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The estimated forward cost of EU legislation for the EU refining industry

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The estimated forward cost of EU legislation for the EU refining industry

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ABSTRACT

This Concawe report provides an estimation of the cost burden imposed on EU refineries over the period from 2010 to 2020 by a number of EU legislative and implementing acts.

It is concluded that the regulations under consideration have the potential to significantly increase the operating costs of the EU refining industry thereby impairing its competitive position relative to other world regions where similar legislation is not enacted or is enforced at later dates.

KEYWORDS

EU refining, cost impact, EU legislation, competitiveness

INTERNET

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SUMMARY

This report provides an estimation of the cost burden imposed on EU refineries over the period from 2010 to 2020 by a number of EU legislative and implementing acts.

The European carbon trading scheme (EU-ETS, Directive 2009/29/EC) generates a cost through the obligation to purchase permits for a portion of refinery CO_2 emissions. The main source of uncertainty is the future CO_2 market price, for which we have considered two scenarios.

The Industrial Emissions Directive (IED, Directive 2010/75/EU) sets emission limit values on the effluents of industrial installations to air and water in order to achieve emission levels consistent with so-called best available techniques (BAT). For the refining sector compliance is to be enforced by October 2018.

Concawe has estimated the investment cost required in EU refineries to meet the lower (most severe) and upper (least severe) air emission levels. The upper levels related costs could be reduced by a third by the application of an integrated emission management technique (the so-called “bubble concept”) for SO_2 and NO_x.

With regard to effluent waters, Concawe has estimated that 5 refinery sites will need to upgrade their water treatment facilities to comply with the upper (least severe) emission levels. Additional investment costs and operational costs should be expected in cases where compliance with more severe water emission limits is required.

In addition, implementation of the Water Framework Directive (Directive 2000/60/EC) and the EU Commission’s proposed “Blueprint to Safeguard Europe’s Water Resources” have the potential to increase the cost of water use in future years. Concawe is planning to conduct a detailed survey of EU refineries in 2014/2015 to obtain an estimate of this potential water cost increase.

The REACH Regulation (EC) No 1907/2006 has created a significant burden on product suppliers into the EU market resulting in additional once-off as well as on-going costs. While the overall financial impact estimate may be relatively low it has to be noted that the regulation may lead to a loss of market for specific products.

The Sulphur in Liquid Fuels Directive (SLFD, Directive 1999/32/EC) and more specifically the regulation relative to marine fuels as amended by Directive 2012/33/EU, commonly referred to as the Marine Fuels Directive (MFD) calls for a drastic reduction of the sulphur dioxide emissions of ships in EU waters by the end of the decade. Although the limits can be met by installing flue gas scrubbers on ships, this is widely expected to result in significant changes in marine fuels markets with far-reaching consequences for refineries in terms of investment in new plants as well as operating costs.

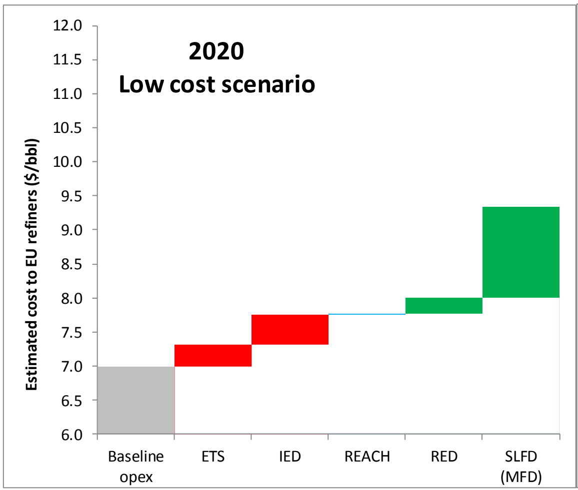
The Renewable Energy Directive (RED, Directive 2009/28/EC) forces introduction of bio-components in road fuels. This is expected to cause a reduction of refinery throughput with consequent loss of margin.

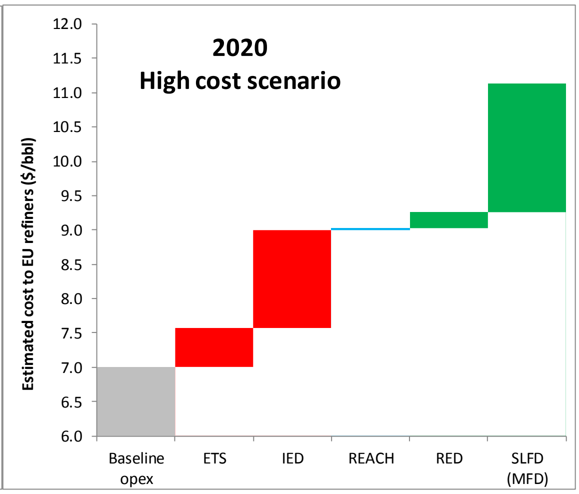
The Fuels Quality Directive (FQD, Directive 2009/30/EC) and more specifically its article 7a imposes a GHG emission intensity reduction target for road fuels. This may include an obligation to assess and take into account the actual GHG profile of individual crude oils. This could artificially enhance the value to EU refiners of “low GHG” crudes which could distort markets and lead to very significant additional supply costs for EU refiners. The current Commission proposal includes an obligation to report the origins of individual crude oils with a view to monitoring their impact on the evolution of the GHG intensity of fossil fuels used in road transport. Because of the

