The Case for Innovative Procurement

Preliminary Report
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FIRED-uP Work Package 2

Fire Services Develop Innovative Procurement

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1 INTRODUCTION

1.1 BACKGROUND ON PROJECT AND PURPOSE OF REPORT

The FIRED-uP project is taking place over three years to examine innovative ways of improving the environmental performance of fire and rescue service vehicles. The objective is to create the conditions in which the procurement of new solutions can take place, by engaging with the market, developing specifications, and addressing legal and operational risk factors. The project is co-financed by the European Commission under the Competitiveness and Innovation Programme (CIP). A specific portion of the available project finance is reserved for the procurement of solutions identified under the project.

This report forms the basis of Work Package 2 “The Case for Innovative Procurement.” It draws upon research carried out by the partners to identify the environmental impact of their existing vehicles and assess future procurement needs. It then turns to an overview of potential solutions to meet these needs. This report addresses the ‘why’ and ‘what’ of innovative procurement for fire and rescue service vehicles. The guidance framework prepared under Work Package 3 “Risk Management” addresses the ‘how’ and ‘who’, by looking at different approaches to supplier engagement, procurement and contract design and implementation.

1.2 PARTNER PROFILES AND OPERATIONS

The partners in the project are London Fire Brigade and the City of Ghent Department of Facility Management - Services and Logistics Division, in cooperation with the Ghent Fire Brigade. Both are responsible for providing front line firefighting and rescue services in their operational areas as well as a number of other functions related to community safety and emergency planning. An outline of the size and scope of operations and the current vehicle fleets of each partner is given below.

LONDON FIRE BRIGADE (LFB)

LFB is one of the largest firefighting organisations in the world, providing services across 1587 square kilometres of Greater London to a resident population of 8.2 million people. It employs some 7,000 staff, operates 112 land fire stations and one river station and attends some 115,000 emergencies every year, including about 27,000 fires.[1] Its fleet consists of over 540 vehicles, including pumping appliances, aerial platform ladders, fire rescue units and other specialist vehicles. A summary of the fleet and Euro emission standards is given below, current as of May 2013, however fleet numbers are subject to change based on operational considerations.

[1] *Draft Fifth London Safety Plan – Incident Profiles* (March 2013) at page 2.

Vehicle Type	Number (May 2013)
Dual Pump Ladder	229
Aerial/Platforms/Turntables	20
Fire Rescue Unit	20
Forklift Trucks	14
Bulk Foam Unit/Water Carrier	9
Command Support Unit	9
Operational Support Unit	7
Other Specialist Vehicles	69
Cars	76
Vans	48
People Carrier	35
Plant	4
Fire Boat	2
Total	542

No. of vehicles (May 2013)	Euro Standard†	% of Fleet
7	Pre Euro	1.29%
7	Euro 1/I	1.29%
14	Euro 2 /II	2.58%
253	Euro 3/III	46.68%
225	Euro 4 /IV	41.51%
31	Euro 5 /V	5.72%
4	n/a -plant	0.74%
1	Unknown	0.18%

† As noted below,268 vehicles have been retrofitted with exhaust abatement traps. The Euro classifications here reflect the standard achieved after retrofit.

Some of the above vehicles are reserves or used for training only. LFB currently has a service contract in place covering provision of fleet and operational equipment, maintenance and management services. This contract provides for phased replacement of front line pumping appliances and other vehicles and equipment. The contract currently in place is an interim arrangement which will expire in May 2014. A re-procurement process to appoint a replacement Contractor is being conducted in 2013.

Currently each vehicle has an agreed life and must be replaced within this period (for example, pumping appliances have a 12 year life – this may be reviewed). The replacement period is based on whole-life costs and value for money. It takes into account parts availability and vehicle obsolescence, usage rates, capital life costs, revenue life costs, corporate image, vehicle reliability, the quantity of reserve vehicles needed and the cost of disposal. Disposal of vehicles at their end-of-life is currently the responsibility of LFB procurement and is managed with due regard to the environment and charitable considerations.

Vehicles are replaced using a project managed process that reviews the LFB requirements, then confirms or changes the LFB output based specification (OBS). Based on the OBS, the Contractor researches and proposes options and prices that comply with the LFB requirements and offer best value for money. The agreed solution is then implemented with risk assessments, operating manuals and training programmes. The Contractor must undertake research and identify new products, technology and materials for the purposes of improving operational capability, cost-effectiveness and to minimise the risk of injury. This involves market research, working with suppliers and undertaking development work.

The Contractor is required to undertake modifications as may be required to vehicles to accommodate different stowage needs, obsolescence, technological change, manufacturers' recalls, design defect, changes in legislation and new operating practices. For example, to meet the requirements of the London Low Emission Zone for 2012 the service provider retrofitted exhaust abatement traps to 268 vehicles. Exceptionally, the cost of this upgrade was met by LFB. Under the

Preventative Inspections and Maintenance Schedule all items are inspected, serviced and maintained to a strict time based schedule that meets the original manufacturer's recommendations, the Chief Fire Officer's Association Fleet Maintenance Best Practice Manual and LFB's specific requirements. There is also a collision damage and repair service and mobile repair technician service.

LFB has been supplied with digital radio terminals as part of the national Firelink project. The Firelink project provides a digital radio system and equipment which conforms to the European TETRA (Terrestrial Trunked Radio) standard. The radios operate by accessing a communications network managed by Airwave Solutions Limited. The Motorola MTM800 vehicle mounted radio is installed on all front-line appliances. This equipment is used for sending and receiving all voice messages, and can be used to send data status updates. A Mobile Data Terminal (MDT) is fitted to pumping appliances and other front-line operational vehicles. The MDT provides a visual communications interface with the main-scheme radio for certain functions (e.g., updating appliance status), and can be used to access additional incident-related information.

Key environmental issues for LFB are reducing vehicle emissions, fossil fuel and water consumption. This ties into the Brigade's overall target for a 32% reduction in CO_2 emissions from its operations by 2015/16, measured against a 1990 baseline[2]. Other greenhouse gas and particulate matter emissions are not currently measured, however there is a need to address these in line with evolving air quality policy for London and Mayor's targets. The frontline fleet primarily runs on diesel which includes a 5% biofuel blend. Diesel has the advantage of having relatively higher fuel efficiency and lower CO_2 emissions than petrol, however emissions of particulate matter are higher if no filter is used. All LFB diesel vehicles are fitted with a particle filter, except for four vehicles limited to skid-training at an LFB facility. Research and testing have also been carried out on the use of electric vehicles and Liquefied Petroleum Gas. Information on emissions from our fleet and fuel consumption are given in Section 3.1 below.

CITY OF GHENT FIRE BRIGADE (GHENT)

Ghent Fire Brigade is responsible for 30 955 ha and a total of 312 552 inhabitants. It employs 533 staff, operates five fire stations and attends approximately 5 562 emergencies every year, including 500 fires. Its fleet consists of about 75 vehicles and fire rescue units.

City of Ghent, FM-Services and Logistics department is responsible for the fleet management of the Ghent Fire Brigade. This department manages a larger fleet of over a 1000 vehicles and machines (including fire brigade and police) and plays an important role in the fleet management of the Fire Brigade, providing administrative and technical expertise. A summary of the fire and rescue service fleet is shown below. More detailed information including on emissions and fuel consumption is given in the Annex.

[2] LFB (2013) LFB Sustainable Development Strategy 2013-2014

SUMMARY OF GHENT FIRE BRIGADE FLEET

Vehicle type	No. of Vehicles	Make	Euro Standards	Fuel
Heavy duty vehicles (CV) Total = 29	4	VOLVO FL	EURO V x1; EURO IV x 3	Diesel
	5	MERCEDES ATEGO	4 x EURO V; 1 x EURO III	Diesel
	2	SCANIA P320	EURO V	Diesel
	1	SCANIA G400 CB	EURO V	Diesel
	1	VW LT46	EURO III	Diesel
	2	IVECO MAGIRUS	EURO III	Diesel
	3	VOLVO FMFH	EURO III	Diesel
	1	VOLVO	2001 build	Diesel
	1	MAN L 15 LC	EURO II	Diesel
	1	MERCEDES 1317X		Diesel
	1	MERCEDES SPRINTER	EURO III	Diesel
	1	MAN 14 LC	EURO III	Diesel
	1	MAN L18LC	EURO III	Diesel
	1	MAN TS 19 F		Diesel
	1	STEYR 19S32/4X2	Pre-Euro	Diesel
	1	VOLVO FLC	EURO II	Diesel
	1	MERCEDES AXOR	EURO IV	Diesel
	1	MERCEDES 1722 RC		
Light duty vehicles (CT) Total = 9	2	PEUGEOT PARTNER	EURO III	Diesel/ Petrol
	2	MERCEDES SPRINTER	EURO V	Diesel
	1	MERCEDES 313CDI	Build 2001	Diesel
	1	PEUGEOT BOXER	EURO III	Diesel
	1	TOYOTA HI-LUX	EURO III	Diesel
	1	FORD TRANSIT	EURO III	Diesel
	1	MERCEDES 310DB		Diesel
Multi-purpose vehicles (AF) Total = 7	1	MERCEDES VITO	EURO IV	Diesel
	2	PEUGEOT 308		
	1	MERCEDES VIANO		
	1	VW LT35	EURO III	Diesel
	1	OPEL VIVARO	EURO III	Diesel
	1	PEUGEOT 307	EURO III	Petrol
Ambulance (SC)	7	MERCEDES SPRINTER	5 x EURO V; 1 x EURO IV; 1 x EURO III	Diesel
Cars	11	Various makes	EURO III and higher	Diesel/ Petrol

The current fire brigade fleet contains the following electric/hybrid vehicles:

Type of vehicle	Number	Purchase Year
Toyota Prius	3	2002, 2007
Volvo C30 electric	1	2012

The City of Ghent has incorporated more electric/hybrid vehicles in its fleet.

The City of Ghent and Ghent Fire Brigade aim to increase fuel efficiency and reduce fleet environmental impact through innovative vehicle technology and power systems for a range of appliances. In 2004-2005 the City of Ghent became one of the first Flemish cities to analyse the environmental performance of its own car fleet. The study revealed that some cars were not fuel efficient and emitted a lot of air pollutants. About 40% of the cars had a good score, 30% average and 30% a rather bad score (red label). In 2009 all cars with a red label were replaced by cars with EURO V engines. In total 25 passenger cars, 48 delivery vans, 10 trucks, 3 big and 1 small school bus were replaced by more environmentally friendly cars.

As a result fuel consumption has declined (annual fuel savings of 11 100 litres) and exhaust of air pollutants has diminished. For example, over the last 10 years the fuel consumption of delivery vans has declined by an average of 20% as a result of the replacement.

The City of Ghent aims to make its fleet less reliant on fossil fuels and to reduce the emission of air pollutants. Under the Civitas Elan project Ghent participated in a measure targeting 'Energy efficient city fleet management'. The idea is that just replacing old vehicles with cleaner ones will not be enough to have a major impact on the total energy use of the city fleet – a more radical approach is needed. The following potential solutions are being examined:

- Replacing existing cars with environmentally friendlier alternatives such as electric cars (around 12 in 2011-2012) and CNG cars
- Exploring the feasibility of the use of biodiesel (30% mix with standard diesel). Current vehicles have the capability to run on a 30% biodiesel mix but this has been placed on hold pending greater clarity in the tax regulation, and the availability of more sustainable second-generation biodiesel. Filling stations are not yet available to deliver this fuel.
- Efficient use of the city fleet: shared cars are provided at important and central locations and a reservation tool is organised for the mutual use of these cars.
- Ecodriving courses

For the acquisition of new cars and trucks for our fleet we have developed environmental and sustainability criteria which have to be respected: engines must meet or exceed the EURO V standard. The total cost of ownership is assessed and vehicles must have an Ecoscore of at least 65 (see information below on Ecoscore).The following criteria and weightings are applied in the procurement process:

- All joint costs with respect to the life span of the vehicle (acquisition and usage cost): 60 - 65 %
- Qualitative aspects of the type of vehicle, seen from the point of view of the user: 25 - 35 %
- Environmental score: 5 to 10%. Ecoscore of at least 65 for passenger cars and light freight vehicles (<3.5ton).

Involvement in the FIRED-uP project gives Ghent the opportunity to continue our search for the most innovative products possible, in this case in the segment of emergency vehicles, without compromising operations. In the coming years the Ghent Fire Brigade will grow into a bigger zone, as the fire brigades in the whole region of east-Flanders are due to merge into one large zone. The innovations developed and procured as a result of this project will therefore go further than the borders of Ghent.

1.3 INNOVATION AND RISK

The purpose of the project is to enable procurement of innovative solutions in a way which meets the needs of the partners and may be replicated by other fire and rescue services. The project is being supported by the European Commission as part of a pilot to encourage public procurement of innovation. It is therefore essential to have an understanding of what is meant by innovation in this context. According to the Oslo Manual:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."[3]

In the context of the FIRED-uP project, this is understood to mean:

- The solution must be new to whichever of the partners is procuring it
- It may consist of technology or processes which are already in use elsewhere, but which have not yet been adopted by fire and rescue services or have not yet attained commercial scale in this context
- The market consultation, specification development and procurement exercises must be conducted in a way which does not exclude small or new operators
- The approach to intellectual property, payments and other contractual terms should be innovation-friendly, in line with European and international good practice

From an operational perspective, the ability to adopt innovative solutions within the fleet depends upon the level of risk involved. Potential sources of risk for both partners in the context of this project will be assessed throughout the project using an agreed framework. Approaches to risk management – through choice of procurement approach, supplier engagement, research and development, testing and prototypes and contract design and management – are explored in the project guidance framework entitled *Risk Management in the Procurement of Innovation*.

As noted above, both partners have some experience in the procurement or piloting of innovative solutions aimed at reducing the environmental impact of their vehicle fleets. LFB uses output-based specifications to define requirements under its main fleet contract, which also includes a technology refresh clause. It has run pilot projects to introduce liquefied petroleum gas (LPG) and a 5% biofuel blend for its frontline fleet, and commissioned detailed research on the use of electric vehicles.

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[3] OECD/Eurostat (2005) (Oslo Manual: Guidelines For Collecting And Interpreting Innovation Data, 2005)3rd Edition, pg 46.

The political framework of the City of Ghent assures a high level of support for innovative procurement. Although City of Ghent is a strong supporter of innovative solutions, the city recognises that procuring innovation is often hindered by regulations. Any deviation from regulation falls under the responsibility of the procuring entity. For fire and rescue services, there are particular concerns about reliability and adequate performance in emergency situations. Therefore it is fundamental to find consensus between innovation and safety regulations**.** Compliance with safety regulations cannot be jeopardised or compromised in any circumstance.

A more detailed consideration of the partners' needs and the methodology to identify and procure solutions is given in the next section. Section 3 sets out the approach to measuring environmental impacts which will inform decisions under the project. Section 4 identifies the partners' key operational priorities and timelines for procurement. Section 5 provides a survey of potential technological areas of focus (the long-list). Section 6 sets out the management decision process and what is needed to make a business case in favour of any proposed solution(s).

2 METHODOLOGY

2.1 NEEDS ASSESSMENT

The primary needs addressed by this project for both partners are to:

1. Reduce emissions of greenhouse gases and air pollutants associated with our frontline fleets, and promote the efficient use of natural resources.

2. Reduce fossil fuel consumption and the costs and risks associated with this.

Secondary needs include:

3. Improve the quality of data on vehicle environmental performance.

4. Improve our ability to adopt innovative solutions and engage with suppliers.

5. Anticipate future developments in fleet requirements and plan for these.

These needs arise both from the existing organisational policies and targets described above, and broader commitments (local, national, EU, international) to sustainable developmentand innovation.

EXPLANATION OF NEEDS

1. REDUCE EMISSIONS OF GREENHOUSE GASES AND AIR POLLUTANTS ASSOCIATED WITH OUR FRONTLINE FLEETS, AND PROMOTE THE EFFICIENT USE OF NATURAL RESOURCES.

EMISSIONS

The introduction of progressively tighter vehicle standards such as EURO V is reducing the tailpipe emissions from individual vehicles. However the size of fleets, usage patterns and emissions from other stages in the vehicle life-cycle mean that a significant carbon footprint still exists. Emissions of greenhouse gases and particulate matter occur in the design, manufacture, delivery, use and end-of-life of vehicles (referred to as the vehicle cycle) and the extraction, refining and transportation of fuels (referred to as the fuel cycle). Road transport alone contributes about one-fifth of the EU's total emissions of carbon dioxide (CO_2) and about 40% of its emissions of nitrogen oxides (NOx). Greenhouse gas emissions from transport increased 36% between 1990 and 2007. This increase has happened despite improved vehicle efficiency, because the amount of personal and freight transport has increased. In 2010, greenhouse gas emissions decreased in all of the main sectors *except* transport.[4] Decreasing emissions from transport requires behaviour change as well as improvements in technologies and infrastructure.

CO_2 and other greenhouse gases are widely agreed to be the primary cause of climate change linked to human activity. According to current models, unchecked emissions will result in average global temperatures rising by up to 6^{o}c by the end of the century, along with rising sea levels, an increase

[4] Source: European Commission, Directorate-General for Mobility and Transport website (visited Nov 2012)

in extreme weather events and loss of habitat and food security. Although CO_2 is the most common greenhouse gas, other emissions such as NOx also have damaging effects on the atmosphere and human health. Particulate matter causes negative respiratory and cardiovascular health effects. It is in the interest of fire brigades, particularly those operating in urban areas, to protect the health and wellbeing of staff and citizens. It is also in our interest to contribute to efforts to limit the extent of human-made climate change, by actively decreasing the volume of greenhouse gas emissions associated with our operations.

In London, it is expected that climate change will result in increasing vulnerability to floods, droughts and heat waves.[5] Summer rainfall in the capital is expected to decrease by 18%[6] whilst demand for energy and water increases with population growth and lifestyles. This is likely to result in longer periods of water shortages and drought, possibly leading to restrictions on use and a fall in London's water pressure. Prolonged periods of hot weather may increase the risk of fire, especially in open grassland and along railway tracks. Conversely, winter rainfall is expected to increase by 15%,[6] increasing the risk of fluvial and surface water flooding. Based on these trends, LFB anticipates that the types of incident that we respond are unlikely to change, but there is likely to be an increase in the frequency, severity and scale of the incidents. The challenge is to maintain our emergency response service, while also being well prepared to manage the impacts of such events on our own infrastructure.

The City of Ghent wants to play an active role in the fight against climate change and its consequences. The city has established the 'Climate Alliance'; through this instrument the city wants its political leaders, citizens and organisations to undergo a transitional process and rethink the functioning of (urban) society in order to become a climate neutral city, less dependent on fossil fuels, that can offer an increased quality of life and work. In 2012 the City of Ghent received the EUROCITIES award recognising its outstanding achievements in developing and implementing innovative measures to engage citizens in the fight against climate change and the political process. Since more detailed information on the efforts of the city are out of the scope of this report we recommend to make contact for further information.

Vehicle use accounts for 26% (4568 tonnes) of LFB's total CO_2 emissions for 2011-2012[7], and 8% (2170 tonnes) of the City of Ghent's total CO_2 emissions for 2009.[8]

NATURAL RESOURCES

Significant volumes of raw materials, water and energy are used to produce, operate and dispose of fire and rescue service vehicles and their components. This covers everything from the sourcing of metals for body and chassis construction, through to the oils and finishes used, water for pumping and maintenance of vehicles, and disposal or recycling of old tyres or other components. Many of

[5] Delivering London's Energy Future, Greater London Authority (2011)
[6] Sustainable Development Strategy 2009 – 12, London Fire Brigade (2009)
[7] LFB (2012) Sustainable Development Annual Report 2011-12
[8] In Ghent's case, 'vehicle use' includes the city services, police and fire brigade and total emissions comprises commuting of employees, private fleet, garbage collection, business trips, public lighting and energy consumption of buildings. For LFB vehicle use includes fleet and lease vehicles, and total emissions comprises vehicle use, buildings and air travel.

these materials are non-renewable and cause air, soil or water pollution. Others, such as water, present significant challenges in the urban environment which can be costly to manage. Resource efficiency is a concept which means using the Earth's limited resources in a sustainable manner while minimising impacts on the environment. In most cases, this means that the material and energy intensity of goods and services should be reduced, or non-renewable resources replaced with sustainably managed renewable ones. In the context of fire brigades, resource efficiency has particular importance in terms of operational resilience (continuity of service) and cost reductions.

Neither LFB nor Ghent have precise measurements of fleet water consumption. However it is possible to estimate water consumption based on the average number of different types of intervention, pumping time and hose type. Ghent has estimated between 4 750 000 and 7 600 000 litres (4750 – 7600 m^3)of water consumption for 2012. Frequent vehicle washing adds to the volume of clean water used for each vehicle. In addition to the consumption of clean water, runoff of contaminated water is amongst the environmental impacts of firefighting. Improvements to the way water is used, and the amount of water used, can help limit the environmental detriment caused by runoff.

Tyre consumption is another aspect of fleet operations with heavy resource usage, as well as impacts on greenhouse gas emissions and fuel consumption. Silica, natural or synthetic rubber, black coal and steel are all used in tyre production, as well as energy from fossil fuels and water. Most of these materials are non-renewable and many can be toxic. While the vast majority of post-consumer tyres are now diverted from landfill, there is still an environmental footprint associated with end-of-life treatments. The cost of tyres includes a levy for end-of-life handling. Tyres which are sufficiently intact are suitable for the resale market while others are eligible for retreading. Tyres not suitable for reuse are recycled. The rubber is either recycled (material recovery) or used as a source of energy (energy recovery). Each of these treatment options implies its own environmental footprint and costs.

The environmental footprint of our fleets goes far beyond tailpipe emissions and includes upstream and end-of-life emissions, energy, water and raw material use. Many of these impacts could be addressed by designing a 'greener fire appliance' suitable for use within our fleets.

Consumption of raw materials, energy and water forms part of the environmental footprint of our fleets. More efficient use of these resources and substitution of more sustainable alternatives can save costs and reduce life-cycle impacts.

