figure A5.1). The only country other than Turkey where Autogas accounts for more than 10% of the fuel market is Korea, where the share is 15%. The share is less than 1% in France and India (as well as in the United States).

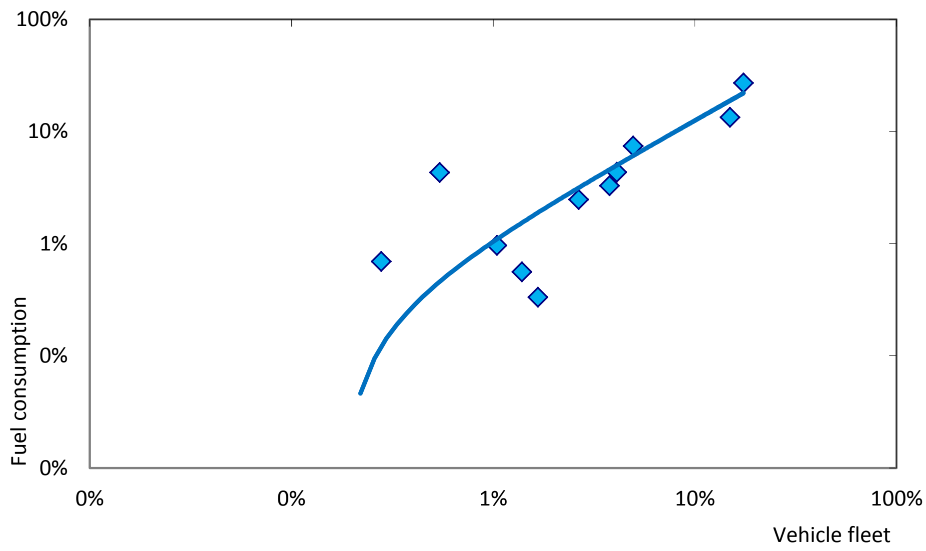
Figure A5.1: Share of Autogas in total automotive-fuel consumption and LDV fleet, 2012 (%)



The share of Autogas vehicles in the total number of passenger vehicles is, unsurprisingly, closely correlated with the share of Autogas in total automotive-fuel consumption (Figure A5.2). Fuel use in Korea is high relative to the penetration of Autogas in the vehicle fleet, largely because taxis and other commercial vehicles account for most Autogas consumption (because of restrictions on the use of the fuel in private passenger cars). The share of Autogas in the vehicle fleet is high relative to its share in total fuel use in India because three-wheelers, which consume less fuel, account for a large share of the Autogas vehicle fleet.

[1] Comprehensive data on total automotive fuel consumption are available only to 2012, though preliminary data for 2013 are available for some countries.

Figure A5.2: Share of Autogas in total automotive-fuel consumption versus vehicle fleet, 2012



Note: Log scale.

5.2 Comparative competitiveness of Autogas

The market penetration of Autogas depends largely on how competitive the fuel is against gasoline and diesel – in other words, how financially attractive it is for an end user to switch to Autogas. This largely depends on the cost of converting the vehicle (or the cost of a dedicated OEM vehicle compared with a gasoline or diesel vehicle) and the pump price of Autogas relative to diesel and gasoline.

Since converting a vehicle to run on Autogas involves upfront capital expenditure and some minor inconvenience, the owner needs to be compensated 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 average distance travelled monthly or annually. The extent to which government incentives lower the initial expenditure (through subsidies) and fuel costs (through favourable taxation) is critical to the payback period. In practice, the payback period generally has to be less than two to three years to encourage commercial vehicle owners to switch; private individuals often demand an even quicker return on their investment.

We have estimated, for all the countries surveyed, the distances over which a typical LDV of recent vintage would need to travel before it becomes competitive with similar gasoline and diesel vehicles. The methodology and assumptions used for this analysis are described in Box A5.1. The results are summarised in Table A5.1 (the detailed results by country can be found in Part B).

Box A5.1: Methodology for calculating the comparative competitiveness of Autogas

In order to analyse the role inter-fuel competition plays in Autogas demand, we have calculated indicative breakeven distances for non-commercial Autogas-fuelled LDVs compared with both gasoline and diesel vehicles for all 12 countries surveyed. This involved compiling information on current pump prices and effective differences in actual vehicle conversion and acquisition costs for Autogas and diesel relative to gasoline vehicles, taking account of any grants or tax rebates currently available (including any differences in vehicle registration and annual road taxes). The cost of running a gasoline vehicle is the baseline against which the cost of running Autogas and diesel vehicles is compared.

To allow cross-country comparisons, uniform assumptions about fuel and vehicle types were adopted. For all countries, a typical passenger car of recent vintage was assumed (a five-door saloon or hatchback) with the same power rating for each fuel. For Autogas vehicles, a vapour-injection system was assumed (unless indicated otherwise). Mileage differences due to the lower per-litre energy content of Autogas and engine performance were also taken into account. The diesel vehicle was assumed to consume 22% less fuel per kilometre on a volume basis than the gasoline vehicle, while the Autogas vehicle was assumed to consume 25% more per kilometre than the gasoline vehicle. No differences in fuel specifications and operating characteristics between countries were taken into account, because of the difficulty in obtaining reliable information for each country (notably the propane-butane mix of Autogas, which varies in practice across seasons and countries).

There is considerable variation in the competitiveness of Autogas against each of the other fuels among the countries surveyed. Converted vehicles eventually break even with gasoline vehicles in all countries except the United States (Figure A5.3). The breakeven distance is almost 200 000 km in Japan. In all other countries, the breakeven distance is less than 80 000 km. Autogas is most competitive in Thailand, where a converted Autogas vehicle breaks even with gasoline at just 15 000 km – little more than one year of driving for a private motorist. Autogas is also highly competitive in Italy, where an OEM Autogas LDV is always the lowest cost fuel/vehicle option, regardless of distance travelled (on the assumption that the additional purchase price of the vehicle over and above that of a gasoline vehicle is fully subsidised). Even for a converted vehicle in Italy, which does not qualify for a grant, Autogas breaks even with gasoline at just 34 000 km – less than two years driving on average. In half of the countries surveyed, the breakeven distance against gasoline is under 50 000 km – or about three years of driving. The equivalent breakeven distance for OEM Autogas vehicles is generally higher, because it is more expensive to buy an OEM than convert a gasoline car in most cases, though in some countries it can be cheaper to buy an OEM than convert an existing vehicle.

The picture is less straightforward when Autogas is compared with diesel. Converted Autogas vehicles are always competitive against diesel in four countries (Italy, Korea, Mexico and Thailand), where both per-kilometre fuel costs are lower and Autogas-conversion costs net of any grants are less than the additional cost of buying a diesel vehicle. In three other countries (India, Turkey and the United States), the running costs of diesel are lower than for Autogas, so diesel eventually breaks even against Autogas (though only after more than 100 000 km in Turkey). In three countries – Australia, France and Japan – Autogas is never competitive against diesel.

Table A5.1: Breakeven distance for a non-commercial Autogas LDV, 2014 (thousand km)

	Autogas conversion against		Autogas OEM against	
	Diesel	Gasoline	Diesel	Gasoline
Australia	67	78	48	57
France	NC	73	0-90	26
Germany	36	37	36	37
India	0-20	22	0-8	28
Italy	22	26	0	0
Japan	NC	169	NC	169
Korea	0-110	40	0-110	40
Mexico	5	43	50	97
Netherlands	120	31	70	20
Thailand	0	15	NA	NA
Turkey	0-105	13	0-75	53
United States	NC*	NC*	NC*	NC*

Note: Zero indicates that Autogas is always competitive. A range indicates the distances over which Autogas is competitve before the competing fuel becomes more economic. NC indicates that Autogas is never competitive. NA. is not available. * In the US Autogas can only compete when additional incentives, such as tax rebates, flat taxation and others are used.

5.3 Impact of Autogas competitiveness on automotive-fuel market penetration

There is a strong correlation between how competitive Autogas is against other fuels and how successful Autogas has been in penetrating the automotive-fuel market. Figure A5.4 plots the market penetration of Autogas against the competitiveness of Autogas (based on the lowest breakeven distance) *vis-à-vis* gasoline for all countries. Autogas use is generally higher in countries where the break-even distance is low. For example, Korea and Turkey have both the highest rates of Autogas penetration and among the lowest breakeven distances. At the other extreme, Autogas is least competitive in the United States, where Autogas accounts for the smallest share of total automotive-fuel consumption among the countries surveyed. The correlation for diesel is weaker, largely because Autogas is always competitive against that fuel in almost half of the countries.

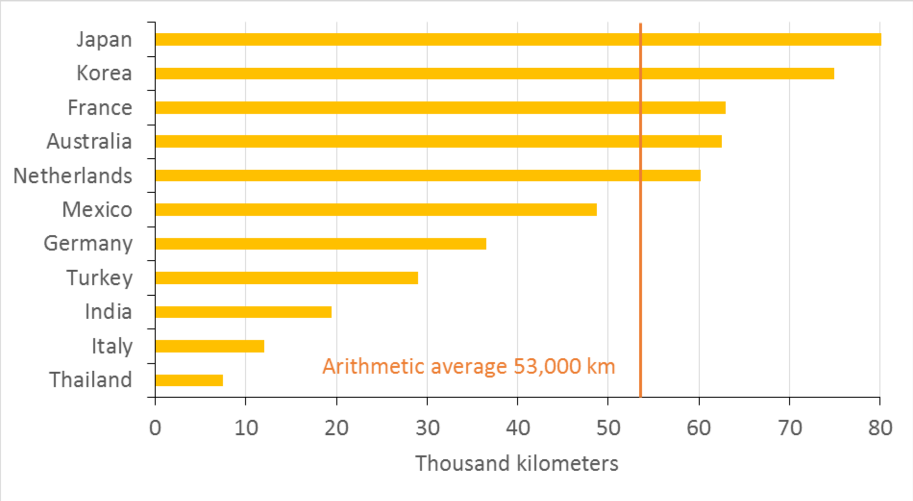


Figure A5.3: Average Autogas break-even distance against gasoline and diesel, 2014

Note: The United States are not shown, as Autogas is never competitive against either gasoline or diesel. In Italy, an OEM is competitive against gasoline at 0 km; in Thailand, no OEMs are available.

5.4 Impact of non-financial incentives

The competitiveness of Autogas is the most important factor in explaining the actual market penetration of Autogas and recent rates of market growth. But is not the only factor: for example, the breakeven distance for Autogas against gasoline in Italy, the Netherlands and Thailand is lower than that of Korea, yet the penetration of Autogas in those countries is much lower – even though Autogas is always competitive against diesel. Several factors explain these divergences:

- *Government policy commitment:* The Autogas market has tended to develop more quickly where the government has shown a strong, long-term policy commitment in favour Autogas. Frequent changes of policy, including shifts in taxation, deter end users, equipment manufacturers and fuel providers from investing in Autogas. For example, a sudden hike in the excise duty on Autogas in the Netherlands at the beginning of 2014 has reportedly already led to a sharp drop in conversions and fuel sales. In contrast, the long-term commitment by the German government in 2006 to keeping Autogas taxes low has been an important factor in the take-off of Autogas demand there.

- *Non-financial policies and measures:* In some cases, the use of non-financial incentives or other measures have either helped to boost or to hinder Autogas use. Public awareness and education campaigns to promote Autogas have certainly made a significant contribution to market growth in several countries, including the United States. Mandates and public transport fleet conversion programmes have also been very successful in several countries, including France and the United States. In other cases, regulations restricting Autogas use, including bans on underground parking (a problem in several European countries), have been a barrier to market development.

- *Restrictions on diesel vehicles:* Local and central government environmental restrictions on the use of diesel vehicles have been an important factor behind the success of Autogas in Korea and Japan.

- *Availability of equipment and fuel:* In some countries, Autogas has struggled to penetrate the fuel market where carmakers have been reluctant to market OEM models or where there is a limited number of refuelling sites selling Autogas. A lack of OEM vehicle availability has been a major barrier to market development in the United States.

- *Public attitudes:* Worries about the safety and reliability of Autogas have clearly affected demand in several countries. This appears to be the main reason why Autogas demand remains weak in France, despite highly favourable taxation policies. Awkward refuelling facilities also deter interest in using the fuel in some cases.

6 Lessons for policymakers

6.1 The rationale for promoting Autogas

For environmental and economic reasons, Autogas remains a particularly attractive alternative automotive fuel for countries looking to tackle urban air pollution and curb rising emissions of greenhouse gases. In most parts of the world, these problems are getting worse as demand for mobility – whether for transporting people or goods – grows inexorably with increasing economic activity and prosperity. Urgent action is needed in many places, especially in Asia. Draconian measures to curb mobility are politically and socially unacceptable. Breakthrough technologies under development today, such as BEVs, hold out the prospect of much lower or even zero emissions, but their widespread commercialisation is still several years away. Biofuels can bring significant reductions in greenhouse-gas emissions, but are often very expensive to produce, requiring large subsidies to make them financially viable.

The most practical approach in the short-term to reducing emissions is by encouraging people and businesses to switch to cleaner-burning fuels that are already commercially available. Autogas is the obvious option. It outperforms conventional fuels and most other alternative automotive fuels for local and regional environmental benefits. It can also play an important role in mitigating greenhouse-gas emissions until such time as ultra-low or zero-emission vehicle technologies are commercialised on a large scale.

Autogas makes economic as well as environmental sense because its raw material costs are competitive and installing the distribution infrastructure costs less than for other alternative fuels. Most gasoline-powered LDVs, including commercial vans and taxis, are highly amenable to conversion to Autogas. OEM Autogas buses have operated for many years in a number of cities around the world, and improved Autogas-fuelled engines for buses and trucks are now available. Yet there are obstacles to market take-off and development. In practice, Autogas can only be successful if there is a concerted effort on the part of all stakeholders – vehicle manufacturers and converters, Autogas suppliers and governments – to make switching attractive to end users.

The loss of revenue from lower taxation of Autogas fuels or vehicle sales may be used by the government as an excuse for not providing fiscal incentives – especially in countries where fuel-tax revenues make up a large share of the overall government budget. In practice, however, any reduction in taxes from automotive-fuel sales can be easily offset by marginal increases in taxes on gasoline and diesel.

6.2 Critical success factors for Autogas market development

In designing Autogas incentives, policymakers need to take account of the critical success factors behind the development of a sustainable Autogas market. The analysis of the preceding two chapters demonstrates clearly that the most important factors are the financial attraction of switching to potential Autogas-vehicle owners, i.e. the speed of payback on the initial investment, and the achievement of critical market mass.

Fuel taxes and vehicle grants are the primary determinants of the financial benefit to vehicle owners of switching to Autogas. In practice, the crucial variable to vehicle owners and operators in their choice of fuel is the speed of payback on the initial additional cost of converting a gasoline vehicle to run on Autogas or the higher price of an OEM vehicle relative that of a new gasoline or diesel vehicle. The payback period has to be sufficiently short to justify the investment and to compensate for the inconvenience associated with Autogas, notably the loss of space in the boot/trunk and the more limited availability of refuelling stations in some countries and regions.

Even where reasonably strong financial incentives exist, Autogas use will not necessarily take off until critical market mass is achieved:

- The market needs to be large enough to demonstrate to potential Autogas users and fuel providers that the fuel is safe, reliable and cost-effective alternative to conventional fuels. The more Autogas vehicles there are on the road, the more confidence other vehicle owners will have to switch fuels.
- Autogas must be widely available. Lack of refuelling stations is a major impediment to persuading vehicle owners to switch to Autogas, even where there is a strong financial incentive.
- The Autogas market must be big enough to support a viable network or properly-trained mechanics to convert and maintain Autogas vehicles and ensure the availability of spare parts and equipment.

The role of the government in giving an initial strong impetus to the simultaneous development of demand and supply infrastructure in collaboration with all stakeholders is vital. Favourable taxation of Autogas relative to gasoline and diesel is a necessary but not always a sufficient condition for establishing and sustaining an Autogas market. Other government incentives may be necessary where the market has not yet reached critical mass. Government grants for vehicle conversions for private individuals and fleets have been particularly successful in kick-starting Autogas markets in some instances. Road and vehicle registration and purchases taxes that favour Autogas vehicles can also be an effective policy, with relatively low implementation costs and few negative side-effects. Conversion of public vehicle fleets to Autogas is also an effective way of demonstrating the benefits of Autogas and driving the development of distribution infrastructure.

Technical and safety standards are another important area of responsibility for governments in partnership with LPG suppliers, vehicle converters and OEMs. It is essential for the authorities to lay down and enforce harmonised operating standards for aspects of both Autogas distribution and vehicle equipment, including installation. Poor-quality conversions can undermine engine and emission performance and jeopardise sustainable development of the market. The European Union, for example, addressed this concern with the adoption of ECE Regulation 67.01. Another issue concerns refuelling nozzles at service stations, which must be compatible with the vehicle connector. Differences between and even within countries was initially a significant barrier to the development of the European Autogas market. The development of a new standardised filling system designed by Autogas providers and the major OEMs helped to resolve this problem and support the development of the market.

Safety should be an overriding concern for policymakers everywhere. Fuel providers and end users need to be reassured that the transportation, handling and storage of Autogas pose no safety risks. But the drafting and implementation of safety regulations specific to Autogas need to be based on an objective assessment of risk. In many countries, regulations still limit unnecessarily access and parking of Autogas vehicles, the siting of refuelling stations and the on-site location of dispensers. Studies have shown that many of these restrictions are unjustified. For example, some countries do not allow the positioning of Autogas dispensers next to gasoline and diesel pumps. This raises the station's capital and operating costs and undermines the customers' confidence in the safety of Autogas refuelling. Experience in countries where this is permitted, such as France and the Netherlands, shows that there is little risk if good equipment and appropriate procedures are in place.