many uncertainties in terms of what the final regulation might entail, we have not included this potential cost element in the overall impact analysis.

The estimated cost impact of these regulations is summarised in the table below while the graphs below show the cumulative impact in a low and high cost scenario, expressed in $ per barrel of refinery intake, and with Concawe's internal estimate of the 2000-2012 average EU refinery cash operating cost[1] of 7 $/bbl as a starting point. These estimated cost impacts should be seen in the context of the EU refining net margin which was less than 3 $/bbl in several of the recent years (source: IEA Oil Market Report).

Legislation	Total	ETS	IED	REACH	RED	SLFD (MFD)
Estimated investment (G€)	24.3 - 47.2		6.6 - 22	0.2		17.5 - 25
Annualised investment (G€/a)	3.6 - 7.1		1 - 3.3	0.0		2.6 - 3.8
Estimated operating cost (G€/a)	3 - 5.2	1 - 1.8	0.4 - 1.2	0.1		1.6 - 2.2
Estimated total annual cost (G€/a)	7.4 - 13	1 - 1.8	1.4 - 4.5	0.1	0.7	4.2 - 5.9





It is concluded that the regulations under consideration have the potential to significantly increase the operating costs of the EU refining industry thereby impairing its competitive position relative to other world regions where similar legislation is not enforced.

[1] Cash operating cost is calculated according to the definition used by Solomon Associates. It includes personnel costs, energy costs (including refinery-produced fuel) and other costs such as maintenance, insurance, chemicals, catalysts, etc.

1. INTRODUCTION

This report provides an estimation of the cost burden imposed on EU refineries over the period from 2010 to 2020 by a number of EU legislative and implementing acts.

The purpose of the refining industry is to transform crude oil, which is not usable as such, into petroleum products that are fit for purpose and produce these in the volumes demanded by the market. Over the years, products specifications have become progressively more demanding in response to increasing end use sophistication (e.g. engines) and to environmental concerns, while demand relentlessly shifted away from heavy fuel oils and towards lighter transportation fuels. To cope with these changes, refineries have become increasingly complex, capital and energy intensive and expensive to run.

Crude oil and petroleum products can be transported easily and relatively cheaply over long distances. As a result the refining industry in a given region is open to competition from other regions. Markets for crude and products are essentially global, price differentials between regions being the reflection of regional supply/demand balance and interregional transport cost. The regional gross refining margin is to a large extent determined by these markets which refiners cannot influence. The gross margin that an individual refinery can achieve is largely a function of its configuration which determines its ability to process cheaper crude oil grades and produce more high value products.

The net margin of individual refiners can be affected by regional or country-specific regulation that can impose extra costs.

Regulation that puts constraints on market products (in terms of e.g. quality or composition) applies to both local refiners and importers. Their impact on domestic margins and the competitive balance depends on the extent to which extra costs are reflected in the market prices for these products and on the relative ability of local refiners and importers to adapt.

However, regulation that imposes operating constraints not encountered in other jurisdictions will affect the competitive balance between local and remote refiners. A specific European issue has been the gradually worsening imbalance between the gasoline and diesel fuel markets, brought about by the growth of commercial road transport and the fast dieselisation of the passenger car fleet. This has created a need to export gasoline and import diesel components, generating additional international transport costs and eroding EU refining margins.

This report provides an estimation of the cost burden imposed on EU refineries over the period from 2010 to 2020 by a number of EU legislative and implementing acts. Whereas previous issues of these regulations (pre 2010) have had an impact on the EU refining industry for many years, this report focuses also on the expected costs associated with the latest embodiment of these regulations that are due to impact refineries in the coming decade. Costs are estimated for the whole EU refining sector and it should be emphasised that actual costs for individual refineries may vary considerably depending on their location, configuration, specific markets etc.

