concawe

ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

review

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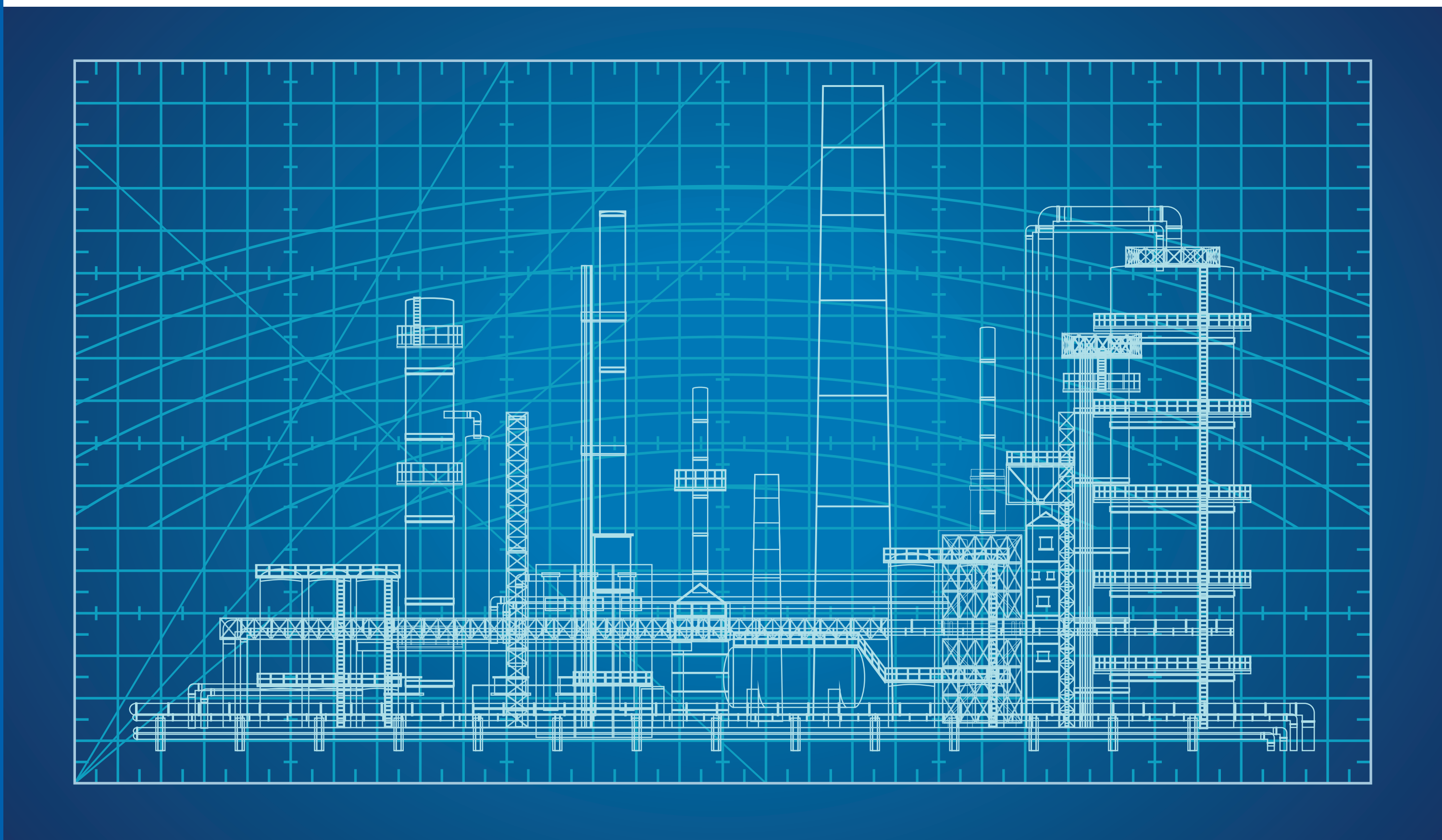

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Editor: Robin Nelson, Concawe

Design and production: Words and Publications • words@words.co.uk

Foreword

Robin Nelson
Science Director
Concawe

Over the past 150 years, the oil industry has contributed to advancement, growth and an improvement in life expectancy across the globe. With the increase in global population there are more people that aspire to a modern lifestyle.

We have a role in meeting the challenge of building a more sustainable future. A modern lifestyle is accompanied by an increase in the per-capita energy consumption. To continue to support the aspirations of the growing population we must also contribute to solving the associated problems of climate change, air pollution and water usage. In turn, these lead to a number of secondary, but still important, challenges such as energy decarbonisation and assuring the safe use of our products.

Concawe has a role in developing and sharing an understanding of the scientific issues faced in the evolution of energy for transport and for the downstream petrochemicals industry. In such context, the 12th Concawe Symposium gave many important insights and I once again thank the speakers for their illuminating presentations during the Symposium and for the summaries included in this edition of the Concawe *Review*.

Contents

12th Concawe Symposium

20–21 March, Radisson Blu Astrid Hotel, Antwerp, Belgium

Monday 20 March 2017

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Session: The future of the transport system

Drive trains and fuels for road transport

Neville Jackson (Ricardo)

Road transport faces significant challenges in meeting both societal and environmental targets. In addition to continuous reductions in greenhouse gas emissions, the World Health Organization has now defined air pollution as the world's largest single environmental health risk. While significant progress has been made in reducing particulate emissions from new vehicles, real-world nitrogen dioxide (NO_2) emissions have remained stubbornly high. The consequential failure to meet legally binding air quality targets has driven a range of city policy measures across Europe, restricting or even banning the use of vehicles with combustion engines.

