Developments in EU refining: looking ahead to 2020 and beyond

An insight into the challenges faced by the European refining industry in meeting future product demand and quality requirements

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Oil refineries are constantly adapting to changes in product quality legislation and market demand. This requires the industry to be aware of such changes and anticipate them. Awareness of product quality legislation changes is generally straightforward, since they require that new product quality specifications be met by target dates. Predicting product demand changes is more complex, as these depend on only a few invariable factors, such as legislative targets for vehicle efficiency, and a myriad of much less predictable factors, such as economic growth and consumer preference for diesel or gasoline vehicles. A further complicating factor in the demand picture in recent years is the introduction of biofuels, which displace a portion of the products produced by refineries from crude oil (i.e. 'refined products').

To guide the refining industry in the complex task of anticipating future changes, Concawe released the 'EU Refining 2020–2030' study in 2013 (report no. 1/13R). This study used the Concawe EU refining model to combine a detailed inventory of the expected product quality changes with a forecast for product demand changes and estimate the impacts on refineries in EU27+2 countries over the period 2008–2030. This article highlights the key outcomes of this study.

What are the expected product quality changes?

EU road transport fuels have not been required to undergo any further changes in quality since the major milestone reached in 2009, when road diesel and gasoline were required to be 'sulphur-free' (i.e. containing less than 0.001% sulphur, compared to 0.005% since 2005). In 2011 this 0.001% sulphur limit was extended to diesel consumed in non-road machinery and inland waterway vessels (previously 0.1% sulphur). Since 2011, 'sulphur-free' products for road and non-road engines constitute about 37% of the total output of EU27+2 refineries.

The biggest changes in product quality in the post-2010 period will be in residual marine fuels, which currently constitute about 7% (40 Mt) of EU refining output. The maximum sulphur content of marine fuels used in EU emission control areas (ECAs) was reduced to 1.5% in 2006 and to 1.0% in 2010. A further reduction to 0.1% sulphur will be required in ECAs from 2015, which can only be met by fuelling vessels with distillate marine fuel instead of residual marine fuel.

In non-ECA areas the marine fuel sulphur content is set to reduce from 3.5% to 0.5% in 2020 or 2025, dependent on an International Marine Organization (IMO) review of worldwide fuel availability due by 2018. The IMO marine fuel regulations allow for on-board exhaust gas scrubbing to be used to achieve the required emissions abatement instead of reducing fuel sulphur content. Some ship owners have announced exhaust gas scrubber retrofits or new-builds, but the number of scrubbers in operation is not likely to have a significant effect on the demand for 0.5% sulphur fuel if the sulphur reduction is imposed in 2020. In the absence of the availability review, the Concawe study base case assumed that the global change to 0.5% sulphur fuel would take place in 2020 and would be entirely supplied by refineries. This includes, de facto, the EU legislation[1] which will impose the 0.5% sulphur limit on all marine fuels used in EU territorial seas (i.e. up to 12 NM off the coast) and exclusive economic zones (EEZs) from 2020, regardless of the IMO decision. In a sensitivity case the opposite extreme was assumed, i.e. that all ships fuelling residual fuel at EU ports would be equipped with scrubbers by 2020.

What are the forecasted changes in refined product demand?

Final demand for refined road fuels is declining in EU27+2 countries due to steadily improving vehicle efficiencies and the penetration of alternative fuels (mainly biofuels) made from non-fossil feedstocks. The combined effect of these factors on refined road fuel demand was assessed using the Fleet & Fuels (F&F)

[1] Directive 2012/33/EU of 21 November 2012, amending Council Directive 1999/32/EC regarding the sulphur content of marine fuels.