2. ESTIMATED FORWARD COST OF LEGISLATION TO THE EU REFINING INDUSTRY

A number of EU legislative and implementing acts have recently been adopted which have the potential to significantly increase the cost burden on EU industry in general and the refining sector in particular. For the refining sector the most relevant regulations are:

- The European Union Emissions Trading System (EU-ETS, Directive 2009/29/EC);
- The Industrial Emissions Directive (IED, Directive 2010/75/EU) and its Commission Implementing Decision of 9 October 2014 establishing Best Available Techniques (BAT) conclusions;
- The REACH Regulation (EC) No 1907/2006;
- The Sulphur in Liquid Fuels Directive (SLFD, Directive 1999/32/EC) and more specifically the regulation relative to marine fuels as amended by Directive 2012/33/EU, commonly referred to as the Marine Fuels Directive (MFD);
- The Renewable Energy Directive (RED, Directive 2009/28/EC);
- The Fuels Quality Directive (FQD, Directive 2009/30/EC) and more specifically its article 7a.

For each of these regulations we have assessed the potential impact on the refining sector and the resulting investment and operating costs over the decade from 2010 to 2020. Costs have been assessed in 2013 “money-of-the-day” euros and no attempt has been made to account for future inflation or apply a discount rate. We have annualised these costs to arrive at a total cost of EU legislation in 2020 expressed in both G€/a and $ per barrel of refinery intake using a fixed €/$ exchange rate. In order to arrive at a consistent set of costs for the various regulations, we have used standard data as well as a number of common assumptions. They are summarised in **Appendix 2**.

The EU-ETS and IED clearly impose a unilateral burden on EU refiners, to which competitors outside the EU and other EU fuel suppliers are not subjected. The RED, FQD, SLFD and REACH impose a burden on products rather than production facilities that should therefore be felt by all market actors. However, domestic producers, whose market is to a large extent inside the EU, have essentially no choice but to adapt to new regulations when they impact production of major products such as gasoline or diesel fuel. In contrast, producers outside the EU may have a choice whether or not to adapt.

2.1. EU-ETS

The EU-ETS seeks to reduce industrial GHG emissions in the EU by creating a carbon price via a cap and trade system. During the first two trading periods which ran from 2005 to 2012, the majority of emissions allowances were distributed free of charge and the cost of CO_2 remained low. In the third trading period, running from 2013 to 2020, the preferred allowance distribution mechanism is regular auctioning by individual EU Member States. In order to limit unilateral costs to the EU industry and avoid carbon leakage[1], certain sectors, including refining, that are exposed to international competition have been granted free allowances on the basis of a sector

[1] i.e. displacement of activities and their associated emissions from inside to outside of the EU.

"best-in-class" benchmark. This excludes any emissions associated with electricity production for which all allowances must be purchased.

For the refining sector the CWT (Complexity-Weighted-Tonne) methodology was adopted leading to a benchmark set at 80% of the average EU refinery emissions. This reduces to 71% after correction for emissions associated with electricity generation (both internal and external), for which no free allowances may be granted. A further "cross-sectoral" correction factor is applied in order to bridge the gap between the total allowances that would be granted according to all sector benchmarks and the overall absolute cap set by the ETS Directive. This is imposed equally to all sectors regardless of the severity of their own benchmark. Although the EU refining benchmark would be within the reduction target set by the ETS Directive, the cross-sectoral factor is applied running from 94.3% in 2013 to 82.4% in 2020, reducing the total free allocation by 11.6% over the 2013-2020 period. Overall the EU refining sector will receive 67% of its baseline emissions as free allowances in 2013, reducing to 58% in 2020. In this analysis we have assumed that total EU refining emissions will remain constant at 144 Mt/a over the 2013-2020 period, although an increase could be expected towards the end of the period if IMO marine fuel regulations are enforced in 2020.[2]

Permits for the balance of emissions have to be purchased either through the regular auctions or on the secondary trading market. In its 2008 impact assessment, the EU Commission used a CO_2 price of 30 €/t. Actual prices have been much lower[3] which led to a reassessment of the projections. In a recent consultant report for the Commission [2], modelling results taking into account the economic downturn suggest a price of 16.5 €/t for the 2020 horizon. We have considered these two price levels as a low and high scenario. The resulting estimated costs in 2020 are shown in the table below. These costs include the effect of an electricity price increase which is assumed to exactly pass through the CO_2 cost from the electricity producer to the consumer. Detailed calculations are given in **Appendix 3**.

Table 1 Estimated costs associated with the EU-ETS for the year 2020

CO_2 price		Low	High
	€/t	16.5	30.0
Estimated cost to EU refiners	G€/a	**0.99**	**1.80**
(purchase of CO_2 emission permits)	$/bbl	**0.31**	**0.57**

At this point in time, it is not known what regime will be in place after 2020. If the current scheme is extended, the costs should remain broadly the same. Any change to the current rules could, however, have a marked impact.