2. REDUCING FOSSIL FUEL CONSUMPTION AND THE ASSOCIATED COSTS AND RISKS.

Energy security is defined as the availability of sufficient, affordable and sustainable energy supplies. Use of fossil fuels is expensive and creates dependency on supply chains which are vulnerable to external shocks. Use of electricity, biofuels or other non-fossil-fuel propulsion is likely to become more secure over time, due to increased contributions from renewable technology production.[9] Costs for alternative fuels and propulsion technology are also expected to decrease significantly over

[9] Hill, N., Brannigan, C.; Smokers, R.; Schroten, A., van Essen, H., and Skinner, I. (2012) *Developing a better understanding of the secondary impacts and key sensitivities for the decarbonisation of the EU's transport sector by 2050*. Final project report available at www.eutransportghg2050.eu. Pages viii and 34.

the next 5-10 years. Conversely, the UK Department of Energy & Climate Change forecasts an increase in oil prices of 14% in real terms by 2025, excluding the impact of any tax increases.[10]

Diesel fuel is reliable in the short-to-medium term but its advantages in the future are uncertain, as alternative fuel sources become cheaper, better-performing and more readily accessible. Excessive reliance on one form of fuel, diesel, makes fire brigades less resilient in case of supply shocks. At the same time, there are certain advantages associated with the use of commonly available fuels such as diesel. Supply chains and refuelling infrastructure are well-developed and diesel performs well to meet operational needs. As noted above, diesel offers relatively higher fuel efficiency and lower CO_2 emissions when compared to petrol, and exhaust abatement technologies reduce other emissions significantly. Costs however are high – at LFB some £2 million[11] (€2.49 million) is spent annually on diesel via station tanks and fuel cards and Ghent spends approximately €230,000 annually on diesel. Tax and other incentives are available to support the switch to alternative fuels which have a better environmental profile than diesel and may offer greater resilience for fire and rescue services in the long-term.

LFB's fleet consumes approximately 1.5 million litres of diesel per year[12] and Ghent approximately 158,000 litres. The costs, risks and emissions linked to this heavy reliance on diesel can be reduced by investing in more efficient vehicles, alternative fuels, smaller fleets or changes in vehicle use.

3. IMPROVING THE QUALITY OF DATA ON VEHICLE ENVIRONMENTAL PERFORMANCE.

Both partners have identified a need for more comprehensive data on the environmental performance of our fleets. The role of this data would be to:

- Assess the overall environmental impact of our fleets and the effect of any proposed changes, including embedded emissions and resources and end-of-life impacts
- Measure actual environmental performance against key indicators, as opposed to making assumptions based on engine type
- Identify areas where performance falls below contractual or regulatory expectations
- Understand how vehicle usage, operator behaviour and other factors affect environmental performance
- Make the case for continuous improvements in performance.

To date, improvement in the environmental performance of vehicles has largely been driven by regulatory requirements (in LFB's case) or by political commitments and comparative assessment of the environmental performance of vehicles in tender procedures (Ghent). While these approaches have led to tangible reductions in CO_2 emissions, other environmental and economic impacts associated with vehicles have not been targeted in a comprehensive manner. In particular, several types of data are missing which would allow for a more systematic approach:

- Comprehensive data on fuel usage and costs, broken down by vehicle type
- Information on non-CO_2 emissions, especially NOx and particulate matter

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[10] DECC (2012) Oil Price Projections, central scenario, October 2012.
[11] Estimates based on supplier data and fuel card analysis
[12] LFB (2012) LFB Sustainable Development Annual Report 2011-12

- Data on how operator behaviour affects environmental performance, including use of pumps, braking, and idling time
- Information which may help identify logistical efficiencies in vehicle management

Accurate and comprehensive data will help both in identifying the most important areas of focus for environmental improvements and in making the business case for innovation.

We are missing reliable and comprehensive data on the environment footprint of our fleets. This makes it more difficult to assess proposed changes to the composition or operation of the fleet and track our performance over time. High-quality data can help to drive environmental improvements while maintaining other operational targets.

4. IMPROVE THE ABILITY OF THE BRIGADES TO ADOPT INNOVATIVE SOLUTIONS AND ENGAGE WITH SUPPLIERS.

The vehicles sector is research and development intensive. Manufacturers of vehicles and components invest heavily in developing, testing and bringing new technologies to market. Many of these technologies aim to deliver better environmental performance in terms of emissions and fuel efficiency. Fire and rescue service vehicles represent a relatively small segment of the market, however the potential for demand-driven innovation exists if future needs are clearly communicated to the market. Where possible, brigades should engage with suppliers at any early stage to allow adequate time for new technologies and processes to be developed, tested and rolled out. This process is complicated by the need to ensure competition and transparency under the public sector procurement rules. Existing contracts and a lack of resources or concerns about risk may also contribute to a reluctance to engage.

Approaches such as forward commitment procurement (FCP), use of the competitive dialogue and phased contracts or frameworks may allow innovation to be captured and applied by the brigade. Experiences with these procedures amongst other public authorities are being studied, and the partners will launch their own market engagement and procurement procedures within the project.

The FIRED-uP project will identify processes for market engagement and procurement which can be used by the partners to capture innovation for future requirements. These processes should be transferable to other procurement categories and to other public authorities in Europe.

Relationships with suppliers are key to how the brigades operate, and the market offers solutions to many of the challenges we face. FIRED-uP will develop new means of engaging with suppliers to help capture innovation while maintaining value-for-money and legal compliance in procurement.

5. ANTICIPATE FUTURE DEVELOPMENTS IN FLEET REQUIREMENTS AND PLAN FOR THESE.

Anticipating operational and regulatory developments allows future operations to be accurately planned and budgeted. Adaptation to climate change requires fleets which are able to respond to changed conditions and ensure continuity of service. Advance knowledge of R&D in the vehicles market and promising technologies can feed into procurement and replacement programmes. The relatively long lifespans and planning horizons associated with replacement of fire and rescue service vehicles means that there is a distinct advantage in anticipating future requirements at an early stage. Even if it is not feasible to purchase certain innovative solutions within the project period, advanced knowledge of the market, more sophisticated data on the life-cycle environmental impact and costs associated with vehicles, and enhanced capacity to engage constructively with suppliers are expected to result.

The outputs of the FIRED-uP project will form a valuable resource for fleet planning and contribute to upcoming tenders both during and after the project period. The process of evaluating environmental impacts will build knowledge and capacity within the brigades and their suppliers to address future environmental issues, including adaptation to climate change.

The need to improve environmental performance is currently driving many developments in the vehicles sector. The ability to critically assess these developments and relate them to our own organisational priorities will be a key output of the FIRED-uP project.

2.2 RESEARCH

The literature surrounding greenhouse gas emissions and other environmental impacts associated with vehicles is vast. During the early stages of the project, it was necessary to gain an overview of which aspects of this literature may be most relevant, without narrowing the scope of research unduly. One of the features of projects targeting innovation is that the precise nature of the solutions is not known. In particular, it is desirable to include emerging or little-known technologies and processes, as well as those which have already been adopted in other sectors. The scope of research is thus not limited to technologies or processes which are in development for, or have been applied by, fire and rescue services.

However there are certain operational features of fire and rescue service vehicles which limit the transferability of technologies designed to reduce emissions or fuel consumption in other types of heavy duty vehicles (HDVs). For example, emergency braking requirements mean that certain types of low rolling resistance tyres are not suitable, and the preponderance of urban driving means that aerodynamic design will not generally make a major contribution to the efficiency of vehicles. Operational requirements – notably the need for most fire and rescue service vehicles to be available at all times and perform multiple functions – make recharging and refuelling less flexible than for other vehicles. This means that some of the more 'obvious' ways of reducing fleet environmental footprint are not applicable to fire and rescue services. In other cases, technologies or processes which are applicable to other HDVs may be relevant if certain adaptations are made.

The expert advisory group met on 5th April 2013 to review the research carried out and assess the relevance of the surveyed technologies to LFB and Ghent's respective needs. Members from other FRS also presented their own experiences in respect of the technologies. An informal scoring process was used to evaluate options with regard to the environmental case, business case, feasibility within the project and potential for innovation. It was clear that a combination of technological measures was likely to result in the greatest gains, with a strong need for further data to support changes.

With these parameters in mind, research was carried out into a range of technologies and processes with the potential to reduce fleet environmental footprint. This preliminary report will be updated as further relevant research is published during the lifetime of the project. The following table summarises the areas of focus during the initial research phase and the main sources used in respect of each of these areas. Full citations are provided at the end of this report.

Area of research focus	Sources reviewed
Environmental impact of vehicles (general)	Clean Vehicle Portal; GLA group; Transport for London; AECC Newsletter; Transport GHG 2050 Final Project Report (2012); Ecoscore (VITO); SMART-SPP LCC-CO_2 tool; Energy Saving Trust; Transport and Environment; London Air Quality Network; US Environmental Protection Agency; Low Carbon Vehicle Partnership; AEA-Ricardo RAC report *Powering Ahead* (2013)
Alternative fuels and propulsion	TfL Alternative Fuels Strategic Analysis (2010); Royal Society Sustainable Biofuels report (2008); Review of Low Carbon Technologies for HGVs (2009); Green Fire Trucks: Is Biodiesel a Feasible Option?; Hydrogen Vehicles: Information Resource; Alternative Fuels Data Center (U.S.); London Borough of Camden *A Life Cycle Assessment of Alternative Fuels for Public Service Vehicles;* Pre-study on the Impact of Introducing Electric Vehicles in the City of Ghent Fleet (2011); Plugged-in Fleets Electric Vehicle Report for London Fire Brigade (2012); Verhelst & Wallner (2009) *Hydrogen -fueled internal combustion engines*
Chassis/body construction and materials	Testing and procurement by Manchester FRS of light-weight body construction; Dublin Fire Brigade investigation of ultra-hard plastic chassis.
Power management systems	EPA Regulatory Impact Assessment 2011; Intelligent Vehicle Power Management using Machine Learning and Fuzzy Logic (2008); Expert advisory group discussions
Particle filters/exhaust treatment	Review of Bus Fleet Compositions and Implications for Emissions Reduction Strategies (2009); LFB internal data
Pumps and flow meters	*Fire & Rescue Service Under Pressure: Time to go with the flow?;* Laois County FRS *Report on the Use of Flow Meters*; Nottinghamshire FRS decision on flow meters (2010); www.fireresearch.com; Recent patent applications.
Magnets	N410a Magnet Technology for Dublin Fire Brigade Fleet Fuel Optimisation (2012); Advisory group discussions
Tyres	Innovation in Truck Technologies— *Discussion Paper 2010-10* — OECD/ITF; Ecolane tyre carbon footprint; Continental LCA study on tyres (1999); Shulman, V. *Tyre Recycling in the EU* (2007); EU GPP criteria for transport (2012).
Lights	Recent patent applications for emergency services lighting; www.fireresearch.com; LFB internal documents.
Finishes and oils	Environment Agency Commodity Sustainability Briefing Document (2003); EU GPP criteria for transport (2012).
On-vehicle data collection	Discussions with suppliers at Emergency Services Show 2012; *Data management and data collection techniques for sustainable distribution* (2009); survey of supplier websites.
Software for logistical/environmental analysis	Green Logistics; COPERT 4 (free download); Cummins idling-reduction modelling tool; survey of supplier websites; Marginal abatement cost curves for HDVs (Delft, 2012).
Operator behaviour	Eco-driving resources; Blue Tree case studies; Civitas Elan report on City Fleet Management (2011)
Vehicle size and load	Innovation in Truck Technologies— *Discussion Paper 2010-10* — OECD/ITF; LFB and Ghent internal documents.
Test cycles	TEDDIE: A new roadworthiness emission test for diesel vehicles involving NO, NO_2 and PM measurements; Transport & Environment report 2013
Lifing policies/ end-of-life	LFB/Ghent internal documents

2.3 INTERNAL CONSULTATIONS

Both LFB and Ghent are undertaking internal consultations as part of the needs assessment and initial research phases of the project. In LFB's case, an internal project group has been formed involving Brigade staff from different sections. This brings together expertise and experience relating to operations, engineering and fleet management, sustainable development, procurement and contract management. Both formal and informal communication and meetings have taken place with this group, in order to maximise the flow of information relevant to the project. Group members are invited to attend external meetings with project partners and workshops. This will ensure on-going involvement in the project's direction and execution.

The project group has been a major source of ideas for the long list of innovative technologies and processes set out in section 5. In addition, a broader consultation is being carried out with operational fire fighters and officers based at stations. This is being done via the existing 'Green Champions' network, by using LFB's internal communications system and with assistance from Third Officer Dave Brown. Visits will be made by the project team to interested fire stations, where ideas for improving the environmental performance of vehicles via their design, use and maintenance will be discussed.

Ghent's needs assessment, a direct consultation with end-users (operational level) and technical experts, will come up with a list of parameters to help define functional needs and identify innovation opportunities from users' and experts' perspectives. Information on innovation opportunities will be gathered on the basis of different brainstorming sessions with operational experts and users. Subsequently the feasibility of the users' and experts' proposed solutions will be assessed by means of a market consultation.

The method used for the research in Ghent will be conducted by an expert team of consultants with ample experience in this field. City of Ghent will report on the procedures used and will compare its methods and findings with those of the LFB.

2.4 EXPERT ADVISORY GROUP

An expert advisory group has been appointed, to offer input into the project throughout its lifetime. The group will serve as a source of ideas and as a sounding board for the project. The members have considerable expertise in the field of fire/emergency services and vehicle procurement. The members are listed below and have been included in the project having shown an initial interest in the work of Fired-uP (non - exhaustive list).

Name	Title	Organisation
John Collier	Head of Engineering & Technical Services	Greater Manchester Fire & Rescue Service
Neil McCabe	Green Plan Manager	Dublin Fire Brigade
Tom Burke	Assistant Chief Fire Officer	Clare County Fire & Rescue Service
Janusz Wozniak	Deputy Head of Technical Department	Fire Service of Torun, Poland
Brian Price	Professor of Engineering	Aston University
Peter Vanspauwen	Captain	Fire Brigade zone Antwerp

Members will be invited to comment on draft documents and to attend meetings and workshops as appropriate. Members of the expert advisory group will be asked to present any similar initiatives on innovation and environmental performance undertaken in their organisations and the results.

2.5 MARKET ENGAGEMENT

The next phase after the initial research is completed involves consultation and engagement with suppliers. The purpose is to allow greater scrutiny of innovative technologies and their potential applications within the LFB and Ghent. It will also be an opportunity to inform existing and new suppliers of the needs identified under the project and how these link to upcoming procurements. A number of different approaches to market engagement and procurement are being analysed, with case studies collected and buyers and suppliers who have direct experience of different procedures asked to comment on them. This information will be brought together in the document "*Risk Management in the Procurement of Innovation: Guidance for the FIRED-uP Project*" being drafted under Work Package 3.

Based on this document, strategies for market engagement within the project will be agreed. This may focus on one or more of the technological/process areas identified in Section 5, or may be related to overall vehicle specification, leaving room for suppliers to submit innovative ideas to improve environmental performance under any heading. LFB and Ghent will conduct separate market engagement activities but cooperate actively to share methods and results. The market engagement activities are expected to lead to the development and testing of seed vehicles or components within the project lifetime. They may also contribute directly to procurement as part of LFB's fleet service contractor replacement and in Ghent the possible procurement of a new second line logistic vehicle with modular functions and specifications determined by the needs assessment and the market consultation phase.

The City of Ghent has identified potential innovation areas for a new method of engagement (see Section 6.1.2) which will enable it to inform the market at an early stage of its upcoming needs. Potential suppliers will be informed in advance of upcoming procurement activity by means of:

- A Prior Information Notice which will be published before starting a needs assessment
- The FIRED-uP website (www.fired-up.eu/)
- Attendance at seminars
- Holding workshops for interested suppliers

Since the nature of this call involves brand new procurement methods at a very early stage and since the procurement of innovation involves high risks, the City of Ghent will engage skilled experts with ample experience in this field, to support internal expert staff and project team members. Engaging external experts will help to ensure equal evaluation of the tenders and their preparation.

The market consultation will collect information on potential alternative solutions for frontline appliances and technical developments which are near market readiness. This will enable Ghent to categorize the end-users desired innovation, which gives information on the risks and value associated with the innovation. The areas of technical focus and procurement strategy will be determined based on the needs assessment and the market consultation.

2.6 SPECIFICATION DEVELOPMENT

Fired up is part of a wider procurement programme for vehicles and equipment. The project results will need to feed into this procurement programme at LFB. In order to incorporate innovative technologies/processes into fire and rescue service vehicles the general specifications for vehicles and equipment must be developed which either explicitly include these technologies or allow room for them to be offered. An output-based specification (OBS) for a pumping appliance of the type used by LFB in its fleet and equipment contract is currently being drafted to reflect the project focus and approach.

An example of the type of requirement included in this OBS is:

> "Power systems
>
> Using innovative solutions all power systems must minimise the use of fuel/power, minimise harmful emissions and maximise the use of renewable power sources. Power systems controls and user interfaces must not only meet the operating and performance requirements but also provide intuitive, easy to understand and easy to operate functions that positively encourage or demand that the use of the systems will minimise power use and consumption."

Each requirement of the OBS is accompanied by assessment criteria. This is expected to lead to further development of specifications later in the project period, reflecting the outcome of the market engagement activities. A 'challenge process' whereby industry or other experts are invited to review the specifications will also be undertaken within the project lifetime.

Specification development will be carried out under Work Package 4 of the project.

2.7 PROCUREMENT

Procurement strategies will be developed based on the following considerations (this is a non exhaustive list):

- Timing to coincide with existing vehicle procurement plans
- Fitness-for-purpose of the innovative solutions being targeted. If solutions are not sufficiently mature or have not been adequately tested within the project lifetime then procurement may focus on seed vehicles to pilot the technologies in operations
- Profile of market for the specific solutions targeted
- Legal compliance and value-for-money
- Ability to claim project co-finance (European Commission criteria)

Work package 5 will coordinate the procurement activities within the project. Actions under the work package include the creation of a procurement team/cell, workshops and working documents and development of evaluation criteria including an appropriate model for life-cycle/whole-life costing (LCC/WLC). Focus points in the procurement process could include, but not be limited to:

- Data collection and analysis
- Energy-efficiency of vehicle superstructure
- Resources used in the superstructure and interior (e.g. plastic, recycled materials)

- End of life-cycle: recovery and recyclability of materials
- Efficient transfer pump structure
- Life-cycle costing (LCC)

The environmental performance and innovative character of proposed solutions will be assessed as part of the contract award criteria applied in procurement. In addition, the financial cost savings associated with solutions (for example, due to fuel savings) will be assessed over the lifetime of the assets. This will be done in a transparent manner which conforms to the requirements under the EU procurement directives and Treaty.

3 MEASURING THE ENVIRONMENTAL IMPACT OF FIRE AND RESCUE SERVICE FLEETS

3.1 EXISTING DATA

3.1.1 LFB

LFB has been collecting key data for a number of years and publishing it as part of its public sustainable development annual reporting. Some of this data has already been subject to base-lining, including against London Mayoral targets and Global Reporting Initiative guidelines. Specifically, LFB has reduced carbon emissions by over 28% from 1990 levels, above and ahead of the Mayor's target of 22% by 2015 and is now aiming to reduce carbon emissions by a further 4% by 2015/16 for a total reduction of 32% against 1990 levels[13].

The purpose of measuring this key data and undertaking a base-lining exercise is to give a snapshot of LFB activity, costs and our environmental impact with a view to supporting our sustainability strategy, contributing to a cleaner London and improving operational efficiency. From a wider perspective, this should allow LFB to support the Mayor's strategy and reduce emissions. There is currently a lack of accurate data for base-lining in a number of areas and LFB would like to implement solutions to improve the methodology for data collection and analysis.

Our pumping appliances are currently given a life of 12 years under the fleet and equipment contract. The fleet has undergone an accelerated programme of upgrades to meet the London Low Emission Zone (LEZ) requirements at considerable cost to the Authority. Before the end of 2012, an upgrade was required to some 75% of the fleet to meet 2012 LEZ requirements (Euro IV for particulate matter). The proposed 2015 LEZ requirements (Euro IV for nitrogen oxide) could also see a further need to upgrade a large proportion of the fleet.

EMISSIONS

The figures below provide the CO_2 emission levels and reductions across the Brigade and include buildings, fleet and air travel.

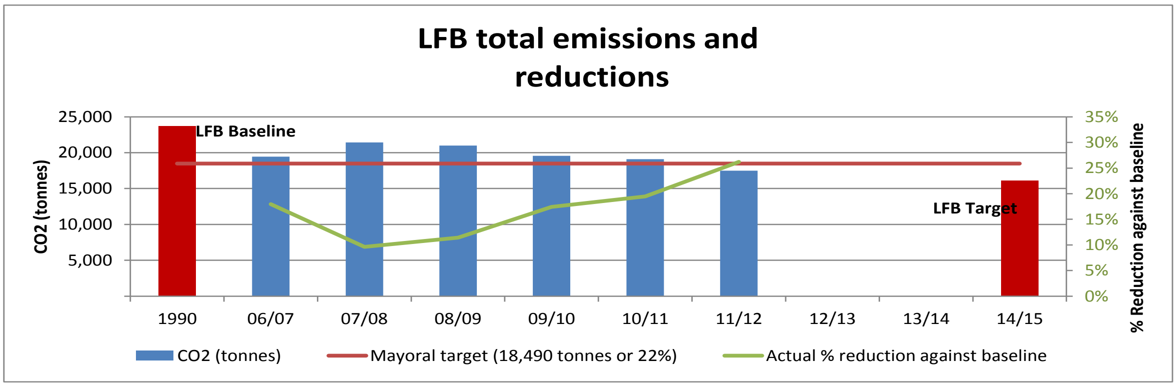


Figure 1: LFB total emissions and reductions[14]

[13] LFB (2013) LFB Sustainable Development Strategy 2013 - 2016
[14] LFB (2012) LFB Sustainable Development Annual Report 2011-12

For the fleet, LFB has some more specific baselines concerning emissions, fuel consumption and particulates, although we acknowledge that there are potential gaps in this data and its accuracy. The figures below are based on the DEFRA conversion rates for CO_2 from fuel production only and do not include tailpipe emissions or other greenhouse gases (GHGs). The targets are applicable for London wide and, as a London body, LFB is responsible for a proportion and this has been projected here for an indication of potential reduction.