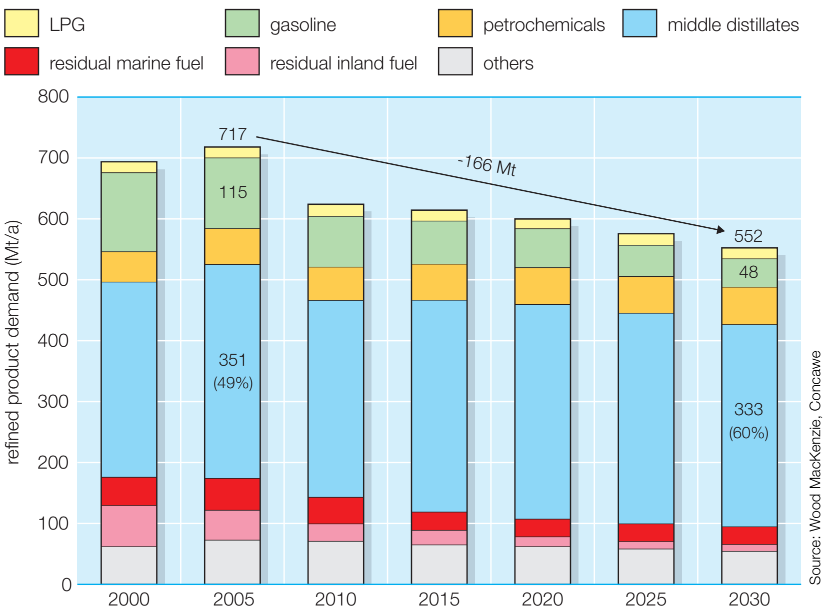
model developed by the JEC consortium, under the assumption that the 2020 vehicle fuel efficiency targets of 95 gCO_2/km average vehicle efficiency and 10% energy renewables would be met. Concawe extended the F&F modelling to 2030, assuming that vehicle efficiency would continue to improve to 75 gCO_2/km by 2030. The results show a continuing decline in gasoline demand (58% lower in 2030 than in 2005) while road diesel demand remains fairly stable up to 2020, then declines by about 9% to 2030. The ratio of refined road diesel to gasoline demand shows a continuous increase from 1.1 in 2000 to 2.0 in 2010, reaching 3.4 in 2030.

The main demand change in non-road transport fuels will be in 2015 with the switch in ECAs from residual marine fuel (1.0%S) to distillate marine fuel (0.1%S). This could remove about 13 Mt/a from residual fuel demand and add 13 Mt/a to distillate fuel demand.

Demand for non-transport refined products is also in decline, mainly due to substitution by natural gas. This is especially the case for heating oil (for domestic, agricultural and industrial uses) and inland heavy fuel oil (for industrial heat and power generation). Wood Mackenzie demand forecasts were adopted for these products in the study.

When these individual product demand trends are combined the overall result is a fall of 166 Mt (23%) in total demand for refined products from 2005 to 2030, as shown in Figure 1. It should be noted that while total demand is in decline from 2005 to 2030, the share of middle distillates[2] increases from 49% in 2005 to 60% in 2030. This will place a considerable strain on the refining system, as declining total demand is likely to lead to more refinery closures. The distillate production capacity lost in closed refineries would need to be replaced with additional energy-intensive distillate production capacity in the remaining refineries in order to meet demand without increasing the EU's reliance on imported distillates to complement domestic production.

Figure 1 Total demand for refined products in the EU27+2 (Mt/a)



How is the EU refining industry meeting the challenges in the short term?

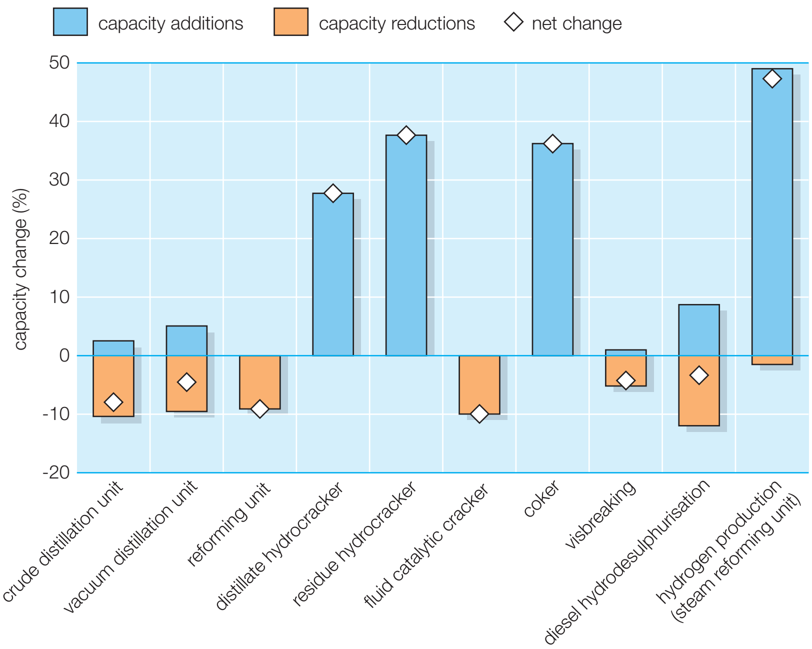
The European refining industry had 760 Mt/a of crude distillation capacity at year-end 2008. This had reduced to 698 Mt/a by year-end 2013 with the closure of 14 refineries under the combined impact of adverse economic circumstances, shrinking refining margins and declining demand. The closed refineries were on average smaller and less complex than the EU average and were oriented towards gasoline production.