[2] Concawe estimates [1] that if IMO marine fuel sulphur reductions are fully met by EU refining in 2020 then the sector's emissions will increase from 144 Mt/a in 2010 to 154 Mt/a in 2015 and 163 Mt/a in 2020. Most of the extra emissions will be generated by new plants for which some additional allowances may be granted.

[3] For example, see European Energy Exchange AG (EEX) website giving current and historical EU CO_2 allowance prices: https://www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances#!/2014/10/17

2.2. IED AND RELATED REGULATIONS

Replacing the IPPC Directive, the IED sets quality limits on the effluents of industrial installations to air and water. It is a complex piece of legislation that seeks to achieve emissions consistent with so-called best available techniques (BAT). The IED is implemented via the “BAT conclusions” document which contains, among other information, the range of Associated Emission Levels (AELs) achievable with the best available techniques (hence BAT-AELs) and the associated monitoring requirements. Four years after the publication of the BAT conclusions for a specific sector, all installations should have their permit conditions updated accordingly with the new emission limits consistent with the BAT-AELs.

The Implementing Decision on BAT conclusions for the refining sector was published in October 2014 which implies compliance by October 2018. The BAT-AELs included in these BAT conclusions represent challenging targets for air and water emission reductions for the sector. Refineries are affected with regards to emissions to air and through their water use and effluent water treatment.

Concawe has carried out a thorough estimate of the investment cost to EU refineries required to meet the new air emissions limits. Extensive work was undertaken to provide updated and comprehensive data on the cost and cost effectiveness of the available abatement technologies aimed at reducing emissions to air from refineries. The results have been documented and published in two Concawe reports [3,4]. Details on the cost elements considered and methodology used are given in **Appendix 4** for two scenarios involving different BAT-AEL severity. The appendix gives a breakdown of the impacted installations, proposed limit values in both scenarios, required technologies and resulting investment requirements.

The required investment for the EU refining sector is estimated at between 6.6 and 22 G€[4] which is equivalent to between 80 and 268 M€ per EU refinery[5] on average. The low and high extremes of the investment range correspond to the requirements for additional equipment to comply with the upper (least severe) and lower (most severe) level of the BAT-AELs, respectively. A breakdown of the investments required to comply with the upper and lower levels of the BAT-AELs is given in **Appendix 4**.

It is to be noted that the above estimates only cover investment costs necessary to meet limits on SO_2, NO_x and Dust. They do not include VOCs or costs associated with emission monitoring.

The investment figures assume that refineries need to meet the emission limit values for each individual stack. The BAT Conclusions adopted by the Commission in October 2014 include the possibility to use an integrated emission management technique (the so-called “bubble concept”) for SO_2 and NO_x as an alternative to applying BAT to individual sources. In 2013 Concawe carried out a study to evaluate the options for meeting the environmental benefit of the BAT conclusions using both individual source and integrated emission management approaches [6]. The results indicate that the estimated CAPEX for complying with the upper level of the BAT-AELs could be reduced by 30% if the integrated management technique is applied while achieving the same environmental benefits.

[4] This report uses the SI symbols G (giga) and M (mega) to denote billion (10^9) and million (10^6), respectively.
[5] The per refinery figures are simple averages calculated by taking the sector totals of 6.6 and 22 G€ and dividing by the 82 mainstream refineries in operation in EU28 at end November 2014, as listed in Appendix 1 which also includes a list of refineries recently permanently shut down.

Other legislation that may impact the air emissions compliance costs are the Ambient Air Quality Directive and the National Emission Ceilings Directive.

With regard to effluent water quality requirements under the IED, Concawe has estimated that 5 refinery sites will need to upgrade their water treatment facilities to meet the upper (least severe) level of the BAT-AEL ranges at a total investment cost of 150 M€. Although significant for the refineries concerned, this has only a small impact on the overall cost figure. It should be stressed that this refining investment estimate represents the best case, lowest investment outcome, which assumes that local authorities will apply limits corresponding to the upper (least severe) level of the BAT-AELs. Additional investment and operational costs should be expected in cases where compliance with more severe water emission limits is required. However, Concawe has not estimated this high cost scenario at this stage.

The resulting total estimated costs associated with the IED are shown in the table below. More detailed calculations are given in **Appendix 4**.