In most cases, there is no need for policymakers to draw up technical and safety standards and regulations from scratch, since several countries have developed effective frameworks based on many years of experience of Autogas use. For example, the European Standards Organisation, CEN, has drawn up detailed minimum safety requirements for Autogas vehicles, fuel and storage systems and installation procedures as well as fuel distribution. The European Autogas industry is working to harmonise technical and safety standards through EU regulations.

6.3 Formulating an effective Autogas strategy

There is no single model or approach to formulating and implementing a government programme of incentives to promote the development of a sustainable Autogas market. The appropriate strategy for each country depends on specific national circumstances. These include budgetary considerations, which might limit available funds for subsidies, the seriousness of local pollution problems, fuel-supply and cost issues, the stage of development of the Autogas market and the prevailing barriers to fuel switching, including restrictive regulations and the local cost of vehicle conversions.

Whatever the circumstances, however, experience in the countries surveyed in this study has clearly shown that the single most important measure to making Autogas an attractive fuel to vehicle owners is favourable fuel-tax treatment compared with conventional fuels. At a minimum, taxes should be set on an energy-content basis and should take account of the environmental benefits of encouraging switching to Autogas. But this is not always sufficient. Complementary policy initiatives, including grants and tax credits to lower the cost of vehicle conversions, and regulatory measures may also be needed – especially during the early stages of market development. Vehicle incentives are particularly important where fuel taxes generally are low, limiting the scope for savings on running costs.

Policy stability and a strong, long-term commitment by the government to achieving environmental-policy objectives are crucial to success in promoting the development of alternative-fuel markets. Stakeholders need to be given clear advance warning of any major shift in policy. Without policy stability, coherence and consistency, neither fuel suppliers, nor OEMs nor consumers will be confident that they will be able to make a reasonable return on the investments required to switch fuels.

PART B: COUNTRY SURVEYS

1 Australia

1.1 Autogas market trends

Australia has a comparatively long history of Autogas use. The federal government has encouraged the use of Autogas use since 1981 for reasons of energy security – the country is a large producer and exporter of LPG, derived mainly from natural-gas processing – and air quality. Today, Australia has the eighth-largest Autogas market in the world and an extensive nationwide retail-distribution network, with 3 600 refuelling sites throughout the country serving an estimated 470 000 vehicles at end-2014 (around 3% of the total car and truck fleet). Over half of all service stations in Australia sell Autogas. The state of Victoria has the largest Autogas market. Autogas use is particularly high among taxis, around 16 000 of which – or about three-quarters of the total taxi fleet – run on Autogas. Autogas accounts for 47% of the country's LPG consumption.

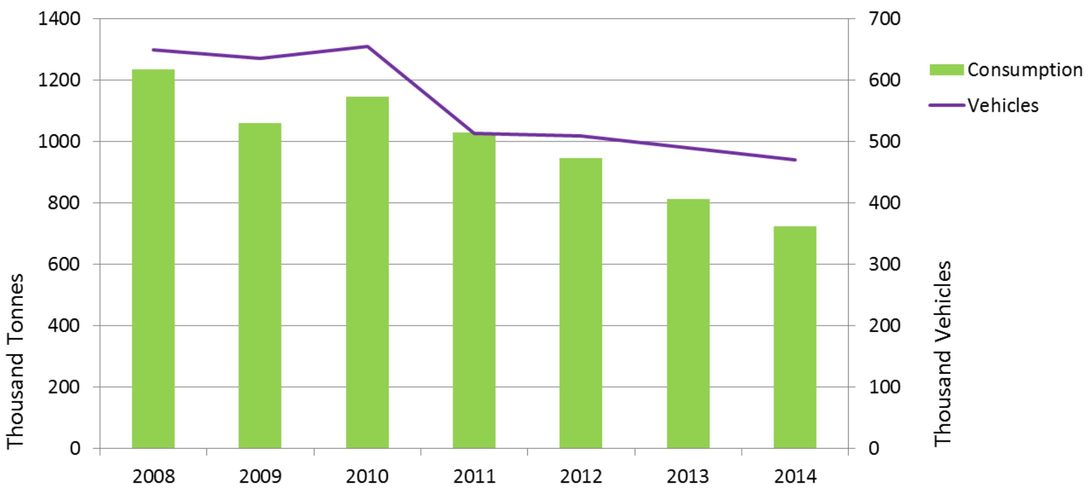


Figure B1.1: Autogas consumption and vehicle fleet – Australia

Note: The sharp drop in the vehicle fleet in 2011 is largely due to a break in the series.

The Autogas market took off in the 1990s thanks to a combination of a zero excise tax on Autogas and generous vehicle-conversion grants (see below). Autogas consumption fluctuated around 1.1 Mt per year between 2004 and 2010, but has since fallen appreciably. A number of factors explain this decline, including the introduction of and progressive increase in an excise tax on Autogas, improved fuel economy and consumers shunning large six-cylinder vehicles, which have been the mainstay of the Australian Autogas market, in favour of smaller four-cylinder vehicles, diesel and hybrids. A reduction in the value of grants for Autogas vehicle also contributed. Sales dropped to 725 000 tonnes in 2014 – their lowest level since 1994 and down from an all-time peak of almost 1.5 million tonnes in 2000 (Figure B2.1). Autogas use was equal to less than 4% of total road-fuel consumption in 2012 and decreased through 2013 to about 3% in 2014, compared with almost 5% in 2010.

The prospects for Autogas use in Australia have been dealt a further blow by decisions by the two carmakers that have production facilities in the country – the US firms Ford and General Motors (Holden) – that they will cease producing Autogas models by 2017, as result of these factories being closed. Ford still offers a factory-fitted Autogas version of the Commodore and Falcon models, while Holden offers Autogas versions of its Sportwagon and exclusively in its V6-powered Caprice. Only 532 Autogas vehicles were sold to private buyers in 2013, down from 725 in 2012.[1] Local production of LPG is also set to fall with the recent closure of one refinery and the planned closure of two others, which could drive up wholesale prices and the price of Autogas at the pump. The LPG being produced at offshore facilities is destined for the Asian market, as it promises greater revenue due to shorter transport routes.

1.2 Government Autogas incentive policies

The federal government has traditionally supported the development of the Autogas market primarily through favourable taxation. Up to 2011, Autogas and other alternative fuels (ethanol, LNG and CNG) benefitted from a complete exemption from excise taxes. A tax was introduced on Autogas (as well as CNG and LNG) on 1 December 2011 at 2.5 cents/litre and was scheduled to rise each year on 1 July by 2.5 cents to 12.5 cents in 2015 – still well below the rates applied to gasoline and diesel. The current rate is 10 cents (having increased from 7.5 cents on 1 July 2014, compared with 38.1 cents for both gasoline and diesel (unchanged for several years). In May 2014, the government announced a proposal to index excise-duty rates for most road fuels to inflation every six months.

Non-commercial users of all types of transport fuels are obliged to pay a 10% Goods and Services Tax (GST) that was introduced in 2000; the tax is refunded for commercial users. The pump price of Autogas including GST is currently half that of gasoline and 47% that of diesel (Table B2.1). Despite the introduction of an excise tax on Autogas, the price differentials between Autogas and the two other fuels have increased slightly since 2011, because pre-tax gasoline and diesel prices have increased, while those of Autogas have fallen – the result of international price movements.

The federal government used to make available grants for the conversion of existing vehicles or purchase of an OEM Autogas vehicle. In 2006, it introduced the LPG Vehicle Scheme, which provided grants to private motorists for the conversion of existing LDVs of less than 3.5 tonnes or the purchase of an OEM Autogas LDV. The subsidy was increased in November

[1] http://www.themotorreport.com.au/59266/federal-government-lpg-incentive-scheme-ends-where-to-from-here

2008 from A$1 000 to A$2 000 for an OEM purchase and a conversion, but the conversion grant was reduced from A$2 000 to A$1 250 in November 2008 and reduced further to A$1 000 in July 2012. From 1 July 2011, the scheme was capped at 25 000 claims per year and was closed at the end of June 2014.

Table B1.1: Automotive-fuel prices and taxes – Australia (A$/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	0.599	0.588	0.704	0.717	0.721	0.781
Diesel	1.344	1.278	1.484	1.497	1.523	1.568
Gasoline*	1.285	1.259	1.430	1.432	1.454	1.488
Total taxes						
Autogas	0.055	0.053	0.064	0.103	0.128	0.171
Diesel	0.503	0.497	0.516	0.517	0.519	0.538
Gasoline	0.498	0.495	0.511	0.511	0.513	0.530
Excise taxes						
Autogas	0.000	0.000	0.000	0.050	0.075	0.100
Diesel	0.381	0.381	0.381	0.381	0.381	0.381
Gasoline	0.381	0.381	0.381	0.381	0.381	0.381
Pre-tax prices						
Autogas	0.545	0.535	0.640	0.614	0.593	0.610
Diesel	0.841	0.781	0.968	0.980	1.003	1.030
Gasoline	0.787	0.763	0.919	0.921	0.941	0.958

* Regular unleaded.

State and local governments have also moved away from policies to promote Autogas. For example, the Western Australian government used to provide a subsidy of A$1 000 for Autogas conversions, but the scheme was halted in 2009. Current government fleet policies focus on fuel efficiency, which favours smaller vehicles and those using hybrid or diesel technology.

In December 2011, the government released the Strategic Framework for Alternative Transport Fuels (AGDRET, 2011). Developed in consultation with industry, government and other stakeholders, the framework establishes a long-term approach to encouraging the adoption of Autogas and other alternative transport fuels in Australia, including identifying specific actions needed to address identified barriers to uptake and raising public awareness about the benefits of alternative fuels. Proposed actions include standardising regulations concerning Autogas conversions kits across states and territories and internationally, and addressing consumer perceptions that Autogas vehicle technology is outdated. Gas Energy Australia (GEA), the national organisation representing the downstream gaseous fuels industry, is working to ensure that these actions are taken on board in the federal government's forthcoming energy white paper. GEA is also seeking support from the federal government and the governments of Victoria and South Australia for a proposal to restructure the Autogas industry, involving the setting up of an Autogas vehicle "centre of excellence" aimed at ensuring that OEM manufacturing continues in Australia.

1.3 Competitiveness of Autogas against other fuels

Thanks to the favourable rate of excise duty and vehicle subsidies, an OEM Autogas LDV broke even with gasoline at about 55 000 km to 73 000 km in 2014 (up from around 53 000 km in earlier years; Figure B2.2). The effective vehicle cost for OEM vehicles was lower than for conversions, reducing the breakeven distance, as the subsidy was bigger and the additional cost of purchasing an OEM was less than the cost of an after-market conversion. The average cost of converting a gasoline-fuelled LDV to run on Autogas is currently A$3 500 (including GST) and the incremental cost of dedicated OEM dual-fuelled vehicle about A$2 500. Diesel breaks even with gasoline at close to 80 000 km, effectively make putting in reach of Autogas. It now offers a competitive option for the typical Autogas users.

As both conversion and OEM purchase subsidies were stopped at the end of June 2014, the breakeven distance has now increased to around 77 000 (based on average 2014 fuel prices). These distances are set to rise further with the final step of the Autogas excise tax increase in July 2015.

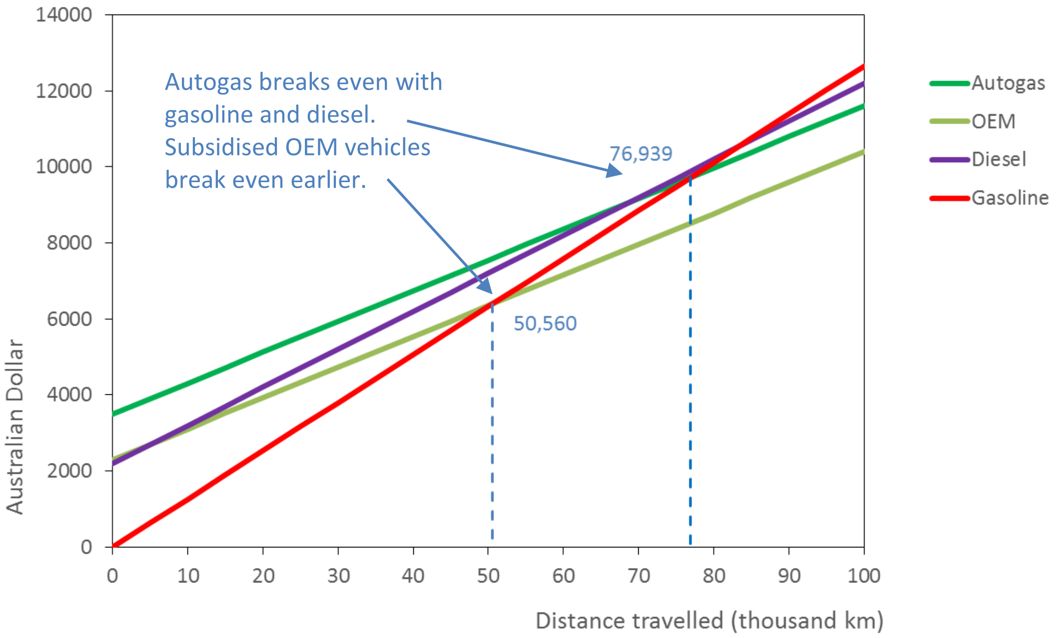


Figure B1.2: Running costs of a non-commercial LDV, 2014 – Australia

2 France

2.1 Autogas market trends

The fortunes of Autogas in France have fluctuated since the market first took off in the mid-1990s following the introduction of a strong fiscal incentive. Initially, consumption grew rapidly to around 220 000 tonnes in 2000, driven by LDV conversions, but then began to decline, to around 100 000 tonnes at the end of the decade. This was largely the result of shifts in policy, as well as a highly publicised accident involving an Autogas vehicle, which undermined public confidence in their safety. Fuel sales recovered a little in 2010-2011, apparently due to a temporary surge in OEM vehicle sales in 2010 in response to an increase in the price advantage of Autogas over gasoline at the pump and the announcement by the government that the tax credit for Autogas vehicles would be scrapped at the end of the year (see below). But fuel use fell back again in 2012,2013 and 2014 (Figure B2.1). Autogas accounts for only around 0.3% of total automotive-fuel use.

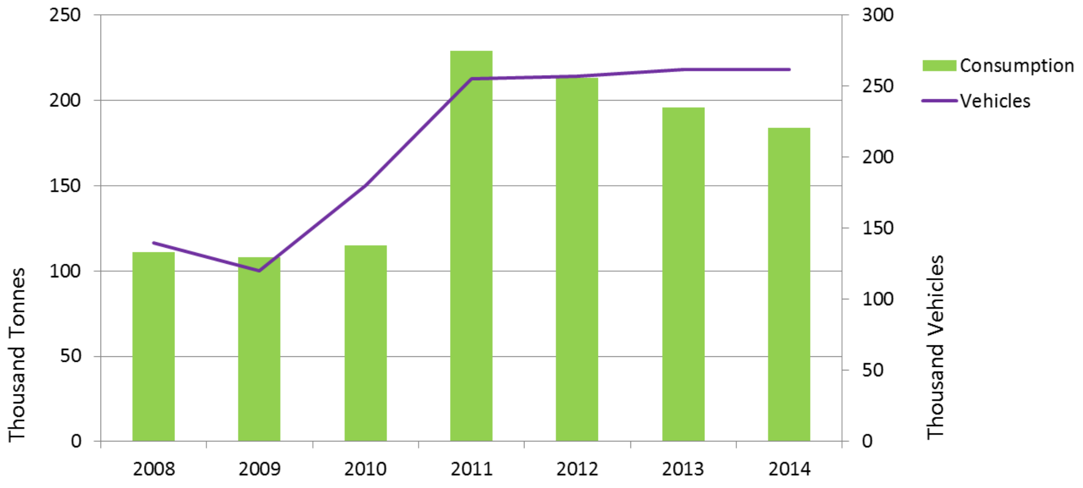


Figure B2.1: Autogas consumption and vehicle fleet – France

The jump in vehicles in 2011, based on Argus/WLPGA data, is due to a break in the series.

The number of Autogas vehicles declined progressively through the 2000s, but jumped to about 180 000 in 2010 and, according to Argus/WLPGA data, to over 260 000 by 2013 (0.7% of the total car and truck fleet) as a result of a surge in new conversions and record OEM vehicle sales of over 75 500 in 2010. However, both conversions and OEM sales have since fallen heavily with the withdrawal of the subsidy: sales dropped to a low of just 1 211 in 2012, though they recovered a little in 2013 to 2 743; a mere 1 500 retrofits were carried out in 2013.[1] The total vehicle number thus remains constant. Several carmakers, including Dacia (the market leader), Fiat, Lada, Lancia, Opel, Mercedes-Benz, Piaggio and Renault, still market OEM Autogas vehicles in France, though the range of Autogas vehicles available has narrowed since 2011. In 2013, Dacia accounted for 80% of all OEM sales.[2] Because of the lack of interest in Autogas vehicles, some carmakers have slashed their prices and introduced latest technology-engines with Autogas to stimulate interest. At end-2014, there were 1 750 refuelling stations across the country, with every metropolitan region well-served.

2.2 Government Autogas incentive policies

The French government adopted a policy of encouraging the use of Autogas (and CNG) in 1996, involving a sharp reduction in the excise duty on the fuel and the introduction of a range of other fiscal and regulatory measures. The duty has been held constant since 1999 at 6 euro cents/litre, while duties on gasoline and diesel, already much higher, have increased over that time Table B2.1). The average excise-duty differential with Autogas in 2014 stood at 42.6 cents/litre for diesel – the leading road-transport fuel in France – and 56.4 cents/litre for gasoline. As a result of the much lower excise tax in Autogas, the price of Autogas at the pump is over a third lower than that of diesel and 45% lower than that of gasoline.

