concawe review

Volume 19 • Number 1 • Spring 2010

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Foreword

Michael Lane,
Secretary General,
CONCAWE

A year ago, I took over as CONCAWE's Secretary General, and I can say that I have greatly enjoyed my first year in the job. More importantly, CONCAWE has maintained its high level of technical work on behalf of the refining industry. In 2009, we conducted more research, in spending terms, than at any time in our long history. We also published 10 technical reports and have made significant contributions in many fields of work that have an impact upon our industry and society.

While I am pleased about these accomplishments, it is also safe to say that preparation for the REACH registration process remains our top priority. We are now nearing completion of the common parts of the dossiers that will be required to register petroleum substances and sulphur later this year under the REACH Regulation. This is a large and complex project of a kind that has never previously been undertaken by CONCAWE. We are not only compiling the technical dossiers, we are also licensing these dossiers to non-member importers of petroleum products and organising the SIEFs that are needed for data exchange and joint product registrations. An article describing CONCAWE's role in REACH and the status of our activities is included in this *Review*.

As this REACH work has progressed, other important technical work has also continued at CONCAWE. The European Commission is currently preparing for the third period of the CO_2 Emissions Trading Scheme (ETS) which will begin in 2013. CONCAWE, in cooperation with Solomon Associates, has developed a CO_2 benchmarking methodology that will be applied to the refining industry. This methodology has now been populated with refinery data and submitted to the Commission for their review and endorsement. We have also conducted an independent verification of the methodology and refinery data using a third-party company, and this work has confirmed the validity and quality of our benchmarking approach. An article describing this methodology appeared in the last issue of our *Review*.

This edition of the *Review* focuses on several additional aspects of CONCAWE's recent work.

For many years, our industry has supported the principle of transparency in the reporting of its safety, health and environmental performance. The European Pollutant Release and Transfer Register (E-PRTR) recently replaced the previous public reporting scheme (EPER), with the aim of providing even more comprehensive and site-specific reporting. The new register is expected to be a significant, positive contribution to pollutant data reporting but the information must be as accurate as possible in order to be useful. It is early days for the new register and there are still opportunities for clarifying the identification of different industry sectors and improving the accuracy of the emissions that these sectors report. An article on this topic explores the challenges of accurately categorising all industrial facilities and offers some thoughts for improvements.

As Europe moves forward with reducing the carbon footprint of transportation without compromising consumers' needs for personal mobility, renewable fuels will play an increasingly important role. On the other hand, Europe's reliance on fossil fuels for the largest share of transport and energy needs is expected to continue for at least the next few decades. For this reason, reducing the fuel consumption of internal combustion engines (ICE), reducing pollutant emissions, and ensuring that future engines and vehicles are compatible with higher biofuel blends remain top priorities for the car industry. It is also possible that advanced ICEs may run more efficiently on different types of fuels and the full environmental and performance impacts of these fuels, including biofuels, must be better understood. Two articles, dealing with these important issues are included in this *Review*.

Every four years, CONCAWE hosts a seminar (COPEX) that is attended by operators of the extensive network of oil pipelines across European countries. These pipelines represent a virtually hidden transport system conveying large quantities of crude oil and refined products and substantially reducing the road, rail and water transport of the same products. European pipeline operators have a good track record for safe and careful operations and, over the longer term, statistics have shown a downward trend in spillage incidents. COPEX 2010 provided an opportunity for pipeline operators and other technical experts to exchange ideas and best practices on how to further improve the performance of this essential crude and fuel distribution network. A summary of this year's COPEX 2010 concludes this issue of our CONCAWE *Review*.

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The 'end of the beginning' of the REACH registration process

CONCAWE's role within the REACH registration process is significantly more extensive than that of most other industry associations. Several years ago, CONCAWE's member companies agreed that the Association should act as the key focal point for many of the activities that will be needed for the successful registration of petroleum substances and sulphur by both manufacturers (refineries) and importers. These activities include:

- producing the common parts of the registration dossiers for use by CONCAWE members;
- licensing these dossiers to non-member companies (importers);
- providing advice and guidance on the practicalities of the preparation and submission of dossiers to both members and non-member licensees;
- acting as a SIEF (Substance Information Exchange Forum) Formation Facilitator for all petroleum products (except gases) and sulphur; and
- working with the European Chemicals Agency (ECHA) to clarify guidance and support the registration process.

REACH dossiers

Registration under REACH will require each registrant to submit a comprehensive dossier via the REACH on-line system, which has been set up by the ECHA. Each substance to be registered will require a substance dossier which is assembled in IUCLID[2]. The dossier comprises both registrant-specific information and the common part of the technical dossier.

CONCAWE is nearing completion of the common parts of the registration dossiers to cover almost 600 individual petroleum substances. A full inventory of these substances can be found on the *REACH Implementation* page of the CONCAWE website.

An extensive database of the properties, hazards, classification/labelling and safe use of petroleum products has been assembled with the significant help of CONCAWE's member companies and other organisations, such as the American Petroleum Institute (API). In this way, the number of new studies needed to complete the REACH dossiers has been reduced and, most importantly, the need for additional testing has been limited.

The common parts of the dossiers will be completed and made available to registrants during the summer of this year, which will be in time for the first registration deadline of 30 November 2010.

Licences for non-member companies

CONCAWE member companies have agreed that the common parts of these registration dossiers should also be made available to non-member companies who need to register. Because almost all European manufacturers are CONCAWE members, non-members are usually those companies that import and sell or use these products in Europe. The dossiers that CONCAWE is preparing are being made available to non-member companies through licence agreements with CONCAWE.

As CONCAWE is a not-for-profit association, the cost of each non-member licence has been set to cover an appropriate share of the cost of the work that has been undertaken to create the dossiers. This fee was initially set at €7000 per substance per legal entity, and was increased to €10,000 from 1 April 2010 after it became clear that the number of non-member registrations would be lower than the estimate upon which the fee was originally based.

In fact, more than 50,000 pre-registrations were made with ECHA for petroleum substances alone. During the

1 *REACH: Registration, Evaluation, Authorisation and restriction of CHemicals*

2 *IUCLID: International Uniform Chemical Information Database*

past year, CONCAWE has written several times to all of these pre-registrants to enquire whether they intend to register those substances for which they have already pre-registered. Because pre-registration was an easy and free process, it is perhaps not too surprising that the majority of pre-registrants have not indicated that they intend to complete the registration process. The replies that CONCAWE has received suggest that only a few hundred importers of large volumes of petroleum substances and a few importers of CMR substances will actually register this year!

Registration fees

The European Commission has set out the fees to be paid to ECHA for each registration, as shown in Table 1.

Table 1 Fees for registrations submitted under Articles 6, 7 or 11 of Regulation (EC) No. 1907/2006

Standard fees (EUR)	Individual submission	Joint submission
Fee for substances in the range of 1 to 10 tonnes	1,600	1,200
Fee for substances in the range 10 to 100 tonnes	4,300	3,225
Fee for substances in the range 100 to 1000 tonnes	11,500	8,625
Fee for substances above 1000 tonnes	31,000	23,500

Source: European Commission Regulation (EC) No. 340/2008 of 16 April 2008 on the fees and charges payable to the European Chemicals Agency pursuant to Regulation (EC) No. 1907/2006.