Table 2 Estimated costs associated with the IED for the year 2020

Cost scenario		Low	High
Emissions to air (SO$_2$, NO$_x$ and dust only, excluding the potential effect of applying the bubble concept)			
Estimated cumulative investment 2010-2020	M€	6600	22000
Estimated cost (including operating cost)	G€/a	1.35	4.5
	$/bbl	0.43	1.43
Emissions to water			
Estimated cumulative investment 2010-2020	M€	150	not
Estimated cost (including operating cost)	M€/a	25	estimated
	$/bbl	0.01	
Total cost to EU refiners	G€/a	**1.37**	**4.5**
	$/bbl	**0.44**	**1.43**

The Water Framework Directive (WFD, Directive 2000/60/EC) commits European Union Member States to achieve good qualitative and quantitative status of all water bodies (including marine waters up to one nautical mile from shore) by 2015. Where refineries discharge into surface water bodies that do not meet the quality standards, they may be requested by local regulators to implement additional effluent treatment measures, over and above those required to comply with the IED. This, together with proposed regulation to minimise net water consumption under the Commission's "Blueprint to Safeguard Europe's Water Resources" initiative (which may result in higher drawing right fees, discharge treatment costs and waste disposal costs), could increase the estimated average cost of water use from around 1 €/m^3 currently to as much as 1.3 €/m^3 in future years, based on preliminary Concawe estimates. This increase would have significant cost implications, if realised across the whole sector. However, this rough estimate is not considered reliable enough to be included in the overall impact analysis. Concawe is planning to conduct a detailed survey of EU refineries in 2015 to obtain a firmer estimate of this potential water cost increase.

An indication of the importance of the cost of water in refinery operating costs can be obtained by estimating the effect of a water cost increase of 0.1 €/m^3 (about 10%). Since the net water consumption of the average EU refinery is about 7 m^3/t crude throughput, or about 4.3 Gm^3/a for the whole EU refining industry, a cost increase of 0.1 €/m^3 would translate into an additional operating cost burden of about 0.7 €/t (1.0 $/bbl) of crude.

2.3. REACH

The REACH legislation has created a significant additional burden on product suppliers into the EU market. Once-off costs have been incurred for:

- Development of methodologies required for the assessment of UVCBs and in the preparation of the common elements of the registration dossiers,
- Registration fees.

For all EU refineries these costs are estimated at 50 M€ and 80 M€ respectively.

There are also potential costs for additional testing, currently estimated at some 50 M€.

On-going costs of 50 M€/a are also incurred for additional personnel directly dealing with the administration of the scheme.

The resulting estimated costs are shown in the table below.

Table 3 Estimated costs associated with REACH for the year 2020

Cumulative once-off costs 2010-2020	M€	180
Capital charge	M€/a	27
On-going cost	M€/a	50
Total cost to EU refiners	M€/a	**77**
	$/bbl	**0.02**

While the overall financial impact estimate may be relatively low, REACH has caused a significant draw on technical support resources in the refineries.

Under certain circumstances the REACH regulation may result in a product being banned for certain applications. There is therefore a potential for loss of certain markets for specific products. For refineries this may be the case for special non-fuels niche products which, although representing small volumes, may offer high added value and may make a significant contribution to the profitability of certain refineries.

2.4. SLFD (MARINE FUELS)

Over the years the proportion of heavy fuel oil in the EU refineries output has steadily decreased as the market for light products expanded rapidly and markets for inland heavy fuel oil (mostly for power generation and heavy industry) steadily decreased. However, demand for marine fuels (also known as “bunker fuel”) remained strong following the growth of long distance maritime transport.

With increasing sea traffic, sulphur oxides emissions from shipping became a concern leading to pressure on the maximum sulphur content of bunker fuel. Legislation regarding international sea transport falls under the International Maritime Organisation[6] (IMO).

The first step was the creation of Emission Control Areas (ECA) where the reduction of SO_2 emissions from sea traffic is cost effective compared to land based measures. It concerns areas where sea traffic is particularly intense and/or near highly populated or environmentally sensitive land areas. In Europe the English Channel, the North Sea and the Baltic Sea were designated as ECAs in 2005. The maximum sulphur content of fuel burned by ships while sailing in ECAs was reduced from 1.5% m/m to 1.0% m/m in 2010 and is due to be reduced to 0.1% m/m in 2015 (IMO legislation).

In 2008 the IMO adopted[7] the principle of a reduction of the maximum allowable sulphur dioxide emissions from all ships consistent with a reduction of bunker fuel maximum sulphur content from the current 3.5% m/m to 0.5% m/m. The limit can, however, be met by installing flue gas scrubbers on ships. Subject to a review by 2018 this will enter into force in 2020 or 2025. Through the Marine Fuels Directive (MFD) the EU has enshrined the IMO limits into EU legislation although the Directive also stipulates that the 0.5% m/m limit will be introduced in non-ECA EU waters by 2020, irrespective of the IMO final timing.

Adapting to these new sulphur limits will represent a major challenge for refiners. In practical terms the 0.1% m/m sulphur limit can only be met by switching from residual fuel to distillates in the gasoil range. This is particularly unwelcome in Europe where so-called “middle distillates” (gasoils and kerosenes) are already in short supply. To produce the additional gasoil new hydrocracking plants are required. To achieve the 0.5% m/m sulphur limit residual streams would have to be desulphurised and blended with low sulphur distillate streams. Although residue desulphurisation processes exist, the plants are complex and expensive to build and run. Only two of them have been built so far in Europe and about twenty in the rest of the world, mainly in Japan, South Korea, Taiwan and China. All such processes require large amounts of energy and hydrogen leading to sizeable extra CO_2 emissions.