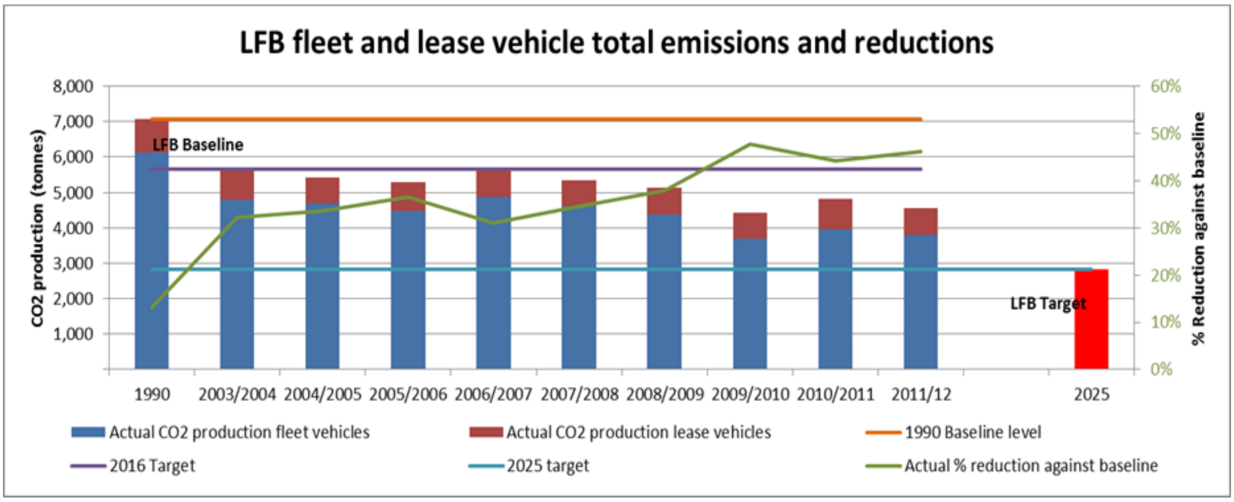


Figure 2: LFB fleet and lease vehicle total emissions and reductions

PARTICULATES

LFB does not measure the particulates emitted from fleet vehicles, they are each checked annually for PM and NOx opacity. However, each vehicle has been sourced or retrofitted with equipment to meet LEZ standards, which bring the particulate matter (PM) *opacity* levels below recognised VOSA (Vehicle & Operator Services Agency) standards, as demonstrated in the following chart:

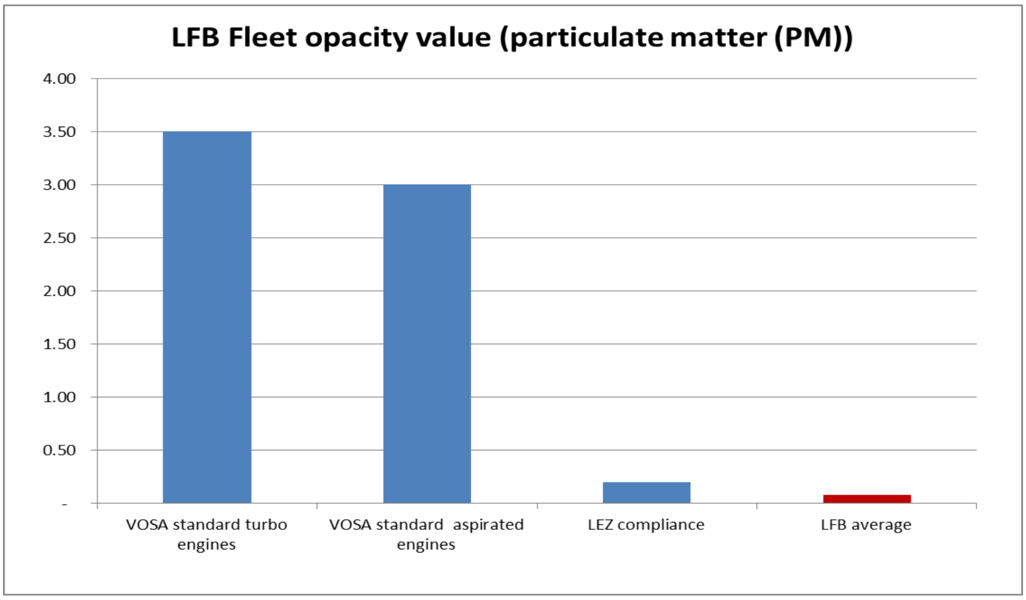


Figure 3: LFB fleet opacity value

FUEL COSTS

It is difficult for LFB to provide a base-line going forward for the costs of fuel due to price fluctuations; however we can provide data for the actual annual costs. Fire fighting staff and officers have two means to fuel vehicles, either by using tanks on station, which are filled by a supplier, or filling up at fuel stations using LFB issued fuel cards. The following chart shows the annual costs of fuel to the Brigade for the last four years:

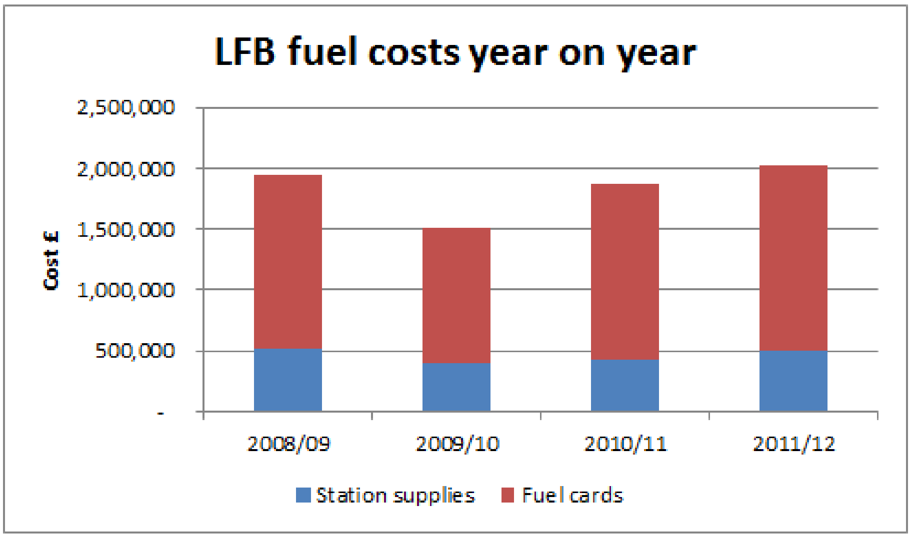


Figure 4: LFB fuel costs year on year

FUEL USAGE

The following chart indicates the annual diesel usage, however, the accuracy of these figures cannot be guaranteed and they should be taken as indicative only:

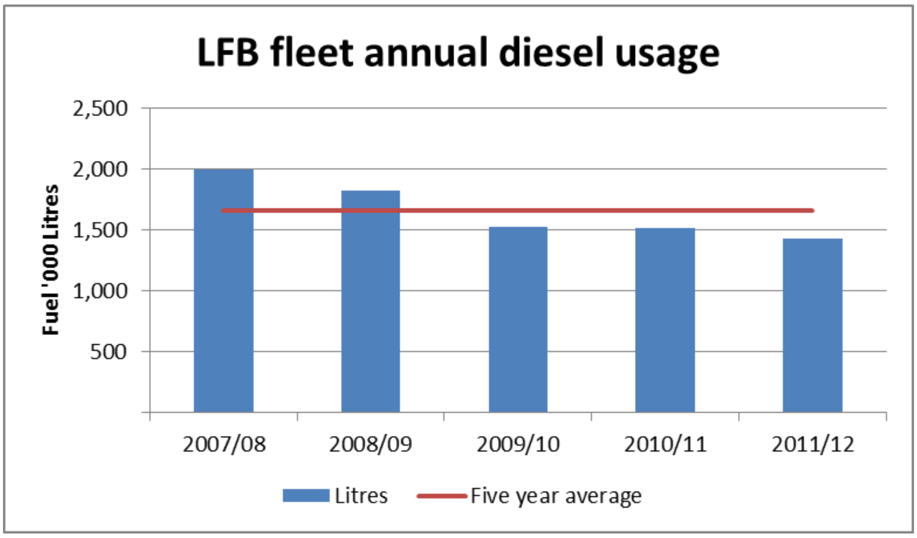


Figure 5: LFB fleet annual diesel usage[15]

Explanatory notes: These baseline figures have been sourced from several datasets including supplier records, annual invoices and costs, service records and externally published material from UK government sources and the veracity of all the figures can not be guaranteed.

[15] LFB (2012) LFB Sustainable Development Annual Report 2011-12

3.1.2 GHENT

The City of Ghent signed the European Covenant of Mayors in 2009 committing it to curb its CO_2 emissions by 20% by the EU 2020 target. This commitment was implemented at local level by means of the local strategic plans “Gent 2020” and “the local air-quality plan 2010-2015”.

In October 2008 the Council approved the Ghent Local Climate Plan (2008-2020) containing following ambitions:

1. For the city organisation: Energy Plan 2008-2013
    - Reduction of energy use by 2013 by 10% compared to 2003
      (or 1,83 million kWh electricity, 8,8 million kWh heating for buildings and 1,56 million kWh for public lighting).
    - Reduction of CO_2 by 50% by 2013 compared to 2003
    - Increase of renewable energy by 40% compared to 2003
    - By 2020, an energy reduction of 20%, a CO_2 reduction of 60% and 50% more renewable energy compared to 2003
    - By 2020 all new buildings should be CO_2 neutral
    - Self-reliance for the production of electricity

2. Ambitions for the City of Ghent:
    - By 2020 an energy reduction of 20% compared to 2007
    - By 2020 a CO_2 reduction of 20% compared to 2007

EMISSIONS

In order to support and monitor policies on climate change, it is crucial to have current and reliable facts and figures. In 2009 Ghent was the first city in Flanders to provide a CO_2 baseline of 2007. The city recorded the emissions of 1990 as well in order to get a clearer picture of the evolution and to be able to benchmark with cities using 1990 as a baseline. Moreover the future emissions in 2050 were estimated in order to obtain a more accurate view on the challenge of becoming climate neutral. The baseline does not contain other GHG. Total figures increase by 7% if other GHG are taken into consideration. A section of the results of the CO_2 baseline is shown below.

The table below gives an overview of the evolution of emissions from the City of Ghent’s urban services between 2007 and 2009.

Emissions (tonnes CO_2)	2007	2009
Commuting of employees	2110	3010
Private fleet	1600	2170
Garbage collection	2100	2470
Business trips	No data available	80
Public lighting	5350	0
Energy consumption of buildings	21 000	18 870
Total	**32 160**	**26 600**

This table shows that the total emissions have fallen by 17 per cent or 5560 tonnes in 2009 compared to 2007. This decrease is mainly due to a decrease in emissions from public lighting and the use of electricity in public buildings by purchasing green electricity. The increase in emissions from commuting can be explained by an increase in the number of employees. In 2007 City of Ghent had 4224 employees, in 2009 the number of employees amounted 4947. The consumption of the own fleet has increased. The increase in emissions from waste collection can be explained by an expansion of the activities of IVAGO compared to 2007 and consequently an increase in the number of kilometres driven and the related consumption. For a complete list of Ghent's fleet figures and current emissions see annex A.

The following table gives an overview of the emissions (at the exhaust of the vehicles) of the entire fleet of the city of Ghent in 2010 (only passenger cars and light weight freight up to 3.5 ton)

Type	Fuel type	CO (kg)	Nox (kg)	PM (kg)	CO2 (ton)
Standard Car	diesel	567,4	326,9	33,1	167,9
Standard Car	hybrid	26,9	16,0	1,6	5,8
Standard Car	electric	0,0	0,0	0,0	0,0
Standard Car	petrol	1.549,5	128,6	4,2	129,9
Light Freight	diesel	1.346,5	776,7	102,1	417,3
Light Freight	hybrid	0,0	0,0	0,0	0,0
Light Freight	electric	0	0	0	0
Light Freight	petrol	2.184,9	96,0	2,8	137,3
	Car tot	**2.143,8**	**471,5**	**38,9**	**303,6**
	LF tot	**3.531,4**	**872,7**	**104,9**	**554,6**
	Total	**5.675**	**1.344**	**144**	**858**

Figure 6 emissions of the fleet at the exhaust of vehicles 2010 (study conducted under Civitas project)

FUEL COSTS

The Fire Brigade of Ghent has two means to fuel vehicles, either by using tanks located at fire stations or filling up at fuel stations using fuel cards. The following chart shows the annual costs of fuel to the Brigade for the last five years. The chart shows data on petrol and diesel. The figures of the fuel cards indicate the actual price paid. The figures for Diesel Station Supply are calculated on the basis of the average annual diesel price listed on the website of the Belgium Federal Public Service Finance. For a complete list of Ghent's fleet figures and consumption see annex A.

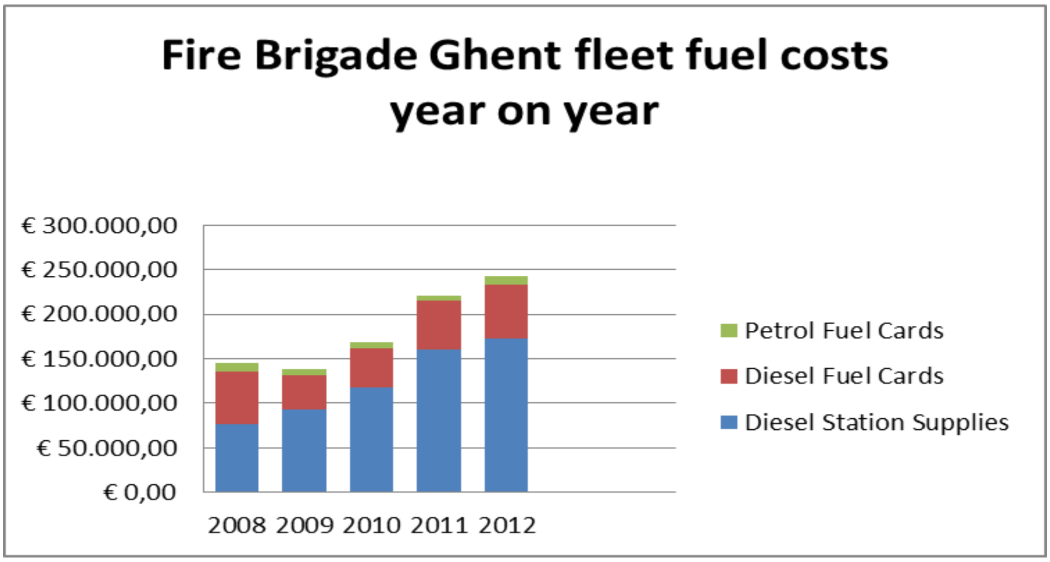


Figure 7 Ghent fleet fuel costs

Year on year, as the Fire the Brigade of Ghent fleet has expanded fuel costs have also risen drastically. In order to demonstrate this rise a table with the average annual price of diesel indicated on the website of the Belgium Federal Public Service Finance is included below.

AVERAGE ANNUAL PRICE OF DIESEL[16]	
2008	€1.2530/litre
2009	€1.0225/litre
2010	€1.2018/litre
2012	€1.4405/litre

FUEL USAGE

The following charts indicate the annual diesel usage and the annual petrol usage.

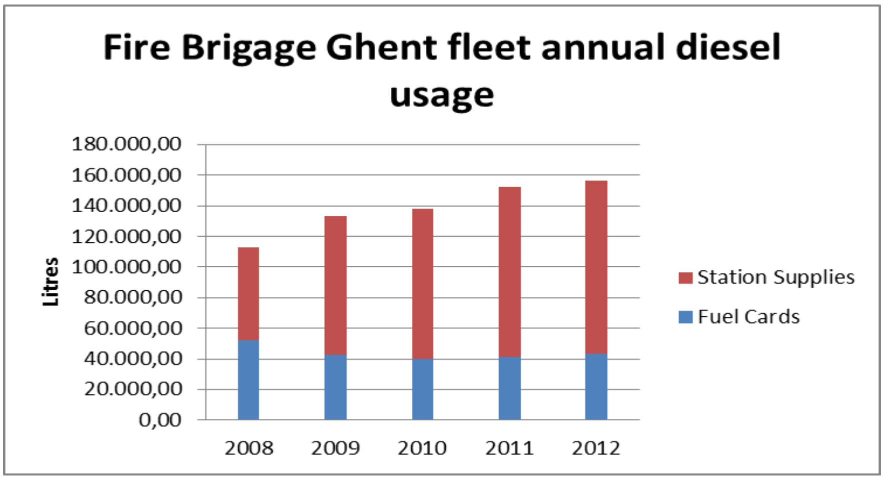


Figure 8 Ghent annual diesel usage

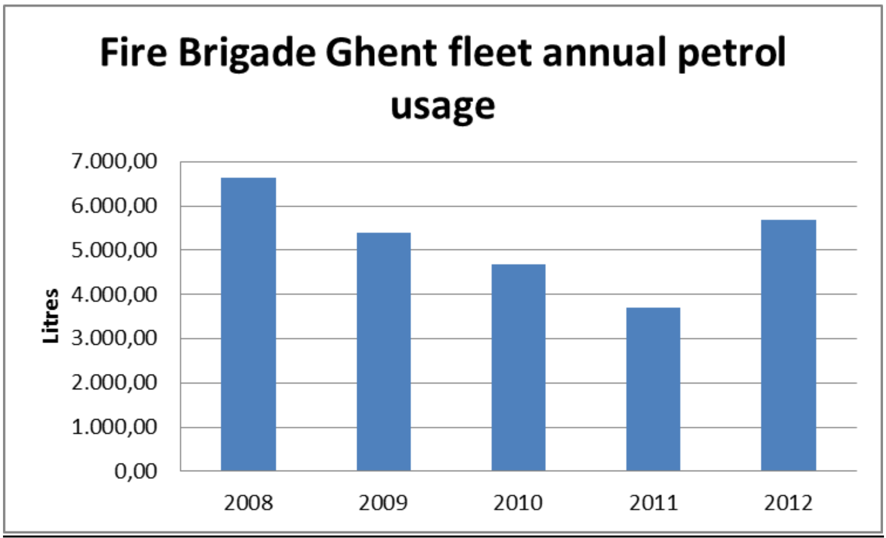


Figure 9 Ghent annual petrol usage

WATER CONSUMPTION

[16] The Figures of the average annual diesel price consulted on the website of the Belgium Federal Public Service Finance

The fire engines have several methods of pumping water onto fire, such as passing water obtained from a fire hydrant through hoses, some trucks also have an on board water reservoir. Ghent currently has no accurate figures on water consumption. A rough estimate delivers the following figures:

In 2012 there were about 950 interventions for fire and smoke development. The average time of water consumption is between 5 to 8 minutes per intervention. Estimated on the basis of the number of interventions, the total time of water consumption in 2012 amounts to approximately between 7600 and 4750 minutes. If we assume that only hoses with an inside diameter of 45-mm were used, water consumption will be at a rate of 1000l per minute, which means that the approximate usage of water in 2012 amounts around 4 750 000l and 7 600 000l.

TYRES

Recytyre is an organisation that manages tyre recycling in Belgium. When a tyre is purchased a contribution to the environment is already included in the purchase price. This environmental contribution (approximately €10.80 per tyre) covers the cost for the collection and environmentally friendly processing of waste tyres.

According to the Flemish environmental agreement for the processing of collected waste tyres, Section IV. Waste tyres, article 3.4.1 the following applies:

- All waste tyres are collected
- First the collected tyres are sorted for reusable tyres
- The sorter’s total reuse percentage, retreading and recycling of the collected waste tyres amounts to at least 55%
- The rest of the collected waste tyres are sent to be energetically valorised
- The disposal of waste tyres is not allowed

The wear and tear of the tyres is not always linear with those of the vehicle. Often tyres are assembled in an excellent state. Those tyres which are sufficiently intact are suitable for the used market and others are eligible for retreading. Tyres not suitable for reuse are recycled. The rubber is either recycled (material recovery) or is used as a source of energy (energy recovery).

The Fire Brigade of City of Ghent spends on average €1 345 on tyres a month. This figure includes: working hours, the price of new tyres, environmental contribution, wheel change summer/winter, repairs of tyres, tyre storage and insurance, counter balancing beads.

3.2 AVAILABLE MODELS AND BEST PRACTICE

In assessing the environmental impact of fire and rescue service vehicles it is sometimes difficult to know where to begin. Environmental issues are inherently complex, and there is a move to view these in the broader context of sustainability, which also includes social and economic considerations. Focusing on a single issue, such as reducing greenhouse gas emissions or improving fuel efficiency, may ignore or even worsen impacts in other categories (such as water consumption, raw material usage or particulate matter). Indirect effects, such as those on operator wellbeing or long-term economic sustainability, may not be immediately apparent. In addition, there is the question of how to measure any environmental gains achieved, whether this should be done on a per-vehicle or fleet-wide basis, and over what period of time. These complicating factors do not mean that it is not worth pursuing environmental improvements, but that a sophisticated approach must be taken to look at impacts 'in the round.'

3.2.1 LIFE-CYCLE ASSESSMENT

Full life-cycle assessment (LCA) is the gold standard for determining overall environmental impact. Two ISO standards exist setting out the principles and requirements of LCA (ISO 14040 and ISO 14044.) For vehicles, LCA should assess the environmental impacts associated both with the **fuel cycle** (primary production, extraction, transportation, refining, and vehicle operation) and the **vehicle cycle** (vehicle manufacture, assembly and disposal).[17] LCA can be costly to conduct, as it requires an inventory of impacts to be drawn up which is specific to the vehicles and fuel under analysis, their use patterns and disposal. It is thus rare for fleet operators to conduct a full LCA, for example when comparing different vehicle models. Nevertheless, the principles, inventory-making and impact assessment processes behind LCA should be kept in mind when fleet environmental footprint is examined.