Table B2.1: Automotive-fuel prices and taxes – France (euros/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	0.676	0.735	0.853	0.882	0.873	0.834
Diesel	1.002	1.145	1.336	1.396	1.350	1.150
Gasoline	1.207	1.344	1.500	1.567	1.538	1.339
Total taxes						
Autogas	0.171	0.180	0.200	0.204	0.203	0.199
Diesel	0.592	0.616	0.656	0.659	0.660	0.633
Gasoline	0.804	0.826	0.857	0.861	0.865	0.837
Excise taxes						
Autogas	0.060	0.060	0.060	0.060	0.060	0.060
Diesel	0.428	0.428	0.437	0.430	0.439	0.486
Gasoline	0.606	0.606	0.611	0.604	0.613	0.624
Pre-tax prices						
Autogas	0.505	0.555	0.654	0.678	0.670	0.635
Diesel	0.410	0.529	0.680	0.737	0.690	0.517
Gasoline	0.403	0.518	0.643	0.706	0.673	0.502

There are a number of other public policy measures in place to encourage the use of Autogas. Until the end of 2010, the principal measure was a tax credit of €2 000 for the purchase of an OEM Autogas vehicle with CO2 emissions of less than 136 grammes per kilometre or the conversion of gasoline-fuelled

[1] http://tempsreel.nouvelobs.com/planete/20140330.OBS1865/comment-la-france-a-boycotte-un-carburant-qui-n-emet-pas-de-particules-fines.html; and http://www.largus.fr/actualite-automobile/lavenir-prometteur-du-gaz-3863383.html
[2] *Argus LPG World*, 20 May 2014.

vehicles with emissions of less than 155 g/km. This incentive, which had been in place for several years, was abolished for budgetary reasons in 2011. Nonetheless, the purchase of any vehicle (including one fuelled by Autogas) with low emissions now qualifies for an ecological bonus (a cash grant). The threshold has been lowered progressively in recent years and now stands at 90 g/km. Grants for the first qualifying category of cars are set at €150 (down from €400 in 2011); the grant rises to €4 000 for emissions of between 21 g and 60 g, and to €6 300 for emissions of less than 21 g. However, despite no OEM Autogas vehicle qualifying for the bonus, the reduction of CO_2 emissions can affect the "malus" (associated with the emissions class of the vehicle) to be paid when registering the vehicle for the first time. The Autogas car with the lowest CO_2 emissions is the Fiat 500, which emits 106 g/km.[1]

Other tax measures include the initial vehicle-registration tax for commercial and non-commercial Autogas vehicles in 13 metropolitan regions, and a 50% rebate in seven (the rebate is also applied to CNG, BEVs and cars that can run on E85 ethanol); only two regions do not offer any rebate. Businesses can also recover all of the VAT on Autogas fuel purchases (compared with 80% of the tax for diesel and zero for gasoline).

Autogas is also promoted through local regulatory measures. In Paris, for example, Autogas vehicles are exempted from alternate-day driving restrictions during periods of peak air pollution (the last time such restrictions were imposed was in summer 2015); Autogas vehicles also benefit from reduced car-parking fees and extended delivery hours in the city centre. Seven other cities – Bordeaux, Alès, Puteaux, Orléans, Creil, Tassin-la-Demi-Lune, Avignon and Chamalières – offer free parking for one-and-a-half hours for Autogas and other clean vehicles; other cities are considering doing likewise.[2]

2.3 Competitiveness of Autogas against other fuels

Until 2010, the large tax credit on Autogas conversions for private individuals, which typically covered the entire cost, ensured that Autogas broke even with gasoline at very low distances and was always competitive with diesel. The removal of that subsidy has altered the competitiveness of Autogas: an Autogas vehicle now breaks even with gasoline at 73 000 km (Figure B2.2). However, an Autogas car, based on a conversion cost of €2 200 over a simple gasoline-powered car, is not competitive against diesel, regardless of distance. The premium for an OEM vehicle over a gasoline vehicle varies markedly, with some carmakers charging little more or even less for a bi-fuelled vehicle. For example, the list price of the bi-fuelled Dacia Duster, on sale in 2014, was at just €11 900 - €1 200 *cheaper* than the same gasoline-powered version. In those cases Autogas is competitive against gasoline regardless of distance and against diesel only for a limited distance. Currently

[1] http://carlabelling.ademe.fr
[2] http://www.voiture-electrique-populaire.fr/actualites/tarif-preferentiel-stationnement-peage-212

France is pushing more for electric vehicles, as these promise stronger emissions savings.

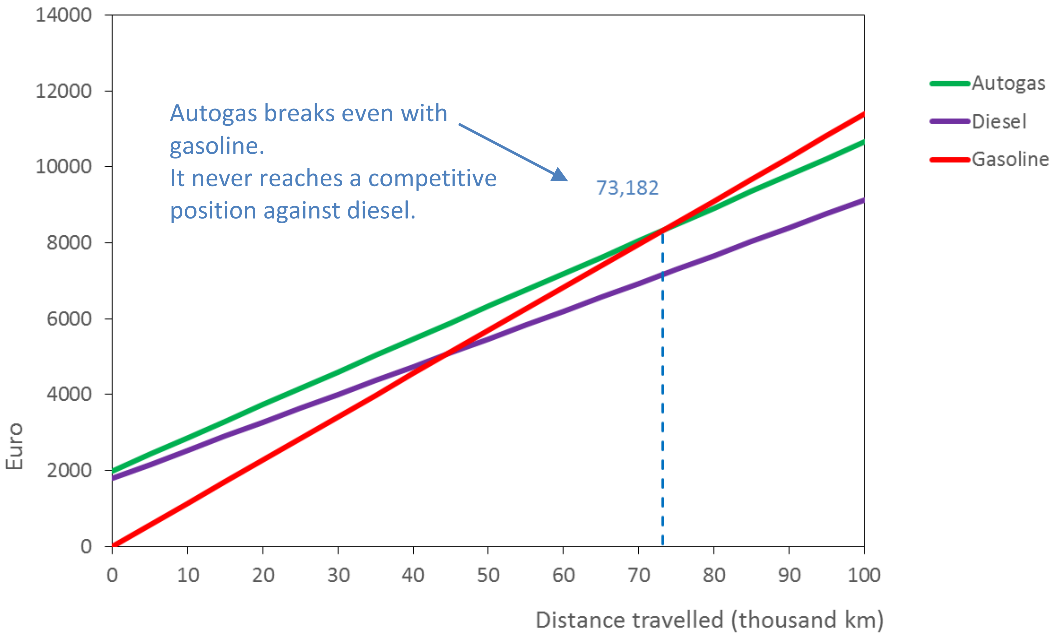


Figure B2.2: Running costs of a non-commercial LDV, 2014 – France

Note: Assumes 100% car registration tax rebate.

3 Germany

3.1 Autogas market trends

The Autogas market in Germany started off at about 2 000 tonnes in 2000 and grew rapidly through the decade as a result of favourable fuel taxation. After peaking at over 500 000 tonnes it has now retreated below this mark (Figure B3.1). Nonetheless, Autogas still accounts for only 1 % of total automotive-fuel use and 16% of total LPG use in the country.

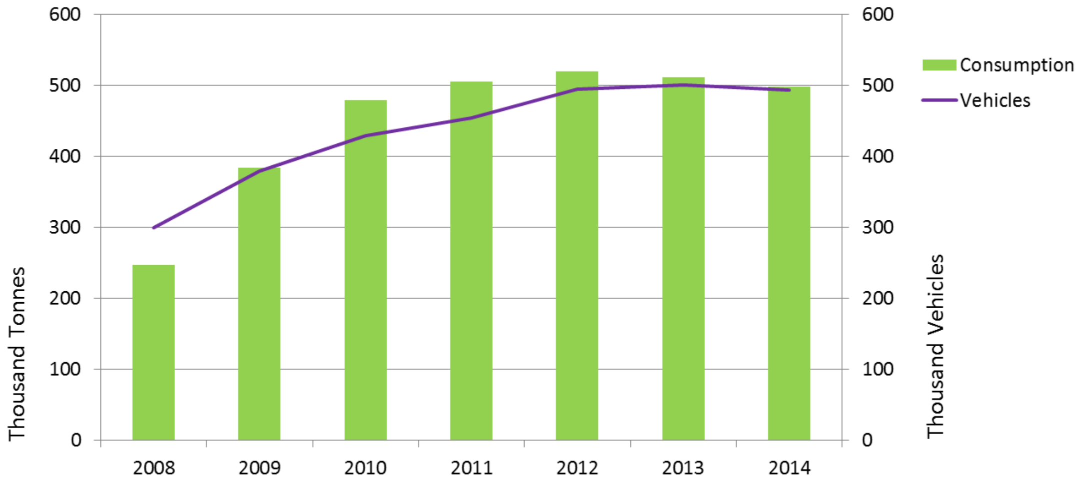


Figure B3.1: Autogas consumption and vehicle fleet – Germany

There are now again slightly less than half a million Autogas-powered vehicles on the road in Germany, most of them converted gasoline cars, accounting for about 1 % of all vehicles. The number of Autogas vehicles continued to grow up to 2012, but the increasing efficiency of the fleet and uncertainty about the government's Autogas policy has held down uptake. Sales of OEM LDVs, in particular, have continued to rise, albeit at a more modest pace than in the 2000s, as the range of OEM vehicles on the market has expanded: many of the main carmakers now offer Autogas models. Dual-fuel diesel-Autogas-powered HDVs are also gaining ground, with around 1 200 vehicles now in use thanks to a change in regulations introduced September 2013.[1] Autogas is widely available throughout the country, with around 6 850 filling stations selling the fuel in 2014.

3.2 Government Autogas incentive policies

The German federal government supports the use of Autogas largely through fuel-tax incentives. Since the completion in 2003 of a major reform of energy taxation aimed at introducing ecological taxes, the rates of excise tax on

[1] *Argus LPG World*, 20 May 2014.

Autogas, gasoline and diesel have been constant. The rate of tax on Autogas is 9.2 euro cents per litre – well below the rate of 47 cents levied on diesel and 65.5 cents on gasoline (Table B3.1). In absolute terms, the price differentials per litre between Autogas and gasoline, as well as between Autogas and diesel, are among the biggest of the countries surveyed for this report. In 2006, the German Bundestag (parliament) adopted an energy tax law that included a commitment to keep the tax rate on Autogas well below that on the other fuels until at least the end of 2018, in order to provide certainty to investors in Autogas distribution and refuelling infrastructure and motorists looking to switch to Autogas. The German LPG Association, DVFG, is lobbying the government to extend this rebate further and the governing coalition has included a commitment to extend the reduction of excise duties for gaseous fuels beyond 2018.

As a result of the favourable rate of tax levied on Autogas, the price of the fuel at the pump is only 43% that of gasoline and about half that of diesel. The price advantage in favour of Autogas, both in percentage and absolute terms, has increased in recent years, as pre-tax prices of Autogas have generally risen less than those of the other fuels.

Table B3.1: Automotive-fuel prices and taxes – Germany (euros/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	0.587	0.624	0.736	0.780	0.738	0.722
Diesel	1.090	1.226	1.425	1.490	1.429	1.449
Gasoline	1.295	1.417	1.560	1.651	1.598	1.659
Total taxes						
Autogas	0.186	0.192	0.210	0.217	0.210	0.207
Diesel	0.644	0.666	0.698	0.708	0.699	0.702
Gasoline	0.862	0.881	0.904	0.918	0.910	0.920
Excise taxes						
Autogas	0.092	0.092	0.092	0.092	0.092	0.092
Diesel	0.470	0.470	0.470	0.470	0.470	0.470
Gasoline	0.655	0.655	0.655	0.655	0.655	0.655
Pre-tax prices						
Autogas	0.401	0.433	0.527	0.563	0.528	0.515
Diesel	0.446	0.560	0.727	0.782	0.731	0.747
Gasoline	0.433	0.536	0.656	0.733	0.688	0.739

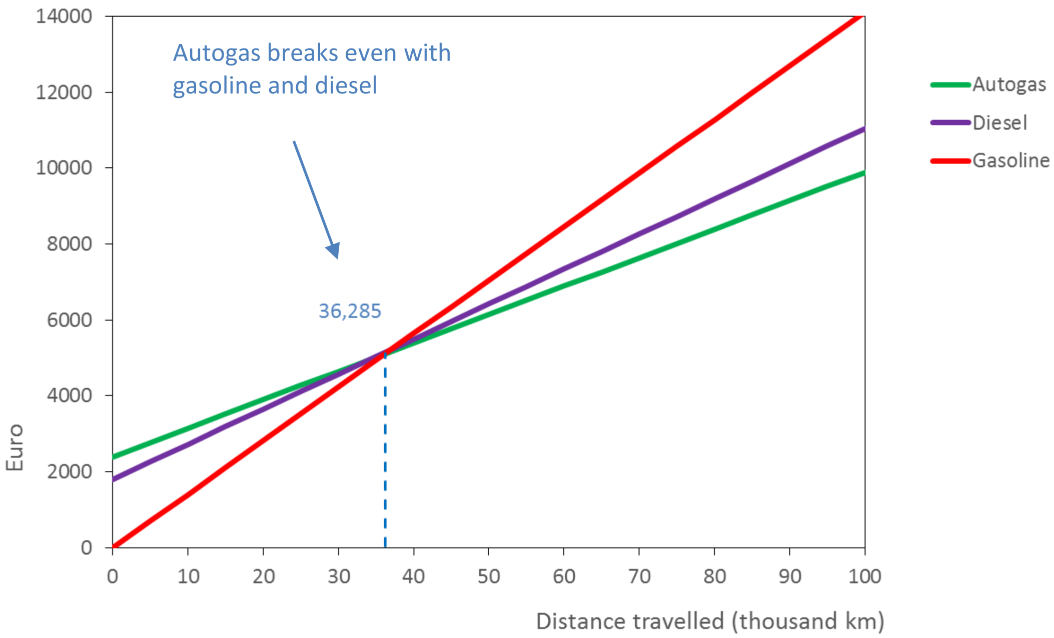
There are no vehicle-related incentives for Autogas in Germany, as the government considers that the fuel-tax advantage is a sufficiently powerful incentive. In 1993, the federal government issued a non-binding ordinance lifting restrictions on parking by gas-fuelled vehicles in underground garages and multi-storey car parks. However, some additional technical requirements for underground car parks remain in the Federal States of Bremen and the Saarland.

3.3 Competitiveness of Autogas against other fuels

The very low rate of excise tax on Autogas relative to the taxes on gasoline and diesel means that an Autogas vehicle (which is assumed to cost about €2 400 more than a gasoline-fuelled equivalent and €600 more than a diesel vehicle) breaks even with gasoline and diesel vehicles at around 36 000 km (Figure B3.2). Thus, the typical motorist pays back the upfront additional cost of an Autogas vehicle within less than three years of driving.

The trend for the future, however, sees the premium on diesel falling as the technology for gasoline car becomes more complex. At the same time the necessary conversion costs also rise due to more technologically advanced systems needed for cutting edge engines. In these cases a dedicated OEM solution can clearly leverage synergies and conversions become less attractive.

Figure B3.2: Running costs of a non-commercial LDV, 2014 – Germany



4 India

4.1 Autogas market trends

The Indian Autogas market grew rapidly through the 2000s, reaching just over 350 000 tonnes in 2011, though sales have since fallen back, to 310 000 tonnes in 2014 – equal to just 0.5% of total road-fuel use in India (Figure B4.1). Consumption took off slowly in the 2000s, after the sale of Autogas was first legalised in April 2000, but grew rapidly over the second half of the decade as a result of favourable pricing.

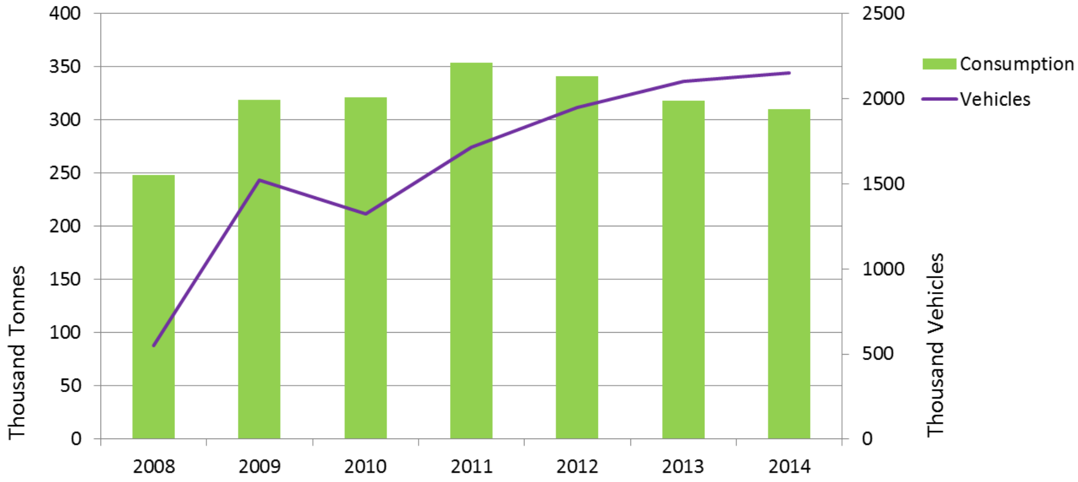


Figure B4.1: Autogas consumption and vehicle fleet – India

Note: Fuel consumption is official sales only. Vehicles include three-wheelers.