A number of policymakers believe that the simple answer to these issues is to fully electrify the entire transport system. In reality, electrification is far from a panacea, and is only one part of the future transport solution. To meet all policy and environmental objectives, it is essential to take a more holistic approach to address transport challenges.

For higher-speed and heavier-duty energy applications, it is difficult to find practical alternatives to the next generation of clean combustion engines operating on lower-carbon fuels. It is clear that the more advanced and efficient emissions control systems for diesel engines will make these powertrains too expensive for all but the premium, larger passenger cars and light commercial vehicles. More efficient gasoline engines, coupled with varying degrees of micro and mild hybridisation will also close the gap in CO_2 emissions with light-duty diesel engines, further reducing the role for diesel. The diesel engine is also likely to remain dominant for heavy-duty applications where further reductions in air quality emissions and step changes in efficiency will deliver substantial environmental benefits.

For city and urban applications, electrification can provide a viable alternative to conventionally fuelled vehicles, but we also need to address the energy infrastructure challenges for recharging. Significant further investments will be required to reduce the cost of battery systems while delivering vehicles with sufficient range and utility that meet consumer requirements. For the battery-electric vehicle to achieve the future market penetration proposed by policymakers, a much more user-centric approach will be needed to ensure that these vehicles offer a more attractive user experience compared to conventional vehicles. The ever larger battery capacities fitted to the next generation of electric vehicles will also require higher power recharging facilities, beyond the capacity of existing local networks, requiring significant investments. It is not clear at present who will make these investments and how they might be funded. Without these investments, the plug-in hybrid vehicle is likely to dominate for many years to come.

We must also consider the total environmental impacts of the future road transport system. Limiting policy decisions to parameters such as air quality or tank-to-wheel emissions will almost inevitably result in the wrong choices and directions being taken. We must take a more holistic view of the total energy system and the life-cycle impacts of future road transport to deliver a system that is fit for purpose in the longer term.

Session: Challenges for hybridisation and electrification of vehicles as a route to decarbonisation

PM emissions from electric vehicles

Peter Achten (INNAS)

Electric vehicles (EVs), most notably electric passenger cars, have been proposed as a solution to several of society's problems. Some of the advertised benefits include reduced greenhouse gas emissions, reduction in oil consumption, less noise pollution, as well as improved air quality.

In terms of air quality, the emissions of particulate matter (PM) are of great importance because of their detrimental effect on human health. Research has shown that traffic is a major contributor to PM levels, especially in urban areas. Therefore, the increase in EVs has been hailed by many as the solution to urban air pollution, offering zero emissions and promising cleaner air for everyone. However, EV proponents often neglect to consider emissions from non-exhaust sources, such as tyre wear, brake wear, road wear and resuspension of road dust.

As tailpipe emissions standards have become increasingly stringent over the past decade, non-exhaust emissions are already considered to be the dominant source of PM from traffic. By the end of the decade, non-exhaust sources are predicted to contribute as much as 90% to total PM emissions from traffic.

EVs have the benefit of having no tailpipe emissions, but still have tyres and brakes. Therefore, just like internal combustion engine vehicles (ICEVs), EVs will emit PM through non-exhaust sources. In addition, EVs tend to weigh more than ICEVs because of their heavy batteries, and are therefore significant contributors to PM. This means that the increasing popularity of EVs will not necessarily have a straightforward effect on PM levels and air quality.

Research has shown that an increase in weight of the vehicle fleet correlates to an increase in non-exhaust emissions. Studies indicate that a linear relationship exists between weight and non-exhaust emissions such as tyre wear and resuspension of road dust. Emission inventories also consistently estimate higher non-exhaust emissions for heavier vehicles.

The relationship between weight and non-exhaust emissions is important because the literature shows that EVs are heavier than ICEVs and likely to remain that way in the future. Estimates for additional weight of present-day EVs compared to ICEVs range from 21 to 56%. For future EVs, the additional weight estimates range from 17 to 75%.

The claims that EVs are emission-free are therefore unjustified. The increase in weight of EVs is likely linked to higher non-exhaust emissions. Results of individual studies vary depending on the methodology used, but it appears that EVs do not result in significant reductions of PM. As a result, EVs cannot be considered the single solution to urban air pollution.

Session: Challenges for hybridisation and electrification of vehicles as a route to decarbonisation

The size and range effect: life-cycle greenhouse gas emissions of electric vehicles

Linda Ager-Wick Ellingsen (Norwegian University of Science and Technology)

The predicted growth of light-duty vehicles forecasts an increase in fossil fuel consumption and greenhouse gas (GHG) emissions. As a measure to reduce dependence on fossil fuels and thereby mitigate climate change, many governments have introduced policies to promote market uptake of electric vehicles (EVs). As EVs have no tailpipe emissions, they offer a potential to reduce GHG emissions. However, a life-cycle perspective is required to obtain knowledge of the sustainability and impacts of EVs. Life-cycle assessment (LCA) can contribute to comprehensive environmental understanding.

The primary objective of this study is to assess how EVs perform across different size segments and against similar-sized internal combustion engine vehicles (ICEVs). For this purpose, we assessed the life-cycle GHG emissions of EVs in four different size segments. The average European electricity mix (521 g CO_2/kWh) was assumed for the use phase. In addition, sensitivity analysis assessed electricity mixes with different carbon intensities. Emissions were calculated in terms of tonnes of carbon dioxide equivalents (CO_2e) per vehicle over a lifetime of 180,000 km. As a point of reference, LCA results for ICEVs were collected from LCA reports published by Daimler and Volkswagen

Across the different vehicle segments, there were large variations in life-cycle emissions. Regardless of power-train configuration, a shift from larger to smaller vehicles was found to be beneficial. The EV production phase was more emission intensive than that of the conventional vehicles, but the EVs compensated the higher production emissions by having lower use-phase emissions. For both the ICEVs and the EVs, the use phase was responsible for much of the GHG emissions, whether directly through fuel combustion or indirectly through electricity production. When comparing equal sizes, the EVs had a 20–27% lower life-cycle impact than the ICEVs. Although the EVs had lower life-cycle impacts than the ICEVs, EVs do not have lower life-cycle impacts than ICEVs regardless of size.