In a recent study [1], Concawe has estimated the cost to EU refining at 10 G€ for the ECA 0.1% m/m limit and 15 G€ for the 0.5% m/m limit assuming all bunker fuel sold in the EU meets that specification. The corresponding extra CO_2 emissions stand at 8 and 9 Mt/a respectively.

Beyond the capital cost, refiners face a sizeable extra energy bill as well as carbon cost through the EU-ETS (or its successor post 2020).

In view of the uncertainty on the timing of implementation of the IMO 0.5% m/m global limit and the alternative for ships to install scrubbing facilities, we have illustrated two cases where either 50% or 100% of the non-ECA bunker fuel sold by EU refineries in 2020 would meet that specification.

The overall estimated costs are summarised in the table below. Detailed calculations are given in **Appendix 5**.

[6] The IMO bunker fuel quality legislation comes under the Maritime Pollution (MARPOL) Convention and more particularly its Annex IV Regulations for the Prevention of Air Pollution from Ships

[7] Resolution MEPC.176(58) adopted on 10 October 2008 (Revised MARPOL Annex VI)

Table 4 Estimated costs associated with the SLFD for the year 2020

% of non-ECA EU bunker fuel @ 0.5% S		Low: 50%	High: 100%
Marine fuels			
Estimated cumulative investment 2010-2020	G€	17.5	25.0
Capital charge	G€/a	2.63	3.75
Estimated additional operating costs	G€/a	1.61	2.19
Total estimated cost to EU refiners	G€/a	**4.23**	**5.94**
	$/bbl	**1.34**	**1.89**

It should be mentioned that the significant changes to the bunker fuels specifications will bring these fuels closer to middle distillates such as diesel and gasoils, with far-reaching consequences on the supply/demand balance. There are many factors involved, including the uptake of on-board scrubbers by ship owners. Recently there has also been renewed interest in LNG as a potential fuel for ships, although there are many issues to consider before LNG could become a mainstream ship fuel. The way markets will react is difficult to predict and beyond the scope of this assessment.

2.5. RED

The overwhelming impact of the RED on EU refiners is the forced introduction of biofuels. This has several consequences.

Handling biofuels requires additional storage and blending facilities. These may physically be located either in refinery sites or in depots but need to be paid for in any case. We have estimated the cost at 10 to 12 M€ per refinery (which would roughly correspond to 2 medium-size tanks and associated facilities). However, these facilities had by and large already been built by 2010 and we have therefore not included the attendant costs in this analysis.

Faced with the introduction of biofuels in an at best stable, if not shrinking market, refiners can follow either of two courses of action:

- Reduce throughput to reduce production of fossil gasoline/diesel,
- Maintain throughput and rebalance the market through import/export.

Europe overall is long in gasoline and short in diesel. Additional biodiesel could be accommodated through reducing imports. However, replacement of a portion of the gasoline by ethanol would require either reduced production or new outlets for export.

As a result of the steady dieselisation of its vehicle population, the EU has been exporting increasing volumes of gasoline over the years, mostly towards the USA. Whether this can be sustained, let alone increased further in the future is unclear. In any case, export is only practically available to refineries located at or near a major sea port. The need to reduce gasoline production could lead to further throughput reduction for EU refiners.

The estimated cost of reducing throughput can be equated to a loss of margin over the entire product range (loss of volume margin). In estimating this cost we have assumed that the changes in product supply or crude oil demand would not materially affect the price structure and therefore the achievable margin. It is to be noted that these loss of margin impacts would apply to the introduction of any alternative fuel, be it biofuels, natural gas, electricity etc. For the purposes of the calculation a notional average EU refinery net margin of 3 $/bbl has been used, which should not be taken as representative of current or historic margins. The EU refining margins published in the monthly IEA Oil Market Report have been below this level in several of the recent years.

Biofuels are today more expensive than their fossil equivalent and this is expected to remain the case for the foreseeable future. This is, however, a cost that will be borne by the entire fuel supply industry and not only by refiners and should therefore not affect the competitive position of EU refiners in this respect. We have therefore not further considered it in this analysis.

The overall biofuels-related costs are summarised in the table below. Detailed calculations are given in **Appendix 6**.

Table 5 Estimated costs associated with the RED for the year 2020

Total estimated cost to EU refiners	G€/a	**0.70**
	$/bbl	**0.22**

2.6. FQD

The FQD was first promulgated in 1993 and has been through a number of updates since. It has imposed gradually tighter limits on a number of gasoline and diesel fuel specifications, most notably sulphur content, to which the EU refining industry has adapted through significant investment and operating changes.