All of CONCAWE's members and all non-member licensees should be able to benefit from a Joint Submission, through the SIEFs that CONCAWE is also organising. In this way, the registration fee will be at the lower fee level, compared with an individual submission.

SIEFs

The REACH Regulation calls for the formation of so-called Substance Information Exchange Fora, or SIEFs, through which any company that has data for a specific substance is obliged to cooperate with others to pool certain information and studies required for registration. This mandatory collaboration can voluntarily be expanded to include all information in IUCLID Sections 2 and 4–13.

To facilitate this, CONCAWE is also acting as the SIEF Formation Facilitator, or SFF, for petroleum substances and sulphur. This SFF role can be established by any entity to contact and communicate with all active SIEF participants in order to ensure that all relevant data are collected and shared. In addition, the SFF can organise the identification of a Lead Registrant (the entity that will register the common parts of the dossiers on behalf of all other registrants participating in the joint submission) and arrange the co-registration process for all other registrants of the same substance.

The REACH Regulation contains detailed requirements for registration but is almost silent on the legal framework for the operation of SIEFs. In other words, it is up to each SIEF to establish its own legal basis for cooperation.

CONCAWE has established such a legal framework for petroleum products, that will be used by both member companies and non-member licensees.

Contractual framework

REACH registration rules require the establishment of contractual relationships between the different actors, i.e. the owners of substance data, the lead registrants, co-registrants and SFFs. In particular, contracts are needed to establish:

1. What access registrants will have to substance data and how much that access will cost: this is set out in CONCAWE's Licence Agreement.
2. Who administers/coordinates the whole process and provides a communication platform so that the various parties can interact: this is set out in CONCAWE's SIEF Terms and Conditions.
3. Who the lead registrant is, and what their responsibilities and liabilities are: this is set out in the Lead Registrant Agreement.
4. How substance data can be assembled by one entity to facilitate its dissemination to all other registrants: this is set out in CONCAWE's Data Sharing Agreements.

These agreements are outlined in this overview (see Figure 1), which was also shared with active SIEF members in CONCAWE's January 2010 Newsletter.

CONCAWE'S role in REACH registration

The 'end of the beginning' of the REACH registration process

Figure 1 The contractual framework for the preparation and submission of joint registration dossiers within REACH

	Who	Purpose	Action
Licence Agreement →	**Between CONCAWE and Registrants** Licence per substance per legal entity, only for 2010 registrations at this stage	Access and usage right of common elements of jointly submitted registration dossiers; sharing of cost associated with preparation of the dossiers	Visit web tool* to order a licence for each substance you intend to register
SIEF Terms and Conditions →	**Between CONCAWE as SFF and SIEF Participants** Subscription per substance per legal entity	Provision by CONCAWE as SFF of SIEF facilitation services to participants of petroleum substances/sulphur SIEFs; sharing of cost associated with SIEF facilitation services	Visit web tool* to subscribe to the service for each substance you intend to register
Lead Registrant Agreement →	**Between CONCAWE as SFF, Lead Registrant and Co-registrants** Tripartite agreement, per substance per legal entity	Roles, responsibilities and liabilities of Lead Registrants, CONCAWE and Co-registrants in the joint registration process; no cost compensation	Co-registrants will be notified by CONCAWE when the Lead Registrant Agreement is available to be signed
Data Sharing Agreements →	**Between CONCAWE and data holders** One agreement per data holder	Terms and conditions for gaining access to, and sharing the cost of, data for the purpose of REACH registration	Contact CONCAWE** if you own relevant and reliable data for petroleum substances or sulphur

** Individualised invitation and link to web tool sent by e-mail ** Contact: info@super-sief.eu*

Status of CONCAWE's preparations for REACH registration

The technical dossiers are now in the final stages of preparation. They will be extensively reviewed by CONCAWE's technical experts and finalised during the period from June until mid-August this year.

In parallel, the licensing of dossiers to non-members has been under way since December 2009. This task will continue almost until the 30 November 2010 registration deadline for those who have not yet purchased access to the dossiers. However, we strongly encourage companies to order their licences as soon as possible in order to give themselves sufficient time to complete the registration process. Moreover, ECHA has recently reminded registrants of the disadvantages of last minute registration.

CONCAWE has also set up a web-based SIEF Communication Tool that is the main vehicle for communicating with all active SIEF members and registrants.

The appointment of Lead Registrants (most of whom will be CONCAWE members) is being finalised and CONCAWE began executing Lead Registrant Agreements (LRAs) in early June.

As soon as each LRA has been signed by the Lead Registrant and by CONCAWE, co-registrants for the same substance will be able to execute the same agreement using an electronic acceptance tool. This tool will greatly reduce the time and complexity associated with these multi-party agreements.

As soon as the common parts of each substance dossier are finished, they will be made available to the Lead Registrant who will then register with ECHA. It is expected that the first registrations will begin in August/September 2010.

Soon thereafter, or possibly in parallel, depending on the final system being designed by ECHA, the dossiers will be made available to all co-registrants so that they can also register.

In conclusion

We are nearing the end of a major milestone in the REACH journey that will continue until at least 2018, and we remain confident that we will succeed in helping our members and non-member licensees to register their petroleum products this year.

European Pollutant Release and Transfer Register (E-PRTR)

Capturing and reporting industrial pollutant emissions data

In November 2009, the European Commission (EC) and the European Environment Agency (EEA) launched a new web-based European Pollutant Release and Transfer Register (E-PRTR), replacing the previous European Pollutant Emission Register (EPER).

The new web-based register can be found at http://prtr.ec.europa.eu and provides public access to pollutant emissions data covered under the terms of the E-PRTR Regulation ((EC) No 166/2006). These data are submitted by about 24,000 industrial and agricultural facilities across the EU-27 Member States plus Iceland, Norway and Liechtenstein.

An article in the Autumn 2007 CONCAWE *Review* (Vol. 16, No. 2) reviewed the main differences between EPER and the new E-PRTR, and made specific recommendations to facility operators regarding the need for accurate collection and reporting of data. This article re-emphasizes the need for accurate and complete reporting and explores some key issues that have been identified in the new web-based register.

Collection, reporting and publication of pollutant emissions data

Under the previous EPER requirements, pollutant emissions data were collected every three years, in 2001 and 2004. The new E-PRTR Regulation now requires that facilities exceeding certain thresholds report pollutant emissions every year starting in 2007. This would have been the third EPER reporting year under the previous regulation. The 2008 data will be available later this year under the new E-PRTR Regulation.

The E-PRTR Regulation specifies a reporting threshold for 91 different substances that have been classified as pollutant emissions. Facilities which fall within the threshold for any of these pollutants are required to report data on:

- releases to air, water and land;
- off-site transfers of pollutants in waste water that is treated outside of the facility; and
- off-site transfers of waste for recovery or disposal.

Pollutant emissions data must be reported for deliberate and routine releases as well as for emissions associated with accidental and non-routine activities. All reporting facilities are named.

The reporting process comprises a number of discrete steps. First, each facility is responsible for collating data for each of its releases and submitting the yearly totals to the relevant authority. This authority is then responsible for compiling the data from all sectors and conducting data validation tests. The compiled data are then submitted to the EC where the final data are entered into a single database for publication on the E-PRTR website. Experience with the first dataset from 2007 is that this publication on the website is really the first opportunity to review the data in its entirety. Should the reporting countries identify any errors with the data appearing on the E-PRTR website, then a window of opportunity exists for amending the data or rectifying omissions.