To explore how the carbon intensity of the electricity used for charging influences the life-cycle emissions of EVs, we evaluated electricity based on energy from world average coal (1029 g CO_2e/kWh), world average natural gas (595 g CO_2e/kWh), and wind (21 g CO_2e/kWh). We also assessed a prospective green energy scenario where only wind-based electricity was available for all value chains. This resulted in very low carbon intensity (17 g CO_2e/kWh). Charging the EVs with coal-based electricity made the EV life-cycle emissions 12–31% higher compared to the conventional vehicles. The EVs powered by electricity from natural gas had 12–21% lower life-cycle impacts compared to their conventional counterparts. When powered by wind-based electricity, the EVs had 66–70% lower emissions than the ICEVs. In this scenario, the use phase was of low importance. Comparing the prospective green energy scenario to the ICEVs, we found that the EVs offered 83–84% lower life-cycle impacts. The use phase contributed very little to the overall impact. Note that the prospective green energy scenario is not an aim at predicting future EV life-cycle emissions. When we compare the different scenarios, we find that the absolute differences in life-cycle impact between the size segments became smaller as the carbon intensity of the electricity mixes decreased. In other words, the size and range effect decreased with lower carbon intensity electricity mixes.

From a GHG perspective, EVs equipped with smaller battery packs are more competitive than the heavier EVs with larger battery packs. However, EVs with small battery packs suffer from shorter driving ranges and are more dependent on infrastructure in the form of fast charging stations. Compared to the ICEVs, the EV production phase was environmentally more intensive. Thus, at the current state of the technology, finding the right balance between battery size and charging infrastructure is an important element in maximizing the climate change mitigation of EVs.

This article is published in an open access journal and can be found at:
http://iopscience.iop.org/article/10.1088/1748-9326/11/5/054010

Session: Ecosystem services—the potential of carbon sequestration

Using forest carbon credits to offset emissions in the downstream business

Lars Hein
(Wageningen University)

This symposium presentation examined whether, and if so how, forest carbon credits can be used to offset emissions from the European refining and road transport sectors. Forest carbon projects aim to reduce emissions from land-use change and/or vegetation to capture CO_2 from the atmosphere. Once certified by an independent agency, carbon credits can be sold on the carbon market. There are two principal carbon markets: the voluntary market and the compliance market.

The voluntary carbon market has an annual turnover of around 90 million tonnes of carbon dioxide equivalent (CO_2e) emissions. Around one-third of the credits traded on the market are from forest carbon projects. Currently, there is oversupply on the market and prices of carbon credits are low, ranging from US$ 3 to 10 per tonne CO_2 for forest carbon projects.

The largest compliance market is the EU Emissions Trading System (ETS), which includes the refining sector, but not emissions from road transport. Other compliance markets such as those in California and New Zealand allow trading forest carbon credits, with a number of restrictions, for instance on where the forest carbon credits are generated. The world's carbon markets are dynamic and the ETS is currently being redesigned for the post-Kyoto period (after 2020). Although the use of forest carbon credits generated in the EU post-Kyoto is currently being discussed, the ETS does not permit using forest carbon credits to offset emissions at the present time.

In the refining sector, there is currently limited scope for using forest carbon credits to offset emissions. They are not recognised in the ETS, and policy conditions are also not conducive to the use of voluntary carbon credits in the sector. Voluntary carbon credits could be purchased to offset emissions but ETS credits would still need to be obtained for the same emissions.

A potentially more promising option is to develop a 'carbon neutral' petrol and/or diesel for sale at retail stations using voluntary carbon credits. The sector would need to show that this fuel is made using Best Available Technology (i.e. most energy efficient). Residual emissions could be offset with forest carbon credits. The price of offsetting these carbon emissions is almost the same for petrol and diesel, and can be estimated (on a well-to-wheel basis) to range from 1.5 eurocent per litre (assuming a carbon price of 5 euro/tonne CO_2) to 3 eurocent per litre (for a carbon price of 10 euro/tonne CO_2). At present, the amount of carbon credits available on the voluntary market would suffice to offset CO_2 emissions of around 7 billion litres of fuel, increasing to around 16 billion litres in 2020 if a willingness to buy is communicated to forest carbon project developers.

Bringing carbon neutral petrol to market would offer a number of benefits: (i) offering consumers an environmental friendly product that is suited for people with driving requirements that cannot be met with electric cars; (ii) offering a low-cost option for compensating emissions from driving; and (iii) several co-benefits from using forest carbon such as biodiversity conservation. Hence, carbon-neutral petrol could bring substantial, low-cost benefits to both the industry and society in general. Further steps required to bring the product to market include a basic life-cycle assessment to compare carbon neutral petrol and diesel to electric and regular cars, working out the specifics of the carbon offsetting mechanism, development of a communication and marketing strategy and piloting the approach in one or more countries.

Session: The future of special refined products

How far a drop of oil took one company

Carl Robertus (Nynas)

Crude oil is a remarkable substance; it can dissolve, purify, lubricate, cool, insulate, bind and protect. Why burn it? At Nynas, crude oil is used to produce bitumen for roads, a crucial part of transportation infrastructure. It is also used in roofing (for waterproofing), and in the production of printing inks, lubricants, adhesives, cars, appliances, tyres, PVC, etc. Most of the Nynas refined products, unlike fuel, can be recycled, some of them many times over. This allows the oil—a finite resource—to last as long as the human imagination and technology will allow.

