Road fuels desulphurisation

How EU refineries are affected by the gradual move to a 10 ppm sulphur limit

For many years CONCAWE has maintained a model of the European refining system in order to be able to evaluate the potential impact of major changes, such as more stringent product specifications or shifts in crude supply and/or product demand patterns. Although the original focus was on costs, the model has now been adapted to also estimate impacts on CO_2 emissions, both from the refinery sites and globally, i.e. including the impact of changes in fuels' carbon/hydrogen ratio on in-use emissions. Originally focused on EU-15 (plus Norway and Switzerland), the model has been extended to cover new member countries as well as near-future members (Bulgaria and Romania).

This particular study aimed to evaluate the cost and CO_2 emissions associated with the reduction of sulphur in EU road fuels to the 10 ppm level, using the year 2000 specifications as the starting point. From this point of view, it is an update of the estimates produced in 2000 (CONCAWE report 00/54). Since this reduction is occurring alongside other specification changes (e.g. gasoline aromatics), as well as evolution of the crude basket and of the product demand, these factors were also incorporated into the study. A full report has recently been published (report 8/05) and is available on the CONCAWE website.

The main estimates were produced on the basis of a relatively favourable core scenario including:

- no change in the crude diet between 2000 and 2010;
- a 1% per year overall energy efficiency improvement in refineries; and
- no change in the specification for non-road diesel fuel.

A number of sensitivity cases were run to show the potential additional effects of these factors, taken individually and combined. Because cracked gasoline desulphurisation is central to the production of 10 ppm sulphur gasoline and because the processes are still relatively new, an additional sensitivity case was considered involving 50% higher energy consumption for such plants.

A reference case was established with the 2010 product demand, road fuels sulphur specifications unchanged from 2000 (i.e. 150/350 ppm for gasoline and diesel fuel respectively), and all other specifications set at the current limit or the already legislated limit for 2010 (e.g. heating oil at 0.1% m/m sulphur maximum). Comparison with a 2000 base case featuring 2000 demand and specifications gives an estimate of the impact of changes in demand and non-sulphur specifications. Further study cases included sulphur limit reduction to 50 and 10 ppm for gasoline and diesel fuel either separately or together.

Table 1 summarises the results in terms of incremental annualised cost and CO_2 emissions from the refining sites.

Reduction of the sulphur specification of road fuels to less than 10 ppm will require an estimated refinery capital expenditure of 6.7 to 7.5 G€. Gasoline and diesel share the burden roughly equally.

These investment figures are in addition to another 7.3 G€ required to meet the evolution of demand and the changes to other specifications between 2000 and 2010. This figure would rise to nearly 8.8 G€ with a heavier crude slate.

The EU refineries will emit an estimated additional amount of CO_2 of 7.3 to 9.2 Mt/a. Gasoline is responsible for 65% and diesel fuel for 35% of the increase.

In order to cope with demand evolution and with the changes in other specifications between 2000 and 2010, EU refineries will further increase their CO_2 emissions by 13.3 Mt/a, increasing to 26.8 Mt/a in the worst scenario considered.

The annualised costs to EU refineries will increase by 1.8 to more than 2 G€/a. This is equivalent to around 6.2 € per tonne of sulphur-free fuel produced.

Table 1 Capital investment, incremental annualised cost and CO_2 emissions from EU refineries

	2000	2010				
	Base	Reference	Alternatives			
Refinery production (Mt/a)						
gasoline	136	136				
diesel fuel	140	195				
Study Case	gasoline 150 ppm	gasoline 150 ppm	both fuels 50 ppm	both fuels 10 ppm	gasoline 10 ppm	diesel 10 ppm
Nominal sulphur specification (ppm max)						
gasoline	150	150	50	10	10	50
diesel fuel	350	350	50	10	50	10
Other key specifications						
gasoline aromatics (% v/v max)	42	35.0				
IGO sulphur (% m/m max)	0.2	0.1				
Capital investment (G€)		Additional to base	Additional to reference			
Core scenario		**7.3**	**2.9**	**6.7**	**4.8**	**4.8**
Sensitivity 1		8.8	3.1	6.9	5.1	5.0
Sensitivity 2		7.4	3.0	6.8	4.9	4.8
Sensitivity 3		7.4	2.8	6.6	4.7	4.6
Sensitivity 4		7.6	3.1	7.3	5.1	5.3
Sensitivity 5		8.8	3.5	7.5	5.6	5.8
Overall annualised cost (G€/a)			Additional to reference			
Core scenario			**0.84**	**1.89**	**1.38**	**1.34**
Sensitivity 1			0.78	1.82	1.37	1.25
Sensitivity 2			0.78	1.85	1.37	1.25
Sensitivity 3			0.76	1.82	1.35	1.24
Sensitivity 4			0.83	1.97	1.41	1.38
Sensitivity 5			0.89	2.05	1.50	1.44
Site CO_2 emissions (Mt/a)	Additional to reference	Total	Additional to reference			
Core scenario	**-13.3**	**154.5** (*)	**3.5**	**7.3**	**5.9**	**4.6**
Sensitivity 1	-19.1	160.3	3.6	7.6	6.4	5.0
Sensitivity 2	-13.3	154.5	3.5	7.9	6.5	4.7
Sensitivity 3	-20.5	161.7	3.5	7.7	6.2	4.9
Sensitivity 4	-13.4	154.6	3.8	8.2	6.5	5.3
Sensitivity 5	-26.8	168.0	4.3	9.2	7.4	5.7

Sensitivities: 1: *Heavier crude slate (5% shift towards heavy crude)* 2: *50% higher energy consumption for FCC gasoline desulphurisation* 3: *Energy efficiency unchanged from 2000* 4: *Non-road diesel at AGO specification* 5: *Combined changes*

(*) *138 when excluding petrochemicals*

When considering the change from 50 to 10 ppm sulphur for both gasoline and diesel, the new estimates represent about 2/3 of the overall costs and of the additional CO_2 emissions estimated in the 2000 CONCAWE study. These changes are the result of the very significant technology developments that have taken place in the intervening period, as well as changes in predicted 2010 demands and crude slate.

It must be kept in mind that the model estimates the overall effect of a change on the industry. In practice, each refinery will seek the most cost-effective route to address its own specific set of technical, financial and other constraints. When expressed as a percentage of the total, the increased CO_2 emissions estimated by the model should therefore only be regarded as an average of a wide range of values. Individual circumstances (crude intake, refinery technology, product mix) will dictate the scale of the actual increase for any given refinery.