The inclusion in the 2009 update of the Directive of a GHG emission intensity reduction target of 6% for marketed road fuels in 2020 versus the 2010 fossil fuels baseline (Article 7a), represented a departure from its traditional quality focus and presented a new challenge for refiners. The introduction of alternative fuels and particularly biofuels under the RED will be the main contributor towards the FQD article 7a target. The ability to close any remaining gap will depend on the final accounting rules (e.g. for advanced biofuels, electricity, etc.) and on the definition of upstream emission reductions which may be used as credits.

Recent discussions have focussed on the GHG profile of crude oil and the extent to which it would be desirable and/or practical to assess and take into account the actual GHG profile of individual crude oils in the calculation of the GHG intensity of road fuels. In a supply chain as complex and diverse as fossil fuel production from crude oils, the difficulties in putting in place, enforcing and policing GHG reporting would be immense. The enhanced value to EU refiners of “low GHG” crudes and the products made from them, has the potential to significantly distort markets leading to crude and product “shuffling” between EU and non EU markets. In the absence of similar legislation in other major consuming markets, there would be no global GHG reduction and probably a small increase due to additional transport. A 2012 study by Wood Mackenzie [7] concluded that the overall negative impact on EU refining gross margins could be considerable, between 2 and 7 $/bbl. This is a very high number, of the same order of magnitude as Concawe’s internal estimate of the 2000-2012 average EU refinery cash operating cost of 7 $/bbl.

The Commission proposal for implementing measures pertaining to article 7a was adopted in December 2014 by the Council and Parliament. This includes an obligation to report the origins of individual crude oils with a view to monitoring their impact on the evolution of the GHG intensity of fossil fuels used in road transport. It imposes the use of an average GHG intensity for fossil fuels in 2020. Consequently, no differentiation of the product GHG intensity based on the feedstock of origin is imposed and the potential costs associated with the above-mentioned crude and product "shuffling" effects would not be incurred.

Because of the many remaining uncertainties in terms of the final accounting rules, we have not included an analysis of the potential costs associated with article 7a compliance in the overall impact analysis.

3. OVERALL ANALYSIS: RANGE OF ESTIMATED COST TO THE EU REFINING INDUSTRY AND POTENTIAL IMPACT ON COMPETITIVENESS

The estimated investment, operating and total annual costs are summarised in the table below.

Table 6 Overall estimated cost of EU legislation for the year 2020

Legislation	Total	ETS	IED	REACH	RED	SLFD (MFD)
Estimated investment (G€)	24.3 - 47.2		6.6 - 22	0.2		17.5 - 25
Annualised investment (G€/a)	3.6 - 7.1		1 - 3.3	0.0		2.6 - 3.8
Estimated operating cost (G€/a)	3 - 5.2	1 - 1.8	0.4 - 1.2	0.1		1.6 - 2.2
Estimated total annual cost (G€/a)	7.4 - 13	1 - 1.8	1.4 - 4.5	0.1	0.7	4.2 - 5.9

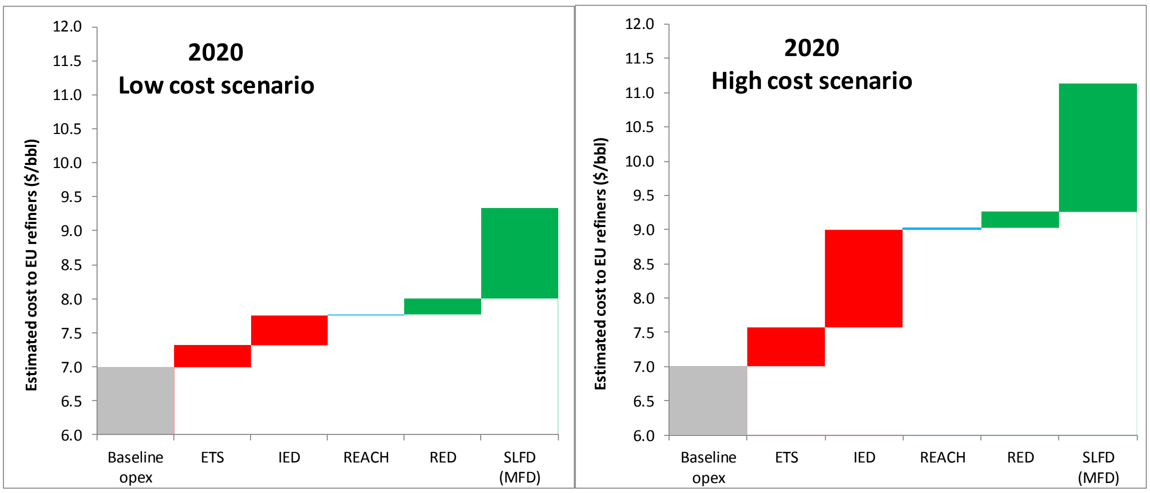
In **Figure 1**, we show the estimated cumulative cost impact of each of the analysed EU legislative measures in 2020, expressed in $/bbl of refinery intake. Concawe's internal estimate of the 2000-2012 average EU refinery cash operating cost of 7 $/bbl has been used as a starting point. It should be noted that this average cash operating cost figure does not include annualised investment costs, whereas the additional costs do include investments. These estimated cost impacts should be seen in the context of the average EU refinery net margin which was less than about 3 $/bbl in several of the recent years (source: IEA Oil Market Report).