Bitumen is a fantastic engineering product made from crude oil, and is the key binding agent in asphalt road surface materials. Roads are essential to our everyday lives, playing a huge role in the transport of goods and people across Europe. Asphalt surfaces offer comfort, safety and sustainability, both today and into the future.

Demands on road materials are growing and becoming increasingly complex. This is not only due to the increasing volume of traffic, but also due to changes in traffic loads, traffic types, vehicle design, road layout, surfacing materials, maintenance techniques, environmental requirements and climate. The typical design life of the road is measured in decades.

Road construction requires long-term, cost-effective solutions that are based on functional performance needs. As the demand for economic and sustainable road networks increases, choosing the right bitumen is now more important than ever in ensuring optimum performance. The Nynas Bitumen Performance Programme is intended to help make that choice and provide specific solutions to meet special requirements in close cooperation with customers. It is about meeting the right level of performance for the particular application while contributing to the benefits of sustainable development for our customers as and when required.

Session: The future of special refined products

The future of automotive and industrial lubricants

Ian Shannon (Shell)

This symposium presentation provided a brief perspective on the future of lubricants in the context of major transitions in the energy and mobility/transport sectors.

The transport sector accounts for more than 25% of the world's total energy use and 20% of energy-related carbon dioxide emissions. Society expects companies to take action at scale—quickly. Electrification is moving at pace, and the use of alternative fuels, such as biofuels, is increasingly common. At the same time, the global population continues to grow, with almost 7 billion people forecast to be living in cities by 2050, bringing into sharp focus issues relating to traffic density and urban air quality. Vehicle ownership will increase, while expectations around vehicle servicing, convenience, cost of ownership and environmental impact will evolve. These changes will have a profound impact on the world of automotive lubricants, with changes in the regional demand mix combined with new technology and customer requirements.

The automotive industry continues to develop and employ a variety of engineering solutions to deliver more fuel-efficient engines, but at significant incremental costs. Modern sophisticated engines provide their own distinct lubrication challenges, many of which are increasingly met by the use of highly fuel-efficient '0W' engine oils blended using high-performance synthetic base oils such as Shell GTL™ base oils and poly-alpha-olefins. The use of a collaborative co-engineering approach can also help to optimise the fuel economy potential of the lubricant. While current projections forecast an increase in the uptake of fuel-efficient '0W' engine oils, the challenge remains as to whether we can move more quickly in adopting this technology.

In the competitive and diverse B2B environment, industrial technology continues to change. Lubricants must deliver improved equipment efficiency while ensuring long-term hardware durability if they are to meet expected reductions in total cost of ownership.

Demands on lubricants are increasing, with smaller sump sizes, longer service intervals, sealed-for-life equipment, higher temperatures, higher pressures and tighter cleanliness requirements all driving performance requirements upwards. Equipment is becoming smaller, faster and lighter, using more special materials, and incorporating greater automation. A key focus for industry is to ensure that the right lubricant-hardware solution can positively impact equipment reliability and productivity, leading to reduced energy consumption and total cost of operations. In this context, the use of higher-performance synthetic lubricants has demonstrated that it can provide significant total cost-reduction opportunities.

Many industry sectors also see an increased diversification of applications, for example the significant increase in wind turbines. These trends suggest that we will need a diverse portfolio of lubricants for multiple applications for many years to come, potentially including more use of bio-derived base stocks and a greater emphasis on waste oil recycling.

In summary, the world of industry and transport is changing rapidly. Lubricant design and selection have a major impact on equipment efficiency and total operational cost. Collaboration between lubricant suppliers, automotive manufacturers and end users, combined with the use of high-performance synthetic lubricants, is key to maximizing opportunities for efficiency across diverse automotive and industry sectors.

Session: The future of special refined products

The future of speciality products waxes

Dirk Danneels (European Wax Federation)

Petroleum waxes are derived from crude oil during the refining process designed to produce lubricating oil. Three general product categories of petroleum waxes are obtained during refining: paraffin wax, microcrystalline wax and petrolatums.

Paraffin wax consists essentially of straight chain alkanes with an average chain length of 20 to 30 carbon atoms while microcrystalline waxes have melting points up to 100°C. Their carbon chain lengths go up to C80 and they are also characterized by a higher content of iso-and cyclic alkyl substituted chains.

The fundamental difference between waxes and oils is that the former are solid at room temperature while oils are liquids. The key functional characteristics of mineral hydrocarbon waxes include their chemical inertness, moisture barrier properties and low viscosity at temperatures above their melting point. While they have a number of industrial or technical uses, such as in candles, as an anti-ozonant in car tires and as a cable filler ingredient, the refined grades of mineral hydrocarbon waxes are also found in foods and food contact materials, in cosmetics, and in pharmaceutical formulations. Many of these applications are governed by EU, Member State or international specifications and purity criteria, laid down in the specific regulatory rules and guidance.

Navigating this maze of often overlapping legal requirements is a challenge in itself, but two specific situations are worth mentioning. At the EU level, most food contact material groups and articles are not yet harmonized. Building on the mixed experience from the limited past harmonization experience, the European Commission is currently studying the best way forward to build a food contact risk assessment and management approach to deal with this non-harmonized domain. Via a cross-sector industry group, industry stakeholders are trying to bring realism and pragmatism to these efforts, but it is clear that we are at the beginning of a tortuous road that will require constant attention and competent resources.

The second example are the indirect, but no less impactful, effects of NGO-driven consumer concerns triggered by the presence of saturated and aromatic hydrocarbon residues in food and food packaging materials. The presence of these materials as raw materials in cosmetics formulation is also under scrutiny.

While the toxicological pedigree of the substances that are placed on the market for use in these applications is very sound, communicating complex scientific data in a world of sound bites and emotional scaremongering is creating its own specific set of challenges.