One of the outputs of an LCA is an inventory showing the key impacts at each stage of the life-cycle. The relative magnitude of these impacts is then scored, and sometimes assigned a monetary value. For example, a 2006 LCA commissioned by the London Borough of Camden compared the life-cycle emissions of different vehicle fuels and technologies, for cars and light vans (CDV and panel). The GHG (greenhouse gas) and particulate emissions associated with different technologies are shown in the figures below. The figures illustrate the relative importance of different phases in the life-cycle in terms of GHG and PM (particulate matter) emissions, and the significant differences between different vehicle technologies.

The results of LCA are sometimes surprising, and do not fit neatly into existing concepts of what is 'green.' For example, in the study done for London Borough of Camden, one of the findings was that vehicle size was as important a determiner of emission impact as fuel/technology type.[17] As existing technologies become cleaner, the relative importance of the production and end-of-life phases in terms of overall emissions grows. The importance of these phases will also be higher where the use of the vehicles is relatively low, as is the case with some fire and rescue service vehicles.

[17] Lane, B. (2006) Life Cycle Assessment of Vehicle Fuels and Technologies London Borough of Camden, p 4.

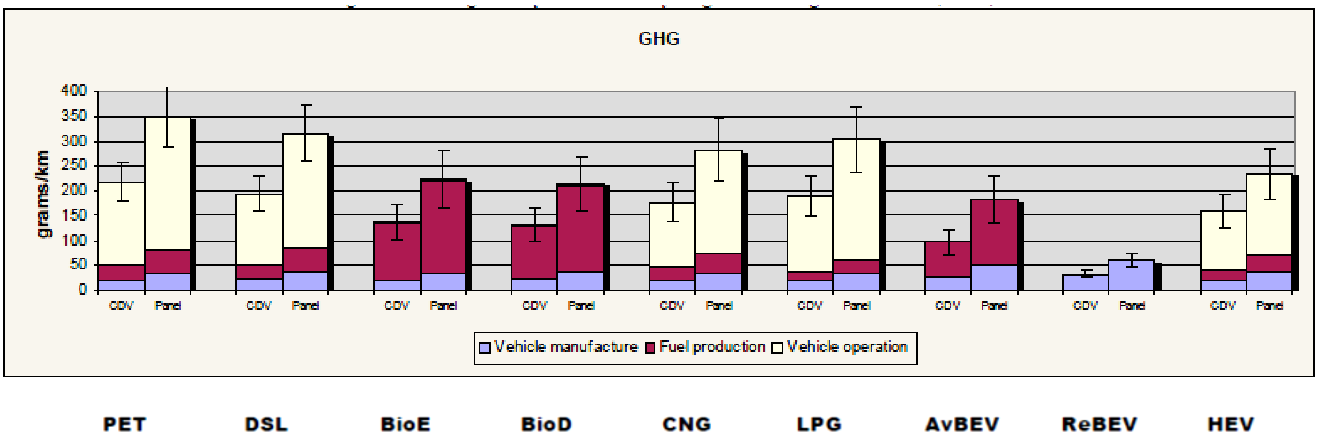


Figure 10 Light duty vans - life cycle green house gas emissions

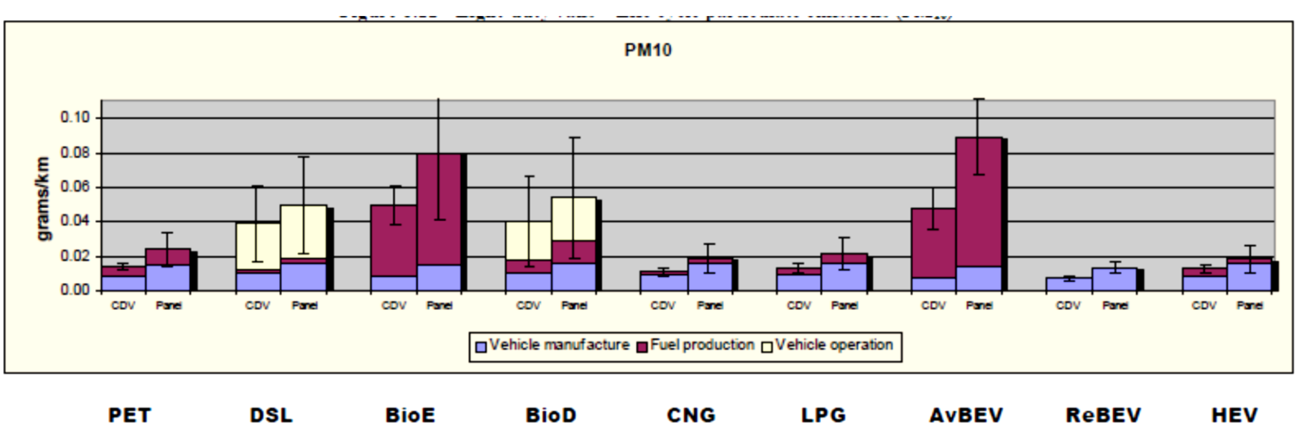


Figure 11 Light duty vans - life cycle particulate emissions (PM10)

Legend: PET = Petrol DSL = Diesel BioE = Bioethanol BioD = Biodiesel CNG = Compressed Natural Gas LPG = Liquefied Petroleum Gas AvBEV = Battery Electric, Average Mix Electricity ReBEV = Battery Electric, Renewable Electricity HEV = Petrol Hybrid

Source: Lane, B. (2006) Life Cycle Assessment of Vehicle Fuels and Technologies London Borough of Camden

If it is not feasible to conduct a full LCA when specifying fire and rescue service vehicles, a review of existing studies may help to identify the key impact headings and flag areas to be addressed.

3.2.2 LIFE-CYCLE COSTING AND PROCUREMENT TOOLS

Life-cycle costing (LCC) is an approach to calculating the total cost of owning and disposing of an asset. This may include a monetary value assigned to environmental externalities such as greenhouse gas emissions during use, and is also sometimes known as whole-life costing (WLC). LCC/WLC differ from LCA in that they include purely financial costs (such as the purchase price and operating/maintenance costs) and they do not normally assign a cost to embedded energy, emissions and materials – as these are assumed to be included in the purchase price. These features make LCC/WLC more suitable for use in procurement; however they are less comprehensive than LCA in measuring environmental impacts. LCC/WLC can be used under the current Procurement Directives (2004/17/EC and 2004/18/EC) to compare the cost of bids, including by assigning a cost to environmental externalities.

In fact the Clean Vehicles Directive (2009/33/EC) explicitly requires public authorities to take operational energy consumption and CO_2, NOx, NMHC and particulate matter emissions into account when purchasing road transport vehicles. This can either be done by setting technical specifications for energy and environmental performance, by assigning a cost to energy and emissions (i.e. as part of the award criteria) or a combination of both approaches. If the second option is chosen, the annex to the Directive provides minimum monetary values to be assigned to different types of fuel/energy and emissions. Contracting authorities may choose to assign a value up to two times higher than those provided. Fire and rescue service vehicles which are not subject to type approval requirements are exempted from these requirements under the UK and Belgian implementing legislation.[18] However the methodologies set out in the Directive may still be adopted voluntarily, with any relevant adjustments to reflect the usage patterns of fire and rescue service vehicles.

A number of LCC/WLC tools have been developed for use in the procurement of vehicles. For example, the SMART-SPP project developed and tested a free excel-based tool for use in vehicle procurement, along with other product and service types.[19] It is specifically targeted at evaluating innovative products, which are still in the phase of development and market introduction. It allows for comparison of total life-cycle costs and CO_2 emissions, using data entered by the contracting authority (e.g. mileage expectations) or by the suppliers in a tender (e.g. grams of CO_2 per kilometre). It allows comparison of up to fifteen different offers/products and a range of graphic outputs and reports. It is possible to specify the planning horizon in order to take into account the different life-span of products and include replacement costs where relevant. It is also possible to specify the drive cycle, maintenance and end-of-life costs. While the tool has not been developed specifically for procurement of emergency services vehicles, it may be adaptable for use in our planning and/or procurement.

The Ecoscore system[20] currently used by Ghent for the procurement of its municipal fleet is not a life-cycle costing tool, but is compatible with an LCC/WLC approach. It assigns a score to vehicles based on emissions of greenhouse gases (CO_2, methane, nitrous oxide) , air pollutants (carbon monoxide, hydrocarbons, nitric oxides, particulate matter, sulphur dioxide) and noise. The relative weight of the various greenhouse gases is determined by their global warming potential (GWP), whereas for air pollutants an external costing methodology is applied (assigning a value based on the impact that the emissions have and the damage they cause to human health and the environment). This takes into account both tank-to-wheel (exhaust emissions caused by driving a vehicle) and well-to-tank emissions (emissions from production and distribution of the fuel).

The various impacts are combined into a single indicator. For all types of vehicles, the impact over the three categories is then compared to the impact caused by a reference vehicle. This reference vehicle is defined as the best available technology in that particular vehicle category. The Ecoscore is expressed as a value between 0 and 100: the higher the score, the more environmentally friendly the vehicle will be. An advantage of this method is that vehicles with different fuels and different

[18] UK Cleaner Road Transport Vehicles Regulations 2011; Belgium Arrêté royal relatif à la promotion de véhicules de transport routier propres et économes en énergie dans le cadre des marchés publics 2010/21131
[19] The tool and guidance and available to download from http://www.smart-spp.eu/index.php?id=7633
[20] A calculator and guidance are available to download from http://www.ecoscore.be

technologies can be compared with the same indicator. However the emissions associated with the production of the vehicle and the recycling or after use-processing are not taken into account. The Ecoscore methodology has not been developed to apply to fire and rescue service vehicles and cannot currently be used for them as the assumptions underlying the calculations would be different.

While these previously-developed methodologies and tools may not be strictly applicable to the needs of this project, they have been consulted in order to identify the most relevant impacts and how these can be taken into account in the context of procurement. The Work Package 3 report on Risk Management will give more detailed consideration to how environmental impacts can be assessed and, where relevant, a monetary cost assigned in the context of the FIRED-uP project.
Application of models: planning, procurement, contract management

One of the objectives of the FIRED-uP project is to develop a methodology for assessing the environmental impact of fire and rescue service fleets. The purpose of this methodology is not just to gather data but to enable continuous improvements in environmental performance. While the methodology will reflect the specific needs and operations of Ghent and LFB, it should also be adaptable by other fire and rescue services. The final reports and outputs of the project will explain the methodology and how it has been developed and used in practice by the partners.

In order to be effective, it is important that the method chosen can be readily understood and applied by a number of different stakeholders: project staff, engineers, managers, procurers, suppliers/service providers, operational staff and contract /fleet managers. This does not mean that all stakeholders must be conversant with all technical details, but it does mean that the approach taken to measuring emissions, fuel and water consumption or other key parameters must be clear and well-communicated to all concerned, and that they understand their specific responsibilities within it. While the methodology will draw upon established research and scientific principles (for example, LCA as discussed above) it will also reflect the specific scope of activities engaged in by the partners. This means that it will outline practical steps which are relevant to the different functions performed by them:

- Identifying procurement needs
- Reporting on environmental targets and setting new ones
- Strategic planning
- Approving budgets and staff resources
- Preparing tender documents and assessing bids
- Testing and maintenance of vehicles
- Training operators
- Operating vehicles
- Contract review and modifications
- Measuring key performance indicators (KPIs)
- Retiring and replacing vehicles

3.3 TRANSFERABILITY FROM/TO OTHER SECTORS

Despite the distinctive aspects of fire and rescue service operations, a degree of transferability exists with other sectors in terms of the technical solutions considered and methods to measure and manage environmental performance. This is important both in terms of the ability of the project partners to benefit from research and approaches undertaken in other sectors, and for the dissemination of the project's results. In particular, the following sectors are considered to be relevant:

- Ambulance and police services
- Municipal fleets including waste management or other specialised vehicles
- Commercial fleets including heavy-goods vehicles (HGV)
- Defence vehicles
- Aviation and aerospace
- Water distribution and management

Depending on the specific areas of technical focus chosen, other sectors may be relevant and some of the above may be less so.

4 OPERATIONAL PRIORITIES

4.1 CORE OBJECTIVES FOR LFB AND GHENT

4.1.1 CORE OBJECTIVES OF LONDON FIRE BRIGADE

The London Fire and Emergency Planning Authority is responsible for the strategic direction of the London Fire Brigade, determining policy and setting priorities and performance targets. Within the framework set by the Mayor, the Authority also sets the budget for the Brigade. In addition to attending emergencies, LFB undertakes prevention activities through community safety and fire safety regulation. There are 20 fire safety teams located across London and LFB works closely with the London boroughs and with a range of other agencies in the public, private and voluntary sectors. LFB carries out inspections to make sure buildings meet fire regulations and will take action to enforce fire safety measures if it is necessary. To improve the safety of buildings, including major projects affecting London's infrastructure, the Brigade works with developers at an early stage to ensure all possible fire engineering solutions are applied during construction.

LFB's priority aims and headline targets are set out in the most recent draft fire safety plan (LSP5):

AIM 1 - PREVENTION

Engaging with London's communities to inform and educate people on how to reduce the risk of fires and other emergencies.

AIM 2 – PROTECTION

Influencing and regulating the built environment to protect people, property and the environment from harm.

AIM 3 – RESPONSE

Planning and preparing for emergencies that may happen and making a high quality, effective and resilient response to them.

AIM 4 – RESOURCES

Managing risk by using our resources flexibly, efficiently and effectively, continuously improving the way the brigade use public money.

AIM 5 – PEOPLE

Working together to deliver high quality services and to create a safe and positive environment for everyone in the organisation.

AIM 6 – PRINCIPLES

Operating in accordance with LFB's values and ensuring that safety, sustainability, partnership and diversity run through all activities.

LFB takes its commitment to environmental protection and sustainability seriously with its Sustainable Development Strategy, which takes into account the risks and impact of climate change. The plan reflects the need to work with communities and partners on prevention and emergency response, acknowledging the risk of increased flooding and scarcer water resources. London Fire Brigade (LFB), as a functional body of the Mayor of London, works with the other organisations under the Mayor (TfL Metropolitan Police Service, Greater London Authority) to deliver the joint Responsible Procurement programme (www.london.gov.uk/rp) The programme aims for the Group to be leaders in sustainable procurement and to influence other organisations.

4.1.2 CORE OBJECTIVES OF CITY OF GHENT DEPARTMENT OF FACILITY MANAGEMENT

The mission statement of City of Ghent is a shared ambition of the administration and the city council for Ghent in 2020: "Ghent, a creating city, a pioneer in the development of a sustainable, solidary and open society by uniting all creative forces." The ambition is concentrated in 5 strategic goals:

- Knowledge and innovation
- Social sustainability
- Economical sustainability
- Ecological sustainability
- Communication and participation

AIM 1: MANAGEMENT AND EXECUTION OF LOGISTIC ACTIVITIES

AIM 2: GUARANTEE A SUSTAINABLE FLEET MANAGEMENT

AIM 3: PERFORM MIXED TASKS AS FACILITY SERVICES BY SERVICE AND LOGISTICS

AIM 4: PLANNING, DIRECTING, COORDINATING AND IMPROVING SERVICE AND LOGISTICS

AIM 5: GUARANTEE MULTI-PROJECT MANAGEMENT

4.1.3 CORE OBJECTIVES OF FIRE BRIGADE GHENT

Mission statement: the Fire Brigade Ghent is a transparent **security organization** which ensures that threats to **humans, environment** and **heritage** will be handled in a adequate and a customer-friendly way and take the necessary measures (preventive and curative) to control the success of safety.

AIM 1 – AID ALLOCATION

Quick and effective response to incidents and security.

AIM 2 – SERVICE

Working environment and central station

AIM 3 – CLIENTS

Prevention Policy, cooperation, integral operation

4.2 TIMELINES AND SCOPE FOR CHANGE BASED ON EXISTING CONTRACTS

The scope for undertaking procurement within the timelines of the FIRED-uP project depends upon a number of factors:

- Does the solution deliver measurable environmental benefits?
- Can a business case be made to undertake procurement?

This depends upon identifying technical solutions (see Section 5) which meet an operational need (Section 2.1) and have the potential to deliver measurable benefits at an acceptable cost. The needs assessment and techniques for assessing environmental benefits (e.g. life-cycle analysis) are outlined in The processes for making a business case and gaining budget approval from upper-level management at LFEPA and Ghent are outlined in Section 6. The process for approval of co-financing from the European Commission is also outlined. One of the key considerations will be whether the proposed solution is innovative, in the sense of being new to the client and the market in which it operates.

- Can the procurement and contracting process be managed in a way which complements existing or planned fleet and equipment contracts?

In LFB's case the outcome of FIRED-uP will need to be integrated with the main fleet and equipment contract, which is currently undergoing re-procurement. This can be done by including the outcome(s) of the project in the output based specifications used within the fleet contract, by nominating a subcontractor for the provision of certain products or services, and/or by linking contractual performance under the main contract to the uptake of innovative solutions identified via FIRED-uP. In Ghent's case, procurement of an innovative fire and rescue service vehicle will be on a pilot basis, with the possibility of further orders based upon its success.

Key dates in the fleet procurement calendar for LFB and Ghent are shown below.

LFB

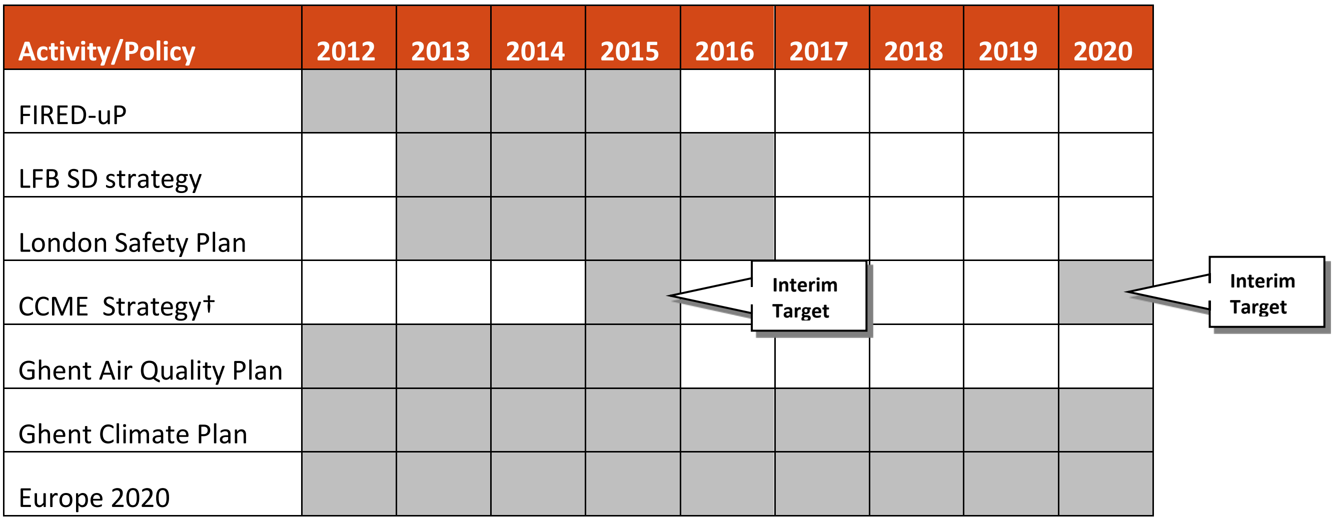
Event	Start Date	End Date
Interim contract for fleet & equipment	November 2012	May 2014
Re-procurement of fleet & equipment contract	March 2013	April 2014
First replacement of vehicles under new contract	Q2/Q3 2014 (order)	Q3/Q4 2016 (delivery)

Ghent

Event	Start Date	End Date
Phase 1: Preliminary study in parallel with LFB	June 2012	March 2013
Phase 2: Needs assessment + market consultation	March 2013	August 2013
Phase 3: Procurement of innovation	August 2013	November 2014

4.3 PLANNING HORIZONS AND LINKS TO OTHER STRATEGIES

While the project duration is relatively short at three years, the impacts of the project are expected to carry through over a longer period. In particular, the planning horizon for fleet upgrades and sustainable development strategies is considerably longer. The below diagram shows the time period of the project in relation to other activities and policies being undertaken at LFB and Ghent.



†The Mayor of London's Climate Change Mitigation and Energy Strategy

5 SURVEY OF GOOD PRACTICE AND EMERGING INNOVATIONS

In order to narrow the technological focus for the FIRED-uP project, 20 different potential areas for innovation have been reviewed. These fall into three categories:

1. Alternative fuels and propulsion
2. Construction and components
3. Data, logistics and life-cycle

The purpose of this initial survey is to cast a wide net in terms of technologies and processes with the potential to address the needs identified above. For each area, a profile is given indicating:

- Description - what is it and how it works
- Latest market developments
- Environmental impact – including how this can be measured
- Readiness – maturity of the technology/process is any required infrastructure in place
- Cost – high-level identification of costs on a whole-life basis
- Relevance to fire and rescue services – operational impact and any examples of emergency use

These profiles will allow the partners to identify the most promising areas for further research, market engagement and specification development/procurement. The selection process will be documented and the main criteria considered will be:

a) Does the innovation meet an operational need and could LFB/Ghent adopt it based on current appliances? If not, could it be adopted based on expected future changes?
b) Is sufficient information available about the innovation to justify engagement with suppliers? In particular, can the environmental impacts be tested/measured?
c) Are there any obvious legal or cost barriers to adoption of the innovation? For example, this may be the case if the innovation involves expensive proprietary technology and is only available from one supplier, or would be incompatible with existing vehicles.

In applying these criteria, potential innovations will be given 'the benefit of the doubt.' That is, they will not be eliminated unless it is clear that one of the above criteria would definitely prevent their adoption, even if operational, technical, legal or cost changes take place. A more detailed impact assessment will take place at a later stage. This would ensure, for example that any proposed technology would have:

- No negative impact on arrival time, pumping capacity, fleet availability or other key operational parameters[21]
- No negative impact on health and safety or welfare of operatives

[21] Any operational impact may also have an environmental footprint, e.g. due to fire burning times or number of appliances required.