There are now over 2.1 million vehicles capable of running on Autogas in India. Close to 5% of all the vehicles on the road in India (excluding two-wheelers) are capable of running on Autogas. As the great majority of them are three-wheelers, the average consumption per vehicle is only around 300 litres per year. Most of those vehicles are converted, even though many vehicle manufacturers now offer factory-fitted Autogas models. There are around a dozen OEM Autogas models on sale in India, including those made by Maruti, Tata Motors, General Motors and Hyundai. In many cities, a large share of three-wheeler rickshaws – thus an important means of public transport – has been converted to run on Autogas.

Another reason why sales of Autogas at Indian filling stations are very small is that subsidised domestic LPG in cylinders is often diverted into illegal use as Autogas – an illegal and very dangerous practice. This problem has been growing in recent years with higher international LPG prices, which have driven up the price of unsubsidised Autogas at the pump and caused the differential with subsidised bottled LPG to widen markedly. A reform of subsidies to domestic LPG introduced in September 2012, including the introduction of a ceiling on the number of subsidised cylinders allocated to each household and the use of direct cash transfers to poor households, helped to curb the illegal use of the fuel as Autogas and boost official sales.[1] But the cap was increased once again at the beginning of 2014. Real Autogas consumption, including diverted cylinder LPG, is thought to be about three times larger than official figures show.[2]

There are 1 200 filling stations across the country, spread over more than 500 cities (mainly in Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Tamil Nadu).[3] State-owned Indian Oil is the leading Autogas marketer, with a 35% share of the national market and more than 270 service stations selling Autogas. Bharat Petroleum and Hindustan Petroleum – also state-owned – are the other main marketers.

4.2 Government Autogas incentive policies

The main public policy incentive for Autogas in India is the exemption from excise tax and the generally lower rates of state sales tax compared with diesel and gasoline (they vary by state and fuel). The Indian government has deregulated retail prices of Autogas, gasoline and diesel: oil marketing companies are now free to revise their Autogas prices every month in line with international prices, though they have to seek permission from the Ministry of Oil if they want to revise their gasoline prices. Excise duties on gasoline and diesel vary according to the type of fuel: high rates are charged on premium, or "branded", fuels – a practice that has all but wiped out sales of these fuels, even though they provide better engine performances and longevity.

In 2014, Autogas prices at the pump averaged 52 rupees per litre – equal to around 70% of the unbranded gasoline price and 88% of the diesel price (Table B4.1). The price of CNG –the other main alternative fuel in India – has generally increased more rapidly than that of Autogas in recent years, undermining its potential as a competitive alternative fuel; the government's policy is to prioritise the use of natural gas in power generation and fertilizer manufacturing. The new government, which came to power in May 2014, has indicated that it aims to boost Autogas use for environmental reasons.

Several Indian cities, including Ahmedabad, Bangalore, Chennai, Hyderabad and Kolkata, have also introduced measures to encourage or mandate the use of Autogas and other alternative fuels for reasons of local air quality. In Bangalore, efforts to promote Autogas have been focused on three-wheelers, which are now obliged to run on Autogas. The city government

[1] http://www.auto-gas.net/newsroom/86/47/India-bites-the-bullet-on-fuel-subsidies#.U_MsScscRaQ; and http://www.auto-gas.net/newsroom/49/47/Autogas-in-India-back-in-business#.U_MsjsscRaQ
[2] http://www.auto-gas.net/newsroom/46/47/Autogas-maintains-its-global-market-share#.U_tQHsscRaQ
[3] http://www.iac.org.in/ALDS-complete.pdf

offers a subsidy of around 2 000 rupees (around US$35) to three-wheeler owners to help bear the cost of conversion. Over 75 000 auto rickshaws have already converted to Autogas and about 70 filling stations have been established. In addition, Bangalore introduced a green tax on older vehicles in 2002, payable each year on renewal of the annual vehicle licence, to encourage owners to opt for more up-to-date, cleaner vehicles. Kolkata and Chandigarh have also launched initiative to replace polluting vehicles with Autogas and other AFVs. All public vehicles more than 15 years old had to be scrapped by end-July 2010. Many of the 32 000 auto-rickshaws in Kolkata and its suburbs have so far been converted to Autogas. And as of September 2009, the Union Territory of Chandigarh allows only Autogas-fuelled three-wheelers to operate on its roads. Chennai and Pune have also encouraged the introduction of Autogas; over 10 000 auto-rickshaws now run on Autogas in Pune.

Table B4.1: Automotive-fuel prices and taxes – India (rupees/litre)

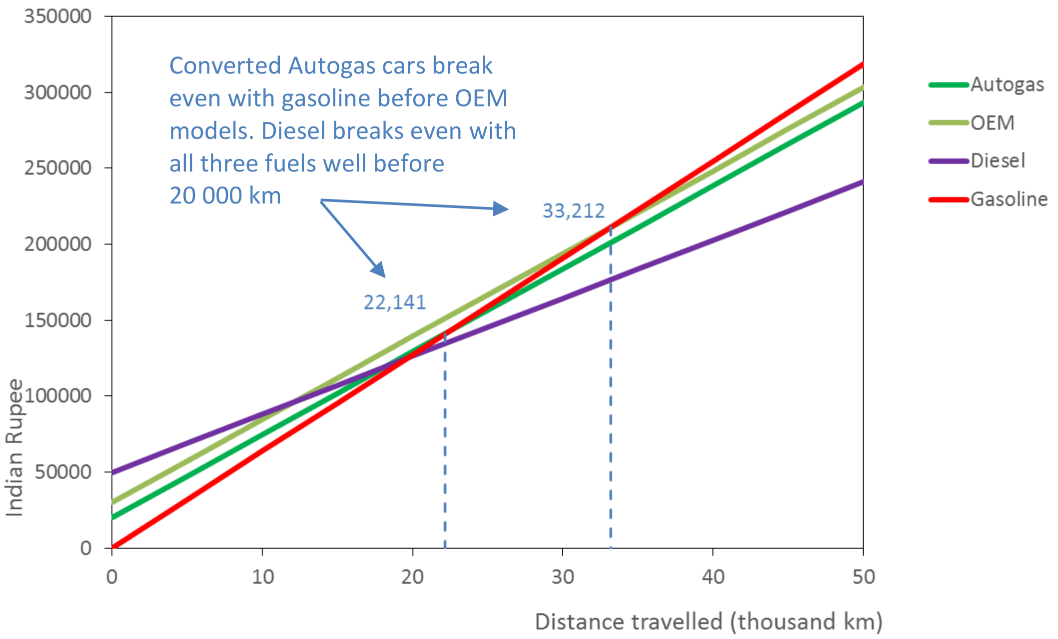
	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	28.13	33.06	40.01	46.27	47.74	52.65
Diesel	33.87	39.34	43.54	46.36	53.90	59.90
Gasoline	45.47	54.75	67.24	73.22	73.18	74.86
Total taxes						
Autogas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Diesel	10.73	n.a.	n.a.	n.a.	n.a.	n.a.
Gasoline	23.56	n.a.	n.a.	n.a.	n.a.	n.a.
Excise taxes						
Autogas	0.00	0.00	0.00	0.00	0.00	0.00
Diesel	3.75	4.50	n.a.	n.a.	n.a.	n.a.
Gasoline	13.79	14.35	n.a.	n.a.	n.a.	n.a.
Pre-tax prices						
Autogas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Diesel	23.14	n.a.	n.a.	n.a.	n.a.	n.a.
Gasoline	21.91	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Price and total taxes are averages across Delhi, Kolkata, Mumbai and Chennai (state tax rates vary).

4.3 Competitiveness of Autogas against other fuels

Low taxes and, therefore, low pump prices mean that converting a gasoline-powered vehicle to run on Autogas pays back after just over 20 000 km (Figure B4.2). The conversion costs is estimated at 20 000 rupees (about €400), which is very low by international standards because of low labour costs and the relatively unsophisticated vehicles that are converted. OEM models, which are assumed to cost 30 000 rupees more to purchase than an equivalent gasoline-fuelled model, break even with gasoline at nearly 30 000 km. However, diesel is the most competitive fuel option after about 18 000, which explains why Autogas is largely confined to three-wheelers for now.

Figure B4.2: Running costs of a non-commercial LDV, 2014 – India



5 Italy

5.1 Autogas market trends

Italy has the second-largest Autogas market in the European Union after Poland and the sixth-largest in the world. It was one of the first countries to introduce the fuel, in the 1950s. Consumption originally peaked at 1.4 million tonnes in 2001, declining steadily to below 1 Mt in 2007; it has since rebounded, to a new all-time high of over 1.5 Mt in 2014, because of the increased attractiveness of the fuel amid rising fuel prices, increasingly favourable taxation and vehicle acquisition and conversion incentives (Figure B5.1). Italy remains home to several Autogas engine and conversion kit manufacturers.

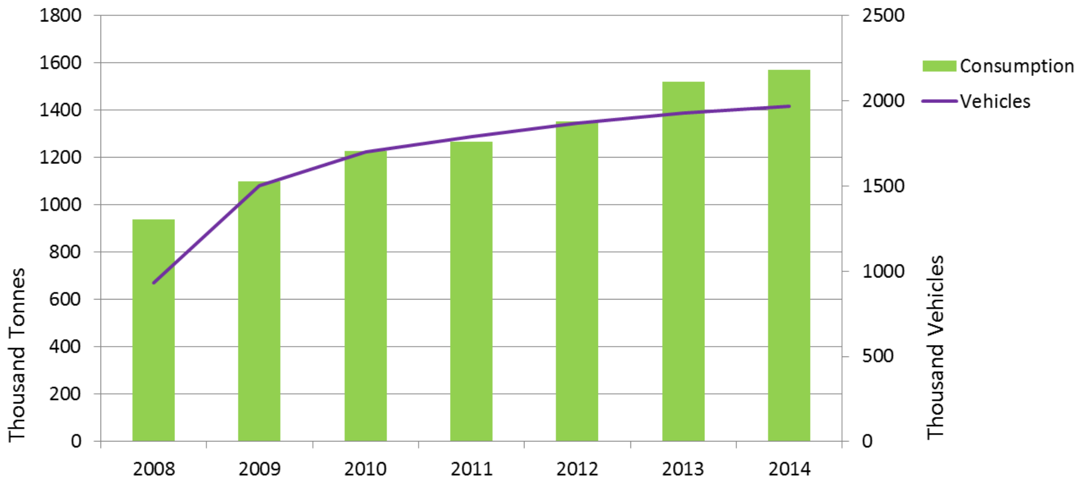


Figure B5.1: Autogas consumption and vehicle fleet – Italy

Autogas accounts for 43% of total LPG consumption in Italy and 5% of total automotive-fuel demand in 2014. The Italian government has traditionally promoted the use of Autogas through fiscal incentives, initially to provide an outlet for surplus volumes of LPG from the large domestic refining industry, though Italy has since become an importer of LPG. In recent years, environmental concerns have been the main driving force behind Autogas policies. The number of Autogas vehicles in use has surged in recent years, reaching 2.04 million at end-2014 (5.4% of all cars) – one third up from the number five years earlier. Most Autogas vehicles are converted gasoline-fuelled vehicles, though sales of OEM vehicles are growing rapidly; in 2014, 24 carmakers marketed over 100 Autogas models in Italy.[1] The number of refuelling sites has grown to 3 600 – 17% of all service stations in Italy.

[1] http://www.ecomobile.it/2014/N-111/Ecolistino%20111.pdf

5.2 Government Autogas incentive policies

The Italian government and local authorities encourage Autogas use through a mixture of policies, including favourable fuel taxes, incentives for clean vehicles and traffic regulations. Autogas currently enjoys a substantial excise-tax advantage of 58 euro cents/litre over gasoline and 47 cents/litre over diesel (Table B5.1). These differentials have increased considerably in recent years: the tax on Autogas was cut in 2006 and 2007, and has increased only modestly since, while the tax on both diesel and gasoline has increased sharply – especially in 2012. As a result, the pump price of Autogas has fallen, to only 45% that of gasoline in 2014 (compared with 50% in 2006) and 48% that of diesel (55%). The increase in the price-competitiveness of Autogas has coincided with the rapid turnaround in Autogas fuel sales.

Table B5.1: Automotive-fuel prices and taxes – Italy (euros/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	0.563	0.660	0.755	0.823	0.807	0.777
Diesel	1.081	1.214	1.447	1.706	1.659	1.620
Gasoline	1.232	1.363	1.554	1.786	1.749	1.712
Total taxes						
Autogas	0.219	0.235	0.254	0.290	0.289	0.287
Diesel	0.603	0.625	0.703	0.902	0.908	0.911
Gasoline	0.769	0.791	0.860	1.027	1.035	1.039
Excise taxes						
Autogas	0.125	0.125	0.127	0.147	0.147	0.147
Diesel	0.423	0.423	0.459	0.606	0.617	0.617
Gasoline	0.564	0.564	0.598	0.717	0.728	0.728
Pre-tax prices						
Autogas	0.344	0.425	0.501	0.533	0.518	0.490
Diesel	0.478	0.589	0.744	0.804	0.751	0.710
Gasoline	0.462	0.572	0.694	0.759	0.714	0.672

The Italian government also encourages Autogas and other clean fuels through vehicle incentives. Grant schemes for the conversion of an existing vehicle or the purchase of an OEM Autogas vehicle have been in place for several years, though they have changed over time and have lapsed on occasion. In May 2014, grants were reintroduced for the purchase of Autogas and other AFVs on condition their CO_2 emissions do not exceed 120 grammes per km for businesses and 95 g/km for private motorists. However, for businesses (but not private motorists), the grants are conditional on scrapping an existing vehicle more than 10 years old, which effectively means that few cars are eligible since the majority of company LDVs are much younger. The grant is limited to 20% of the total cost of the vehicle (before tax) up to a maximum of €4 000 euro for cars with emissions of between 51 and 95 g/km and€2 000 for those purchased by companies with emissions of between 96 and 120 g/km. In 2015, the incentive will dropped to 15% and the limits to €3 000 and €1 800 respectively. For the year 2014, the total budget for these incentives has been set at €31.3 million, plus an additional €32.1

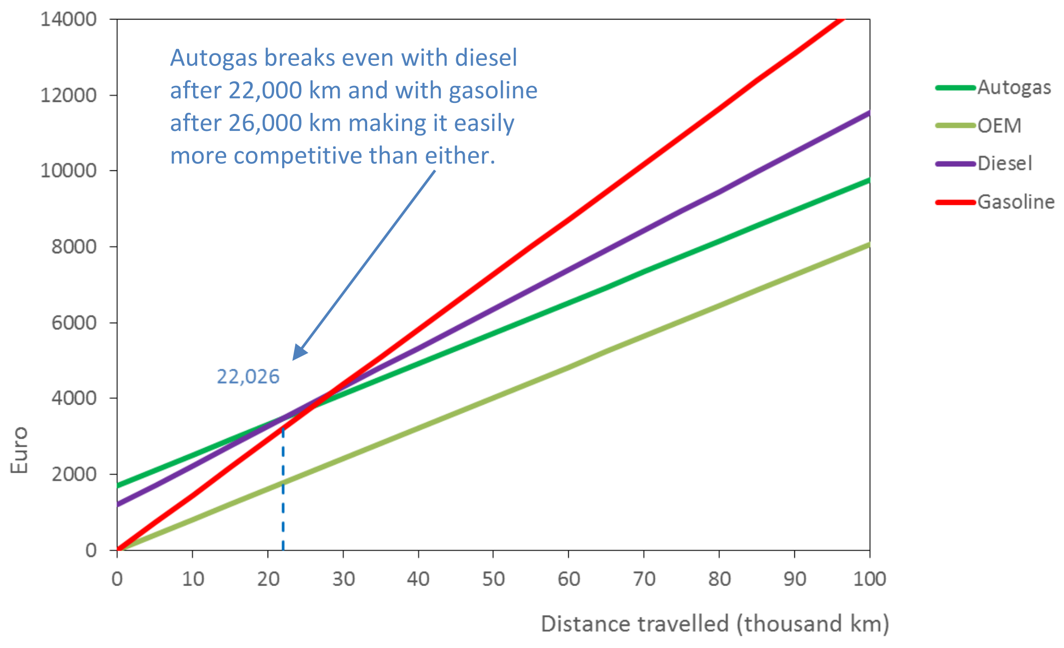
million that was not spent in 2013. This 2013 scheme involved the same level of grants, but private motorists were obliged to scrap an existing car to qualify. The 2013 budget was €40 million, of which only €8 million was actually disbursed.

Many Autogas vehicles also benefit from a lower annual vehicle road tax, which depends on engine power and CO2 emissions. Exemptions are granted for new vehicles or conversions in several regions (Lombardia, Toscana, Piemonte, Puglia, Trentino Alto Adige). Moreover, a number of cities have mandated the conversion of bus and other public vehicle fleets to either Autogas or CNG for environmental reasons and have adopted traffic regulations that exempt Autogas vehicles from driving restrictions imposed on gasoline and diesel vehicles during periods of acute pollution.

5.3 Competitiveness of Autogas against other fuels

In 2014, the large fuel-tax advantage over gasoline and the grants for OEM purchases meant that a qualifying OEM Autogas vehicle was always competitive against diesel and gasoline-powered vehicles regardless of distance. In the case of a converted vehicle (for which grants were not available), the breakeven distance was 22 000 km against diesel – less than two years of driving for a private motorist (Figure B5.2). Diesel also breaks even against gasoline, but at a greater distance (around 30 000 km). This demonstrates very clearly the vital role that vehicle incentives, alongside favourable fuel taxes, play in making Autogas competitive, though the effectiveness of the vehicles incentives is greatly reduced by the onerous conditions applied by the government.