Long-term prospects for petrochemicals and their feedstocks

Philip de Smedt (Petrochemicals Europe)

The petrochemical industry in Europe has a production volume of about 150 million tonnes per year. At the start of the petrochemical chain are the ethylene crackers, which provide the basic building blocks (ethylene, propylene, butadiene and aromatics) for the rest of the petrochemical industry.

The dominant feedstock for ethylene crackers in Europe is naphtha, and there seems to be consensus among experts that this will remain the case in Europe despite the rise of ethane cracking due to shale gas developments in the US, and the development of alternative processes for producing the basic building blocks of the petrochemical industry. This is due to the high degree of integration of the petrochemical industry in Europe.

Tuesday 21 March 2017

Session: Perspectives on the EU refining industry of the future

The European refinery of the future

Gordon McManus (Wood Mackenzie)

The European refining industry has been undergoing a period of consolidation with a 2.1 million barrels per day (b/d) net capacity reduction since 2000. Our view is that the strong growth in global demand and consolidation of refining capacity have reduced the immediate need for further capacity rationalisation. Planned changes to global bunker fuel sulphur limits in 2020 should initially be positive for average refining margins.

Regional demand is in decline

In the longer term, European oil demand will decline. Increasingly stringent vehicle efficiency requirements will impact the transport fuel sector, while further impacts on transport fuel demand are possible if battery costs fall rapidly, enabling electric vehicles to penetrate the market more quickly and widely than expected. Nevertheless, hydrocarbon fuels are forecast to dominate transport fuel demand through the mid-2030s. Petrochemical feedstocks and other speciality products will provide further stability. Our base case indicates that European oil demand will exceed 12 million b/d in 2035.

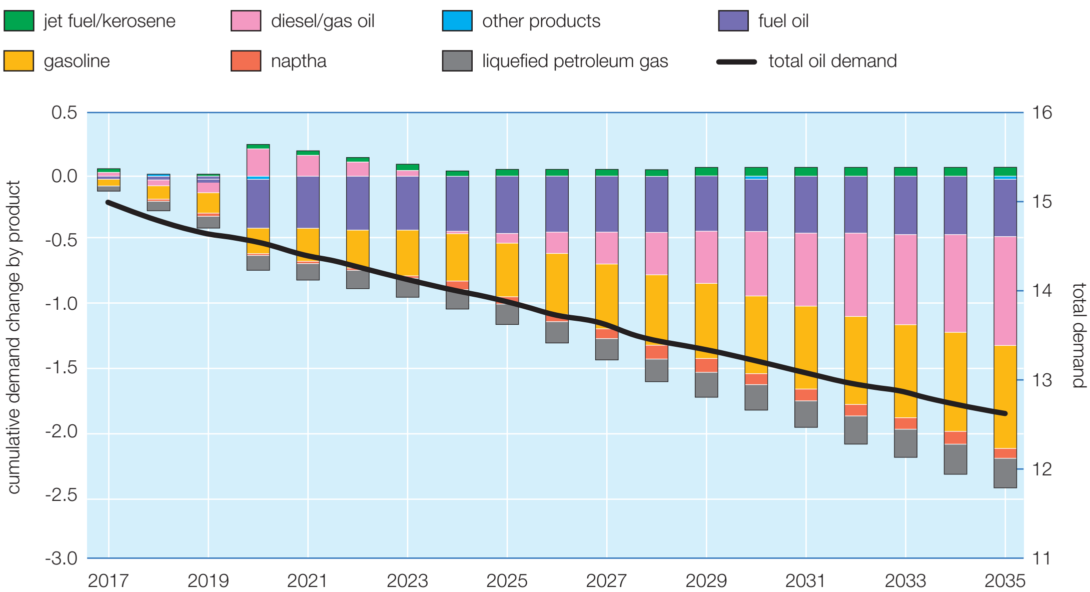
These demand trends would leave Europe with surplus product in the absence of further capacity rationalisation. The gasoline surplus in particular is expected to weigh on European refining economics. Competitive pressures will once again increase, leading to the inevitable closure of weaker assets.

Competitive pressure will grow

European refiners will also continue to face challenges competing with refiners in other regions. On average, the region's refineries are modestly complex, but have relatively high feedstock, energy and other operating costs. Large-scale, modern, complex export refineries in other regions will continue to target Europe's middle distillate market. European refiners will also face a number of additional costs as a result of the Industrial Emissions Directive and Emissions Trading Scheme (ETS), which may further weaken their competitiveness relative to other regions.

European oil demand growth forecast, million barrels of oil per day (b/d)