This data correction process took place in the first quarter of 2010 for the 2007 data. Some of the findings concerning data completeness and errors are now available as a report that can be accessed from the *About E-PRTR* page of the website. Eight member states reported a few errors in their submissions for 2007 while two other countries (Germany and Italy) reported that data, known to have been collected for a considerable number of facilities, were missing entirely from the database. The lost data included submissions from a number of oil refineries in both of these countries.

The report explains that the incomplete data reporting was due to a combination of technical issues related to

European Pollutant Release and Transfer Register (E-PRTR)

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data format, confidentiality claims, and delays in data collection, validation and compilation. The expectation is that these errors will be corrected in 2010 during the 2008 data submission phase, when reporting countries will also have the opportunity to re-submit corrected data for 2007. It is clear, therefore, that the current version of the E-PRTR database will be incomplete, at least until the next update of the E-PRTR database, and hence will be misleading to those interested in undertaking sectoral analyses.

Initial review of air pollutant data

The E-PRTR website includes a search engine which enables searches to be carried out using one or more criteria, for example, by pollutant, facility, country/region/river basin, industrial/economic sector, etc. In addition, a 'map search' option provides a graphical approach to searching the E-PRTR database. The complete database (in Microsoft Access format) can also be downloaded via the website.

As well as information on controlled releases from facilities, the register currently contains limited data on emissions from diffuse sources to water. This feature will be expanded in due course as more information becomes available.

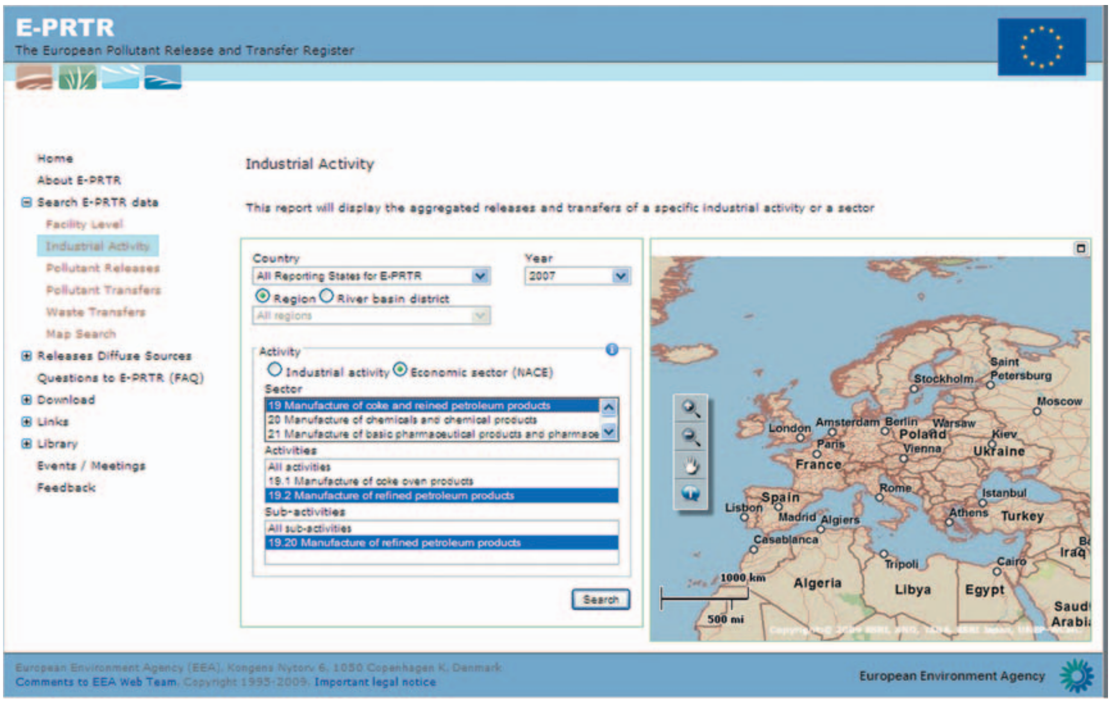
Historical data from the 2001 and 2004 EPER submissions are also available in the E-PRTR, allowing a trend analysis for common substances.

Using these search facilities, for example by industrial activity or economic sector, it is possible to refine the search according to specific sectoral codes. The two sectoral codes that are relevant to oil refineries are:

- Industrial Activity (IA) Code 1.(a): 'mineral oil and gas refineries'; and
- Economic Sector (NACE) Code 19.2: 'manufacture of refined petroleum products'.

Although most IA codes are limited and tend to be somewhat generic, the refining sector is fortunate in that there is a particularly tightly-scoped IA code covering 'mineral oil and gas refineries'. In comparison, there are 740 NACE codes that are very specific for each economic sector.

The E-PRTR website, at http://prtr.ec.europa.eu, includes a search engine that enables searches to be carried out using a range of criteria; this example shows a request for 'Industrial Activity' data.



Classification of facilities

Using these search features, CONCAWE has undertaken an initial review of the data provided in the E-PRTR database for pollutant emissions to air from those facilities which fall within the sectoral codes for oil refineries.

In the first release of the E-PRTR database, 172 facilities were classified with IA Code 1.(a) and 160 with NACE Code 19.2. Unfortunately, the number of facilities classified with these codes is considerably greater than the number of oil refineries that are known to actually exist in the reporting countries. By examining the 105 facilities that are coded as 1.(a) and as 'oil refineries' in the register, it can be seen, for example, that a number of these include very specialised sites manufacturing lubes or bitumen. It is clear, therefore, that the database includes a significant number of facilities that have been incorrectly classified.

One very obvious example of a coding error is an Italian poultry farm that has been allocated the correct Economic Sector (NACE) code but which has an IA classification identifying it as an oil refinery!

A number of the remaining facilities that are clearly not 'refineries' are related to upstream oil and natural gas activities. For example, some facilities listed under IA Code 1.(a) have NACE codes that classify their economic activity as 'extraction of natural gas' or 'support activities for petroleum and natural gas extraction'. An example of this is the misclassification of two UK gas pipeline compressor stations as refineries. Although certain sites may have the correct NACE code, no IA code is available which accurately describes their activity.

So why is this important? The inclusion of these incorrectly coded sites within IA Code 1.(a) results in a sectoral estimate of total emissions for some pollutants that is significantly greater than those for which oil and gas refineries are actually responsible. For example, facilities that are not oil refineries but are listed in E-PRTR under IA Code 1.(a) contribute 99% of the total sectoral emissions of hydrofluorocarbons (HFCs), 61% of hydrochlorofluorocarbons (HCFCs), 46% of methane, and 19% of carbon monoxide.

There are similar issues with facilities that are incorrectly identified with NACE Code 19.2. These errors have a smaller, although still significant, impact on total sectoral emissions. For example, facilities identified with NACE Code 19.2 but which are clearly not oil refineries are responsible for 31% of total emissions of HCFCs and 20% of total CO emissions.

Thus, there are two serious problems with the current E-PRTR classification scheme:

- sites which have been allocated an incorrect code; and
- upstream oil and gas facilities for which no IA code exists to accurately describe their 'industrial activity'.

It should be relatively easy for a facility to identify which NACE code accurately describes their activity because these codes are quite specific. However, a supplementary list should be added to the EC *Guidance Document for the Implementation of the European PRTR*, providing the NACE codes and their corresponding IA codes in order to reduce the number of misclassifications. This information should be provided in addition to the current Annex 1 Industrial Activities list.