- Acceptable total cost of ownership (e.g. including any impact on insurances, training, maintenance, replacement schedules)
- Environmental performance which meets or exceeds current policy targets

The impact assessment will also attempt to quantify the environmental performance gains so that different technologies can be compared. For example, a 2011 study by TIAX compared the greenhouse gas reduction potential from different technologies for heavy-duty vehicles. The below figure illustrates the findings of this study , together with those of a similar study carried out in 2011 by AEA/Ricardo.

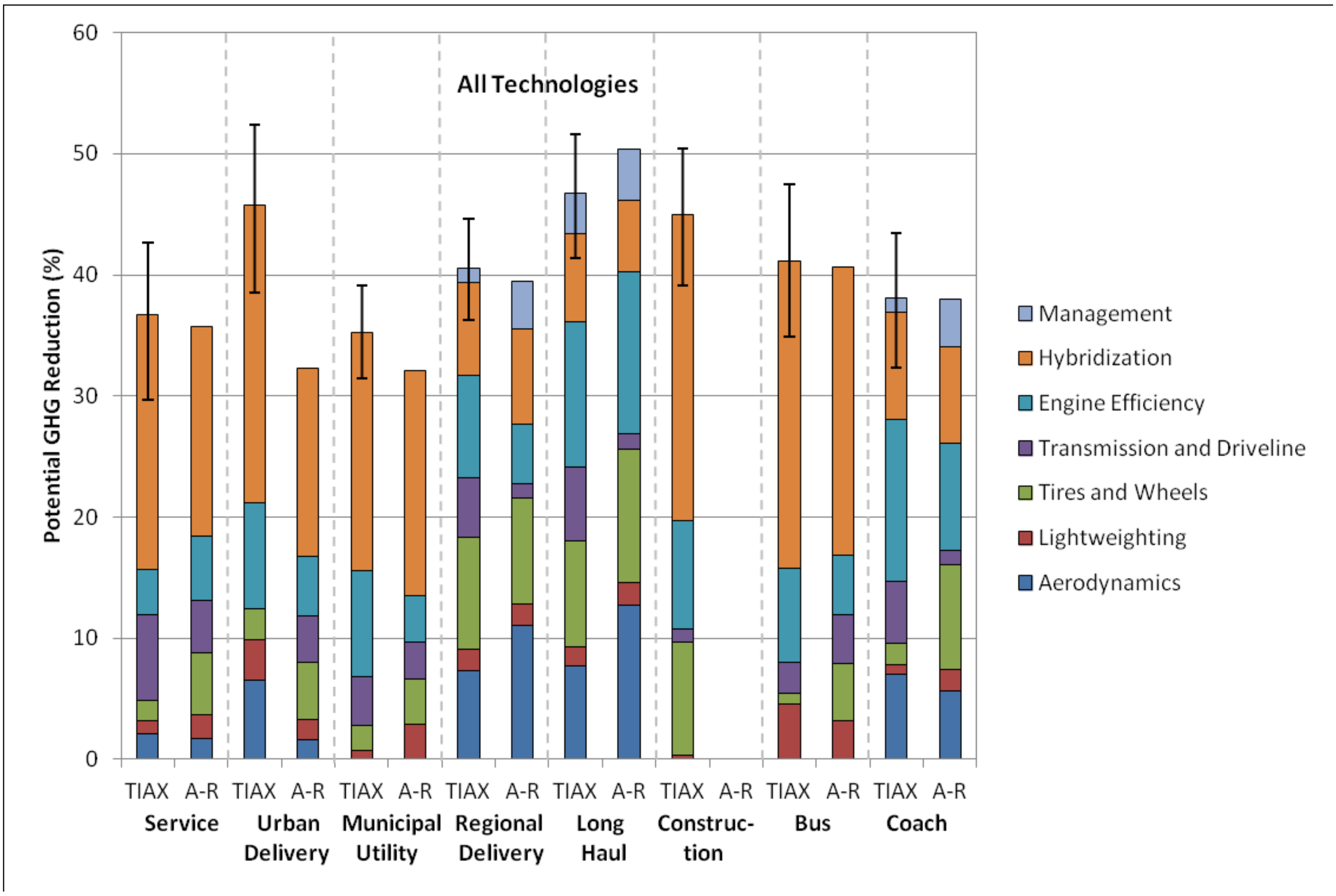


Figure 12 Potential New EU Vehicle GHG Reductions from All Technologies

A-R: AEA-Ricardo

Source: TIAX (2011) *European Union Greenhouse Gas Reduction Potential for Heavy-Duty Vehicles*

5.1 ALTERNATIVE FUELS/PROPULSION

5.1.1 BIOFUELS (INCLUDING BIOGAS)

DESCRIPTION

Biofuels may be solid, liquid or gaseous and include all kinds of biomass and derived products used for energy purposes. Biofuels used for transport include biodiesel, syndiesel, DME (gaseous), methanol, ethanol, biobutanol and biogas. Biodiesel can be used as a replacement for petroleum diesel fuel and is currently manufactured from plant or vegetable oils, recycled cooking greases, or animal fats. A European standard (EN) exists for biodiesel.

Biogas is produced from agriculture manure wastes and food wastes. To be used as a transport fuel biogas is upgraded to 95% methane by a process of anaerobic digestion (fermentation) and compressed. It can then be used in vehicles modified to operate on natural gas.

BioDME is suitable for use in diesel engines due to its low-self-ignition temperature and high cetane number. However DME cannot be blended with fossil diesel and its volumetric energy content is much lower, approximately half that of diesel. The production of BioDME through gas synthesis technology is still at a developmental stage.

LATEST MARKET DEVELOPMENTS

Biofuels consumption was 4.7% of transport fuels in the EU in 2010 based on energy content, and demand is growing. A range of biofuels are currently on the market , however the cost, environmental profile, performance and refuelling infrastructure vary widely between them. In September 2012 the EU proposed to limit the percentage of food-based biofuels to 5%, while introducing new supports for second and third-generation (non-food based) biofuels such as those based on waste oils, biogas and algae. However some of these are still in the early stages of development as transport fuels. The U.S. Department of Defence is currently testing a number of advanced biofuels for use in jets, ships and tanks. The results of these tests and other pilots can be expected to yield data which will help determine the viability of different biofuels. [22]

Aston University has also invested in a new facility which will produce biofuel from algae (European Bioenergy Research Institute – EBRI) They will be looking for fleet operators to undertake trials of this. A standard exists for the fuel and visits to the facility can be arranged.

ENVIRONMENTAL IMPACT

The theoretical potential for plant based biofuels to reduce GHG emissions is large, as they absorb CO_2 during their growth phase. However net GHG impacts differ significantly between biofuels, depending on many variables such as the feedstock type, energy use of conversion processes, etc. Some achieve significant GHG savings, while others do not achieve any savings, or cause more emissions than the fossil fuels that they replace.

Adding biodiesel to fuel blends reduces emissions of air pollutants (carbon monoxide, hydrocarbons and particulate matter). Biodiesel in blends of up to 20% can also reduce CO_2 emissions by more than 15% compared with 100% petroleum diesel, but it can also result in higher well-to-wheels GHG emissions than diesel, depending on how it is produced (ITF 2008). NOx emissions can be higher with biodiesel than conventional diesel, although additives can address this. Biogas fuelled vehicles can reduce CO_2 emissions by between 75% and 200% compared with fossil fuels.[23] Biogas can also deliver a 90% reduction in PM_{10} and 60% reduction in NO_x emissions.[24]

[22] See US Air Force's Strategic Studies Quarterly, March 2013.
[23] National Society for Clean Air and Environmental Protection (2006) *Biogas as a Road Transport Fuel*, at page 1. The upper figure shows a negative CO_2 contribution which arises because liquid manure left untreated generates methane emissions, which are 21 times more powerful as a greenhouse gas than CO_2.
[24] Transport for London (2010) *Alternative Fuels Strategic Analysis* at slide 20.

Negative impacts associated with biofuels can include indirect land-use change (ILUC) and upwards pressure on food prices. Second and third-generation biofuels, derived from non-food sources, are intended to address these problems while maintaining performance and low exhaust-pipe emissions. The Fuel Quality Directive (2009/30/EC) establishes sustainability criteria which must be met by biofuels if they are to count towards greenhouse gas reduction obligations. Greenhouse gas emissions must be at least 35% lower than the fossil fuel they replace. From 2017 this increases to 50% and from 2018 the saving must be at least 60% for new installations. The raw materials for biofuels cannot be sourced from land with high biodiversity or high carbon stock. Ghent has researched biofuel usage as part of the Civitas project and has decided to wait for second generation biofuels to become more readily available, to avoid the ILUC questions.

READINESS

Biodiesel blends can typically be used in conventional combustion engines without engine modifications and do not require substantial changes to the fuelling infrastructure. Other types of biofuels may require engine modifications, and in some cases can pose a problem with regards to vehicle warranties. Refuelling capacity for biofuels other than biodiesel is currently limited in the UK and Belgium. However technology and infrastructure for biogas is well-established in areas with LPG. Dual-Fuel (biogas/diesel) vehicles are most suited to HGVs travelling long distances at high average speeds. Issues affecting greater use of biofuels include the availability of refuelling infrastructure and vehicles with the appropriate fuel tanks.

The compatibility of biodiesel with EURO 6/VI engines is likely to pose some challenges. Blends above 7% may not be possible due to their effect on the new equipment and sensors.[25] However given the long lead-in period for all frontline fleet vehicles to meet EURO VI, there is ample scope for use with older vehicles.

COST

Commercial biodiesel typically has a comparable cost-per-litre to diesel from fossil fuels. In the UK, biodiesel made from waste cooking oil enjoys tax relief at the rate of 20p/litre. Ghent is waiting for tax reductions in order to make biofuels more affordable. Although biodiesel contains about 8% less energy per gallon than petroleum diesel, it does not significantly affect fuel economy in its blended form. Research conducted in the UK in 2006 indicated that in terms of fuel costs, biogas was about 40% cheaper to run than diesel and 55% cheaper to run than petrol. Fuel cost savings were off-set in the short term by higher capital costs, some £25,000 for heavy duty vehicles and £5,000 for light duty vehicles, and potentially higher maintenance costs. **Nevertheless, HGVs using biogas were found to be competitive with a diesel vehicle over an operating life of four years.**[26]

RELEVANCE TO FIRE AND RESCUE SERVICES

LFB currently uses a 5% biodiesel blend to refuel its fleet. This percentage was decided based upon a number of considerations, including refuelling capacity and performance. By law in Belgium all diesel is blended with 5% biodiesel at every fuel pump. This level has not posed any operational difficulties although LFB encountered an initial reluctance from some vehicle manufacturers to allow biodiesel

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[25] Nicol, A. "Emissions Engineering" *Transport Engineer* (November 2012) at page 13.
[26] National Society for Clean Air and Environmental Protection (2006) *Biogas as a Road Transport Fuel*, page 1

use under vehicle warranties. While cold weather performance of biodiesel can be an issue, higher blends up to 20% represent a good balance of cost, emissions, cold-weather performance, materials compatibility, and ability to act as a solvent for many applications. Storage of some biofuels also presents difficulty as they have a shorter shelf-life than conventional fuels. Additives can aid preservation but will also increase costs/environmental footprint.

Potential applications of biofuels would include **increasing the mix of biodiesel in fuel blends** or exploring the use of **biogas** or other biofuels in specially adapted fire and rescue service vehicles. An example of innovative applications in an emergency services context can be found in the development of a green ambulance which runs on biogas on behalf of Stockholm County Council in Sweden.[27] There are also examples of local authorities using recycled vegetable oil to power their fleets, such as the London Borough of Richmond in the UK. It undertook extensive trials to see if the fuel could meet the requirements of its diverse fleet which contains vehicles of many different sizes, types and ages. At the end of the trials, the Council concluded that many of its vehicles – from vans and buses to refuse collection lorries - were able to run safely and efficiently on biodiesel at 100% purity.

5.1.2 ELECTRIC

DESCRIPTION

Electric vehicles use one or more electric motors for propulsion, instead of relying on the combustion of fuels. On board electrical storage devices such as batteries, flywheels, or supercapacitors store electricity which in turn is used to drive the electric motor. Most recent EVs use lithium-ion batteries and can recover energy lost during braking.

LATEST MARKET DEVELOPMENTS

Recent developments in the electric vehicles market are delivering increased range and performance while reducing purchase costs. Most the major vehicle manufacturers now produce electric or hybrid models and these are being expanded to include heavy-duty and special-purpose vehicles, as well as passenger cars and vans. Batteries are typically leased rather than bought, due to their high cost and uncertain life span.

ENVIRONMENTAL IMPACT

'Tank-to-wheels' efficiency for electric vehicles is about three times higher than internal combustion engines. Electric vehicles emit no tailpipe CO_2 and other pollutants such as NOx, NMHC and PM at the point of use. Overall emissions depend upon the source of electricity and whether this is renewable – as illustrated in the figures from the LCA above. Emissions of air pollutants are virtually eliminated if electricity generation switches to renewable energy sources or nuclear. Electric vehicles may produce higher levels of NOx, SOx and PM overall if the electricity is generated using the average European grid mix, due to the high contribution of coal power plants. Future emissions will decline with the introduction of newer and cleaner plants and greater contributions from renewable generation. Ghent uses only green power, but neither the UK nor Belgium have a significant

[27] See case study http://ec.europa.eu/environment/gpp/pdf/news_alert/Issue15_Case_Study34_Stockholm_ambulance.pdf

contribution overall to their grid from renewable energy sources at present. Investments in further capacity are planned to achieve shares of 15% and 13% respectively by 2020.[28]

When assessing the environmental impact of electric or hybrid fire and rescue service vehicles, the effect of the battery on vehicle weight must also be considered - less the effect of removing or downsizing the diesel engine. The production and disposal of batteries also has an effect on their life-cycle environmental impact. End-of-life impacts can be reduced where batteries are given a 'second-life' in other industries, e.g. to store energy for use in restaurants or other premises. Energy from the grid can be stored during off-peak hours and then used during peak periods.

READINESS

Electric vehicles are suitable in the following circumstances:

- City traffic
- Short distances (radius <120 km)
- Start-stop traffic
- Small loads (eg. work materials)

Ghent City has already introduced 13 electric vehicles in its fleet and has ordered several more for 2013. The main study around electric driving possibilities was done under the Civitas project. Recharging infrastructure for electric vehicles is a major consideration, as most are limited in their range to 120 kilometres or less – and this is reduced in practice due to the operation of on board systems and driving patterns. Greater range can be achieved with hybrid vehicles, however these typically have higher costs and environmental impacts than purely electric vehicles.

COST

The relative costs of electric vehicles depend on the level of usage. Initial purchase costs are higher than comparable diesel or petrol vehicles, due to the cost of the battery. Depending on fuel and energy prices, running costs may be as low as 15-20% of the cost of diesel, especially if vehicles are charged overnight. Research conducted on behalf of LFB on the potential applications of electric vehicles within the brigade found that:

"The cost structures of internal combustion engine (ICE) vehicles and EVs are very different. The only realistic way to compare these vehicles is to look at whole life costs (WLC). This is vital, as most EVs on the market cannot currently compete with the purchase price and range of conventional fossil fuel vehicles. They can, however, offer other key advantages; there is a significant drop in running costs, noise and tailpipe emissions when EVs are deployed in the right places.

For example, it can cost a quarter of the price to refuel an EV compared to a conventional vehicle at today's prices. Over its lifetime, the WLC of an EV can be less than a conventional vehicle if deployed correctly. A whole life costing approach is required to take into account a large number of variables beyond simply the purchase price of a vehicle, including some costs that will alter over time. Vehicle taxes, subsidies, fuel and electricity use, battery lifetime, service maintenance and repair (SMR) and length of ownership are the major factors that should be taken into account."[29]

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[28] Target for share of energy from renewable sources in gross final consumption of energy, as set out in Annex 1 of Directive 2009/28/EC.
[29] Moore, H (2012) Plugged in Fleets Electric Vehicle Report: London fire Brigade Energy Saving Trust

The analysis carried out for LFB looked at cars and vans used by the Duty Transport Officer and water team (responsible for checking hydrants). Taking into account the existing usage patterns of these vehicles, the whole-life costs for an electric van were just over 20% higher than for a comparable diesel van. This takes into account the subsidies currently available for electric vehicles, but does not assume any major increase in diesel prices.

RELEVANCE TO FIRE AND RESCUE SERVICES

Electric vehicles provide quiet and smooth operation and consequently create less noise and vibration. However it is doubtful that a complete conversion to electric fire appliances is possible for the following reasons:

- Emergency character: the down time required to recharge poses a problem for vehicle availability
- Load: the electric motor would need to be capable of transporting a fully loaded fire truck
- A battery powerful enough to make the motor and on-board machinery run will probably be too large and heavy to be economically viable.

While fully electric fire-service vehicles may not be feasible, **it would be worth investigating if part of the equipment or even better the complete equipment can run on electricity**. For example, **an electrical pump drive**, which is a standard part of all fire appliances, could be taken into consideration.

5.1.3 HYBRID-ELECTRIC (INCLUDING REGENERATIVE BRAKING)

DESCRIPTION

Hybrid vehicles include plug-in hybrids and extended range electric vehicles. These are equipped with both an electric motor/battery pack and internal combustion engine. Regenerative braking allows energy that would otherwise be dissipated as heat to be stored in high-voltage batteries and then used to propel the vehicle the next time it accelerates. For vehicles which continuously speed up or slow down the fuel savings from regenerative braking are particularly high. Most hybrids can only operate in electric-only mode over very short distances or not at all.

LATEST MARKET DEVELOPMENTS

Hybrids have been available on the market for some time and improvements in performance continue. In addition to engine hybridisation, many auxiliary vehicle functions can now be powered by hybrid powertrains or fuel cells. This is of particular relevance for heavy-duty fleets, where engines may idle 40% of the time or more at stops to meet auxiliary needs such as air conditioning, heating and running electronics inside the cab. Supercapacitors can be used to capture energy from braking and apply this during acceleration to save fuel. This allows downsizing of the combustion engine, saving space and weight. The development of hydrogen fuel cells for use in hybrid vehicles is well underway, but commercially feasible applications are still limited.

ENVIRONMENTAL IMPACT

The air quality benefits of hybrid electric vehicles and plug-in hybrid vehicles depend on the drive cycle - they are most beneficial when used in urban environments. Hybrids typically offer a 20-40% reduction in lifecycle CO_2 emissions depending on usage patterns. For plug-in vehicles the reduction will also depend on the grid mix. They can also offer up to 50% reduction in NO_x and PM_{10} The exact environmental profile depends in part on the relative use of the ICE and electric engines during operation. The manufacturing process for batteries, and their recyclability, also form part of the environmental impact of hybrids as with electric vehicles.

READINESS

Hybrid technology is in use for buses, waste management vehicles and other heavy goods vehicles. U.S. company Peterbilt has developed a hybrid vehicle used by fire services, although without pumping capability: http://www.peterbilt.com/hybrid337.1.aspx

COST

The initial purchase costs of hybrid vehicles are considerably higher than diesel vehicles of the same class, but usually cheaper than fully electric vehicles due to the smaller lithium ion battery . The cost differential depends on the vehicle type, but current purchase costs are typically 30 -50% higher than a comparable diesel vehicle. This differential is expected to shrink as ICE costs go up to meet higher standards, while battery costs go down. Hybrid vehicles use less fuel (partly through regenerative braking) and have reduced maintenance costs, so whole-life-costs may be lower than comparable diesel models. Regenerative braking also reduces wear and tear on the braking system as the conventional brakes are used less. Despite these factors, use of hybrids in fleets is currently associated with some cost premium, for example Transport for London's use of hybrid buses.

RELEVANCE TO FIRE AND RESCUE SERVICES

Plug-in hybrid electric vehicles tend to have large batteries and rely on recharging capacity, so the issues which arise in relation to electric vehicles would also apply. **The potential GHG and fuel savings from hybridisation and regenerative braking are significant, so further research on fire and rescue service applications should be done**.

5.1.4 HYDROGEN

DESCRIPTION

Hydrogen (H2) is often seen as the ultimate energy transporter in combination with fuel cell technology or as fuel for internal combustion engines. In hydrogen fuel cell vehicles an electrochemical cell provides power to an electric motor. There are no harmful exhaust pipe emissions (only a small amount of NOx is released during the burning process). Hydrogen is not readily available in its molecular form and has to be produced using other energy sources. Therefore hydrogen is considered an energy carrier rather than an energy source. A wide variety of methods can be used to produce hydrogen from fossil fuels or renewable sources such as biomass, wind, solar or nuclear power.

LATEST MARKET DEVELOPMENTS

Hydrogen vehicles currently include vehicles with internal combustion engines, but in the longer term fuel cell powered vehicles are expected to prevail. A model hydrogen-fuelled fire appliance has been designed by Peugeot: http://hydrogenhouseproject.org/peugeot-h20-fire-engine.html

While many companies are researching and developing hydrogen vehicles, application of the technology is still limited by the volume of fuel required and lack of safe storage.

ENVIRONMENTAL IMPACT

Hydrogen generates no CO_2, PM_{10} and NO_{10} emissions at tailpipe. However it is often generated from fossil fuel sources which can even lead to increased life-cycle CO_2 emissions. The environmental impact and emission chains of CO_2 strongly depend on the energy source used. Cradle-to-grave impact has to be taken into account to ensure reductions in greenhouse gas emissions relative to conventional fuels.

READINESS

Hydrogen may not yet be commercially feasible for use by fire and rescue service fleets, due to challenges concerning production, distribution and storage. Significant efforts are still needed to resolve safety issues:

- Ventilation in order to remove heat created from the engine, as well as any hydrogen leakage
- Detection of leakage using hydrogen sensors
- Since hydrogen-air flames are invisible to the human eye, hydrogen flame detectors are needed to detect fire
- Automated or manual monitoring of fuel consumption used for leak detection

The greatest risk to personnel would be the presence of a fire around the tank of the vehicle. In this case, tanks are fitted with Temperature Pressure Relief Valves (TPRVs) which rupture at elevated temperature. These are designed to vent the contents of the tank to prevent explosion. In this case a jet of hydrogen will exit the vent-line of the vehicle and should be avoided to prevent injury.