Figure B5.2: Running costs of a non-commercial LDV, 2014 – Italy



6 Japan

6.1 Autogas market trends

Japan has the seventh-largest Autogas market in the world with a long history of Autogas use. Consumption amounted to 1.1 million tonnes in 2014, equal to 1.6% of total road-transport fuel consumption. Consumption was flat at around 1.5-1.6 Mt between 2000 and 2007, but then began to decline, because of a significant improvement in the fuel economy of the fleet and a fall in the number of Autogas vehicles (Figure B6.1). Autogas accounts for about 6% of total Japanese LPG consumption. Japan's Ministry of Economy, Trade and Industry (METI) predicts that Autogas use will continue to decline slowly through to the end of the 2010s largely as a result of a decline in the number of Autogas-powered taxis as the overall taxi fleet contracts (see below).[1]

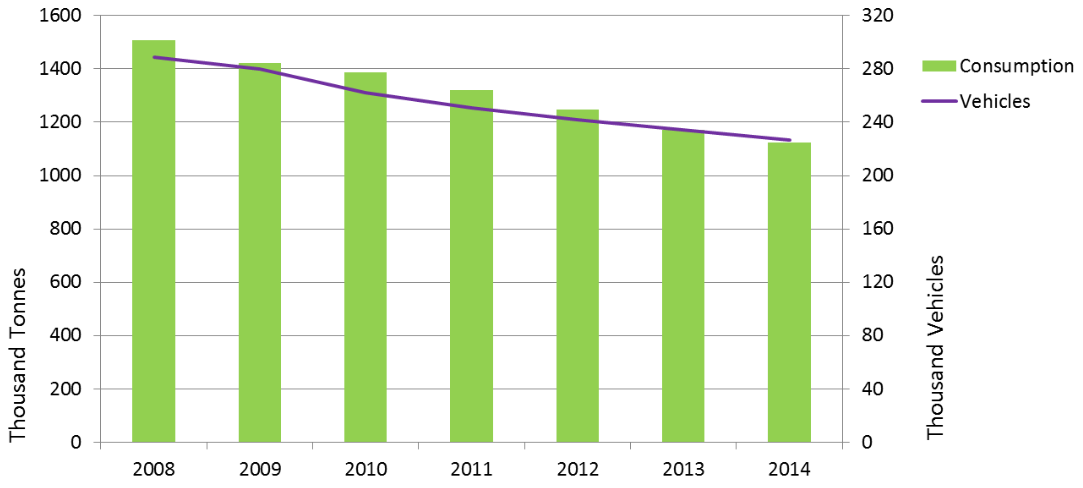


Figure B6.1: Autogas consumption and vehicle fleet – Japan

The size of the Autogas fleet has contracted from a peak of just under 300 000 vehicles in 2004 to 226 000 in 2014 (just around 0.3% of all motor vehicles in Japan). Taxis make up four-fifths of the fleet (90% of all taxis are Autogas-fuelled), and commercial fleet LDVs and HDVs, and minibuses for almost all the rest; these vehicles are generally high-mileage, which is why the share of Autogas in total fuel use is much higher than the share of Autogas vehicles in the total fleet. The two largest OEMs, Nissan and Toyota, produce dedicated mono-fuel taxis for the national market. Nissan recently launched an Autogas version of the "Vanette NV200" taxi cab, which meets government criteria for the so-called "Universal Design Taxi cab", which can

[1] *Argus LPG World*, 7 May 2014.

accommodate passengers in a wheelchair together with other passengers in the same cabin. Toyota, which has manufactured Autogas taxis for many years, has reportedly decided to stop supplying conventional Autogas vehicles to the Japanese taxi industry by 2018, because they would not be able to meet the regulatory requirement recently imposed by the Japanese government. However, Toyota will reportedly introduce van-type hybrid vehicles fuelled by Autogas, which should qualify as "Universal Design Taxi-cabs", onto the Japanese market in 2016. A concept model had previously been presented at the Tokyo Motor Show.[1]

6.2 Government Autogas incentive policies

The Japanese government has maintained lower excise duties on Autogas than on diesel and gasoline for many years, though the size of the differentials is large enough to incentivise the use of Autogas only in high-mileage vehicles. Excise duties have not changed for more than a decade. The duty on Autogas is about one-third the level of that on diesel and less than a fifth of that on gasoline (Table B6.1).

Table B6.1: Transport-fuel prices and taxes – Japan (yen/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	79.1	85.3	89.2	93.8	98.1	98.2
Diesel	105.1	114.4	127.6	129.0	136.8	136.9
Gasoline	120.2	133.0	145.8	147.1	156.0	158.0
Total taxes						
Autogas	13.6	13.9	14.0	14.3	14.5	17.1
Diesel	37.1	37.5	38.2	38.2	38.6	39.9
Gasoline	59.5	60.1	60.7	60.8	61.2	65.5
Excise taxes						
Autogas	9.8	9.8	9.8	9.8	9.8	9.8
Diesel	32.1	32.1	32.1	32.1	32.1	32.1
Gasoline	53.8	53.8	53.8	53.8	53.8	53.8
Pre-tax prices						
Autogas	65.6	71.5	75.2	79.5	83.6	81.1
Diesel	68.0	76.8	89.4	90.8	98.2	97.0
Gasoline	60.6	72.8	85.0	86.3	94.8	92.5

Note: Pre-tax prices include a carbon tax levied on imports of crude oil and petroleum products (2.4 Yen/litre on LPG and 2.3 Yen/Litre on gasoline and diesel).

A small carbon tax is levied on imports at almost the same rate on all three fuels. The pre-tax retail price of Autogas has increased much less than that of both other fuels in the last few years, thanks to favourable movements in international prices. The pump price of Autogas is currently 72% of that of diesel and 62% of that of gasoline in per-litre terms.

The Japanese government also provides subsidies to both Autogas distributors and vehicle owners. In the wake of the 2011 tsunami, the government introduced a scheme covering 2012-2013 to help LPG

[1] http://www.toyota-global.com/tokyoms2013/taxi/

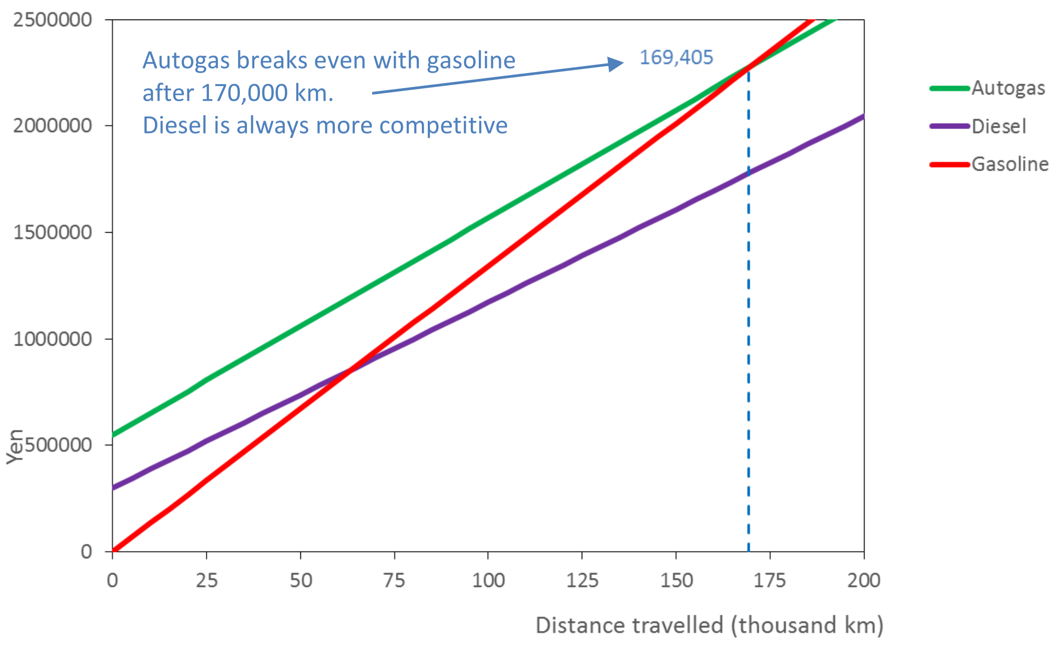
distributers improve the resilience of the LPG refuelling stations by introducing LPG fuelled stand-by generators, satellite telecommunication systems and Autogas-powered vehicles for transporting cylinders. An estimated 400 million yen (about US$4 million) was allocated to Autogas vehicles. Grants for Autogas vehicles are also available. In 2013, a total of 200 million yen (about US$ 2million) was allocated to pay for grants to cover 50% of the cost of converting a gasoline-powered vehicle to run on Autogas (or the additional costs of an OEM vehicle) up to a maximum of 250 000 yen (US$2 500). The new scheme effectively replaces the one that had been in place since 2003 and that had been stopped in March 2012. The new Basic Energy Plan, announced in April 2014, sets an objective of increasing the role of Autogas, though it does not set any targets.

The Japanese government also offers grants to the buyers of those diesel-powered vehicles categorized as "clean". The grant depends on the model of the vehicles and ranges from 100 000 to 150 000 yen (US$1 000 to US$1 500). Taking this grant into account, the price of a diesel LDV is, on average, around 300 000 yen higher than that of an equivalent gasoline-powered vehicle and about 200 000 yen lower than that of an OEM Autogas vehicle.

6.3 Competitiveness of Autogas against other fuels

Autogas breaks even against gasoline at a distance of close to 200 000 km for both converted and OEM LDVs on the assumption that they both cost ¥520 000 ($5 200) more than a standard gasoline-fuelled vehicle (Figure B6.2). However, diesel is always competitive against Autogas and is competitive against gasoline at distances of more than about 60 000 km. This analysis demonstrates why Autogas is largely confined to taxis and public fleets and why, in most cases, diesel vehicles are now preferred to Autogas vehicles at the time of purchase of a new vehicle.

Figure B6.2: Running costs of a non-commercial LDV, 2014 – Japan



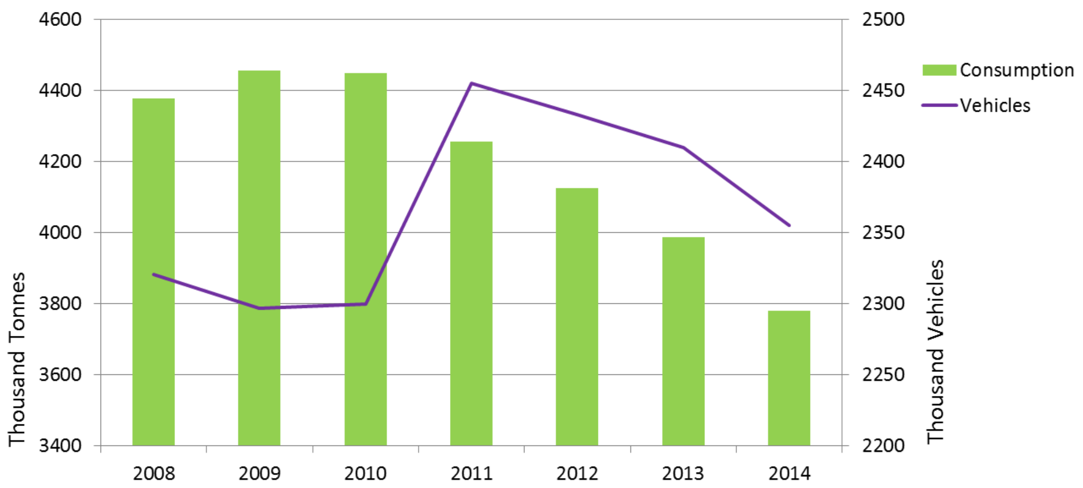
7 Korea

7.1 Autogas market trends

The Republic of Korea was one of the first countries to promote the widespread use of Autogas and, for many years, has had by far the largest Autogas market in the world. Demand surged in the 1990s in response to strong government support for the fuel's use in taxis, other fleet vehicles and public buses, mainly through a large fuel-tax advantage. Environmental restrictions on diesel vehicles also helped encourage Autogas use by high-mileage vehicles.

The phenomenal growth in Autogas demand began to slow at the beginning of the 2000s, mainly due to a change in government policy towards Autogas use. This was motivated by the perceived improvement in emissions performance of new diesel and gasoline vehicles relative to Autogas vehicles, and the objective of boosting revenues from automotive-fuel taxes. Excise duties on Autogas were raised in step-wise fashion with the aim of realigning the pump prices of Autogas with those of diesel and gasoline (see below). Despite these changes and a continuing ban on the use of Autogas in private passenger cars, Autogas use continued to grow with rising demand for automotive fuels generally, reaching a peak of 4.2 million tonnes in 2009 (Figure B7.1). Consumption has fallen back every year since then, now under 4 Mt – first as a result of increased efficiency of the vehicle fleet and then also due to the shrinking Autogas fleet. Autogas accounts for just under half of total Korean LPG use and an estimated 10% of total road-transport fuel consumption in 2014 (12% in 2013).

Figure B7.1: Autogas consumption and vehicle fleet – Korea



The total number of Autogas vehicles on the road in Korea doubled since 2000 to reach its peak in 2011 at over 2.4 million units. It has since decreased to currently around 2.3 million. Three-quarters of the current Autogas vehicle fleet are private LDVs (including taxis) and the rest are sports utility vehicles and light-duty commercial vans and trucks. Around 95% of the country's taxis run on Autogas, accounting for an estimated 40% of total Autogas consumption. The Autogas fleet is equal to around 13% of the country's total vehicle fleet. Most Autogas vehicles are locally manufactured OEMs. A large range of vehicles is marketed, including hybrids, with Hyundai and Kia the leaders in Autogas vehicle sales. However, sales have fallen significantly in the last few years, which is starting to lead to a contraction in the fleet as cars that were introduced more than ten years ago are now being phased out (over 1m Autogas vehicles were introduced in the South Korean market between 1999 and 2002)[1] and are not being replaced by Autogas vehicles. Along with a reduced offering of OEM Models the industry expects a negative trend. Autogas is available at almost 2 000 service stations across the country.

7.2 Government Autogas incentive policies

The exceptional size and pace of growth of the Korean Autogas market was attributable to many years of highly supportive government policies, including favourable taxation of Autogas. Excise-tax differentials were reduced progressively over the five years to 2006 under a plan to restructure the taxation of all automotive fuels, but the tax on Autogas is still significantly lower than that on diesel and gasoline (Table B7.1).

Table B7.1: Automotive-fuel prices and taxes in Korea (won/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	831	952	1 076	1 102	1 071	1051
Diesel	1 384	1 501	1 745	1 806	1 730	1637
Gasoline	1 582	1 709	1 929	1 986	1 925	1827
Total taxes						
Autogas	297	308	319	321	318	317
Diesel	646	655	677	693	686	678
Gasoline	890	901	921	926	921	912
Excise taxes						
Autogas	221	221	221	221	221	221
Diesel	520	518	518	529	529	529
Gasoline	746	746	746	746	746	746
Pre-tax prices						
Autogas	534	645	757	781	753	625
Diesel	737	847	1 068	1 113	1 044	821
Gasoline	693	808	1 008	1 059	1 004	785

[1] http://www.auto-gas.net/newsroom/41/47/Strategies-for-growing-the-Autogas-market-in-Korea#.U_SowMscRaQ

Since July 2007, government tax policy has aimed to keep pump prices of Autogas at roughly 50% of those of gasoline and diesel prices at 85% of gasoline prices. Since July 2008, the tax on Autogas has stood at 221 won/litre, compared with 746 won for gasoline and (since 2012), 529 won/litre for diesel. In 2014, the pre-tax price of Autogas was also markedly lower than that of both diesel and gasoline (partly because LPG imports attracts a lower duty than those of the other fuels). As a result, the pump price of Autogas was equal to 58% that of gasoline and 64% that of diesel. Thus, both Autogas and diesel prices are somewhat higher than the official targets. Higher international butane prices have also pushed up pre-tax Autogas prices, as butane makes up the bulk of Autogas supply in the country. In May 2011, the import duty on LPG, which was 2%, was removed, giving a small price advantage to Autogas other the other fuels.

The government continues to place restrictions on the ownership of Autogas vehicles, allowing the fuel to be used only by commercial vehicles such as taxis and rental cars. Private passenger cars are not allowed to be converted to Autogas, nor are private sales of OEM Autogas vehicle permitted. There are exemptions for disabled people, compact cars, vehicles that can carry more than seven people and hybrids. In addition, Autogas vehicles owned for more than five years by handicapped people and citizens of national merit can be sold to the general public.

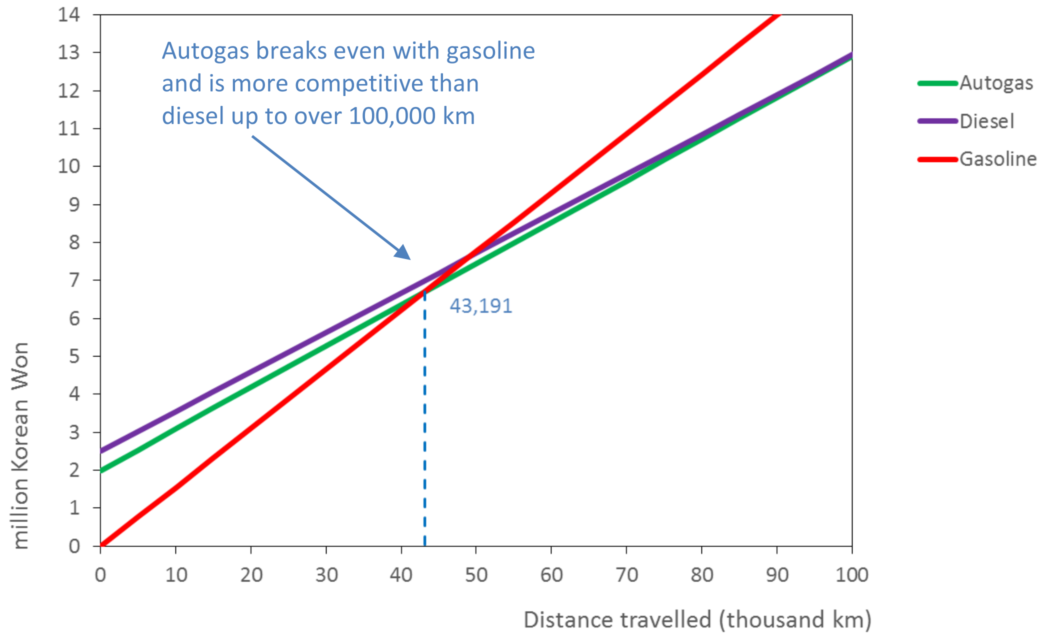
The Korean government recently announced a change of policy with regard to taxis, which could have a major impact on Autogas demand. Until now, the government has not allowed taxis to use diesel vehicles for environmental reasons, effectively encouraging them to use Autogas (which is much cheaper than gasoline). However, as of September 2015, taxis are allowed to use diesel cars that meet Euro-6 standards (see Section A2).