For upstream facilities, there is also a clear need for IA codes that would allow these facilities to be properly segregated from mineral oil and gas refineries.

The addition of new codes would appear to fall within the remit of the committee established under the terms of Article 19 of the E-PRTR Regulation. CONCAWE has already highlighted the type of classification errors that it has identified, and the EC has undertaken its own analyses to confirm these findings. It is clear that sectoral analyses of this type are valuable in identifying errors and omissions and CONCAWE will continue to work closely with the EC to find ways to reduce errors in the register. Although our particular focus is to ensure that facilities listed under our own industry's sector codes are correct, the lessons learned will be of much wider benefit.

A key message for refineries is that they can also help to reduce the number of errors in the E-PRTR database by checking their individual codes and data on the register.

European Pollutant Release and Transfer Register (E-PRTR)

Capturing and reporting industrial pollutant emissions data

If sites identify any errors, then these should be reported to their competent authority for correction. It would also be helpful to notify CONCAWE, who can then report the correction for the sector. It is almost inevitable that errors will be found given the complexity of the data collection process and the amount of data handling between a facility reporting its pollutant emission data and the transcription of the collated data into the electronic register.

The need for data quality

It is, of course, essential that data provided by all industries are complete and accurate. The purpose of the on-line database is to allow the general public to easily search for information on pollutant emissions from individual facilities, across national regions, and from specific industrial sectors. Moreover, the review of pollutant emissions data over time will provide an important indication of the effectiveness of pollution control measures and legislation. It is important for the data to be properly handled and correctly coded prior to input, in order to ensure that the potential of the E-PRTR is fully realised.

Key points

The web-based E-PRTR is now available on-line and contains 2001, 2004 and 2007 pollutant emissions data from every European facility that exceeded reporting thresholds. All facilities are named.

The current (first) version of the E-PRTR contains a number of coding errors and omissions and these must be corrected. Until a corrected 2007 dataset has been published, however, the reported emissions from non-refinery facilities can have a significant impact on the sectoral total for some pollutant emissions, such as HFCs, HCFCs, methane and CO. This could easily result in a misrepresentation of the emissions data for our industrial sector.

The complexity and volume of data handling, from the collation of individual site data to their publication in the E-PRTR database, provides real potential for data errors to occur. Refineries should check their data in the E-PRTR, report any errors they find to their competent authorities, and notify CONCAWE so that a sectoral overview of issues can be developed for further discussions with the EC and EEA.

To help with this reporting, CONCAWE published a new edition of the report, *Air pollutant emission estimation methods for E-PRTR reporting by refineries* (Report 1/09) in 2009. This report is accompanied by a software toolkit, available to CONCAWE member companies only, to assist facilities in their emission calculations. The aim of this report is to promote consistency and completeness in the estimation of pollutant emissions to air, and the guidance provided in the report has been accepted as a sector-specific methodology by the European Commission.

CONCAWE also continues to provide input to the revision of the EMEP/EEA *Air pollutant emissions inventory guidebook*, which is recognised by the European Commission as providing an internationally approved calculation methodology. This is important work to ensure that updated sectoral information is rapidly assimilated and harmonised. As a result, nearly all of the emissions factors for the refining sector in the EMEP/EEA publication are now aligned with CONCAWE Report 1/09.

The impact of biodiesel on vehicle performance

Evaluating fuel consumption and emissions in modern diesel vehicles

Introduction

The use of bio-derived blending components in road fuels is increasing around the world as a result of legislative initiatives to reduce greenhouse gas (GHG) emissions, reduce dependence on imported fossil fuels, and support agriculture. Within the European Union, the Renewable Energy Directive (2009/28/EC), passed by the European Parliament in 2008, will require transport fuels to contain 10% of renewable products (calculated on an energy basis) by 2020. The European Committee for Standardization (CEN) is already working to change the market fuel specifications in order to enable this mandate.

For much of the coming decade, the most common bio-components will be ethanol for petrol blending and fatty acid methyl esters (FAME) for diesel fuel blending. Although progress is being made on advanced bio-components derived from biomass and other sources, these products are not expected to contribute substantially to meeting the EU renewable fuel mandate before 2020[1].

The current European diesel fuel specification (EN 590) allows blending of up to 7% v/v FAME in diesel as long as the FAME complies with the European standard (EN 14214). Many different FAME types, derived from vegetable oils and animal fats, are now used in Europe but rapeseed methyl ester (RME) is most widely used due to its especially favourable chemical and physical properties.

As vehicles adapt to new emissions requirements and the FAME content of diesel fuel increases, it is important to understand what impact changing fuel blends will have upon the fuel consumption and regulated emissions of modern light-duty diesel vehicles, particularly for newer Euro 4 compliant vehicles.

The fuel consumption (FC) of light-duty vehicles is also an important issue, as attention increasingly focuses on the GHG savings that can be achieved from FAME/diesel fuel blends. In most well-to-wheels (WTW) studies[2], the vehicle's efficiency is assumed not to change when the engine runs on an oxygenated fuel, i.e. the same megajoules (MJ) of fuel will be needed to complete a prescribed driving cycle for both hydrocarbon-only and oxygenated diesel fuels. This means that a slightly higher volumetric fuel consumption is expected for oxygenated fuels because their energy content is somewhat lower than that of hydrocarbon-only fuels. This effect will be more evident as the concentration of FAME in diesel fuel increases.

For this reason, CONCAWE was interested in measuring whether modern vehicles might be capable of recovering a portion of this volumetric penalty through better engine efficiency when running on oxygenated fuels. The published literature is not entirely clear on this point because most work has focused on the impact of FAME on emissions performance rather than on fuel consumption. In addition, the energy content of FAME is only about 10% lower than that of hydrocarbon-only diesel fuels and detecting small differences in volumetric fuel consumption can be difficult.

CONCAWE's vehicle study[3] was designed to carefully control experimental variability and collect sufficient data in order to measure small differences in fuel consumption among vehicles and fuels. The opportunity was also taken to see how significantly higher FAME levels affected both regulated and unregulated tailpipe emissions.

[1] *Wood Mackenzie, 2009.* Food and Fuel: The outlook for biofuels to 2020.

[2] *For example, the JEC Well-to-Wheels Study, Version 2c (2007)*

[3] *SAE 2010-01-1484*

The impact of biodiesel on vehicle performance

Evaluating fuel consumption and emissions in modern diesel vehicles

Table 1 Diesel fuel properties

Fuel property	Units	Test method	B0	B10	B30	B50
Derived Cetane Number (DCN)		IP 498	55.5	56.1	56.3	58.1
RME content	% v/v	EN 14078	<0.1	10.7	30.6	50.9
Oxygen	% m/m	In-house method	<0.04	1.1	3.3	5.4
Density at 15°C	kg/m^3	EN ISO 12185	823.1	829.1	841.0	853.0
Lower Heating Value (LHV)	MJ/kg	ASTM D240/IP12	42.89	42.32	41.22	40.06
Volumetric LHV (VLHV)	MJ/l	Calculated	35.30	35.09	34.66	34.17

Fuels and vehicles

Four diesel fuels were specially blended and tested in this programme. One base diesel fuel (B0, complying with the EN 590 specification) was blended with commercially sourced RME (complying with the EN 14214 specification) to give diesel blends containing 10% (B10), 30% (B30), and 50% v/v RME (B50)—see Table 1. Although these RME concentrations are higher than are allowed in today's marketplace fuels, they were selected in order to magnify the effect of RME on vehicle performance and emissions and to anticipate future increases in bio-content.