Despite these adverse conditions, EU refineries have announced capital expenditure projects over the 2009–2015 period amounting to an estimated total of $30 billion (€21 billion)[3]. These projects will increase capacities of EU refinery units that boost distillate production and reduce residue production, making a major contribution to meeting future product requirements, and in particular allowing the switch to 0.1%

[2] The term 'middle distillates' covers the range of refined products from kerosene fuel (for heating or jet engines) to diesel fuel (for road and non-road vehicles) to heating oil (typically used in oil-fired domestic boilers) and marine distillate fuel (for ships not equipped to burn residual fuel and for ships in port and in ECAs from 2015).

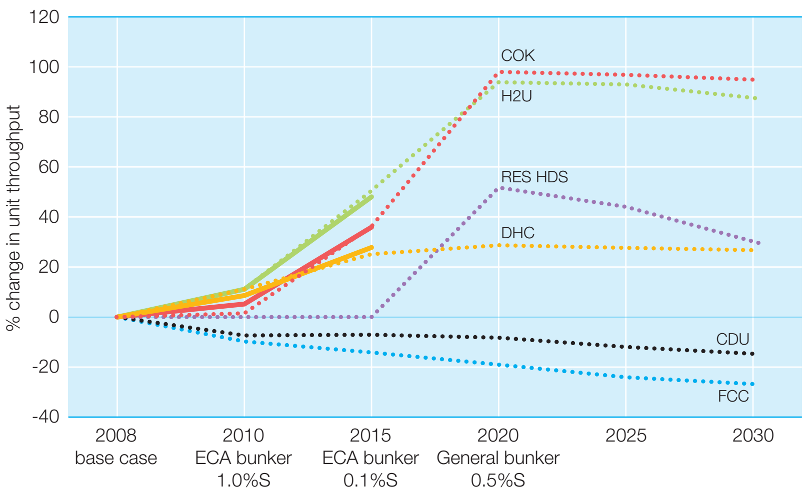
[3] All the capital investment figures in US dollars and Euros in this article are based on costs in 2011, unadjusted for inflation.

Figure 2 EU27+2 refinery projects, 2009–2015
(capacity change by process unit relative to year end 2008)



Above: Figure 2 is an updated version of Figure 2.1.2 in Concawe report no.1/13R. It includes six additional refinery closures that were not included in the report, totalling 43 Mt/a of CDU capacity (Petit Couronne, Berre, Coryton, Rome, Porto Marghera and Wilhelmshaven).

Figure 3 Percentage changes in unit throughputs relative to a 2008 baseline



sulphur marine fuel in ECAs in 2015 without needing additional imports of distillate fuels. The changes in process unit capacities resulting from announced projects and closures over the 2009–2015 period are shown in Figure 2.

How much more investment is required in the longer-term?

The announced EU refining projects in the 2009–2015 period do not address the additional equipment needed to reduce the sulphur content of non-ECA marine fuels to 0.5% in the scenario of a worldwide cap in 2020 which is an unprecedented step change. Under the assumption that the IMO decides to impose this reduction by 2020, and that the entire non-ECA demand for residual marine fuel at EU ports in 2020 (about 30 Mt) would be supplied by EU refineries and not by additional imported diesel, the Concawe refining model has estimated that €15 billion of additional investment would be required. The investment would chiefly be in coking units (which convert residual fuel to coke and lighter distillate products), residue desulphurisation units (which reduce sulphur content) and hydrogen units (which produce hydrogen feedstock for the desulphurisation units). The scale of the required changes in unit capacities is indicated in Figure 3 which shows the percentage changes in unit throughputs relative to a 2008 baseline. Solid lines show to what extent announced investments can achieve the required increases in unit throughputs.