Source: Wood Mackenzie

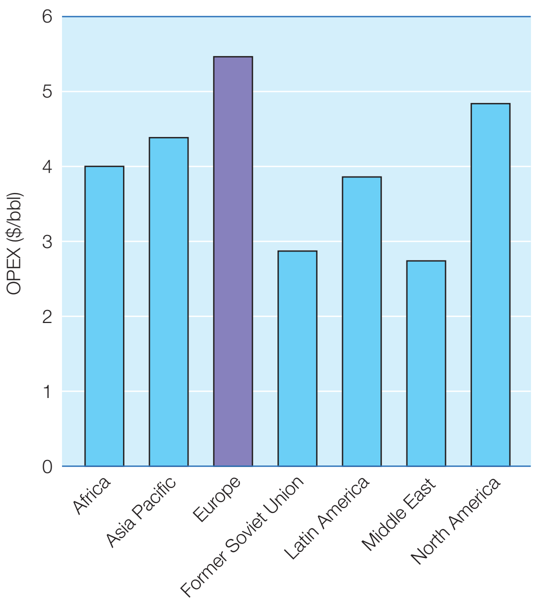


Session: Perspectives on the EU refining industry of the future

… The European refinery of the future *(continued)*

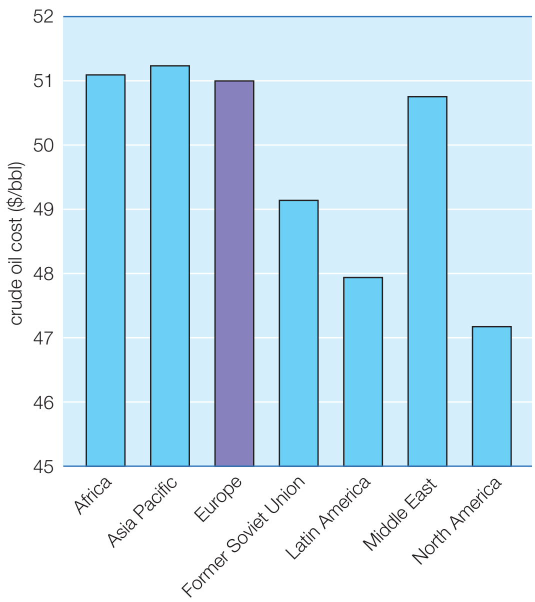
Average regional refinery operating expenditure (OPEX), 2015 ($/bbl)

Source: Wood Mackenzie



Average regional refinery crude cost, 2015 ($/bbl)

Source: Wood Mackenzie



Despite these pressures, the region still has plenty of strong, sustainable refining assets. Refinery owners have a track record of investing to improve their efficiency, to comply with environmental and product quality regulations, and to improve their competitiveness. And those investments continue, with a number of residue upgrading and hydrotreatment projects due for completion before 2019.

How will refiners adapt?

How does a European refinery evolve to become the 'refinery of the future' under this market and competitive environment?

We do not expect a revolution in terms of the main refinery processes and product slates in the next 20 years. And there will be fewer refineries in Europe as the industry adapts to falling demand.

Those that remain will evolve, if they are not doing so already, into industrial complexes with deep conversion capability, and yield and feedstock flexibility. They will add value through petrochemicals integration and specialities production, as well as by having close integration with trading operations and local markets. Some will be involved in the production of renewables and have the ability to sell power. They will be increasingly automated, but remain safe and efficient suppliers of the clean transport fuels and other products that society relies on.

Refiners will need to continue to find solutions to the challenges that the market and society presents them with. We would suggest that this is a challenge that many are capable of meeting.

Session: Perspectives on the EU refining industry of the future

How might the EU refining industry evolve in response to current and future challenges?

Michiel Nivard (Clingendael International Energy Programme)

Structural developments in the global refining market are challenging the long-term competitiveness of the 81 operational refineries in the European Union. The emergence of modern, low-cost refining centres in Asia, Russia and the Middle East and their ability to trade the various petroleum products globally are becoming an important competitive factor for refiners in the EU to take into account. Apart from the new competition, the EU's refining market already suffers from maturing demand and an underinvested asset base. Finding itself between a rock and a hard place, the 14 Mb/d of refining capacity in the EU is increasingly competing with refined product imports from low-cost and low-regulated refining centres. This brings into question what the broader implications might be for the EU refining sector of a potential increase in the share of imports for Europe's oil product supply mix in a post-2025 time frame.

In answering this question, the Clingendael International Energy Programme (CIEP) is publishing a study on the developments in the EU-28 refining sector, in which it first identifies the strong points in European refining and secondly describes the most prominent barriers to exit. Aiming to exclude short-term gyrations in refining competitiveness, the analysis of the strong points in EU refining focuses on structural, long-term indicators, such as the level of integration in (part of) a value chain of individual refineries. Hence, this stark but plausible scenario couples the integration in wider economic value chains to the competitive long-term outlook of a refinery, distinguishing 'must-run' refining capacity from refineries that are 'exposed to competition' with product imports.

The study incorporates political and economic realities as a context for a second scenario, analysing the factors that nevertheless constrain refineries from closing if they have difficulty withstanding increasing competition from imports. Implications of competing oil product imports stretch well beyond individual Member States, while constraining factors such as security of supply, economic footprint, secondary integration and, in particular, government ownership and regulatory enforcement are largely set within national jurisdictions. This implies a foothold of EU Member States in their domestic refining sector as a market player, perhaps complicating the realisation of a level playing field and keeping national or regional markets intact. Hence, the forthcoming CIEP study will shed light on (future) developments in EU refining by incorporating both economic and political factors.

Session: IPIECA vision for water use in the oil and gas industry, and its relevance for EU refineries

Future trends in water availability, use and discharge, regulations and price, and cross-sector collaboration

Artemis Kostareli (IPIECA)

Alfio Mianzan (IPIECA)

Driven by increasing demand for fresh water, increasing water scarcity, tightening regulations, changing societal expectations, as well as developments in the global sustainable development agenda, the IPIECA Water Working Group (WWG) has undertaken a structured, scenario-based process to build a long-term vision (to 2030) for water management in the oil and gas sector. The intention of this visioning work was to:

- help IPIECA and its members to align our understanding of potential water challenges and opportunities based on an assessment of future changes in water management for the oil industry;
- guide IPIECA's future strategy and long-term planning for water management, including the 2017–20 Strategic Plan; and
- help member companies target their approaches to ensure business continuity, and continue to manage water effectively in the light of future changes.

The process was done in three main stages. The first stage was carried out to gain a broader understanding of the current and emerging trends in water management. This was followed by the development of the scenarios themselves, the identification of signposts to help the group flag trends in a number of water-related issues and, finally, the development of themes that will form the basis of IPIECA's WWG strategic plans going forward and a development of a new updated IPIECA Vision for Water.