Three light-duty diesel vehicles, complying with the Euro 4 emissions regulations, were selected for this study—see Table 2. All three vehicles were equipped with direct injection (DI) common rail engines, exhaust gas recirculation (EGR) for controlling NO_x emissions, and a diesel oxidation catalyst (DOC) for reducing CO and HC emissions. Vehicles 1 and 3 were also equipped with diesel particulate filters (DPF) for controlling particulate matter (PM) emissions using two different types of DPF regeneration strategies. Vehicle 3 was the same test vehicle that had previously been used in a major European study on particulate emissions[4].

Table 2 Light-duty diesel vehicles

Vehicle characteristics	Vehicle 1	Vehicle 2	Vehicle 3
Model year	2009	2004	2005
Euro certification	Euro 4	Euro 4	Euro 4
Cylinders	4	4	4
Displacement	2.2L	2.2L	2.0L
Fuel injection system	Common rail direct injection	Common rail direct injection	Common rail direct injection
Transmission	Automatic	Manual	Manual
Diesel particulate filter (DPF)	Catalysed DPF with in-cylinder fuel injection	No DPF	Fuel-borne catalyst with in-cylinder fuel injection

Fuel consumption and tailpipe emissions data were collected over the New European Driving Cycle (NEDC), which is the European regulatory test procedure. In addition to the typical measurements used to monitor engine and vehicle operation, emissions measurements also included NO_x, CO, HC, PM and particle number (PN) emissions using standard techniques. Similar testing was conducted over a European transient driving cycle and two fixed-speed driving conditions.

The impact of RME on fuel consumption

The primary objective of this study was to find out whether modern vehicles can compensate for the lower energy content of RME/diesel fuel blends by improving their engine efficiency. Since the energy content of FAME is only slightly lower than that of diesel fuel, higher RME contents and a rigorous test protocol were used to control experimental variability. All vehicles responded in a similar way for both CO_2 emissions and fuel consumption (FC) with increasing RME content.

Over the NEDC, the vehicle is driven by a trained technician according to a prescribed cycle of speed versus time. For fuels having slightly different energy contents, this means that different volumes of fuel will be consumed over the regulatory cycle and converted to CO_2 exhaust emissions through combustion.

As shown in Figure 1, the volumetric FC was found to be proportional to the energy content of the RME/diesel

[4] *Andersson, J.,* et al. *(2007)* Particle Measurement Programme (PMP): Light-Duty Inter-laboratory Correlation Exercise (ILCE_LD)—*Final report (EUR 22775 EN) GRPE-54-08-Rev.1*

blend over the NEDC cycle. Figure 2 shows the average percentage change in FC and CO_2 emissions versus the hydrocarbon-only diesel fuel (B0). These results demonstrate that modern engine management systems are not able to compensate for the lower energy content of FAME-containing diesel fuels through better engine efficiency when running on oxygenated fuels.

The impact of RME on tailpipe emissions

In addition to the FC data, regulated tailpipe emissions were also measured and used to evaluate the impact of RME on exhaust emissions. The average results for all three vehicles, compared to the emissions measured on the B0 fuel, are summarized in Figure 3. The changes in PM emissions are also differentiated between the non-DPF car (Vehicle 2) and the average results for the two DPF-equipped cars (Vehicles 1 and 3).

These figures show that the NO_x, CO, and HC emissions systematically increased as the RME content in the B0 diesel fuel increased up to 50% v/v. On the other hand, the PM emissions systematically decreased with increasing RME although these effects were most evident only on the non-DPF equipped vehicle (Vehicle 2). This effect has been seen in other studies in which the oxygenated RME reduces the fraction of solid PM emissions. The PN emissions also decreased with increasing RME content on the non-DPF equipped vehicle but this effect was not evident for the DPF-equipped vehicles where the PN emissions levels were much lower.

This study on modern diesel vehicles has helped to answer some key questions related to the impact of higher RME concentrations in diesel fuel on vehicle fuel consumption and tailpipe emissions. As has already been observed with the fuel consumption of ethanol/petrol blends, the lower energy content of the RME blending component increases the volumetric fuel consumption. RME also has an impact on tailpipe emissions, most notably increasing the NO_x, CO and HC emissions and reducing the PM emissions.

Figure 1 Change in vehicle fuel consumption with RME content over the NEDC

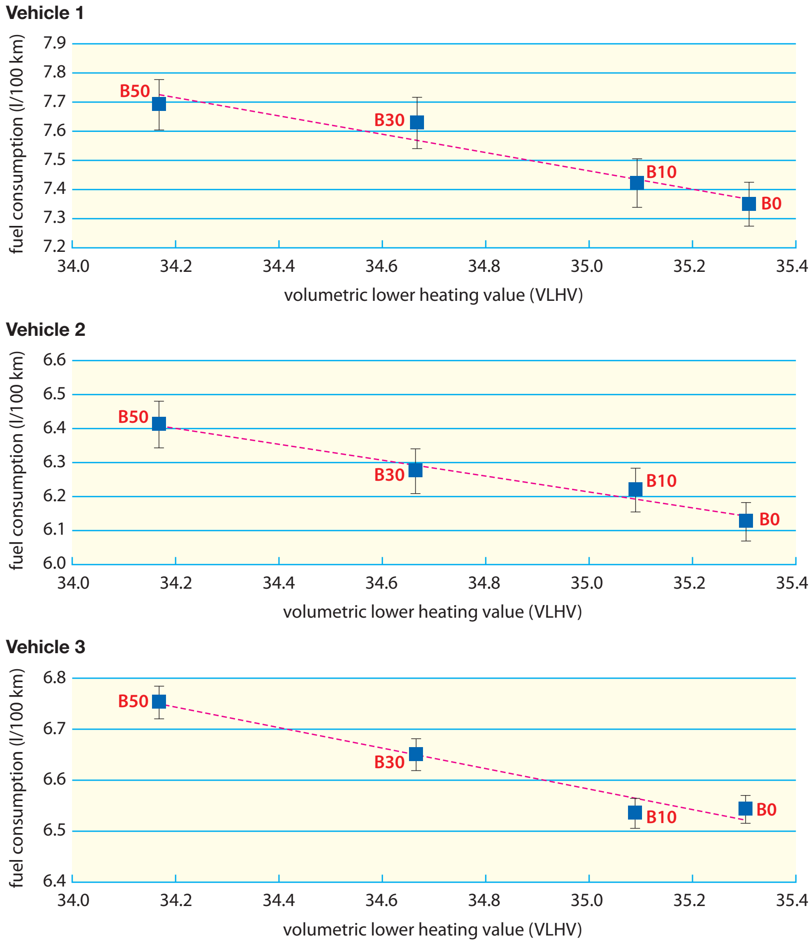


Figure 2 Average percentage change in vehicle fuel consumption over the NEDC (all cars)