The Korean government does not make available grants or any other form of financial incentive for OEM Autogas LDV purchases on the grounds that favourable taxation is sufficient to encourage the use of Autogas. However, it has in the past promoted the conversion of old diesel trucks to Autogas and, under a clean vehicle programme, mandates the purchase of minimum proportions of Autogas and other clean vehicles in its own LDV fleet. The government also funds a research and development programme for Autogas LDVs and HDVs.

7.3 Competitiveness of Autogas against other fuels

Autogas remains highly competitive with both gasoline and diesel, despite a marked narrowing of the fuel price advantage of Autogas against the other two fuels since 2000. Converted Autogas LDVs break even with gasoline passenger LDVs at a little over 40 000 km (Figure B7.2). The payback period is, thus, a little over three years for those private motorists permitted to own an Autogas vehicle and under a year for taxis. Diesel vehicles break even with Autogas after 100 000 km, based on a price premium for a diesel car of 2.5 million won over a gasoline car. This analysis clearly demonstrates the continuing appeal of Autogas vehicles in Korea, despite concerns within the Autogas industry that taxis may be tempted to switch to diesel.

Figure B7.2: Running costs of a non-commercial LDV, 2014 – Korea

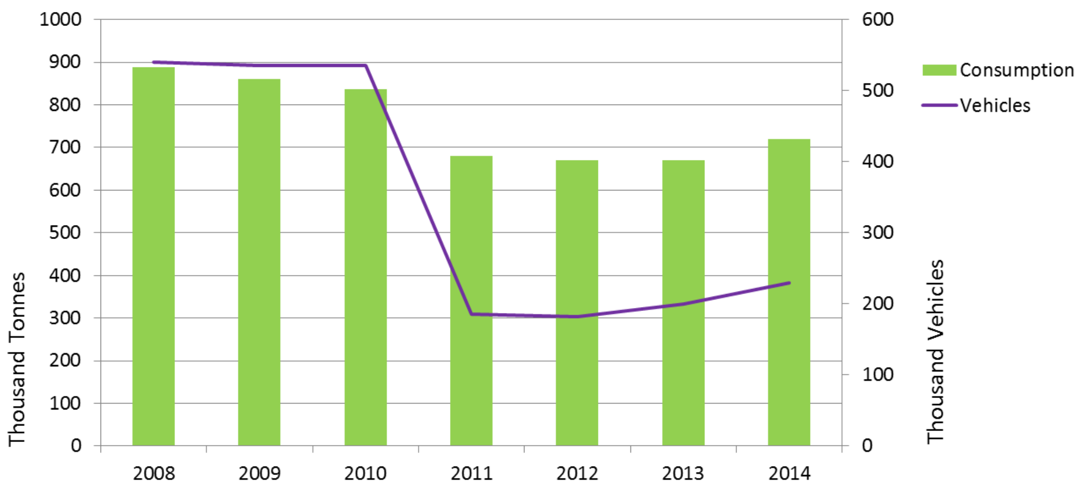


8 Mexico

8.1 Autogas market trends

Mexico's Autogas market – once one of the largest in the world – has contracted markedly in recent years, mainly because of a sharply narrowing of the price differential with gasoline and, especially, diesel in the mid- to late 2000s. Sales peaked at around 1.3 million tonnes in 2004 and then slumped to less than 800 000 tonnes in 2007; sales fluctuated around that level until 2010, but then fell to below 700 000 tonnes in 2011 and to 654 000 in 2013. The renewed widening of price differentials (Figure B8.1) has taken effect growing consumption to over 720 000 tonnes and expanding the size of the fleet to 230 000 vehicles. The main competitive threat to Autogas comes from cheaper diesel: several new diesel models have been introduced onto the Mexican market to meet rising demand, driven initially by a significant fall in the price of diesel against both gasoline and Autogas (though diesel prices have risen sharply since 2008).

Figure B8.1: Autogas consumption and vehicle fleet – Mexico



Note: The number of reported vehicles for Mexico is always an approximation, numbers vary according to the source used.

Autogas accounts for just 1.4% of total automotive-fuel consumption, down from almost 4% in the early 2000s. The number of Autogas vehicles has similarly declined in recent years, to about 180 000 at the end of 2012 – about 0.6% of the total car and truck fleet. Most vehicles are old converted gasoline cars, most of them operating in the northern and central-western regions (Mexican Ministry of Energy, 2008). There are 2 100 refuelling sites around the country – a very large number relative to the size of the fleet.

8.2 Government Autogas incentive policies

The government controls wholesale and retail oil product prices directly in Mexico. While the prices for transport fuels vary almost daily in the international market, retail prices in Mexico are set by the federal government on a monthly basis according to a formula that takes account of a distribution margin based on actual costs and value-added tax. When the benchmark international price is greater than the domestic price, the rate for the country's excise tax effectively becomes negative (though the tax is not explicit). Pemex, the national oil company with a monopoly over retail sales, obtains a compensatory tax credit equivalent to the price difference. A new tax on oil products, known as the Special Production Tax and Service (IEPS), was introduced at the start of 2014, which pushed the prices of transport fuels up by around 0.20 pesos per litre. A carbon tax was also introduced in 2014, payable by producers and importers; the tax was set at 6.60 US cents/litre for Autogas, compared with 10.38 cents for gasoline and 12.59 cents for diesel.[1]

Table B8.1: Transport-fuel prices and taxes – Mexico (pesos/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	5.04	5.26	5.59	6.09	6.71	6.91
Diesel	7.70	8.54	9.49	10.52	11.74	14.20
Gasoline	9.43	9.81	10.30	10.89	12.00	14.38
Total taxes						
Autogas	0.66	0.73	0.77	0.84	0.92	0.95
Diesel	1.16	1.18	1.31	1.45	1.62	1.96
Gasoline	1.62	1.35	1.42	1.50	1.66	1.99
Excise taxes						
Autogas	0.00	0.00	0.00	0.00	0.00	0.00
Diesel	0.19	0.00	0.00	0.00	0.00	0.44
Gasoline	0.44	0.00	0.00	0.00	0.00	0.55
Pre-tax prices						
Autogas	4.38	4.53	4.82	5.25	5.78	5.96
Diesel	6.54	7.36	8.18	9.07	10.12	12.24
Gasoline	7.82	8.46	8.88	9.38	10.34	11.84

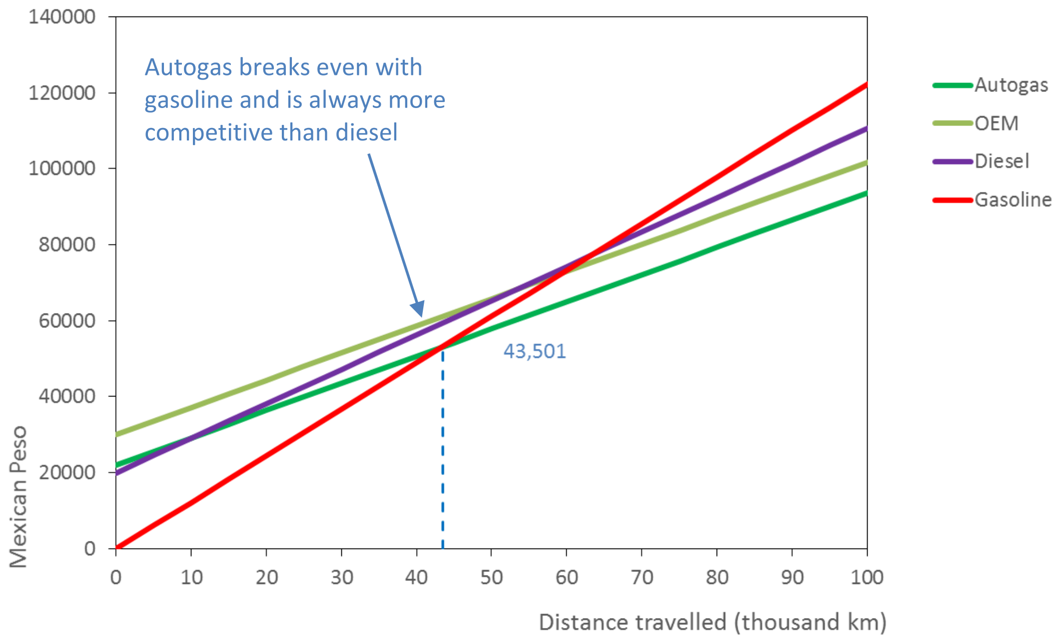
In 2014, the pump price of Autogas was on average equal to only 48% of that of gasoline and 49% of the diesel price, providing a relatively strong financial incentive for motorists to use Autogas (Table B8.1). The price of Autogas relative to gasoline has been fairly constant in the last few years, while its price relative to diesel has fallen significantly. The prices of all transport fuels have increased significantly in recent years as the government has passed through rises in international prices. There are no subsidies for vehicle owners to convert to Autogas or purchase OEM vehicles. However, some Autogas vehicles are exempted from driving restrictions in Mexico City for anti-pollution reasons.

[1] www.thepmr.org/system/files/documents/Carbon%20Tax%20in%20Mexico.pdf

8.3 Competitiveness of Autogas against other fuels

Assuming an average conversion cost of about 22 000 pesos ($2 400), Autogas becomes competitive with gasoline at 43 000 km (Figure B8.2). The conversion cost for vehicles using more sophisticated fuel systems is estimated at over 20 000 pesos and as much as 30 000 pesos for some vehicles. The higher cost of a new OEM vehicle means that it becomes competitive with gasoline only at almost 100 000 km. A converted Autogas vehicle is always more competitive than diesel, while an OEM vehicle beats diesel at little more than 50 000 km. The breakeven distance of Autogas has dropped substantially in the last five years thanks to lower prices, which suggests that a recovery in Autogas sales may be imminent.

Figure B8.2: Running costs of a non-commercial LDV, 2014 – Mexico

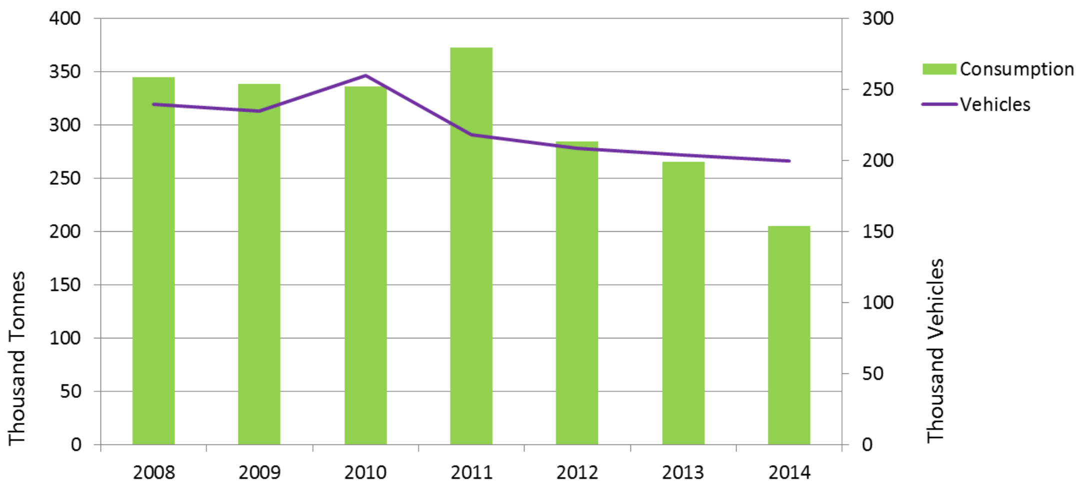


9 Netherlands

9.1 Autogas market trends

The Netherlands has the sixth-largest Autogas market in the European Union after Poland, Italy, Germany, Bulgaria and Romania, with consumption in 2014 running at an estimated 205 000 tonnes – equal to 2.0% of total road fuel use. Autogas consumption has drifted lower since the early 2000s, due to improved fuel efficiency and a contracting vehicle fleet and reduced dramatically due to a significant shortening of the gap between Autogas and diesel prices (Figure B9.1).

Figure B9.1: Autogas consumption and vehicle fleet – Netherlands



Note: The fall in the number of vehicles in 2011 is partly due to a break in the series.

The Dutch government has encouraged the use of Autogas and LPG generally for many years – mainly through favourable fuel taxes – because the country, with a large refining industry, used to be a major producer and exporter of the fuel, though policy support has waned recently. The country is now a net importer of LPG, so the rationale for encouraging Autogas now is purely environmental. At end-2014, there were 200 150 Autogas vehicles in use – down from 350 000 at the beginning of the 2000s – and 1 850 refuelling stations (about half of the total). Only 6 000 conversions were recorded in 2013 – down from 14 500 in 2012.[1] A hike in the excise tax on Autogas that took effect at the beginning of 2014, alongside much smaller increases in the tax on gasoline and diesel, in combination with generally lower fuel prices is expected to drive vehicle numbers and fuel sales down even further.

[1] *Argus LPG World*, 20 May 2014.

9.2 Government Autogas incentive policies

The Dutch government maintained a policy of encouraging the use of Autogas through fuel and vehicle tax incentives for many years. The excise tax on Autogas has been raised almost every year since 2007, but by less in absolute terms than the taxes on gasoline and diesel (Table B9.1). At only 17.8 euro cents/litre in 2014, it remained far lower than the tax on gasoline (85.3 cents/litre) and diesel (48.2 cents/litre). As a result of the lower rate of tax and the significantly lower wholesale price, the price of Autogas at the pump was only 52% of that of diesel and 42% of the gasoline price. Autogas was just over 1 euro/litre cheaper than gasoline at the pump – the biggest differential of any country included in this survey at prevailing market exchange rates. However, the price gap has narrowed since the start of 2014 with an 80% increase in the duty on Autogas to almost 18 cents/litre (duties on gasoline and diesel increased much less).

Table B9.1: Automotive-fuel prices and taxes – Netherlands (euros/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	0.578	0.644	0.700	0.769	0.732	0.680
Diesel	0.996	1.170	1.348	1.444	1.421	1.267
Gasoline	1.343	1.503	1.640	1.759	1.736	1.661
Total taxes						
Autogas	0.163	0.189	0.199	0.219	0.228	0.296
Diesel	0.579	0.615	0.645	0.672	0.693	0.702
Gasoline	0.923	0.963	0.986	1.023	1.054	1.141
Excise taxes						
Autogas	0.071	0.087	0.087	0.094	0.101	0.178
Diesel	0.420	0.428	0.430	0.437	0.446	0.482
Gasoline	0.709	0.723	0.724	0.736	0.753	0.853
Pre-tax prices						
Autogas	0.414	0.455	0.502	0.549	0.504	0.384
Diesel	0.417	0.555	0.703	0.772	0.728	0.565
Gasoline	0.419	0.540	0.654	0.735	0.682	0.520

There are no grants or tax credits available for Autogas conversions or OEM purchases. However, vehicle-purchase taxes are significantly lower than for diesel cars (and the same as for gasoline cars). On the other hand, the annual vehicle (road) tax, known as the *holdership* tax, for Autogas vehicles is higher than for both gasoline and diesel vehicles (except for the lightest vehicles). For example, the tax rate for a car weighing one tonne is €304 per year for gasoline, €676 for diesel and €724 for Autogas.[1]

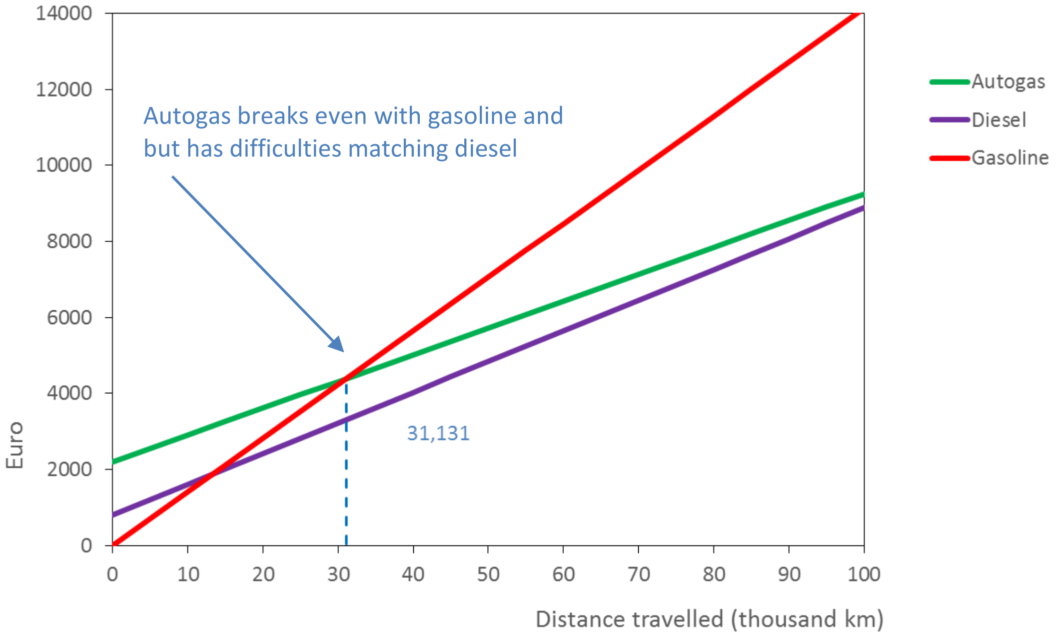
9.3 Competitiveness of Autogas against other fuels

The large excise-tax differential with gasoline in 2014 resulted in a breakeven distance for Autogas against gasoline of around 31 000 km (Figure B9.2). These calculations take account of the higher annual road tax payable by Autogas vehicles. Like in other Western European countries the additional cost of an Autogas conversion is fairly high (at around €2 200). Autogas was

[1] http://www.cfe-eutax.org/taxation/road-tax/netherlands

always more competitive than diesel (regardless of distance) based on the assumption that a diesel LDV costs around 3 000 euros more than for a gasoline model. This now has changed significantly and break even distances with diesel are now past 100 000 km and expected to increase even further in the coming years for a converted LDV as a result of the narrowing of excise-duty differentials and OEM significantly lower the premium on diesel models to around 800 €.