COST

The cost of hydrogen vehicles is currently considered to be prohibitive for most fleet applications. This is due to the cost of hydrogen from renewable sources, the fuel cell technology and the high cost of supporting infrastructure.

RELEVANCE TO FIRE AND RESCUE SERVICES

The same properties that make hydrogen a desirable fuel also increase the level of risk. Safety risks arise from the high flammability, low required ignition energy and invisibility of the gas as well as the flames. Although hydrogen applications have made significant progress recently, there remain issues requiring further investigation before applying this technology on emergency vehicles loaded with electrical appliances. More specifically, there is an increased risk of abnormal combustion events associated with hydrogen: surface ignition, backfiring and autoignition. There are concerns that hot spots could initiate surface ignition or backfire.

A key practical consideration which must also be taken into account is hydrogen's low density compared with other fuels. This means that greater onboard storage area is needed, compromising applicability in the context of fire and rescue service vehicles where space is at a premium. This combination of unresolved safety and practical issues, together with the cost and lack of infrastructure for hydrogen refuelling, mean that it is not currently considered suitable for fire and rescue service vehicles.

Hydrogen is still to be researched in Ghent. We are open for possibilities but are concerned about operational and safety issues.

5.1.5 LIQUEFIED PETROLEUM GAS

DESCRIPTION

Liquefied petroleum gas (LPG) is a mixture of hydrocarbons – mainly propane with some ethane and butane. It is a by-product of refining crude oil or the extraction of natural gas. LPG can be used within a internal combustion engine with a bi-fuel modification. LPG is a gas at room temperature, so a pressurised tank is required. Being pressurised, these tanks are significantly heavier than conventional fuel tanks for the same range. In most respects, current bi-fuel and dedicated LPG vehicles have an engine performance similar to conventional cars.

LATEST MARKET DEVELOPMENTS

Whereas older bi-fuel conversions often had poor performance (the engine being optimised for petrol operation), recent conversions use electronically controlled gas-injection systems. A UK-based company (G-volution) has developed a multi-fuel technology that allows HGVs to be powered by a diesel engine that simultaneously combusts more than one fuel. The current system uses diesel as the primary fuel source and liquefied petroleum gas (LPG) as the secondary source from a separate tank – use with other fuels is being explored. An electronic control unit determines how much diesel to release into the engine at any point in time. The advantage of bi-fuel operation is that vehicles are less reliant on a fully developed LPG refuelling infrastructure and are able to be used in areas where the gas is unavailable. However, bi-fuel cars do not achieve the full emission benefits offered by LPG because a compromise in engine tuning is required for the two fuels.

ENVIRONMENTAL IMPACT

There are several advantages of using LPG which include an extended engine life due to the fuel's clean burn characteristics and reduced engine stress. Conventional (petrol) catalytic converters are used by most bi-fuel cars, whereas dedicated LPG vehicles use catalysts optimised for the gas, further reducing vehicle emissions. Real-world tests show around a 10%-15% reduction of life cycle greenhouse gas emissions (per km) for bi-fuel LPG cars as compared to petrol operation – placing the level of greenhouse emissions between those from petrol and diesel (VCA 2005).[30] Up to a 50% reduction in No_x emissions and 50%-90% reduction in PM_{10} emissions are also achievable.

READINESS

[30] Lane, B. (2006) Life Cycle Assessment of Vehicle Fuels and Technologies London Borough of Camden, p 9.

LPG refuelling is available at 19,748 stations across Europe, of which 1596 are located in the UK (326 in London) and 481 in Belgium (5 in Ghent).[31] However the market in terms of vehicle development seems to slowing – with greater concentration on compressed natural gas.

COST

Initial conversion costs to bi-fuel capacity vary depending on vehicle type – some vehicles are now equipped with this as standard. At the pumps LPG is considerably cheaper than diesel, costing on average a little over half the price per litre. Fuel consumption is higher but not sufficiently so to cancel out the cost advantages.

RELEVANCE TO FIRE AND RESCUE SERVICES

LFB operated dual-fuel fleet cars on LPG for six years from late 2002 until early 2009. This was discontinued due to negative user feedback, which is summarised below.

- Limited range
- Need to start on petrol then switch over to LPG
- Difficult to start (as above) resulting in the user opting for the easy option of just running on petrol
- Constantly going defective on the LPG side resulting in a few vehicles having the LPG side decommissioned towards its latter years
- Difficult to find refuelling points
- Refuelling required use of PPE (gloves) due to likely splash back when inserting nozzle, could burn hands
- Spare tyre stowage used for the LPG tank, losing the use of the spare tyre

The ability to address these drawbacks would need to be evaluated as part of any proposal to use LPG in other fire and rescue service vehicles.

Ghent does not consider LPG as a suitable fuel within the character of the Fire Brigade.

5.1.6 COMPRESSED NATURAL GAS/LIQUEFIED NATURAL GAS (CNG/LNG)

DESCRIPTION

Natural gas can be used within a modified internal combustion engine to provide motive power. It makes an ideal fuel for spark-ignition engines due to its high octane rating, low levels of volatile organic compounds and the fact that it mixes easily with air prior to combustion. This offers lower idling speeds, better performance, easier cold starting and a more complete combustion, all of which help to reduce exhaust emissions. The most significant difference between natural gas and conventional fuel is the method of fuel storage. Given that natural gas is gaseous at room temperature and pressure, it is stored on-board either as compressed natural gas (CNG) or as liquefied natural gas (LNG) which is cooled to – 160 to -190°C.

LATEST MARKET DEVELOPMENTS

[31] Source: www.mylpg.eu (Visited on 13 February 2013)

A 100% compressed natural gas powered fire appliance has been developed and marketed in the United States (HME Ahrens-Fox – see http://www.firetrucks.com/HMEInnovations). Cummins have developed CNG bi-fuel truck, but its use is banned in tunnels. Marks & Spencer use CNG trucks and have identified variations in the energy value of the gas which implies different range capabilities depending on refuelling station.

ENVIRONMENTAL IMPACT

Natural gas is the second most abundant fossil fuel, with ample reserves available to meet demand in Europe. Some methods of extraction, such as fracking, have a high environmental impact which must be considered in the overall analysis. In principle, carbon emissions from natural gas vehicles are reduced due to the fuel's low carbon content and high octane number (which enables a high compression ratio to be used). However methane (the main constituent of natural gas) has a very high global warming potential. Taking carbon dioxide and methane emissions into account, natural gas bi-fuel cars (and car-derived vans) currently show an improvement in life cycle greenhouse gas emissions (per km) of around 15%-20% compared to those using petrol. This means that greenhouse gas emissions for natural gas cars are approximately the same as for light-duty diesel vehicles (Concawe 2004).[32]

The use of optimised catalysts and improvements in the fuel economy of conventional vehicles means that the relative environmental benefits of CNG/LNG now mainly relate to reductions in regulated emissions (especially PM_{10}) and noise.

READINESS

CNG is widely used worldwide whereas the vehicle-ready infrastructure for LNG is more limited. Two types of natural gas re-fuelling systems are available: fast-fill units use high pressure CNG to refuel vehicles in a matter of minutes; slow-fill compressor units 'trickle charge' one or two vehicles over 5-6 hours. To refuel, a flexible hose is connected between the dispenser and the vehicle and is locked into place creating a sealed system. For fast-fill systems, the amount of gas required is then pre-selected before being automatically dispensed. Slow-fill units continue to operate until the tank is either full or the filling process is halted by the user.

COST

Fixed costs for natural gas vehicles are higher due to the higher purchase price (if bought new from a manufacturer) or to the cost of conversion of an existing vehicle. However, fuels costs are significantly reduced for natural gas vehicles as a result of the fuel's low duty rate and better fuel economy (approximately 30% cheaper than diesel). CNG has lower production and transport costs than LNG.

RELEVANCE TO FIRE AND RESCUE SERVICES

The variability in methane content of natural gas can adversely affect engine performance. Ghent has questions about the guarantee of safety during interventions.

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[32] Concawe (2004) Well-To-Wheels Analysis Of Future Automotive Fuels And Powertrains In The European Context. Report by Concawe, Eurcar and the EU Joint Research Centre, 2004, in Lane, B. (2006), page 18.

5.1.7 AMMONIA

DESCRIPTION

Ammonia (NH_3) is extensively used in agriculture as a fertilizer and is the second most prevalent chemical in the world. It is stored as a liquid for use as a transportation fuel and can be combusted like fossil fuel in an engine or used in a fuel cell. It can be used either as a sole fuel or in bi-fuel vehicles. Ammonia is not flammable and is lighter than air so will dissipate into the atmosphere. It requires low pressure tanks (significantly cheaper than hydrogen tanks) at 150PSi for storage and transportation. Ammonia has 52% of the energy density of petrol.

LATEST MARKET DEVELOPMENTS

While the use of ammonia for agriculture is widespread, its use as a transport fuel is less well known and developed. No major manufacturer is currently developing ammonia based propulsion vehicles, however several smaller companies based in the U.S. and Canada have developed fuel production.

ENVIRONMENTAL IMPACT

Ammonia is a non-carbon fuel, so no CO_2 emitted at tailpipe. However, production can be energy-intensive and emit CO_2 directly and indirectly. It offers significant reductions in PM_{10}, and potential for large NO_x reduction using a urea based filter.

READINESS

Only minor engine modifications are required to run most vehicles on ammonia. The infrastructure for production is well-established to serve agricultural needs, but distribution for transport is not in place.

COST

As noted above ammonia is in the early stages of development as a transport fuel so costs for conversion/new manufacture of vehicles and refuelling are not known at this stage.

RELEVANCE TO FIRE AND RESCUE SERVICES

Given the lack of developed vehicles and refuelling infrastructure, ammonia is not currently considered suitable for use by fire and rescue services.

5.2 CONSTRUCTION AND COMPONENTS

5.2.1 CHASSIS AND BODY

DESCRIPTION

The design and construction of the chassis and body of fire and rescue service vehicles is an area of potential innovation in terms of raw material usage, weight and functional design. The use of lighter weight and/or lower impact materials, such as plastics or biomaterials, can reduce fleet environmental footprint. Construction of the chassis and body also determines the center of gravity for vehicles, influencing stability, ergonomics and safety.

LATEST MARKET DEVELOPMENTS

In the UK there has been a move towards lightweight polypropylene body construction. This has now become the most common material for new vehicles due to its durability, lower weight, ease of repair and recyclability. It can also be directly embedded with colour, avoiding the need for painting. When damaged, polypropylene can be easily welded without fumes. Aluminium and glass-reinforced plastic (GRP) construction remain popular in some parts of Europe, however these are considerably heavier and can be difficult to repair.

ENVIRONMENTAL IMPACT

The weight of the body and chassis is a major factor influencing fuel consumption and wear and tear. Traditional chassis construction is from steel, made from iron ore. Mining operations to extract ores create local ecological issues such as the disruption of local habitats. The iron ore has to be processed to create steel, which takes large amounts of energy given the high temperatures and scale of operations needed. This energy use has its own environmental impact in the form of CO_2 emissions, which vary depending on the energy source. The steel then needs to be transported to manufacturers, which due to the global scale of the market could involve large distances with an associated impact from CO_2 emissions. Similar impacts exist with the extraction of aluminium for traditional body construction.

Plastics can either be derived from fossil fuels or from biomass sources. Most common plastics are derived from oil. Extraction and processing leads to a range of environmental impacts from energy use to ecological impacts from the use of oil wells/rigs. Polypropylene as a base material is a by-product of natural gas. The energy required to manufacture is far less than steel or alloy, and when recycled the energy requirements are even lower, making remanufacture more sustainable. When polypropylene is developed that is not dependent on natural gas the manufacturing process for bodywork will remain the same. One potential area for innovation is the development of bioplastics. Bioplastics are formed from biomass, which is a renewable source. Common sources include vegetable oil and corn starch. Although a renewable source, environmental impacts of biomass do exist, notably land use change as discussed above in relation to biofuels.

READINESS

Polypropylene is widely available and is becoming the most popular option for construction of new fire and rescue service vehicles in the UK and several other countries.

COST

The initial investment costs of polypropylene exceed that of aluminium, but life-cycle costs may be lower.

RELEVANCE TO FIRE AND RESCUE SERVICES

Greater Manchester FRS have implemented a light weight body construction (typically a 750kg weight reduction on a standard pumping appliance when compared with traditional alloy construction). Polypropylene has the ability to be refurbished and remounted onto a new chassis in later years, or completely recycled. The energy required to manufacture the base material is far less than aluminium or steel, making this all round a more sustainable product. Over 50% of the pumping appliance fleet is now fitted with polypropylene bodywork, and to date the design has fared well in service since its introduction in 2008.

Since this type of bodywork is designed and manufactured using CNC machinery, each body superstructure is identical (traditional alloy and GRP bodywork is coach built and no two are exactly the same) This means that once a design is arrived at, endless production numbers can be achieved and the economies of scale realised. Furthermore, although accident damage is usually limited to the point of impact (i.e. does not resonate through the rest of the body shell) and repairs are relatively inexpensive and quick to complete, if a section of bodywork is deemed to be beyond economical repair the manufacturer can quickly replicate and remanufacture a new section since the designs are all held electronically.

5.2.2 POWER MANAGEMENT SYSTEMS

DESCRIPTION

A vehicle power management system, or powertrain control module, is an on-vehicle computer which collects information and can adjust systems automatically. It consists of an engine control unit (ECU), transmission control unit and multiple sensors. The system can collect data on a wide range of power functions and usage including engine cooling, airflow, throttle and crankshaft positions, vehicle speed and other parameters. The ECU adjusts the engine based on readings from the sensors to ensure optimal running. Power management logic calculates the optimal applied power for the vehicle engine and transmission based on the input information. As on-board systems proliferate, the potential efficiency gains from power management also increase.

LATEST MARKET DEVELOPMENTS

Modular, intelligent systems are available. It is possible to use electrical drives for auxiliary functions: for example, having power take off (PTO) systems controlled by electrical systems rather than a mechanical system linked to the transmission. It is also possible to use small-capacity fuel cells for auxiliary functions, such as lighting and communications. Another approach to power management that has been developed by some vehicle manufacturers is variable displacement which aims to improve fuel economy by shutting down cylinders when they are not needed.

ENVIRONMENTAL IMPACT

Power management systems can reduce energy loss by managing and monitoring battery usage, charge and discharge, and can limit the power drain of unnecessary systems and components ensuring that systems are operating efficiently. This will reduce fuel consumption and emissions, although some energy will be consumed by the system itself. PM systems can also extend the life of the vehicle or individual components including the battery. The PM system also provides a warning if any of the connected systems or sensors are malfunctioning. This allows operators to deal with problems which may adversely affect emissions or performance.

New systems are future proof so they can be updated, reprogrammed for, or linked to, new software systems and so extending the potential life of any devices used allowing a power management system to be linked to new equipment included on the vehicle.

READINESS

There is hardware in place in the vehicles and most of the work for power management systems would be in procuring and developing appropriate software and accompanying tools to manage a system, interrogate data and undertake programming.

RELEVANCE TO FIRE AND RESCUE SERVICES

In recent years, Greater Manchester FRS have programmed the engine management system to limit speed and power output when not operating under blue lights. Evidence shows that this initiative along with lighter bodywork has resulted in a 10% reduction in fuel consumption. Fire and rescue service vehicles only actually require maximum horse power while accelerating to speed, and this only takes a few seconds so horse power could then be reduced. The knock on impact of this is that some components are designed for a maximum level that in reality is never actually reached, e.g. the cooling system, which could be downsized with smaller radiators and less water.

5.2.3 PARTICLE FILTERS

DESCRIPTION

A diesel particulate filter (DPF) is a device designed to remove diesel particulate matter or soot from the exhaust gas of a diesel engine. DPFs act to trap the particulate matter in a filter in the exhaust system, which is then burnt off periodically during normal use. DPFs have two methods of cleaning the filter, either through active or passive regeneration. In active regeneration the engine management system (ECU) will adjust the fuel injection timing when the filter starts to fill up to increase the temperature of the exhaust system to burn the soot. If the exhaust reaches a suitable temperature through normal usage this will automatically burn the soot and is called passive regeneration.

ENVIRONMENTAL IMPACT

There are advantages and disadvantages to using DPFs in vehicles. The nature of the filter means that harmful particulates will be collected and burnt off. However, as the DPF in a vehicle gets older its performance may deteriorate and the filter may reduce the fuel economy of the vehicle[33]. The DPF must be operated within manufacturers guidelines and be serviced correctly to work correctly and maintain its intended environmental impact. This is likely to reduce the service interval of the vehicle and thus use more environmental resources.

READINESS

DPFs are already retrofitted on all LFB and Ghent large fire and rescue service vehicles.

COST

Costs per vehicle depend upon the technology being retrofitted. As noted below maintenance and replacement costs may be higher in the context of fire and rescue service fleets.

RELEVANCE TO FIRE AND RESCUE SERVICES

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[33] ECU-Flash 2013 http://www.ecuflash.co/ and DieselNet Technology Guide 2013 www.dieselnet.com/tech/dpf_ash.php

There may be potential problems with the maintenance of particle filters for fire and rescue service vehicles. The regeneration is designed to take place at higher engine speeds for a prolonged period, which may not happen in vehicles used at speed for short periods then idling on incidents. Failure to carry out routine maintenance can cause irreparable damage to the filter substrate. Although filters are expected to have a service life equal to the vehicle itself, in practice their efficiency drops and service intervals increase although some of this can be attributed to ash accumulation brought about by excessive oil consumption of the engine when it becomes worn.

5.2.4 MAGNETS

DESCRIPTION

Trials have been undertaken with N410A magnets being placed on the fuel tank to assess their potential to improve fuel performance, including for fire and rescue service vehicles.

LATEST MARKET DEVELOPMENTS

The idea of magnets being used to improve vehicle fuel performance is not new, however there has been a lack of consistent evidence to support their use. Some tests show that the use of magnets could improve the engine performance and save fuel at all speeds and loads[34], although their application to replace certain features of combustion engines remains at a conceptual and research phase. Currently, the commercial use of magnets is to provide technological advantages for some components to improve particular driving features such as vehicle handling under loading[35], for example, instead of containing hydraulic fluid, some performance vehicles have begun using fluid with suspended iron particles which can adjust viscosity of the fluid depending on the driving conditions or needs.

Magnetic resonance charging is a developing technology in consumer electronics to allow wireless recharging of devices. The technology is being introduced in electric concept vehicles to enable convenient charging, which would theoretically save space, resources and costs as these systems would not need to be connected to a mains electricity source, and in the longer term could theoretically charge the vehicle while moving via wireless charging in the road network[36] . The technology might have some value in the future for electrical equipment or as a method to recharge battery operated fire and rescue service components.[37]

ENVIRONMENTAL IMPACT

The potential environmental gains associated with magnets arise from the savings in fuel and the associated emissions.

READINESS

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[34] University of Bolton, 1995
[35] Ferreira G, 2013. Geneva Motor Show 2012 – Porsche, 3d Car Shows http://3d-car-shows.com/2013/geneva-motor-show-2013-porsche/
[36] Shwartz M, 2012, Wireless power could revolutionize highway transportation, Stanford researchers say, Stanford News
[37] IDT, 2013, Wireless Power Overview, www.wirelesspowerbyidt.com

Permanent magnets are readily available and the process for fitting them to vehicle fuel tanks is relatively straightforward. However there is a need to consider any potential impact on warranties or equipment.

COST

The up-front investment costs for the Dublin Fire Brigade solution amounted to a few hundred euro per vehicle.

RELEVANCE TO FIRE AND RESCUE SERVICES

Dublin Fire Brigade has undertaken an 11-month study modifying ten fire service vehicles with permanent magnets. The initial results indicate that an average 9% saving in fuel was achieved amongst the vehicles fitted with magnets. Results are currently being reviewed under the Brigade's ISO 14 064 auditing process. Drivers were not aware of the vehicles being modified and other steps were taken to avoid the Hawthorne effect. Further research is needed to confirm the effect and its causality.

5.2.5 TYRES

DESCRIPTION

A large number of tyres are consumed by fire and rescue service fleets and the associated costs are high (approximately £560 to replace a tyre including installation in LFB's case). Environmental impacts include fuel consumption and emissions, use of raw materials and energy in the manufacture of tyres, and end-of-life issues such as reusability and recyclability.

LATEST MARKET DEVELOPMENTS

The 21st Century Truck Partnership in the United States aims for a target of 40% reduction in rolling resistance. It has identified that major breakthroughs in material dissipation properties, tyre construction, and wear and traction optimization are needed to improve rolling resistance. The tyre manufacturer Michelin expects to reduce the rolling resistance (and the wear) of truck tyres by 50% in the 25 years to 2030 by continuous improvement with a potential 20% fuel saving per vehicle.[38]

Tyre pressure monitors (TPMS) are now common place in cars and vans, however on commercial vehicles their reliability is somewhat questionable. During retardation the heat generated by the braking system will transfer through the wheel hub and road wheel into the tyre itself increasing tyre pressures. Increases of up to 20psi have been experienced when carrying out brake testing to BSEN 1846. This effectively alters the rolling radius of the tyre enough for the increase in tyre pressure to activate the tyre pressure monitor on the vehicle's dashboard.

ENVIRONMENTAL IMPACT

Tyres influence fuel consumption due to differing rolling resistance. In order to maximise fuel efficiency, two measures can be applied: the use of low rolling resistance tyres (LRRT) and the installation of tyre pressure monitoring systems (TPMS). As a tyre rotates, due to the weight of the vehicle, it experiences deformations where energy is lost as heat. LRRT minimise this loss and thus

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[38] Innovation in Truck Technologies— *Discussion Paper 2010-10* — OECD/ITF, 2010, page 8

reduce the amount of energy needed to propel the vehicle forward. Tyre pressure also affects this energy loss and TPMS inform the driver when tyre pressures are not optimal. LRRT and TPMS have **CO_2 reduction potential estimated at 3% and 2.5% respectively**.[39] All passenger vehicles manufactured after 1st November 2014 must include TPMS. When using TPMS the vehicle owner, user or vehicle fleet manager must ensure tyre pressure is adjusted regularly according to the indications of the TPMS.