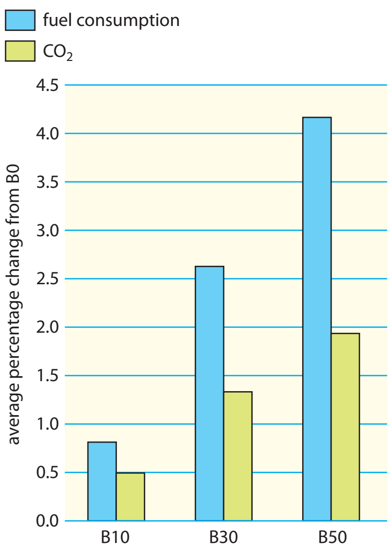
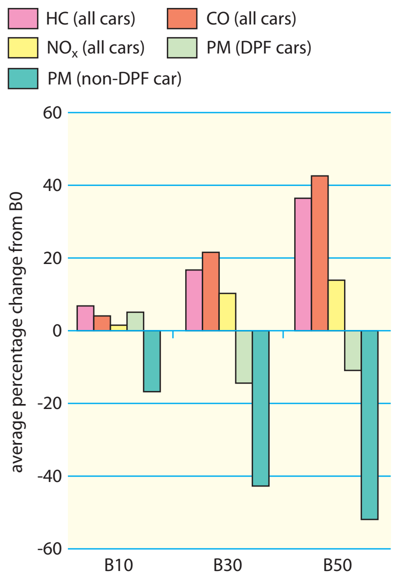


Figure 3 Average percentage change in regulated emissions over the NEDC



Fuels for advanced combustion engines

Better performance by engine and fuel working together

Over the past two decades, air pollutant emissions from motor vehicles have fallen dramatically as a result of continuing improvements in vehicle, engine and aftertreatment technologies aided by the widespread introduction of sulphur-free fuels.

While air pollutants are still important, today's priority is to improve engine efficiency and fuel consumption in order to address new concerns regarding future energy supplies and greenhouse gas emissions. These new targets must be met while further reducing air pollutant emissions. Manufacturers of engines and engine equipment are rapidly responding to meet these new challenges. Fuel manufacturers are also interested in knowing what fuels might enable these engine improvements and are ready to contribute to vehicle studies that help to clarify the performance of future fuel and biofuel blends.

Considerable research is focused today on enhancing the combustion performance of compression-ignition (CI) passenger car engines. Compared to spark-ignition (SI) engines, CI engines are already very efficient so today's challenge is to maintain or improve the CI engine's efficiency while further reducing its air pollutant emissions. Engines using advanced combustion concepts are being developed that achieve improved efficiency with lower engine-out emissions, thus reducing the demand on exhaust aftertreatment systems and, potentially, also their cost. Because these concepts typically combine features of both SI and CI combustion, the best fuel characteristics could be quite different from those that are needed by today's petrol and diesel engines.

In general, these advanced combustion concepts are designed to substantially homogenise the fuel-air mixture before it is combusted in the engine at relatively low combustion temperatures. This approach helps to simultaneously reduce soot and NO_x formation, two important air pollutant emissions from diesel engines. Achieving this result requires more sophisticated engine technology to better disperse the fuel while simultaneously lowering the oxygen content of the fuel-air mixture and the combustion temperature. Any improvements in engine-out emissions can reduce the demands on the vehicle's exhaust aftertreatment system.

In the engine, the use of higher injection pressures, cooled exhaust gas recirculation (EGR), and advanced injection nozzle designs are just a few of the hardware enhancements that improve performance. In addition, a robust and rapidly-responding combustion controller is increasingly important in order to better control the fuel injection timing and optimize the combustion process on a cycle-by-cycle basis. These concepts are rapidly moving from research into production engines. If successfully marketed in most new vehicles, these approaches have the potential to impact the types of fuels that may be needed in the future.

As reported in CONCAWE *Review* Vol. 17, No. 2, CONCAWE and FEV Motorentechnik in Aachen, Germany have explored these engine technologies using an advanced combustion single-cylinder bench engine and found that similar and very acceptable engine efficiency, exhaust emissions and noise could be obtained using a very broad range of fuels[1]. Compared to a bench engine running at steady-state speeds and loads, achieving the same level of performance and emissions in an advanced combustion vehicle operating over a European driving cycle is a substantially bigger challenge and was the next major milestone for the CONCAWE and FEV collaboration.

FEV's demonstrator vehicle

Through their own research, FEV had already developed a 'demonstrator vehicle' (Figure 1) equipped with a novel high-efficiency combustion system (HECS)[2] and were

[1] *SAE 2008-01-2404 and 2008-01-2405*

[2] *17th Aachen Colloquium, October 5–7, 2008. Aachen, Germany*

interested in testing this vehicle concept on CONCAWE's fuel set. The objective of the study was similar to the previous bench engine study: to investigate what performance could be achieved in an advanced combustion vehicle and how changes in fuel properties would influence the overall results[3]. Unlike the bench engine study, the performance hurdle was the demonstrator vehicle's driveability, fuel consumption and tailpipe emissions over the European regulatory cycle.

The FEV vehicle was equipped with a 4-cylinder high-speed direct injection (HSDI) diesel engine. A downsized 1.6-litre engine replaced the vehicle's standard 2.0-litre engine, providing the same power output and much lower pollutant emissions. Tests were completed over the New European Driving Cycle (NEDC).

The vehicle's engine was equipped with the same upgrades that had previously been used on the bench engine and are likely to be needed to meet future exhaust emissions regulations. These included a high-pressure common rail fuel system, piezoelectric fuel injectors, EGR cooling and 2-stage charge air boosting. This 2-stage strategy used both low- and high-pressure turbocharging and allowed recirculation of high amounts of exhaust gas while achieving good driveability and fast engine transient response. Although a diesel oxidation catalyst and diesel particulate filter (DPF) were used to control some emissions, tailpipe NO_x emissions were controlled by the engine combustion and EGR process alone, and a special NO_x aftertreatment system was not used.

Pressure sensors were also inserted into the cylinders in order to provide cycle-by-cycle feedback to a sophisticated engine management system (EMS). The EMS was responsible for automatically adapting to changes in fuel properties without limiting vehicle driveability and acceleration. The control strategy included an injection pre-controller that provided fast and precise fuel injection timing information to the EMS in order to maintain a constant centre of combustion from cycle-to-cycle. This so-called 'closed loop combustion control' (CLCC) approach was found to be especially important to achieve fuel flexibility while maintaining exceptional engine performance.

Figure 1 FEV demonstrator vehicle

What fuels were tested?

Previous studies[4] have suggested that three fuel properties are especially important to enable advanced combustion:

1. lower cetane number (CN), to lengthen the ignition delay and provide time for more fuel-air mixing;
2. higher volatility, to increase fuel-air mixing before auto-ignition occurs; and
3. fuel composition, to promote combustion and reduce engine-out emissions.