Figure B9.2: Running costs of a non-commercial LDV, 2014 – Netherlands



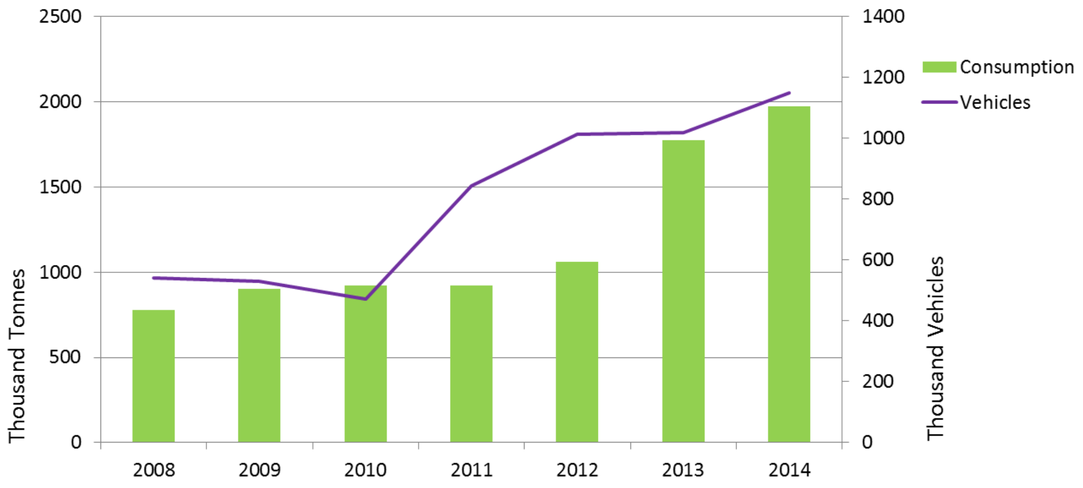
Note: The analysis takes into account differences in annual vehicle road taxes (assumed to be €30/1 000 km for Autogas and €26.5/1 000 km for diesel based on 14 000 km distance per year).

10 Thailand

10.1 Autogas market trends

Thailand's Autogas market has boomed in the last few years as a result of highly favourable taxation aimed at encouraging a switch away from more polluting diesel and gasoline in major urban centres. Between 2008 and 2014, Autogas consumption increased almost tripled, to nearly 2 million tonnes, with the biggest annual increase – a remarkable 710 000 tonnes, or 67% - occurring in 2013 (Figure B10.1). Autogas now accounts for about 9% of total road-transport fuel sales (5% in 2012) – one the highest shares in the world – and 26% of total LPG use in Thailand. The rapid growth in Autogas demand has contributed to Thailand becoming a large net importer of LPG.

Figure B10.1: Autogas consumption and vehicle fleet – Thailand



The number of vehicles running on Autogas grew rapidly after 2003 to around 550 000 in 2008; the number levelled off at the end of the 2000s, but has recently resumed its upward trend, reaching almost 1.2 million in 2014 – equal to over 7% of all the cars and trucks on the road in Thailand. The growth in the Autogas fleet was originally driven by converted taxis and motorised rickshaws, but private passenger cars are accounting for a growing share. There are no OEM Autogas models for sale at present in Thailand. There are an estimated 1 150 refuelling stations, most of which are in or around Bangkok.

10.2 Government Autogas incentive policies

Thailand's oil market was largely deregulated in 1991, but the government still caps the wholesale and retail prices of LPG for social reasons, using an oil stabilisation fund to balance differences in the ex-refinery prices (which are deregulated) and wholesale prices. The retail price of Autogas, which used to be same as that of LPG sold in cylinders, remained unchanged between 2008 and 2011. Since then the price has increased, though less than those of gasoline; the diesel price has increased marginally after been capped at around 27 baht/litre.

The average pump price of Autogas in 2014 was only 32% of that of gasoline and 43% of that of diesel – the lowest rates of any of the countries surveyed in this report (Table B10.1). All automotive fuels, including Autogas, are subject to an excise tax, a conservation fund tax and an oil stabilisation levy. Overall, these taxes are much lower for Autogas than the other two main transport fuels. On a net basis, both Autogas (and LPG generally) and diesel are subsidised (IISD, 2013). There are no subsidies for vehicle conversions.

Table B10.1: Automotive-fuel prices and taxes – Thailand (baht/litre)*

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	9.79	9.79	9.79	11.21	11.55	11.77
Diesel	24.77	28.69	27.04	27.04	27.04	27.61
Gasoline	31.34	36.10	39.72	41.96	45.19	36.55
Total taxes**						
Autogas	2.07	2.28	2.34	2.56	4.31	4.24
Diesel	6.88	8.07	3.47	3.47	3.47	5.48
Gasoline	15.92	17.81	18.25	18.39	18.61	15.76
Excise taxes***						
Autogas	1.43	1.64	1.70	1.83	3.55	3.47
Diesel	5.26	6.19	1.70	1.70	1.70	1.70
Gasoline	13.87	15.45	15.65	15.65	15.65	15.65
Pre-tax prices**						
Autogas	7.72	7.51	7.45	8.64	7.24	7.53
Diesel	17.89	20.62	23.57	23.57	23.57	22.13
Gasoline	15.42	18.29	21.47	23.56	26.58	20.79

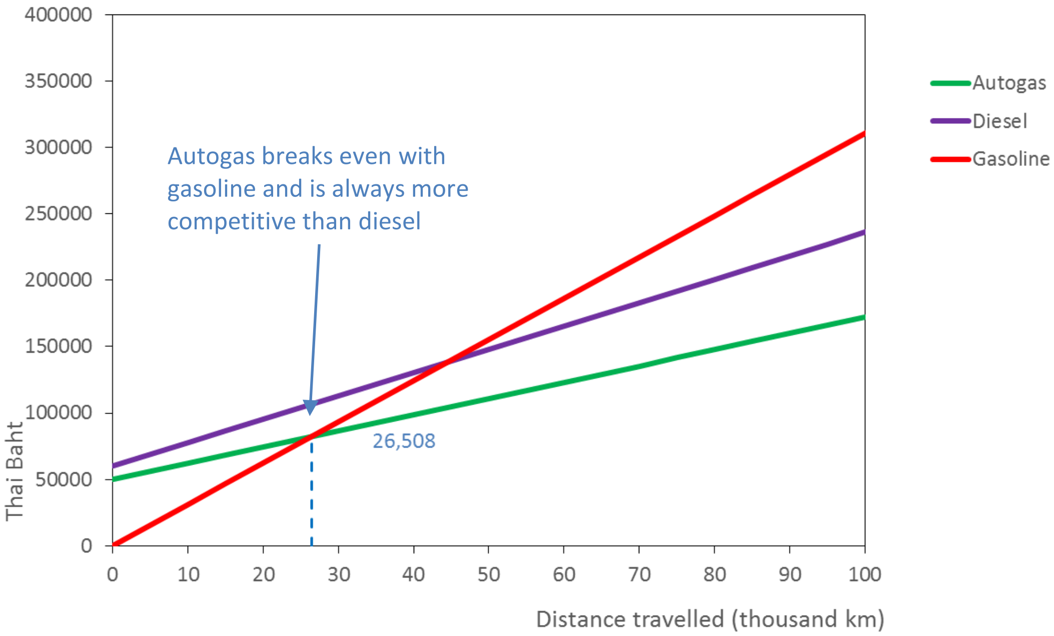
* In Bangkok. ** Estimated. ***Including oil fund and conservation levies.

The Thai government has, at various times over the last few years, attempted to raise the price of Autogas and even to restrict the use of the fuel in order to reduce the cost of subsidies, but these moves have always met strong public resistance. The government is now pushing instead for vehicle owners to switch to natural gas vehicles, which has started to bear fruit: CNG use grew by over 20% to 2.9 billion cubic metres in 2012 and accounts for over 10% of road-fuel use – more than double the share of Autogas. CNG has a price advantage over Autogas, retailing at just 8.50 baht per kilogramme compared with over 20 baht for the equivalent quantity of Autogas.

10.3 Competitiveness of Autogas against other fuels

The current very low Autogas price results in a breakeven distance for a typical passenger car converted to run on Autogas against gasoline of around 26 000 km (Figure B10.2). This analysis assumes a conversion cost of 50 000 baht (US$1 000). Diesel breaks even with gasoline at a distance of more than 40 000 km (assuming a premium of 60 000 baht, or around US$1 200, for a diesel car over a gasoline car), but as retrofit is lower than the diesel premium and running costs for Autogas cars are much lower than for diesel cars, Autogas is always more competitive.

Figure B10.2: Running costs of a non-commercial LDV, 2014 – Thailand



11 Turkey

11.1 Autogas market trends

As a result of spectacular growth in consumption since the end of the 1990s, when a ban on Autogas vehicles was lifted, and especially since 2003, Turkey today has the third-largest Autogas market in the world after Korea and Russia. Consumption has more than doubled since 2010, reaching 2.83 million tonnes in 2014 (Figure B11.1). In 2009, Autogas consumption exceeded gasoline consumption for the first time, with Autogas making up 17% of total automotive-fuel consumption in 2012. Autogas accounted for 75% of Turkey's total LPG consumption in 2014, more than four-fifths of which is met by imports.

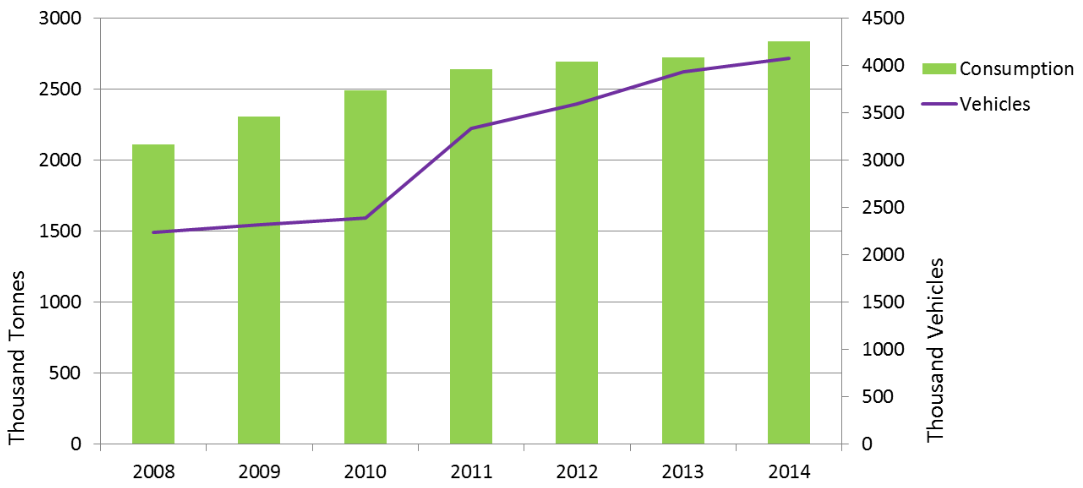


Figure B11.1: Autogas consumption and vehicle fleet – Turkey

Note: The data on vehicle numbers are from the General Directorate of Public Security.

The number of vehicles able to run on Autogas has continued to rise, reaching 4.073 million at end-2014, or roughly 30% of the country's total vehicle fleet. More than 46% of private cars now run on Autogas. The number of conversions has been running at about 300 000 per year since 2006. Most vehicles that use Autogas are privately owned, converted gasoline-powered cars; taxis, which make up just 2% of the total Autogas fleet, account for 10% of Autogas fuel sales because of their high mileage (their share of the fleet has fallen sharply in recent years as taxi-owners now opt most often for diesel).

The number of carmakers offering Autogas models has diminished in recent years as interest in diesel has grown, with Dacia, Honda and Hyundai now accounting for most sales. But conversion-kit manufacturers now offer engine warranties to new cars, so that the range of cars that are converted after purchase has expanded tremendously. There are 10 397 refuelling sites, accounting for about three-quarters of all service stations across the country.

11.2 Government Autogas incentive policies

The take-off in Autogas use in Turkey came about more as a result of a social policy of low taxation of LPG as a household fuel than a deliberate policy of promoting alternative fuels. An unregulated conversion industry took root to allow motorists to take advantage of the low price of LPG and low taxes on Autogas. Tax policy changed several times during the early 2000s, as the government sought to control the growth of the market and prevent suppliers from illegally diverting LPG from the cylinder market to the Autogas market. The Turkish LPG market was deregulated at the beginning of 2005, allowing retailers to set prices freely. But the government continues to exert influence over pricing through control of ex-refinery prices and taxation. No non-fiscal incentives for Autogas are currently in place.

Table B11.1: Transport-fuel prices and taxes – Turkey (liras/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas	1.68	2.02	2.32	2.51	2.70	2.76
Diesel	2.84	3.49	3.67	4.27	4.30	3.99
Gasoline	3.35	3.68	4.19	4.77	4.78	4.66
Total taxes						
Autogas	0.87	1.02	1.07	1.27	1.30	1.30
Diesel	1.58	1.84	1.86	2.41	2.43	2.22
Gasoline	2.20	2.03	2.53	2.91	2.91	2.78
Excise taxes						
Autogas	0.61	0.72	0.72	0.88	0.88	0.88
Diesel	1.15	1.30	1.30	1.59	1.59	1.59
Gasoline	1.69	1.89	1.89	2.18	2.18	2.18
Pre-tax prices						
Autogas	0.81	1.00	1.25	1.25	1.41	1.45
Diesel	1.26	1.66	1.81	2.03	2.05	1.79
Gasoline	1.15	1.65	1.66	1.86	1.87	1.77

Since the middle of the 2000s, a more stable tax policy has been in place, though rates of tax have risen. The same rate of value-added tax is now applied to Autogas as to gasoline and diesel (a higher rate had been applied in 2000-2002 to rein back demand) and excise taxes on Autogas have been held well below the level of those on the other two fuels. Since 2011, the excise tax on Autogas has increased moderately from 0.61 liras/litre to 0.88 liras/litre, while the tax on gasoline has climbed steadily to 2.18 liras and that on diesel to 1.59 liras on diesel in 2012 (Table B11.1). As a result, the price advantage of Autogas over the other two fuels has risen. The average per-litre pump price of Autogas was less than two-thirds that of gasoline and

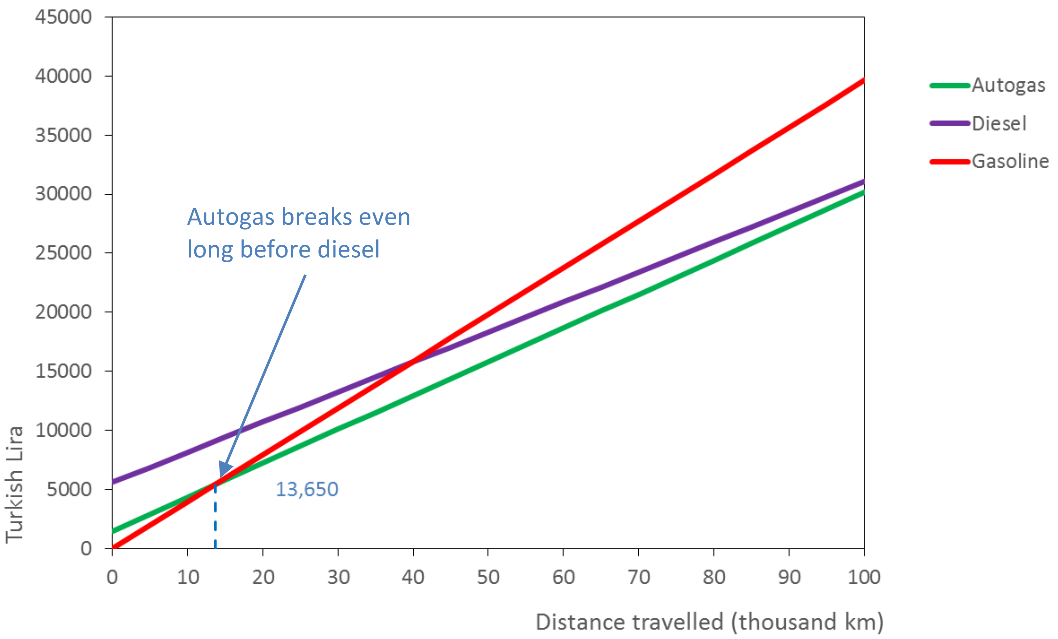
69% that of diesel in 2014. The per-litre price advantage of Autogas over the other two fuels has increased in both in absolute and percentage terms since 2012.