Two key uncertainties—how water stress will change in the future, and how local and global regulations may change providing constraints and opportunities for the industry—were selected to define the four quadrants corresponding to the following four scenarios:

Sandstorm: water challenges constrain water-consumptive industries and the global economy, while governmental responses are fragmented and public pressure grows.

Oasis: increasing water stress and scarcity while effective, efficient and collaborative water management options limit the impact of water constraints across all sectors.

Water World: water stress plateaus and policies promoting innovation and collaboration lead to improvements in sustainability of global water consumption.

Tidal Wave: water users become trapped in a cycle of reactive policies and increasing stakeholder pressure, even if water stress is not objectively increasing.

Throughout the process of developing the scenarios, common themes arose which are relevant across all scenarios. Eight themes were identified:

- Stakeholder engagement and working in partnership.
- Tracking policy/regulation/trends.
- Climate change adaptation and resilience.
- Industry seen as 'part of the solution'—the voice of the industry.
- Enhanced reporting and disclosure.
- Technology and innovation.
- Water price and value.
- IPIECA to provide more regional/local scale perspective.

IPIECA's strategic plan for water will allow IPIECA to systematically review the signposts identified during the development of the scenarios in order to assess how the scenarios are developing, and thereafter to develop actions, within the above themes, that will feed into the annual planning cycles.

The presentation ended with comments on current trends and policies relevant to the EU, and opportunities of collaboration between IPIECA and Concawe.

Session: The future of human health assessment

Using new methodologies for a better understanding of the health impacts of petroleum substances

Hans Ketelslegers (Concawe)

Ivan Rusyn (Texas A&M University)

Lenny Kamelia (Wageningen University)

Cat-App was initiated with the aim of minimizing the need for testing in vertebrate animals under regulatory programmes. This is achieved by grouping petroleum substances (PS) to make the most optimal use of the toxicological information on PS by read-across of the available data within and (where needed and justified) between these groups. A framework will be developed for grouping based on chemical-biological properties combining multiple streams of information comprising PS production type/refining process, physical-chemical properties, chemical analytical profiles, existing (eco)toxicological data and a comprehensive array of biological responses in a broad spectrum of in-vitro systems.

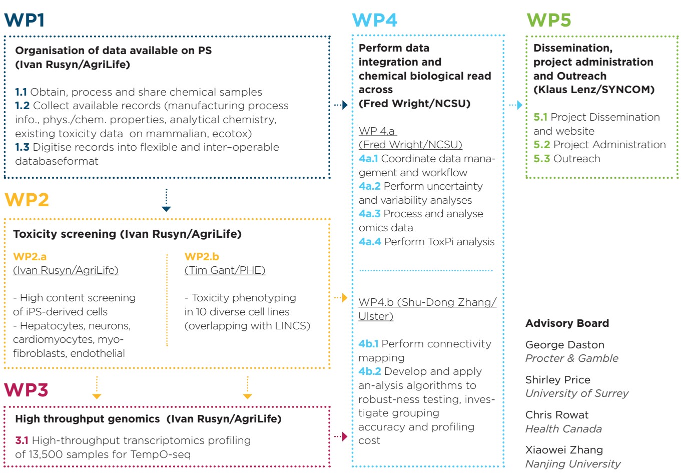
Direct implementation of the Cat-App framework in the Concawe REACH strategy by applying the approach and submitting the data in the petroleum REACH dossiers will fill data gaps in the already-existing in-vivo toxicological data on PS, and help to develop a pragmatic and informed testing approach only as a last resort when read across to fill data gaps is not possible.

This strategy will eventually address mandatory human health hazard end points under REACH while significantly reducing the use of vertebrate animals for toxicity testing without underestimating the potential hazards.

The intention is to inform a broad spectrum of stakeholders globally (commercial entities, regulatory agencies and non-governmental organizations), concerned with public health and well-being, and to promote application of the Cat-App framework which is expected to eventually have a wide and diverse applicability domain.

Cat-App work programme

Cat-App: New technologies to underpin the category approaches and read across in regulatory programmes
Project Management: Hans Ketelslegers / Concawe
Steering: Scientific Committee / Concawe



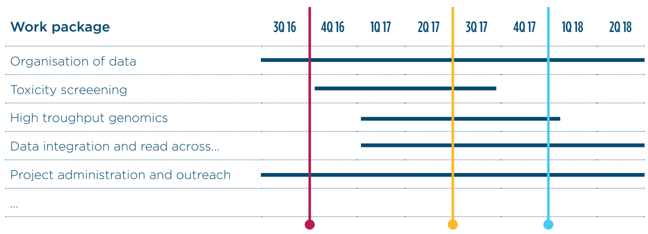
Institute abbreviations:
AgriLife: Texas A&M AgriLife Research - NCSU: North Carolina State University - PHE: Public Health England
Ulster: Ulster University - SYNCOM: SYNCOM R&D consulting GmbH

Timeline

MS1: All petroleum substances available as DMSO extracts for testing in in vitro assays

MS2: Quality control report of preliminary in vitro analyses

MS3: Initial workflow for Chemical-Biological Read-across and ToxPi visualisation available



Session: The impact of the use of diesel on the quality of air in cities

Aeris Urban Air Quality Study—the impact of diesel use on air quality in European cities

Chris Boocock
(Aeris Europe)

This symposium presentation provided an overview of the work carried out by Aeris Europe on behalf of Concawe to explore the impacts of diesel use on compliance with the current European Ambient Air Quality Standards (AAQS). This work is fully documented in the *Urban Air Quality Study* (Concawe report no. 11/16)[1] which was published in March 2016. The report used the same data sources that are used for EU policy making, and the analysis capabilities of Aeris' software tools and GIS skills.

The lack of compliance with AAQS for both particulate matter (PM) and nitrogen dioxide (NO_2) across Europe has become a headline issue in both politics and the media, with much of the attention being focused on the contribution of diesel fuel in particular.