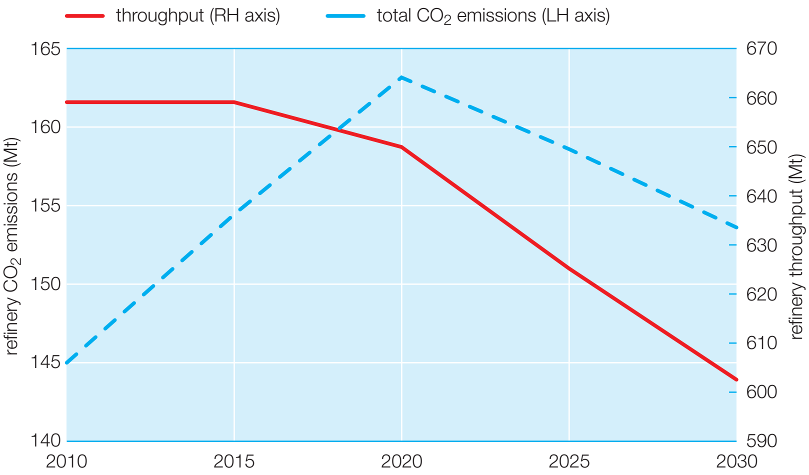
It will be exceptionally difficult for EU refiners to decide whether to make these major investments, which would be entirely dedicated to producing a marine fuel representing only about 5% (30 Mt/a) of the output of EU refineries. The future demand for this low-sulphur product will also be shaped by ships equipped with exhaust gas scrubbers allowing them to switch back to high sulphur marine fuel, or by ships adapted to burn LNG fuel.

These factors point to weak long-term demand prospects for low sulphur marine fuel, which could lead to progressive under-utilisation of any new investments in process unit capacity dedicated to its production. Such uncertainties could make it difficult to economically justify additional refining investments.

What is the expected impact on refining CO_2 emissions?

CO_2 is emitted in refineries by fuel burned to supply heat for the refining processes and by chemical reactions taking place in hydrogen production units, which reject the carbon in the feedstock as CO_2. In spite of declining throughput, CO_2 emissions from EU refining are expected to be driven higher from 2010 to 2020, mainly by the marine fuel sulphur reductions in 2015 and 2020 and, to a lesser extent, by the need to produce an increasing share of distillates to satisfy demand. Figure 4 shows the expected 13% increase[4] in CO_2 emissions from 2010 to 2020 and the subsequent decrease from 2020 to 2030, driven by steeply falling refining throughput. Hydrogen production accounts for 22% of refining CO_2 emissions from 2020 onward, up from 14% in 2010.

Figure 4 The expected 13% increase in CO_2 emissions from 2010 to 2020



Concluding remarks on the outlook for EU refining

EU refining faces many challenges in meeting product demand and quality requirements in the period from 2010 to 2030. The Concawe study gives some insight into the combined impact of these challenges under the important assumption that refiners will invest to meet the challenges without becoming more dependent on product imports and exports. In reality, refiners will make decisions affecting investment and import/export balances based on their own individual circumstances.

One of the study's key outcomes is that the €21 billion of announced investment projects over the 2009–2015 period should adequately equip EU refining with the appropriate conversion unit capacity to satisfy future demand and quality requirements, with the important exception of the IMO marine fuel sulphur reduction to 0.5% which would require additional investments estimated at €15 billion, and would incur additional refining CO_2 emissions. Without this further investment beyond 2015, the available conversion and desulphurisation capacity would permit the production of only 10% of the estimated demand for 0.5%S marine fuel in 2020. In this case, Europe would have to resort to imported diesel to satisfy the remainder of the demand, significantly increasing EU dependence on imports.

[4] The estimated 13% increase in CO_2 emissions assumes that the energy efficiency of refining process units remains unchanged from 2008. There could, in reality, be some margin for improvement in energy efficiency, which would mitigate the expected increase in energy-related CO_2 emissions but would not improve the 'chemical' CO_2 emissions from hydrogen production units.