Following technical and safety problems during the early period of market development, the government established stringent conversion standards and laws in 2005: all conversion centres must be licensed by the Turkish Standards Institute and all conversions must be approved by a qualified engineer; the converted vehicle must then be tested for leaks by an independent organisation every two years. As a result, the safety and reliability of conversions has increased. There are now more than 1 000 accredited conversion centres offering a wide range of kits, some of which have been developed by Turkish firms.[1] The European Autogas Quality Standard EN 589 became mandatory at the beginning of 2004, which has helped to reduce problems caused by poor fuel quality.

11.3 Competitiveness of Autogas against other fuels

The low cost of conversions in Turkey, due to low labour costs and economies of scale, and the competitive prices of OEM vehicles mean that Autogas breaks even with gasoline at relatively short distances. For a good-quality conversion,[2] which is assumed to cost around 1 500 lira ($700), the distance is less than 14 000 km, about one year driving for an average private motorist (Figure B11.2). Diesel breaks even with an Autogas conversion at over 100 000 km. This analysis clearly demonstrates the continuing attractiveness of Autogas over both gasoline and diesel.

Figure B11.2: Running costs of a non-commercial LDV, 2014 – Turkey



[1] *Autogas Updates*, June 2011. Available at: http://www.auto-gas.net/uploads/Modules/AutogasNewsletter/autogas-updates-june2011-2.pdf
[2] Cheaper conversions are available for as little as 1 100 lira (around $500).

12 United States

12.1 Autogas market trends

Despite federal and state efforts to encourage vehicle conversions and refuelling stations, US Autogas (propane) sales have declined slowly since the middle of the last decade and remain extremely small compared to the rest of the automotive-fuel market. Autogas consumption amounted to just 559 000 tonnes in 2014, equal to less than 0.1% of total road-fuel sales (Figure B12.1). High pump prices of Autogas relative to conventional fuels, caused mainly by a relatively high federal excise tax, is the main reason for the low market penetration of Autogas, though tax credits are available in some states to lower the cost of fuel purchases and vehicle conversions or OEM purchases.

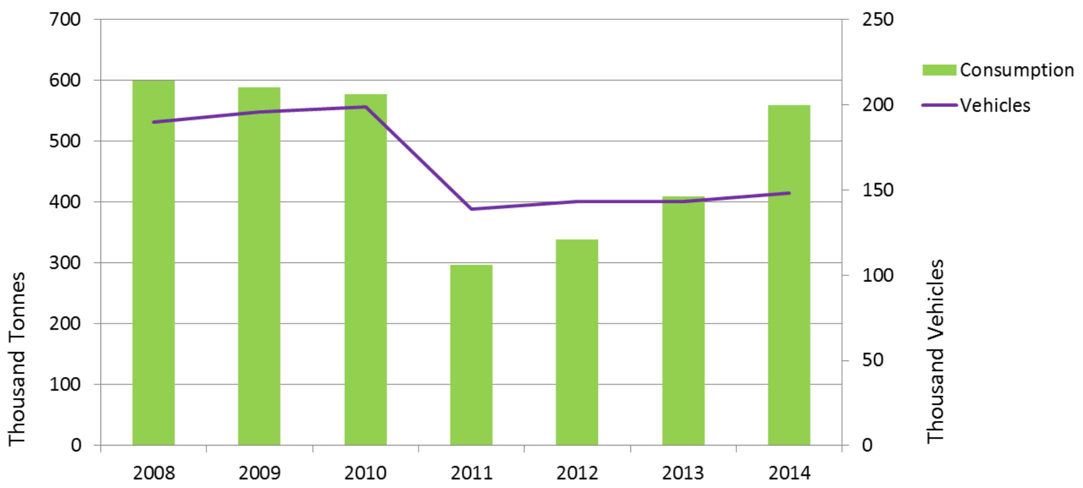


Figure B12.1: Autogas consumption and vehicle fleet – United States

Note: The sharp decline in fuel consumption and vehicle numbers in 2011 is due to breaks in the series.

There are currently around 148 000 road vehicles, mostly fleet vehicles, operating on Autogas across the United States – a mere 0.1% of the total US car and truck fleet. In total, there are over half a million vehicles including forklift trucks. A number of OEM Autogas vehicles are available and several new vehicle platforms under development, including medium- and heavy-duty trucks and school buses. Manufacturers include Alliance AutoGas, Blue Bird Corp, CleanFuel USA, Collins Bus, Icom North America, Impco Technologies, Roush CleanTech and Freightliner. The number of Autogas-powered school buses has increased by 20% since the end of 2012 to around

3 000. Blue Bird has partnered with alternative fuel producer Roush CleanTech to create two propane bus models, the Vision and Micro Bird G5.[1]

The expansion in the range of OEM vehicles on offer and an expected favourable trend in spot propane prices relative to those of gasoline could boost the US Autogas market in the coming years. A recent report prepared on behalf of the US Propane Education and Research Council projects Autogas vehicle sales to increase from fewer than 5 000 in 2011 to more than 40 000 per year by 2020, with the potential for much higher growth depending on national energy policy and the rate at which the industry choses to develop propane refuelling infrastructure and promote vehicle saleo (ICF International, 2013). There are currently 2 956 refuelling stations across the country.

12.2 Government Autogas incentive policies

There are a number of federal, state and local government incentives to encourage the supply and use of Autogas. These are summarised below. More details can be found at the web site of the Alternative Fuels and Advanced Vehicles Data Center run by the US Department of Energy (DOE): www.afdc.energy.gov/fuels/laws/LPG/US.

12.2.1 Fuel-tax differentials

Rates of federal fuel taxes have changed for 2014 since they were last adapted in 1993. While the excise duty on Autogas remains at 3.6 US cents/litre, the rates for gasoline and diesel have been altered (lowered and increased respectively). Despite the rate for Autogas being now being even lower than that on gasoline (5.5 cents/litre, up from 4.9), the difference to diesel (5.3 cents/litre, down from 6.4) is now much less. Alternative fuels, including Autogas, that are used for certain purposes, including farming, some types of local bus services, school buses, non-profit educational services and by state governments, are fully exempt from federal fuel taxes. Pre-tax Autogas prices have fallen significantly relative to the prices of conventional fuels since 2010, due to a surge in the supply of natural gas liquids in the United States from booming shale-gas production. As a result, the average price of Autogas at the pump in 2013 (including state taxes) was 45.5 cents/litre (or 38%) lower than that of gasoline and 30.7 cents/litre (30%) lower than that of diesel. Falling oil prices have led to a stagnation in gasoline prices, reducing the gap to less than 9ct/litre thus nullifying the advantage for Autogas (Table B12.1).[2]

[1] http://www.auto-gas.net/newsroom/46/47/Autogas-maintains-its-global-market-share#.U_yoasscRaQ

[2] The prices shown in Table B19.1 are compiled from data published by the DOE Clean Cities Program – the only published source of data on retail Autogas prices in the United States. These reports can be downloaded from http://www.afdc.energy.gov/afdc/price_report.html However, there is evidence that these prices may overstate the actual prices paid by Autogas users. A report prepared by ICF International on behalf of the National Propane Gas Association (NPGA), released in March 2012, finds that the price of Autogas is actually significantly lower than that of gasoline and that the differential is

Until the end of 2013, Autogas prices were effectively lower for many users thanks to the Alternative Fuel Excise Tax Credit. This federal tax credit, which amounted to 50 cents/gallon (13.2 cents/litre), was available for any alternative fuel, including Autogas, and for any entity that retailed or used Autogas (a private citizen, bulk fuel retailer, company or state/local government) that is registered with the Internal Revenue Service (IRS). This credit effectively reduced the pump price by the full amount of the credit. The credit was not allowed if an incentive for the same alternative fuel was also determined under the rules for the ethanol or biodiesel tax credits. The credit, which had been in place for several years, was not renewed in 2014.

Table B12.1: Automotive-fuel prices and taxes – United States ($/litre)

	2009	2010	2011	2012	2013	2014
Pump prices						
Autogas*	0.693	0.769	0.819	0.739	0.734	0.810
Diesel	0.663	0.786	1.007	1.049	1.041	1.009
Gasoline	0.756	0.890	1.157	1.242	1.189	0.906
*Total taxes***						
Autogas	0.114	0.117	0.081	0.067	0.070	0.079
Diesel	0.136	0.139	0.139	0.141	0.142	0.144
Gasoline	0.127	0.130	0.133	0.135	0.135	0.129
*Excise taxes****						
Autogas	0.036	0.036	0.036	0.036	0.036	0.036
Diesel	0.064	0.064	0.064	0.064	0.064	0.053
Gasoline	0.049	0.049	0.049	0.049	0.049	0.055
Pre-tax prices						
Autogas	0.579	0.652	0.738	0.672	0.663	0.731
Diesel	0.515	0.652	0.877	0.908	0.894	0.865
Gasoline	0.495	0.605	0.799	0.823	0.791	0.777

* Not including the federal Alternative Fuel Tax Credit. ** Average across states. In the absence of official data, state taxes on Autogas are assumed to be the same as those on gasoline.*** Federal excise duties only.

12.2.2 Federal clean-fuel incentive and programmes

There a number of federal programmes, regulations and incentives in place to encourage alternative fuels, including Autogas. The main form of federal support for Autogas is alternative vehicle acquisition and fuel-use mandates. Under the Energy Policy Act of 1992, 75% of new LDVs acquired by certain federal fleets must be alternative fuel vehicles (AFVs); Autogas was classified by the Act as an alternative fuel. Federal fleets are also required to use alternative fuels in dual-fuel vehicles unless the DOE determines an agency qualifies for a waiver; grounds for a waiver include the lack of alternative fuel availability and cost restrictions. Additionally, Executive Order 13423, issued in January 2007, requires federal agencies with 20 vehicles or more in their US fleet to reduce petroleum consumption by 2% per year, relative to their Fiscal Year (FY) 2005 baseline, through to FY 2015. Agencies must also

likely to grow as the supply of natural gas liquids expands with booming production of shale gas.

continue to increase their alternative fuel use by 10% per year, relative to the previous year.

Executive Order 13514, issued in October 2009, requires each federal agency to develop, implement, and annually update a Strategic Sustainability Performance Plan. Federal agencies must measure, reduce, and report their greenhouse gas (GHG) emissions, with an overall federal government GHG emissions reduction goal of 28% by 2020, relative to a 2008 baseline. Federal fleets of 20 vehicles or more must reduce petroleum consumption by a minimum of 2% per year through to the end of FY 2020 as compared to 2005 baseline usage. Each agency must establish a comprehensive inventory of GHG emissions for FY 2010, to be updated on an annual basis thereafter. Reductions may be achieved through a variety of measures including the use of AFVs, and fleet optimization efforts.

Additional requirements for federal fleets were included in the Energy Independence and Security Act of 2007, including requirements to acquire low GHG-emitting vehicles. These requirements are dependent upon formal rulemaking by DOE.

The 1992 Act also requires certain state government and alternative fuel provider fleets to acquire AFVs. Compliance is required by fleets that operate, lease, or control 50 or more LDVs within the United States. Of those 50 vehicles, at least 20 must be used primarily within a single Metropolitan Statistical Area/Consolidated Metropolitan Statistical Area. Those same 20 vehicles must also be capable of being centrally fuelled. Covered fleets earn credits for each vehicle purchased, and credits earned in excess of their requirements can be banked or traded with other fleets. On March 20, 2007, the DOE issued a rule that allows fleets the option to choose a petroleum reduction path in lieu of acquiring AFVs.

The federal government also runs a number of programmes that encourage the use of alternative fuels. One of the most important is the Clean Cities Program, which supports local public/private initiatives to promote the deployment of AFVs and reduce conventional fuel consumption in urban areas.[1] As part of the 2009 American Recovery and Reinvestment Act, the DOE allocated nearly $40 million spread across 25 Autogas projects as part of $300 million given to Clean Cities projects. These grants funded the purchase of 2 400 Autogas vehicles and the construction of nearly 250 new Autogas refuelling stations.[2] 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.[3] Clean School Bus USA provides funding for projects designed to retrofit and/or replace older diesel school buses with AFVs; Autogas accounts

[11] For more information, go to www1.eere.energy.gov/cleancities/

[2] The largest project is the Southeast Propane Autogas Development Program, an initiative to convert around 1 100 public and private fleet vehicles from gasoline to Autogas and install 20 refuelling stations in the south-eastern United States.

[3] For more information, go to http://www.afdc.energy.gov/uploads/publication/60619.pdf

for a large number of the buses that have been converted under this programme.

Until the end of 2013, the Alternative Fuel Infrastructure Tax Credit was available to cover up to 30% of the cost of installing alternative fuelling. The credit was limited to $30 000. Fuelling station owners who install qualified equipment at multiple sites are allowed to use the credit towards each location. The credit provision was not renewed in 2014. Federal grants are no longer available for Autogas vehicle purchases or conversions. Until the end of 2010, the Qualified Alternative Fuel Motor Vehicle (QAFMV) Tax Credit, introduced under the Energy Policy Act of 2005, subsidised the incremental cost of purchasing or converting vehicles to run on Autogas. The credit amounted to $2 500 for an LDV and up to $32 000 for a heavy-duty truck.

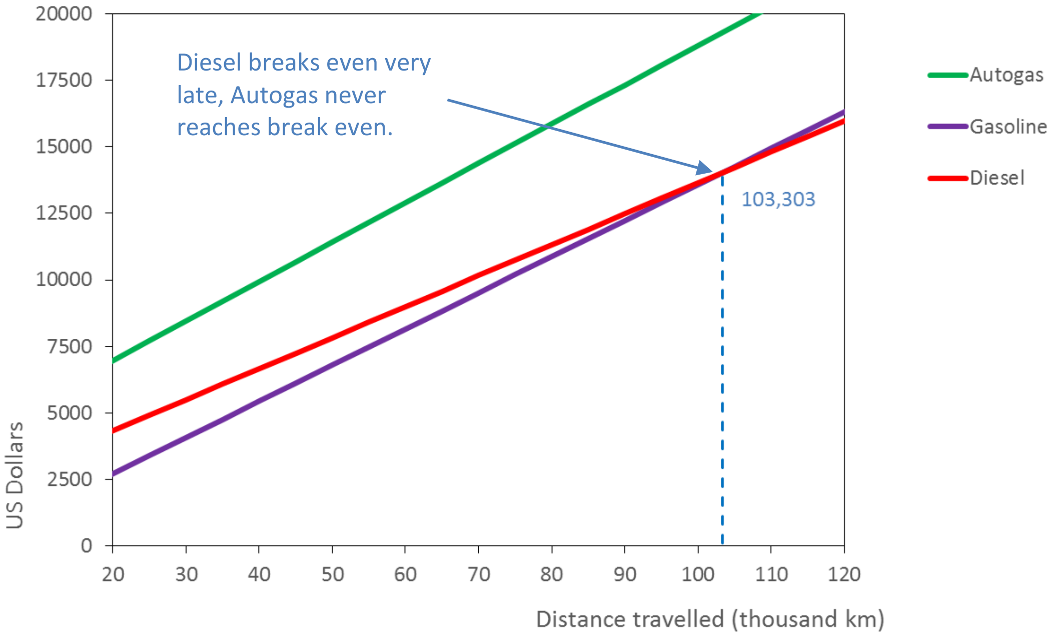
12.2.3 State programmes

Most US states make available additional fiscal incentives to support the use of Autogas and other alternative fuels, including grants and loans for vehicle conversions and purchases, as well as refuelling infrastructure. Some states also have AFV purchase mandates. In some states, tax rebates and exemptions are also applied to Autogas. For example, in California, Autogas is exempt from the state excise tax of 6 cents per gallon when the vehicle owner pays a flat-rate sticker tax ($36 per year for a LDV weighing less than 4 000 lbs). The Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), administered by the California Energy Commission, provides financial incentives for developing and deploying alternative and renewable fuels.

12.3 Competitiveness of Autogas against other fuels

Autogas struggles to compete with either gasoline or diesel regardless of distance travelled, even allowing for the Alternative Fuel Tax Credit that still applied in 2013. This is essentially because of low federal and state taxes on all automotive fuels. Figure B12.2 compares the running costs of Autogas vehicles against gasoline and diesel vehicles in 2014. Assuming a cost of $4 000 for converting or buying an OEM Autogas vehicle and taking into account the fuel tax credit the breakeven distance is close to 200 000 km; without the tax credit, Autogas is never competitive. In addition, actual conversion and purchase costs can be considerably higher for some types of vehicle. Diesel is a more competitive alternative to gasoline, as its breakeven distance is over 100 000 km, explaining in part why LDVs are not so popular in the United States. This analysis demonstrates very clearly why Autogas needs considerable support to make inroads into the road-fuel market in the United States. Nonetheless, breakeven distances may be significantly lower in places where Autogas is available at lower prices (see above).

Figure B12.2: Running costs of a non-commercial LDV, 2014 – United States



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Annex 2: Note on data sources

Data on automotive-fuel prices and taxes were compiled from a range of sources. For most countries, *Energy Prices and Taxes*, a quarterly report published by the International Energy Agency (IEA), was the source for historical price and tax data for Autogas, diesel and gasoline. For the others, national sources, including national LPG associations, government agencies and fuel providers, were used.

Estimates of Autogas vehicle conversion costs and the incremental cost of OEM vehicles and diesel vehicles were compiled from industry sources in each country, including car and equipment manufacturers and conversion-kit installers. Where country-specific information was not available, generic cost estimates were used.

Most data on Autogas consumption, vehicles and refuelling sites are from the WLPGA/Argus annual publication, *Statistical Review of Global LPG*, except where otherwise stated. Data on total road-vehicle fleets were compiled from national sources.

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