Six fuels were tested that covered a broad range of these properties (see Figure 2, overleaf), and included some fuels that could be imagined to fuel a growing

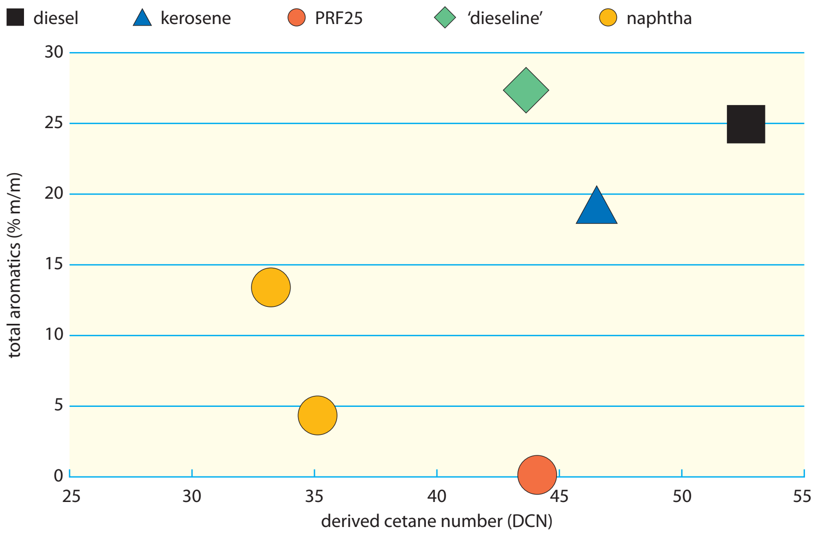
[3] *SAE 2010-01-0334*

[4] *CONCAWE Report 4/08 and CONCAWE* Review *Vol. 17, No. 1*

Fuels for advanced combustion engines

Better performance by engine and fuel working together

Figure 2 Fuels evaluated in the study



fleet of advanced combustion vehicles. The fuels included both conventional and experimental blends. In addition to a typical European diesel fuel and commercial kerosene, a 'dieseline' blend of diesel and gasoline fuels and two naphtha fuels sampled from refinery process units were tested. A Primary Reference Fuel (PRF25), blended from pure chemicals boiling in the gasoline range, was also tested.

Vehicle performance

With the vehicle hardware and EMS described above, emissions tests were completed over the NEDC. Vehicle driveability was evaluated, especially cold engine starting and responsiveness to acceleration and high load operations. Most importantly, regulatory procedures were followed to evaluate how closely the vehicle would come to meeting future (Euro 6) exhaust emissions limits for a 1700-kg vehicle.

Remarkably, good vehicle driveability performance was achieved for all six test fuels. Regardless of the fuels' properties, the vehicle operated successfully over the NEDC with few or no hesitations in engine performance. Even with the refinery naphthas, having the lowest cetane numbers in the fuel set, the demonstrator vehicle was able to complete the full NEDC regulatory protocol.

Exhaust emissions, with a focus on NO_x and particulate matter (PM), were also measured to see whether the vehicle would meet the Euro 6 limits. The NO_x emissions versus engine-out particle emissions are shown in Figure 3a for two different tests on each fuel. The NO_x and PM tailpipe limits are also shown although the PM limits only apply to tailpipe emissions and not to engine-out emissions.

Figure 3a Tailpipe NO_x versus engine-out particle emissions over the NEDC

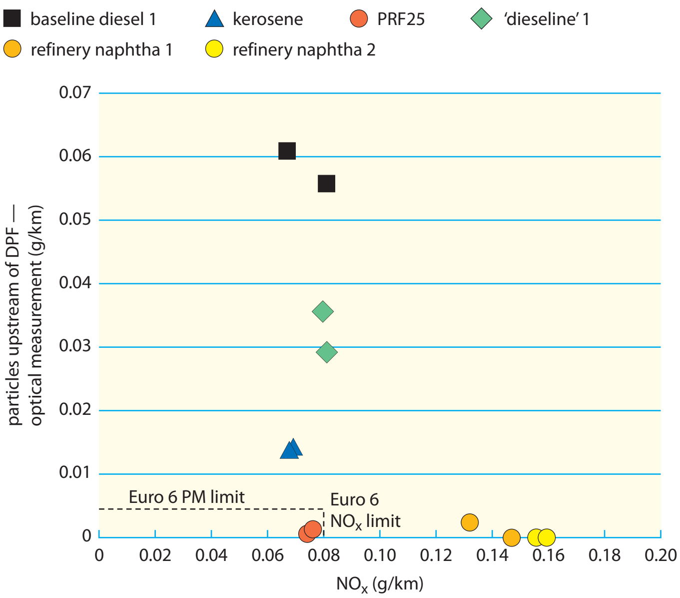
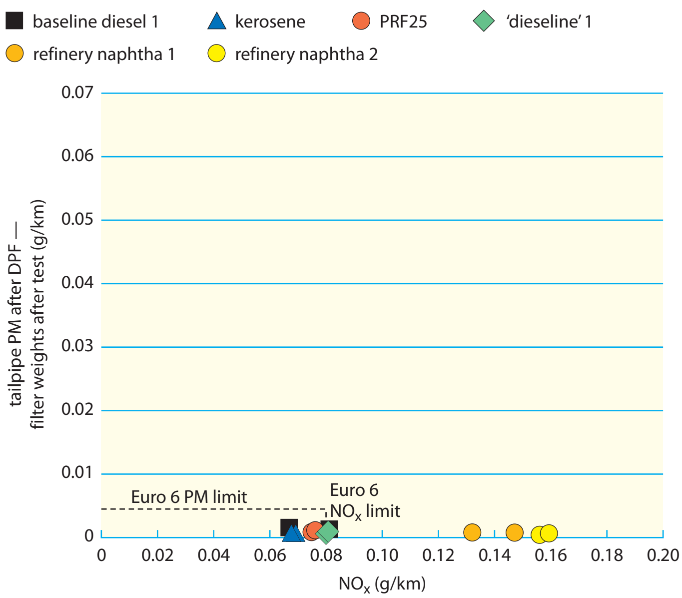


Figure 3b Tailpipe NO_x versus PM emissions over the NEDC



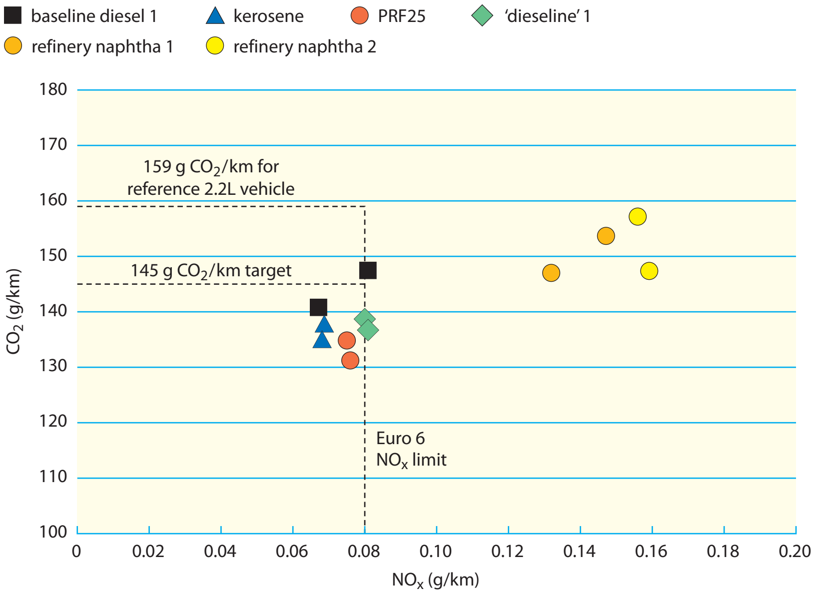
The engine-out particle emissions varied widely between the fuels and were generally in line with the aromatics contents and volatilities of the six fuels. Nevertheless, the PM emissions measured at the tailpipe by standard procedures were all within the Euro 6 PM regulatory limits when using a conventional DPF aftertreatment device (see Figure 3b).