READINESS

Both LRRT and TPMS technologies are well-advanced however there is a lack of FRS-specific research.

COST

As noted above the current cost to the brigades of fitting and replacing tyres is significant across the fleet, and cost savings may be achievable through more intelligent tyre design and usage.

RELEVANCE TO FIRE AND RESCUE SERVICES

The potential use of low rolling resistance tyres is limited by emergency vehicle braking requirements. However, measures to reduce the overall consumption/increase the lifespan of tyres may be considered, with significant potential cost and natural resource savings. LFB's current tyre policy requires a minimum tread depth on all fleet vehicles (light and heavy) of 3mm, in addition to an imbalance criteria across the axle/hub of 5mm. There is a lack of data on the mileage achieved by tyres and factors affecting wear and tear, which could be addressed by introducing a more sophisticated tracking system based on serial numbers.

Sometimes tyre life is sacrificed for improved handling and the emergency nature of the environment the vehicle is operating in. Although, good tyre maintenance is vital, including weekly checks and audited records. The driver is a key part of this process and with minimal training can quickly spot potential problems and identify when a tyre requires rotation or regrooving to maximise its life. In front line appliances vehicle axle operating weights will remain consistent, however, regular checks on other large fleet vehicles such as LGV support vehicle vehicle axle operating weights could also be carried out to determine the correct operating pressures for the given weight.

5.2.6 PUMPS

DESCRIPTION

Fire and rescue services generally use two types of pump: portable pumps and vehicle mounted pumps. Portable pumps are contained units with an engine running diesel or petrol, which are controllable to deliver water at a measurable pressure and flow. Vehicle mounted pumps have traditionally used the engine of the vehicle to operate the pump using a power take off (PTO) system to divert power from the drive wheels to the vehicle pump. In over 90% of interventions the only

[39] Commission staff working document. Accompanying document to the Communication from the Commission to the Council and the European Parliament. Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles. Impact Assessment {COM(2007) 19 final}{SEC(2007) 61}

element of the fire pump system is the high pressure stage and the first strike hose reels. It is important that the system can be engaged and operated with minimal effort by the driver / pump operator since often on first attendance the importance of setting the pump correctly is lost in the urgency of the incident.

LATEST MARKET DEVELOPMENTS

There may be opportunities to use separate engines to operate the pump or to use electrically power to support the pump, for example with flow rates and pressure, however, these are developments which fire and rescue services have investigated unsuccessfully in the past. Electronics and computer management can be used to support pumping, such as systems whereby the engine rpm can be set at its optimum point to ensure the hose reel system is operating at its most efficient output maximising the efficiency of the hose reel branch, and minimising risk to fire fighters.

ENVIRONMENTAL IMPACT

A PTO uses the main vehicle engine, which may make it inefficient in power, fuel and emissions use. However the design is simpler than some alternatives such as mid-engine pumps in the US, which results in lower maintenance costs, reduced breakage and longer life, in addition to cheaper and more environmentally sustainable initial manufacture. Modern pumps using electronic management systems should be able to measure the flow of water/ pressure so it will be easier to assess the environmental impact of a particular incident or exercise.

It is important that the correct power take off ratio is selected at vehicle specification which should permit the engine rpm to run at the most efficient rev band ("sweet spot") whilst delivering the optimum output for the hose reel system. The use of a pre-set engine speed system ensures the engine, power take and pump are operating at maximum efficiency. Running an engine in a steady state condition permits the on board engine management system and exhaust after-treatment systems to control and minimise harmful gases and particulates in the exhaust stream that fire fighters will be exposed to.

RELEVANCE TO FIRE AND RESCUE SERVICES

Potential combined technical innovation of pumps, power management systems and data management could be explored to increase the efficiency of pumping operations such as automatically adjusting to optimum water flow, reducing under/over running of supply and minimising safety concerns such as jet reaction. There may be potential for innovation linked to the location of the pump on appliances as moving the pump to the front of a vehicle would reduce noise, change the centre of gravity and potentially allow more water storage. However this would require a fundamental vehicle redesign and may compromise other functionality, in addition the efficiency savings may be minimal if a lighter pump set-up results in weight gains through larger water tanks on appliances.

5.2.7 FLOW METERS

DESCRIPTION

A flow meter is a device designed to accurately measure flow. They operate by either a mechanical paddle wheel or by measuring the electromotive voltage caused by the flow of water through the delivery/inlet. On pumping appliances, flow meters are fitted between the pump manifold and the delivery valves and are powered by the vehicle 24V system. They are accurate regardless of the flow (from 30 lpm to 3000 lpm). Flow data can be stored electronically and analysed to inform fire brigades on operational performance issues.

LATEST MARKET DEVELOPMENTS

Modern flow meters either use an electro magnetic sensor in the pump, which records the flow of water passing over the sensor or use a paddlewheel sensor in the pump. The flow meters are traditionally used at the pump by the pump operator, however, exponents of flow meters suggest that the branch operator could also make use of a flow meter at the branch to support their fire fighting, although the market has not yet demonstrated suitable demand.[40]

ENVIRONMENTAL IMPACT

Fire and rescue services can use flow meters to improve their tactical fire fighting, for example, increasing the flow of water at a growing fire will reduce the total volume of water required to put out a fire.[41] Research has suggested that considerable numbers of brigades "flow far less water through their attack hose-lines…and were flowing as little as 16 per cent of their target flow rates"[42] which can actually result in a dangerous limit to the water used for effective fire fighting. Attacking fires with less water than required to extinguish them has potentially detrimental environmental effects including greater fire damage and greater use of resources such as pumping fuel and foam . The recommended minimum flow rates for growing fires (gaseous phase cooling) is 100 litres / minute.[43]

RELEVANCE TO FIRE AND RESCUE SERVICES

Since 1991 Greater Manchester FRS has fitted flow meters onto fire pumps as standard. This informs the pump operator of the relevant flow rates being delivered to each hose. Knowing the nominal flow rate of the fire fighting branch being operated, the operator confirms the appropriate flow rate is set. This ensures the branch is working at its optimum flow rate, whilst the droplet size can be guaranteed to maximise the fire fighting effect of the branch.

This equipment has since been enhanced by the use of on board telemetry which can show either as live data or after an event the amount of water used at a particular incident to make better use of limited resources. It also includes an automatic water inlet system which only takes as much water as the pump requires at a given flow rate. This information can be used to determine the tank size of future appliances, the design of fire fighting branches, and different techniques in fire fighting.

Manchester FRS is about to embark on a process of fitting ultra-high pressure water systems onto its pumping appliances. This method uses high pressure "misting" at approx. 300 bar pressure, but at a

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[40] Arrowsmith, M. (2008) *Go with the Flow* Hertfordshire Fire and Rescue Service
[41] Sardqvist, S. (1999), Fire Brigade Use of Water, Interflam, in Grimwood P 2005.
[42] Grimwood, P. (2005) "The Hazards of Firefighting Operations in Residential Tower Blocks" in Harrow Court Initial Report, Fire Brigades Union
[43] Grimwood, P. (2004) "Changing Tactics" in Fire Engineers Journal, Fire Protection Association

much reduced flow rate than a conventional first strike hose reel (approx. 60 litres per minute instead of 120 litres/ min). This reduces the amount of water needed and also limits the amount of contaminated run off since the mist turns to steam on impact with the fire and resultant fire damage. This approach is supported by further studies about fire-gas cooling.[44] Early research shows that as little as 30 litres of water when applied at ultra-high pressure (around 300 bar) will reduce the internal temperature of a compartment fire (typically 300c to 50c in approx. 30 seconds) to such a level that fire fighters can safely enter a building.

This technique which includes the use of positive pressure ventilation fans and thermal scanning ensures only water is applied at the exact seat of the fire, rather than systematically moving from room to room. Although in its early stages further research is on-going and GMFRS expects to finalise the process and roll out the systems during 2014/15.

5.2.8 LIGHTS

DESCRIPTION

Operationally, the brigades use emergency scene lighting/ flood lighting, appliance lighting and various smaller lights including torches and mini LEDs. Traditional emergency scene lights have taken their power directly from a petrol driven generator running at 110 volts or directly from the fire appliance. There are also 24v scene lights and rising “night owl” lighting integrated into the appliances. Each of these options involve the use of fossil fuels (petrol or diesel) to operate the lighting. In addition to these direct fuel costs, the lighting equipment is large, heavy and cumbersome to use, creates potential trip hazards and takes up valuable storage space.

LATEST MARKET DEVELOPMENTS

- LED lights for fire fighters PPE
- LED lights for cab torches
- LED lights for scene lighting
- Rechargeable lighting instead of generator lighting – rechargers mounted in the cabs

ENVIRONMENTAL IMPACT

Any reduction in fossil fuel would be measurable, in addition to any space and weight saving in fire appliances. Modern lighting equipment would use rechargeable batteries so the life policy and afterlife disposal of these batteries would need to be considered.

READINESS

LEDs are well developed for many applications, including on-vehicle and floodlighting.

COST

Reduction in fuel consumption and replacement costs can be considerable, and upfront investment costs are falling steadily.

RELEVANCE TO FIRE AND RESCUE SERVICES

[44] Grimwood P 2013 www.firetactics.com/3D%20GAS%20COOLING.pdf

GMFRS fitted on board 240v chargers onto their appliances as part of the roll out of Tetra Radios (FireLink Project). This also enabled other rechargeable equipment (BA Lamps, telemetry, hand lamps battery operated saws etc.) to be charged from the vehicles 24 volt battery systems, whilst the vehicle batteries themselves are managed and maintained by the on board 240v charger. All appliances are fitted with dual battery systems with split charge circuits enabling ancillary equipment to be charged without risk of the appliance failing to start.

5.2.9 FINISHES AND OILS

DESCRIPTION

A variety of finishes and oils are used in the operation and maintenance of fire and rescue service vehicles. These range from engine lubricants to exterior paint and seat upholstery.

LATEST MARKET DEVELOPMENTS

All major vehicle and chassis manufacturers have already moved towards water-based paints to reduce VOCs . Use of polypropylene bodywork negates much of the need for further paint finishing, and some elements can be manufactured from colour impregnated base materials. Environmentally-friendly lubricants present a huge market opportunity, but tough performance requirements and the low price of petroleum alternatives make this a difficult market to enter.

ENVIRONMENTAL IMPACT

One of the major impacts associated with finishes is the release of Volatile Organic Compounds (VOCs) and in the production phase, painting and lacquering of bodywork can lead to harmful solvent emissions. Elements such as lead, chromium VI and cadmium compounds have potential health effects and can be found in paints.

The environmental burden of lubricants is considerable due to the nature of the substances that form them (mostly petroleum-derived compounds and additives characterised by their toxicity and low biodegradability). Environmental concerns relate more to their impact on fuel consumption and issues related to the proper collection and recycling of used oil.

RELEVANCE TO FIRE AND RESCUE SERVICES

Lower-impact finishes and oils are widely available on the market and many of these may be suitable for application in the context of fire and rescue service vehicles. Newer technologies such as polypropylene body construction and the use of transfers is reducing the need to use paints and other chemical finishes on vehicles.

5.3 DATA, LOGISTICS AND LIFE-CYCLE

5.3.1 ON-VEHICLE DATA COLLECTION

DESCRIPTION

A data logger is an electronic device that records data over time or in relation to location. This can be done either with a built in instrument or sensor or via external instruments and sensors. Modern data loggers are generally small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer and utilize software to activate the data logger and view and analyse the collected data, while others have a local interface (keypad or LCD) and can be used as a stand-alone device.

Data loggers vary from general purpose devices to those designed to measure in one environment or application type only. It is common for general purpose devices to be programmable; however some are static machines with only a limited number or no changeable parameters. One of the primary benefits of using data loggers is the ability to automatically collect data on a 24-hour basis. Upon activation, data loggers are typically deployed and left unattended to measure and record information for the duration of the monitoring period. They then communicate this data to a computer, normally in XML format.

In the case of vehicles, a data logger can be connected to the CAN-bus (controller area network, a vehicle standard to simplify how electronic devices communicate within a vehicle) to record information from the electronic control units. This then feeds into a supervisory control and data acquisition (SCADA) software system.

Applications include:

- Monitoring fuel and water usage, emissions, engine performance
- Monitoring vehicle location
- Preventative and predictive maintenance
- Operator behaviour and usage
- Control/calibration
- Automation

LATEST MARKET DEVELOPMENTS

A large number of companies of varying size and focus are active in the portable data collection and analysis market. Many offer integrated solutions which incorporate backend software, and there is sometimes a proprietary link between the data collectors and the software, for example based on a specific communication protocol. However the industry is starting to converge around IEC 61131-3 standard language. Communication between the remote units and control centre may be by GPS, WiFi, 3G, GPRS, cellular or Bluetooth.

For vehicles, the protocols used by data loggers are usually based on CANbus. Some data loggers utilize a flexible scripting environment to adapt themselves to various non-standard protocols. Data loggers are beginning to serve web pages for current readings, e-mail their alarms and FTP their daily results into databases or direct to users.

ENVIRONMENTAL IMPACT

The environmental case for vehicle data logging depends upon how the data will be used. The mere existence of the data will be insufficient to drive change at the managerial or operational level – however it may create incentives and identify opportunities for this. The following benefits can be envisioned:

- Reducing fuel consumption by identifying more efficient vehicle use
- Reducing emissions and water consumption
- Reducing vehicle and component wear-and-tear and associated maintenance

- Enabling more sophisticated reporting to meet regulatory and organisational objectives

The extent to which these or other benefits would be realised in practice depends on the way in which the technology is used. These considerations should be at the forefront of any market engagement and procurement process in this field.

READINESS

As discussed above a number of vehicle data logging technologies are developed and on the market. As the FIRED-uP project targets innovation we would be looking at specific applications in the FRS context which may require adaptation of existing loggers, protocols or software.

COST

The cost of data loggers has been declining over the years as technology improves and costs are reduced. However it is necessary to assess all associated software, licensing and installation costs over the entire lifetime of any proposed system. Economies of scale may be realised where larger numbers of vehicles are outfitted or systems are shared with other fire and rescue service fleets, for example.

RELEVANCE TO FIRE AND RESCUE SERVICES

It is very difficult to calculate the efficiency of fire and rescue service vehicles without the use of on board telemetry. Much of an appliance's engine use takes place at incidents when the pump is running. A system which monitors the fuel and water consumption, real time emissions, use of the pump and operational equipment (e.g. when removed and returned to stowage) and other indicators would allow a more sophisticated understanding of how vehicle use can be optimised.

5.3.2 EMISSION TEST CYCLES

DESCRIPTION

Test cycles are used to compare and measure the exhaust emissions for the vehicle fleets. Any standardized test, by definition, is only a single, averaged instance of a drive cycle. There is natural variability in the real-world, even if the same route were to be driven repeatedly (temperature, humidity, driver behaviour, vehicle variability, traffic conditions, etc.). Test cycles are developed to mitigate or normalize all of these conditions, and so reduce everything down to a single data point for comparison. There is thus always a spread of results (deviations).

ENVIRONMENTAL IMPACT

The choice of test cycle for new vehicles and any adaptations (e.g. for emergency braking requirements) should reflect evolving requirements in terms of environmental performance. The test cycle should reflect actual patterns of usage as closely as possible in order to ensure that vehicle emissions can be accurately measured. Evidence suggests that **there is a substantial difference between the levels of fuel consumption and emissions from official test results and those achieved in the real world**, for most vehicle types. This is due to a number of factors, such as:

- Tests normally exclude the use of on-board systems which consume fuel, such as heating, air conditioning, navigation and media systems

- Vehicle manufacturers and testing laboratories carry out tests in unrealistic ways, such as by using special lubricants, adjusting brakes, over-inflating tyres and taping up gaps between body panels to reduce air and rolling resistance, and testing in warmer conditions to improve engine running
- Test cycles do not accurately reflect real-world driving conditions.

Independent research indicates that for cars and vans in Germany, **CO_2 emissions and fuel consumption are on average 23% higher than the reported test results**.[45] The gap between test results and real world performance also appears to be growing, as the number of on-board systems increases and manufacturers claim ever-better levels. Addressing the flaws in test cycles and procedures would allow for better decision-making to identify vehicles which offer genuine environmental improvements, and to measure these.

READINESS

LFB has already contracted with a number of suppliers to undertake fleet maintenance, which includes an annual emissions test in addition to all fleet vehicles being serviced four times per year. As part of quality commitments the fleet vehicles are also all subject to separate annual emissions testing as part of vehicle inspections.

RELEVANCE TO FIRE AND RESCUE SERVICES

During 2001 GMFRS embarked on creating a duty cycle to test the effectiveness of exhaust after-treatment systems. This was carried out on a rolling road under test house conditions with full telemetry fitted to the vehicle. During these tests fuel consumption was measured to be on average 6 mpg during the emergency journey cycle and 7 mpg on return. Test cycles which accurately reflect the specific conditions of driving for fire brigades would allow more accurate appraisal and comparison of vehicle environmental performance and contribute to better decision-making.

5.3.3 OPERATOR BEHAVIOUR/ECO-DRIVING

DESCRIPTION

The main principle of eco-driving is adapting driving style to save fuel and reduce emissions of CO_2 and other matter. Training may also cover related topics for operators such as correct tyre pressure.

LATEST MARKET DEVELOPMENTS

A number of training modules are available on eco-driving, ranging from a few hours' to several days' duration. Some eco-driving content is already incorporated into standard driving tests in the UK and Belgium, however there is a need for more specialist training in the emergency services.

ENVIRONMENTAL IMPACT

While operator behaviour clearly has an important role to play in reducing overall environmental impact, its contribution should not be overestimated. For example a 2010 study for Transport for London found that operational factors (including driving techniques, smoother traffic flows and

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[45] Dings (2013) *Mind the Gap! Why official car fuel economy figures don't match up to reality*, pg 14.

more efficient freight deliveries) were likely to contribute 25% to meeting reduced emissions targets, whereas fuel and technology factors (including increased use of biofuels, electric and hybrid vehicles and improved fleet efficiency) were expected to contribute 61% of the targeted reductions.[46]

READINESS

Eco-driving techniques are well-developed and considerable research has been conducted on the impact of operator behaviour on vehicle efficiency. However our research to date has not identified data specifically relevant to fire or other emergency services. In some cases this may be extrapolated from more general studies, but there is a need to examine and test assumptions about operator behaviour and its effect on vehicle environmental performance within the context of our operations.

In 2011 Ghent organized an eco-driving programme with 54 employees in order to encourage more economic and safer driving behaviour. The eco driving programme was a success, figures indicate that on a yearly basis for 42 participants the following results could be achieved:

- A reduction of about 3000 litres of fuel
- About 7400 kg less CO_2
- A financial profit of around €3800

Today, eco driving still remains an important part of Ghent's fleet management. However over the long term monitoring with an Intelligent Transport System (ITS) is recommended to achieve the best possible, economical and environmentally friendly driving style. During the project results revealed that tyre pressure is also an important factor.

The City of Ghent considers eco driving relevant for fire and rescue services when returning to the station, but not when driving to an emergency situation.

COST

The cost of implementing eco-driving depends upon the duration of training and frequency of updates. A short payback period would be expected against this initial investment.

RELEVANCE TO FIRE AND RESCUE SERVICES

Emergency driving requirements mean that eco driving is not suitable for all frontline appliance usage. However it may be particularly suitable for non-emergency usage such as returning from an incident or prevention activities.

5.3.4 VEHICLE SIZE, LOAD AND FLEET SIZE

DESCRIPTION

The size of individual vehicles, their load and the overall size of our fleets are major factors affecting our environmental footprint. Vehicle size has traditionally been determined by station size, pumping capacity, crew safety, stowage needs, performance and durability, and image considerations. Load is

[46] Transport for London (2010) *Alternative Fuels Strategic Analysis* at slide 9.

determined by the number of crew needed to attend incidents, equipment, water and foam carrying requirements. Fleet size is determined by a complex range of factors – from operational demand and target attendance times to training and reserve requirements, to budgetary considerations. There is an interrelationship between the three considerations of vehicle size, load and fleet size. The functionality of individual vehicles is also an important consideration, for example larger vehicles with a bigger load may be able to fulfil more functions, allowing a reduction in total fleet size.

LATEST MARKET DEVELOPMENTS

Market developments have largely focused on reducing the weight of vehicles and equipment. Vehicle size and fleet size are seen to be driven by organisation and sector-specific concerns, so there may be less pay off against research and development work in these areas.

ENVIRONMENTAL IMPACT

Reducing vehicle size, weight and fleet size offer considerable benefits throughout the life-cycle of fire appliances. Using smaller or lighter vehicles offers savings through reduced raw materials used in their manufacture, lower fuel consumption, emissions and maintenance costs during their use phase. Smaller vehicles also require less end-of-life processing. To quantify these impacts, it is necessary to have data on the actual usage patterns of all vehicles in the fleet.

READINESS

Technologies for weight reduction are well developed for some components, but the basic design considerations which make fire and rescue service vehicles large and heavy, such as the amount of water carried, location of the pump and other mechanical components, and body design and storage have not been widely challenged.

COST

Variable payback periods for changes to vehicle design can be observed, whereas reduction in fleet size is likely to result in immediate savings.

RELEVANCE TO FIRE AND RESCUE SERVICES

The possibility of using smaller vehicles to fulfil some functions has been demonstrated at LFB by the adoption of Minis as first-response units at the Olympics. However from an environmental perspective such initiatives are only worth pursuing if they involve the substitution of lower-impact vehicles for higher-impact ones for some operational activities. This may occur either through the reduced use of larger vehicles, or through their eventual replacement within the fleet. To calculate the environmental gains, the knock-on effects on attendance and vehicle management and deployment would need to be assessed.