Successive reductions in the PM tailpipe emissions limit for passenger cars show that tailpipe PM emissions are becoming an increasingly small element of total PM emissions when abrasion sources (tyre wear, break wear, road wear, etc.) are included. Since Euro 5 the PM tailpipe standard has been equivalent for both diesel and gasoline powertrains. Examining IIASA GAINS data it can be seen that the contribution to $PM_{2.5}$ emissions from road transport is 10% of that from all sectors combined (2015 data). The largest contribution of 46% is from the domestic sector and this is driven by the use of solid fuels for domestic heating.

In contrast, in 2015 road transport accounted for 41% of total NO_x emissions. This reduces in the future as the vehicle fleet evolves towards the later Euro standards.

From these baseline emissions, Aeris ran a modelling study exploring the anticipated change in AAQS compliance for both the policy embodied emissions reductions and also for several alternative scenarios. The scenarios modelled the compliance impacts for a total of 13 alternatives. This presentation focused on two cases:

1. The relative merits of replacing solid fuels in the domestic sector versus elimination of diesel exhaust emissions.
2. Accelerated turnover of the vehicle fleet to bring forward the benefits of Euro 6 technology.

These two cases show that:

1. For compliance with the PM AAQS, elimination of diesel will not offer earlier achievement of the ambient air quality limits, whereas replacement of solid fuels in the domestic sector will.
2. For compliance with the NO_2 AAQS, both the removal of all diesel emissions from 2015 in the urban area and a hypothetical 100% replacement of pre-Euro 5 vehicles would offer improved compliance in 2020. However, by 2025 and 2030 these benefits are reduced.

The presentation also gave a first look at some of the subsequent work done using a reanalysis of public domain data shared by the UK Government Department for Environment, Food & Rural Affairs. This data was produced as part of the air quality plan for NO_2 in the UK (2015)[2]. This work shows that analysis of emission sources needs to be undertaken to inform policy actions aimed at improving compliance. Additionally, it demonstrates the variation in population exposure at the scale of UK Government statistical 'Output Areas'.

1 Available for download at www.concawe.eu/publications/concawe-reports
2 www.gov.uk/government/collections/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2015

Session: The impact of the use of diesel on the quality of air in cities

The importance of non-exhaust particulate matter from road traffic

Ranjeet Sokhi (University of Hertfordshire)

Local air quality can be heavily influenced by road traffic air pollutant emissions. While road traffic air pollutants have been long recognised as significant, most of the research and policy-driven attention has been devoted mainly to tailpipe or exhaust emissions which result from incomplete fuel combustion and volatilisation of lubricants. In addition, it has generally been assumed that emissions from vehicle exhaust are dominant compared to other vehicle-related air pollutant emissions. However, studies over the past decade are demonstrating the importance of emissions of particles from non-exhaust sources such as tyre, brake, clutch wear as well as resuspension of road dust.

Some studies are suggesting that the contribution of PM_{10} (particulate matter with aerodynamic diameter of 10 µm or less) from non-exhaust sources are comparable to those from exhaust emissions. This has major implications for the control of airborne particulate emissions in towns and cities, particularly as all current regulation is targeted against exhaust emissions. As stricter tailpipe emission controls are implemented (e.g. Euro 6 standards), the relative contribution of PM^{10} from non-exhaust sources becomes increasingly important.

Quantifying non-exhaust emissions requires sophisticated approaches, usually combining extensive field sampling, with detailed chemical analysis of the sampled particles and the use of sophisticated receptor modelling that link the speciated particle concentrations to exhaust, non-exhaust and other urban sources. Deciphering these source contributions relies on quantifying inorganic and organic chemical markers that are associated with the sources. This presentation focused on contrasting the contribution of exhaust and non-exhaust emissions of particulate matter from road traffic. It assessed recent studies and provided estimates of traffic-related particle emissions, and discussed the various factors that influence these emissions.

Concawe publications

Reports published by Concawe from 2016 to date	
4/17	Air pollutant emission estimation methods for E-PRTR reporting by refineries
3/17	Experimental evaluation of the flux chamber technique to determine VOC emissions from a water surface
2/17	An evaluation of an optical gas imaging system for the quantification of fugitive hydrocarbon emissions
1/17	Estimating the marginal CO_2 intensities of EU refinery products
14/16	Impact of FAME Content on the Regeneration Frequency of Diesel Particulate Filters (DPFs)
13/16	Phase 1: Effect of Fuel Octane on the Performance of Two Euro 4 Gasoline Passenger Cars
12/16	European downstream oil industry safety performance—Statistical summary of reported incidents 2015
11/16	Urban Air Quality Study
10/16	Gasoline Direct Injection Particulate Study
9/16	Emission factors for metals from combustion of refinery fuel gas and residual fuel oil
8/16	Environmental fate and effects of poly- and perfluoroalkyl substances (PFAS)
7/16	Performance of European cross-country oil pipelines—Statistical summary of reported spillages in 2014 and since 1971
6/16	Critical review of the relationship between IP346 and dermal carcinogenic activity
5/16	The Natural Attenuation of Fatty Acid Methyl Esters in Soil and Groundwater
4/16	Review of recent health effect studies with sulphur dioxide
3/16	Assessing the aquatic toxicity of petroleum products: comparison of PETROTOX calculations and SPME-GC screening
2/16	Analysis of N-, O-, and S- heterocyclics in petroleum products using GCxGC with specific detection
1/16	Sulphur dioxide emissions from oil refineries in Europe (2010)

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Concawe

Boulevard du Souverain 165, B–1160 Brussels, Belgium

Telephone: +32-2 566 91 60 • Telefax: +32-2 566 91 81

info@concawe.org • www.concawe.org