Because of the high EGR rates used in this engine, four fuels gave NO_x emissions that were within the Euro 6 limit. The two refinery naphthas produced higher NO_x emissions over the NEDC, primarily due to higher emissions during the cold engine portion of the driving cycle.

Very good performance was also observed for CO_2 emissions (Figure 4), again with two results on each fuel obtained on different test days. Over the NEDC, four fuels showed similar performance, between 132–148 g CO_2/km. These emissions values were in line with the study targets and well below those of a comparable 2.2-litre engine. The two naphtha fuels gave slightly higher CO_2 emissions, between 148–158 g/km.

Although four fuels gave very acceptable exhaust emissions over the NEDC, the two naphtha fuels did not perform as well, especially during the cold engine portion of the driving cycle and at the lower engine load points. Higher noise emissions were also recorded for these two fuels due to longer ignition delays and a rapid pressure increase in the cylinder after auto-ignition of the fuel-air mixture. The combustion performance of these fuels is being investigated further.

Figure 4 Tailpipe NO_x and CO_2 emissions over the NEDC



Controlling the centre of combustion on a cycle-by-cycle basis allowed the engine to quickly adapt to changes in fuel properties, meeting future NO_x emissions limits without a dedicated NO_x aftertreatment system. Engine-out particle emissions were also low enough to be handled by a standard exhaust system DPF. The versatility of the demonstrator vehicle on a range of fuel types suggests that a sophisticated EMS controller, perhaps utilising in-cylinder pressure sensors, could be essential hardware for future advanced combustion engines.

In the light of today's priorities for better fuel consumption and emissions, the overall performance of the demonstrator vehicle over the NEDC was very exciting. These results suggest that even better performance and lower emissions can be achieved by ensuring that the engine, fuel and vehicle work together to meet future targets.

What did we learn?

Although the six fuels tested in the demonstrator vehicle covered a wide range of chemical and physical properties, the advanced engine hardware and sophisticated EMS controller provided good driveability over the EU regulatory cycle, with excellent test-to-test performance on the same fuel.

All of the engine enhancements played their part, but the CLCC approach was especially important to provide fuel flexibility and consistent vehicle performance.

COPEX 2010

The four-yearly gathering of the EU's oil pipeline experts

The 2010 CONCAWE Oil Pipeline Operators Experience Exchange seminar (COPEX 2010) took place in Brussels on 25–26 March, continuing a long-established tradition started in the 1980s. The COPEX seminar has been held on a four-yearly schedule since 1994, its purpose being to provide European oil pipeline operators with a forum to update their knowledge and exchange information on legislative, regulatory and technical developments. Although regulators are frequently invited to present their perspectives, most contributions are provided by the pipeline operators themselves, who also form the majority of the audience. COPEX 2010 was attended by some 85 participants from 14 countries, representing most of the oil pipeline operators in Europe.

The COPEX seminar is traditionally opened by a presentation of the latest results from CONCAWE's annual survey of the environmental performance of the EU's cross-country oil pipelines, which is based upon input from about 70 companies and agencies operating oil pipelines in Europe. These organizations are responsible for transporting around 800 million m^3 of crude oil and refined products per year over 150 pipeline systems having a combined length of more than 34,000 km. CONCAWE's report[1] now covers 37 years of data from 1971 to 2007.

Following this introduction, the first session at COPEX 2010 was dedicated to relevant legislative and regulatory developments over the past four years. Although no specific pipeline legislation has been implemented at the EU level, many EU Directives and regulations have an impact on pipeline operations or will have an impact in the very near future.

Because the EU pipeline network was essentially built in the 1960s and 1970s, pipeline age and integrity are increasingly in focus and this provided a topical theme for the second session of the seminar. Over the long term, safety statistics in the 'spillage report' do not suggest that older pipelines are more prone to incidents. In fact, the frequency of pipeline incidents related to corrosion and mechanical causes has decreased over the years. This is a testimony to the effectiveness of improved integrity management systems and increasingly sophisticated inspection techniques. However, continued vigilance is needed to ensure that these inspection and maintenance techniques are effectively applied. Data collected over the past few years suggest that the continuous downward trend in mechanical failure incidents has stabilized or perhaps reversed and this trend will be carefully monitored over the coming years.

The third session of COPEX 2010 covered a variety of current operational matters including: the development of a process safety benchmarking scheme in the UK; efforts to reduce damage to UK pipelines from third parties; experience with drag reducing additives in Spain and France; the introduction of FAME into the UK's multi-product pipelines; and experience with a sophisticated leak detection system in Hungary. The closing presentation considered contingency planning and the changing environment for pipeline operations.

COPEX 2010 underlined the fact that oil pipelines are an essential way to safely and efficiently transport crude oil and refined products across the EU. The integrity of the EU pipeline system is paramount in order to ensure a safe and reliable supply to refineries and customers. By bringing pipeline operators together to exchange learnings and best practices, COPEX contributes to pipeline integrity management and to continuous improvement in pipeline operations. CONCAWE is proud to be a partner in this very important activity.

The COPEX 2010 presentations can be found on the *Events* page at www.concawe.org.

[1] *CONCAWE Report 10/09*

Abbreviations and terms used in this CONCAWE *Review*

API	American Petroleum Institute
CEN	European Committee for Standardization
CI	Compression Ignition
CLCC	Closed Loop Combustion Control
CMR	Carcinogenic, Mutagenic or toxic to Reproduction
CN	Cetane Number
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COPEX	CONCAWE Oil Pipeline Operators Experience Exchange Seminar
DCN	Derived Cetane Number
DI	Direct Injection
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
EC	European Commission
ECHA	European Chemicals Agency
EEA	European Environment Agency
EGR	Exhaust Gas Recirculation
EMEP	Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
EMS	Engine Management System
EN 590	CEN Specification for European Diesel Fuel
EN 14214	CEN Specification for European Fatty Acid Methyl Ester (FAME)
EPER	European Pollutant Emission Register
E-PRTR	European Pollution Release and Transfer Register
ETS	Emissions Trading Scheme
EU	European Union
EU-27	The 27 Member States of the European Union
FAME	Fatty Acid Methyl Ester
FC	Fuel Consumption
GHG	Greenhouse Gas
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbons
HECS	High-Efficiency Combustion System
HFC	Hydrofluorocarbons
HSDI	High-Speed Direct Injection
IA	Industrial Activity
ICE	Internal Combustion Engine
IUCLID	International Uniform Chemical Information Database
LD	Light-duty
LHV	Lower Heating Value
LRA	Lead Registrant Agreement
MJ	Megajoule
NACE	Economic Sector, in full 'Nomenclature Generale des Activites Economiques dans l`Union Europeenne' (General Name for Economic Activities in the European Union)
NEDC	New European Driving Cycle
NO_x	Nitrogen Oxides
PM	Particulate Matter or Mass
PMP	Particle Measurement Programme
PN	Particle Number
PRF	Primary Reference Fuel
REACH	Registration, Evaluation, Authorisation and restriction of CHemicals
RME	Rapeseed Methyl Ester
SI	Spark-Ignition
SIEF	Substance Information Exchange Forum
SFF	SIEF Formation Facilitator
UNECE	United Nations Economic Commission for Europe
VLHV	Volumetric Lower Heating Value
WTW	Well-to-Wheels

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