5.3.5 VEHICLE LIFETIME AND END-OF-LIFE

DESCRIPTION

Fire and rescue service vehicles typically enjoy a long lifespan due to their robustness and relatively low mileage. LFB pumping appliances are currently subject to a 12-year lifing policy. End-of-life disposal and recycling can be influenced by security considerations – to prevent fraudulent use of vehicles. Disposal of vehicles is the responsibility of LFB procurement and is managed with due regard to the environment and charitable considerations.

LATEST MARKET DEVELOPMENTS

Remanufacturing of many automotive components is well-established, however in the specialist fire and rescue service vehicle sector there may be less demand.

ENVIRONMENTAL IMPACT

Determining the optimal vehicle lifespan from an environmental perspective means taking account of the trade-off between the energy and emissions required to produce a new vehicle, and the environmental benefits of upgrading to cleaner technology.

READINESS

Infrastructure for the recovery, recycling and remanufacture of automotive components is widespread.

COST

Vehicle lifing policies and end-of-life decisions can result in financial savings where these maximise the value embedded in vehicles.

RELEVANCE TO FIRE AND RESCUE SERVICES

There is scope for optimising the lifetime of vehicles based both on more robust construction or components and more intelligent data regarding individual vehicles. Recyclable materials can reduce end-of-life impacts.

5.4 AREAS OF FOCUS: LONG LIST

The above technology profiles are intended to feed into the process for selecting areas of focus for the market engagement and procurement activities. A broad view is being taken in order to avoid missing potential opportunities for innovation and environmental performance linked to our vehicle fleets. Comments received from the Expert Advisory Group and the workshop held at LFB headquarters on 5th April 2013 have helped to access information and guide the decision-making process.

Innovation in the following areas is being considered.

- Gearbox: new model of robotic gearbox
- Data logging/telemetry to monitor vehicle and equipment usage
- Innovation concerning material used for the cabin and superstructure, taking into account the life cycle cost of the vehicle
- Location of pump
- Drive mechanism of pump: alternative system e.g. hydraulic
- Charging vehicle batteries: brake energy regeneration
- LED technology
- Finishes and oils with low environmental impact
- Comfort of Firefighters: noise, soundproofing and location of equipment

- Training, Eco driving
- Documents supplied by tenderer: environmental impact, total life cycle cost, recycling

For Ghent, an innovative second-line vehicle may be developed, to be used by the rescue team and consisting of a modular structure with the following elements:

- Limited water storage for extinguishing smaller fires (2nd line)
- Pumping system, used in case of a flood event
- ITS: further development of the current GPS system for monitoring energy and water consumption
- Crane: drive electric power

LFB is less likely to be able to procure a whole-vehicle solution within the project timelines and so is focusing on technologies which can either be retrofitted to existing vehicles or help establish the case for vehicle upgrades in the future. The area of data logging/analysis is of significant interest at this stage and a market survey of suppliers and technologies within this field is being undertaken.

6 MAKING THE BUSINESS CASE

6.1 MANAGEMENT DECISION PROCESS AT LFB AND GHENT

6.1.1 THE LONDON FIRE BRIGADE PROCESS

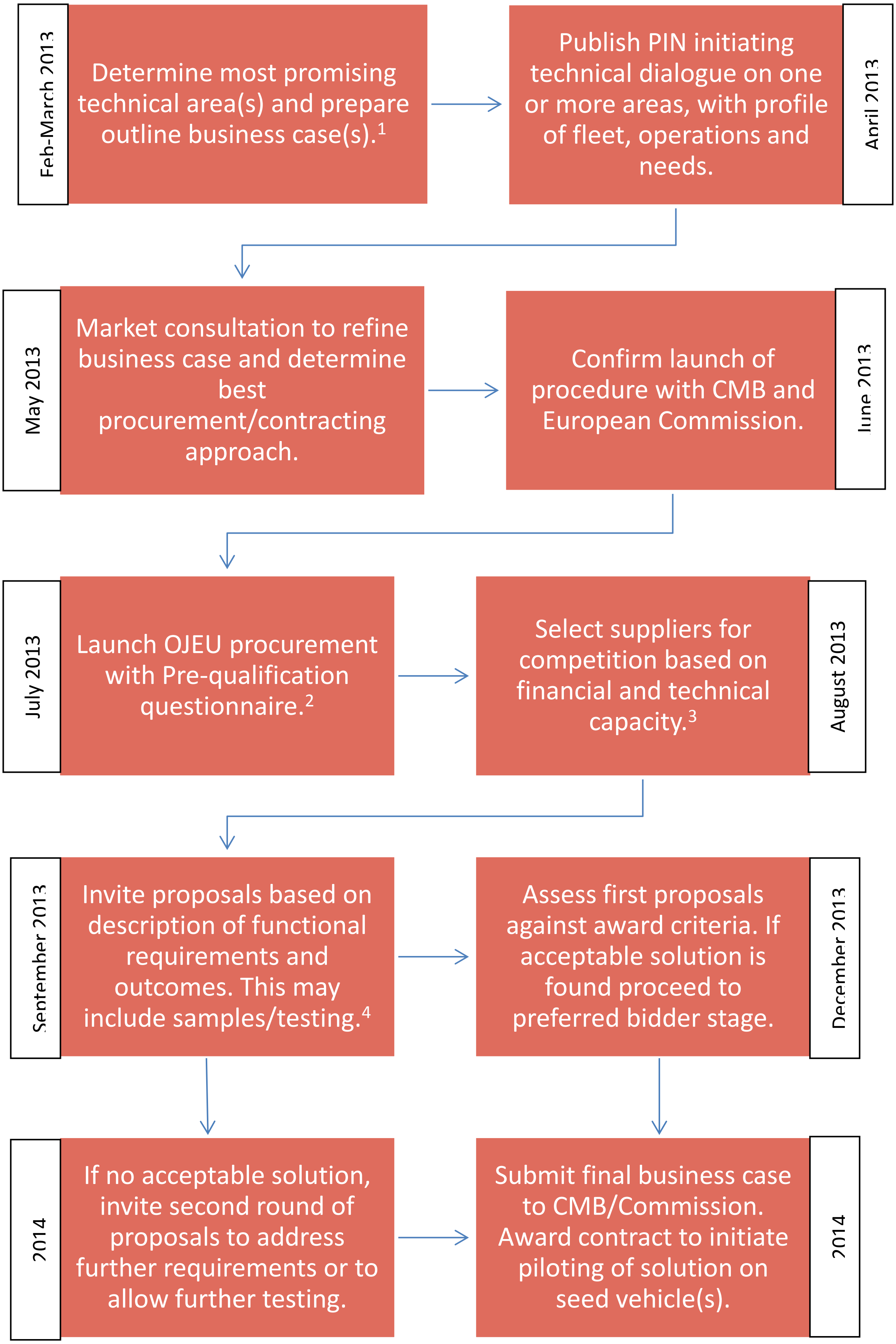
LFB uses the forward planning system. This is an internal management tool to plan business to the appropriate level of authority within the London Fire and Emergency Planning Authority (LFEPA), which may be one of: the project or programme board, the Corporate Management Board (CMB), panels, committees and the Authority. Decisions can only be taken by the Authority, a committee (or sub-committee to whom a committee has delegated a function) or by a named officer acting under delegated authority. Individual members do not have decision-making powers. To allow the Authority to operate effectively and efficiently it has established a supporting decision-making framework. The CMB is responsible for the development of policy proposals for consideration by the Authority. In addition to these officer level business management meetings, there are various forums (including steering groups and project boards) that exist within a directorate, department or across the organisation which focus on the management or progression of specific areas of business.

As any procurement will have funding implications, the decision-making process is likely to need to go to a member-level body (i.e. Authority). Within the Fired-uP project, initial decision making for the potential procurement of goods and services will be reported by the project team to the Head of Procurement (who is a member of the Fired-uP project board) and from there a forward planning report will be written for a programme board and then upwards to committee, panel and the Authority, as appropriate. A brief overview of the process of forward planning is published in specific LFB policy documents[47].

Considering that the decision making process will involve internal consultation and a decision from the Authority, FIRED-uP should allow six months to get from business case to resolution. The steps in the process are illustrated below.

[47] LFB Business management arrangements published 14 October 2008 (policy number 628)

FIRED-uP Steps for Market Consultation and Procurement (LFB)



Notes

1. The business case will contain i) Description of technology and proposed operational use in LFB ii) Market profile and state-of-the-art, including potential for innovation iii) SDIA, including a statement of how environmental impact would be measured iv) Examples of any similar uses by other FRS/emergency services, or of similar previous projects at LFB v) Cost estimates, including application of EU co-finance vi) Framework for procurement and testing vii) Framework for risk management.

2. The procurement is likely to take the form of a competitive dialogue for the award of a framework agreement or phased contract. Competitive dialogue is considered to offer more opportunities to refine the requirements during the procedure, and a framework/phased contract will allow LFB and other interested FRS including Ghent (to be mentioned in the notice) to purchase the solution in a flexible manner.

3. Given the intention to encourage innovation and participation of SMEs, the PQQ should be clearly designed to minimise barriers to participation and allow the formation of consortia.

4. We will need to decide whether it makes sense to test more than one solution. If so, then the competition will be kept open until final approval testing is signed off. Award criteria for the solution might include:

- Fitness for purpose
- Environmental performance (can the environmental gains be quantified and what order of magnitude are they)
- Innovative character (does the solution meet one or more of the Oslo report definitions)
- Whole-life-cost
- Warranty and delivery/development schedule

Specific performance requirements would be built into the contract, which could include a requirement to demonstrate payback over a defined period.

Phase 1: Preliminary study in parallel with LFB	
15-jun-12 until 01-mrt-13	**Needs Assessment**
	Establish Expert Group
	Identify model(s) for environmental impact
	Research
	Survey of good practice
	Collect case studies
	Risk assess good practice
	Long list innovations
	Select shortlist
	Review survey and study visit 1
	Review survey and study visit 2
	Consultations and reporting
	Workshop to review good practice
	Draft specifications
	High level specifications developed
	Report summarising needs ass, findings on good practice & key focus (2.1)

Phase 2: Market consultation	
8 months	**Working method Ghent**
	PIN 1. Identification of the innovation potential - Users point of view 2. Market consultation -Technological point of view 3. Feasibility check & risk assessment in cooperation with LFB (LEAD) Results: * Final report Output related (Functional requirements)

Phase 3: Procurement of innovation	
	3.1 Procurement of innovation
6 à 2 year	Phase 1: Solution exploration Phase 2: Determining procurement procedure to be followed

3.2 The procurement procedure

	Phases	Tasks
9 Months	Design Phase Preparation	Preparation of specifications and decision
		Legal review of documents and decision by knowledge cell
		Submission of decision
		After approval by the Mayor and the Board of Aldermen/Deputies of Mayor, the Council: duplicate specification, instruct Contact Point publication, competition
	Publication Phase	Publishing of contracts
		Call for candidates
		Providing information on specifications
		Receive, open, registration of tenders (in collaboration with the protocol and Logistics office)
	Assessment Phase	Assessment of bids
		Preparation of award report and instruct Knowledge Cell to review the report
		Legal review of award report and decision
		Submission of decision
		After approval by the Mayor and the Board of Aldermen: instruct Contact Point to imply decisions
		Notification of decision
		Provision of information concerning notification
	Implementation Phase	Succession of payments of bail
		If still applicable: send command of commencement
		Monitoring of assignment: Review/ approval of progress reports, delivery notes ...; initiate notice of default; Completion of assignment (settlements and decisions); instruct Contact Point to release bail (partial)
		Release bail (partial or residual)

6.2 CONDITIONS FOR AVAILING OF EU CO-FINANCE

The conditions for availing of the specific budget set aside for procurement costs are detailed in the Grant Agreement signed by the parties. For the purpose of this document it is sufficient to note that the provision of co-finance is dependent on the procurement being advertised in the Official Journal of the European Union (OJEU) and conducted in accordance with the EU procurement directives and Treaty principles. It will also be necessary to establish the innovative character of the proposed purchase, in accordance with the definition given in Section 1.3 Innovation and Risk. A further condition is that the funds must be committed no later than June 2015.

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8 ANNEX

8.1 ANNEX A – FULL GHENT FLEET FIGURES

Mark AND Type	Object type	Euro norm	Fuel	Total consumption (litre)	Total price (EURO)	CO2 Emission (ton)[48]
MERCEDES SPRINTER	Ambulance (SC)	EURO V	Diesel	8417	11784	22.25
VOLVO FL	Heavy duty vehicle (CV)	EURO IV	Diesel	5077	6979	13.42
VOLVO FL	Heavy duty vehicle (CV)	EURO IV	Diesel	2568	3577	6.79
MERCEDES VITO	Multi-purpose vehicle (AF)	EURO IV	Diesel	903	1262	2.39
WEIDEMANN 1370 CX50	Agriculture equipment (LA)			245	343	0.65
PEUGEOT PARTNER	Light duty vehicle (CT)	EURO III	Diesel	928	1299	2.45
PEUGEOT 308	Multi-purpose vehicle (AF)			951	1336	2.51
PEUGEOT 308	Multi-purpose vehicle (AF)			1006	1410	2.66
MERCEDES VIANO	Multi-purpose vehicle (AF)			4067	5694	10.75
MERCEDES ATEGO	Heavy duty vehicle (CV)	EURO V	Diesel	5716	8069	15.11
MERCEDES ATEGO	Heavy duty vehicle (CV)	EURO V	Diesel	5640	7992	14.91
MERCEDES SPRINTER	Multi-purpose vehicle (AF)	EURO V	Diesel	1436	2011	3.8
VW LT46	Heavy duty vehicle (CV)	EURO III	Diesel	1381	1937	3.65
MERCEDES SPRINTER	Ambulance (SC)	EURO V	Diesel	5657	7917	14.05
PEUGEOT 206	Station wagon (AC)			91	129	0.24
VOLVO C30	Coupé (AD)			928	1299	2.45
MERCEDES SPRINTER	Ambulance (SC)	EURO V	Diesel			
VOLVO FL	Heavy duty vehicle (CV)	EURO V	Diesel	4258	5918	11.26
VOLVO FL	Heavy duty vehicle (CV)	EURO IV	Diesel	5635	7887	14.09
MERCEDES ATEGO	Heavy duty vehicle (CV)	EURO V	Diesel	6882	9638	18.19
MERCEDES ATEGO	Heavy duty vehicle (CV)	EURO V	Diesel	4270	5969	11.29

[48] Calculated with aid of CO-2 meter of the Department Environment, Nature and Energy of the Flemish Government, 2012

MERCEDES SPRINTER	Ambulance (SC)	EURO V	Diesel	6261	8762	16.55
MERCEDES SPRINTER	Ambulance (SC)	EURO V	Diesel	3951	5531	10.44
SCANIA P320	Heavy duty vehicle (CV)	EURO V	Diesel	3607	5050	9.54
PEUGEOT PARTNER	Station wagon (AC)	EURO IV	Diesel	2109	2952	5.58
SCANIA P320	Heavy duty vehicle (CV)	EURO V	Diesel	4000	5597	10.75
SCANIA G400 CB	Heavy duty vehicle (CV)	EURO V	Diesel	3854	5395	10.19
PEUGEOT EXPERT	Station wagon (AC)	EURO IV		1300	1818	3.44
MAN TS 19 F	Heavy duty vehicle (CV)		Diesel	5516	7717	14.58
MERCEDES 1722RC	Heavy duty vehicle (CV)			542	760	1.43
VOLVO	Heavy duty vehicle (CV)	Build 2001	Diesel	1243	1739	3.28
MERCEDES 313CDI	Light duty vehicle (CT)	Build 2001	Diesel	267	369	0.7
MAN L 15 LC	Heavy duty vehicle (CV)	EURO II	Diesel	1670	2338	4.41
MERCEDES 1317X	Heavy duty vehicle (CV)		Diesel	388	543	1.03
TOYOTA LANDCRUISER	Car double use (SW)	EURO III	Diesel	1597	2232	4.22
PEUGEOT 106	Passenger car (VP)		Petrol	258	398	0.62
PEUGEOT 106	Passenger car (VP)		Petrol	171	260	0.41
PEUGEOT 306	Car double use (SW)		Petrol	1019	1426	2.46
PEUGEOT 306	Car double use (SW)		Petrol	954	1335	2.3
MERCEDES SPRINTER	Light duty vehicle (CT)		Diesel	862	1207	2.28
MERCEDES SPRINTER	Heavy duty vehicle (CV)	EURO III	Diesel	401	574	1.06
MAN 14 LC	Heavy duty vehicle (CV)	EURO III	Diesel	1133	1586	3
MAN L18LC	Heavy duty vehicle (CV)	EURO III	Diesel	3497	4845	9.24
TOYOTA PRIUS	Passenger car (VP)	Pre-EURO	Petrol	250	400	0.6
STEYR 19S32/4X2	Heavy duty vehicle (CV)	Pre-EURO		1851	2592	4.89
PEUGEOT PARTNER	Multi-purpose vehicle (AF)	EURO III	Petrol	177	280	0.43
RW	Trailer (AR)			313	437	0.83
IVECO MAGIRUS	Heavy duty vehicle (CV)	EURO III	Diesel	2463	3443	6.51
IVECO	Heavy duty vehicle			455	630	1.2

MAGIRUS	(CV)					
PEUGEOT BOXER	Light duty vehicle (CT)	EURO III	Diesel	1099	1538	2.91
VW LT35	Multi-purpose vehicle (AF)	EURO III	Diesel	987	1378	2.61
OPEL VIVARO	Multi-purpose vehicle (AF)	EURO III	Diesel	912	1279	2.41
VOLVO FMFH	Heavy duty vehicle (CV)	EURO III	Diesel	6539	9062	17.28
VOLVO FMFH	Heavy duty vehicle (CV)	EURO III	Diesel	7570	10494	20.01
PEUGEOT 307	Multi-purpose vehicle (AF)	EURO III	Petrol	2420	3808	5.85
TOYOTA HI-LUX	Light duty vehicle (CT)	EURO III	Diesel	1083	1521	2.86
FORD TRANSIT	Light duty vehicle (CT)	EURO III	Diesel	1122	1579	2.96
AGA	Trailer(AR)					
VOLVO FLC	Heavy duty vehicle (CV)	EURO II	Diesel	502	700	1.32
MERCEDES SPRINTER	Ambulance (SC)	EURO III	Diesel	939	1312	2.48
VOLVO FMFH	Heavy duty vehicle (CV)	EURO III	Diesel	3069	4296	8.11
MERCEDES ATEGO	Heavy duty vehicle (CV)	EURO III	Diesel	4898	6885	12.95
PEUGEOT 206	Hatchback (AB)			259	363	0.68
MERCEDES SPRINTER	Ambulance (SC)	EURO IV	Diesel	1613	2255	4.26
MERCEDES AXOR	Heavy duty vehicle (CV)	EURO IV	Diesel	2532	3540	6.69
MERCEDES 310DB	Light duty vehicle (CT)		Diesel	196	265	0.52

		Petrol Fuel Cards	Diesel Fuel Cards	Diesel Station Supplies
2008	Litres	6.646,68	52.181,29	60.866,30
	Costs	€ 8.906,23	€ 59.435,83	€ 76.265,47
2009	Litres	5.390,23	42.561,89	90.915,05
	Costs	€ 6.523,39	€ 39.064,18	€ 92.960,64
2010	Litres	4.694,78	40.006,77	98.403,05
	Costs	€ 6.354,70	€ 43.681,39	€ 118.260,79
2011	Litres	3.689,74	41.363,40	111.080,54
	Costs	€ 5.463,25	€ 54.778,92	€ 160.011,52
2012	Litres	5.695,12	43.353,89	43.353,89
	Costs	€ 8.986,35	€ 60.369,58	€ 60.369,58

8.2 ANNEX B – LFB MILEAGE AND EMISSIONS FIGURES

LFB MILEAGE AND ASSOCIATED COST SUMMARY 2011/12

Category	Measure
Approx. mileage for 543 vehicles	4,724,520 km
Average mileage per vehicle	8,700 km
Fuel bill 2011	£2,013,570
Average fuel cost per vehicle (543 vehicles)	£3,708
2011 diesel use	1,432,756 litres
Approx. km/litre	3.2975
Approx. cost per litre	£1.41

EMISSIONS

Year	LFB Actual CO_2 production: Property and fleet (kg)	LFB actual CO_2 production: fleet only (kg)	LFB actual CO_2 production: lease vehicles only (kg)
1990	23,709,989	6,136,000	936,559
03/04	19,451,046	4,797,462	839,606
04/05	-	4,699,041	726,861
05/06	-	4,488,812	793,056
06/07	19,451,046	4,878,597	808,156
07/08	21,431,977	4,623,584	719,950
08/09	21,002,815	4,385,687	740,070
09/10	19,575,834	3,694,052	735,876
10/11	19,098,041	3,946,087	875,484
11/12	17,500,633	3,800,065	767,862
LFB Target	16,122,792 (2014/15)	2,454,400 (2024)	

LFB FLEET SIZE

Year	Size
2007/08	535
2008/09	543
2009/10	553
2010/11	559
2011/12	544
5 year average	547

TOTAL DIESEL USAGE PER YEAR

Year	Litres
2007/08	1,996,728
2008/09	1,823,529
2009/10	1,527,582
2010/11	1,514,414
2011/12	1,432,756

AVERAGE DIESEL USE PER VEHICLE

Year	Litres
2007/08	3,408
2008/09	3,055
2009/10	2,762
2010/11	2,709
2011/12	2,634

FUEL COSTS

	Station supplies	Fuel cards	Total
2008/09	£510,906	£1,431,829	£1,942,735
2009/10	£404,411	£1,110,033	£1,514,443
2010/11	£424,880	£1,444,190	£1,869,070
2011/12	£504,397	£1,509,173	£2,013,570

PARTICULATE MATTER

Type	Opacity Value (particulate matter / PM)
VOSA standard turbo engines	3.50
VOSA standard aspirated engines	3.00
LEZ compliance	0.20
LFB average	0.076