Costs associated with the EU-ETS and the IED (coloured red) are unavoidable and specifically apply to EU facilities, thereby directly affecting the competitive position of EU refiners.

The costs associated with REACH (coloured blue) are equally unavoidable but apply to all EU fuel suppliers.

Other costs related to marine fuels (SLFD) and the RED (coloured green) only apply to EU refiners but are more uncertain because they will be the result of investment decisions and market adjustments.

Figure 1 Estimated cumulative cost of EU legislation in 2020



Considering that the total EU refinery cash operating costs are around 7 $/bbl on average (although there are considerable differences between sites), it is clear that the regulations under consideration have the potential to significantly increase the operating costs of the EU refining industry, thereby impairing its competitive position relative to other world regions where similar legislation is not enacted or is enforced at later dates. It should also be borne in mind that these figures do not include the uncertain impact of FQD article 7a compliance on costs, as discussed in **Section 2.6**.

4. GLOSSARY

BAT	Best Available Techniques, a concept developed in the context of emission reduction under the IED
BAT-AEL	Emission levels associated with the Best Available Techniques
bbl	Barrel (0.159 m^3)
Cash operating cost	Variable and fixed operating costs, excluding investment financing costs.
Capital charge	Annualised capital investment cost, including return on capital
CWT	Complexity-Weighted-Tonne, a metric developed by Solomon Associates to characterise CO_2 emissions from a refinery and used in the EU refinery benchmarking scheme under the EU-ETS
ECA	Emission control area (in relation to marine SO_2 emissions)
EGTEI	The UN-ECE's (United Nations' Economic Commission or Europe) Expert Group on Techno-Economic Issues
EU-ETS	European Union (GHG) emissions trading system under Directive 2009/29/EC
FQD	Fuels Quality Directive 2009/30/EC
G€	Billion (10^9) euros
GHG	Greenhouse Gas
IED	Industrial Emissions Directive 2010/75/EU
IMO	International Maritime Organisation www.imo.org
IPPC	Integrated Pollution Prevention and Control, EU Directive now superseded by the IED
LNG	Liquefied Natural Gas
M€	Million (10^6) euros
MFD	Marine Fuels Directive 2012/33/EU
REACH	Registration, Evaluation, Authorisation and restriction of Chemicals, Regulation (EC) No 1907/2006
RED	Renewable Energy Directive 2009/28/EC
REF BREF	BAT Reference Document (BREF) for the Refining of Mineral Oil and Gas (REF)
SLFD	Sulphur in Liquid Fuels Directive 1999/32/EC
UVCB	Substances of unknown or variable composition, complex reaction products or biological materials, collectively called UVCBs under REACH
VOC	Volatile Organic Compound

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APPENDIX 1: REFINERIES IN EU28

Mainstream refineries in operation at end November 2014

	Country	*Refinery*	*Ownership*
1	AT	Schwechat	OMV
2	BE	Antwerp	ExxonMobil
3	BE	Antwerp	TOTAL
4	BE	Antwerp	Gunvor
5	BG	Burgas	Lukoil
6	CZ	Kralupy	CRC (PKN Orlen/ENI)
7	CZ	Litvinov	CRC (PKN Orlen/ENI)
8	DE	Bayern oil	BP/Ruhr Oel/ENI/Varo
9	DE	Heide	RHG (Klesch)
10	DE	Rheinland	Shell
11	DE	Ingolstadt	Gunvor
12	DE	Harburg (Holborn)	Tamoil
13	DE	Leuna	TOTAL
14	DE	Kalrsruhe	MiRO (Ruhr Oel/ Phillips66/ExxonMobil/ Shell)
15	DE	Burghausen	OMV
16	DE	Schwedt	PCK (Ruhr Oel/ Shell/Total/ENI)
17	DE	Gelsenkirchen	Ruhr Oel (BP/Rosneft)
18	DE	Lingen	BP
19	DK	Fredericia	Shell
20	DK	Kalundborg	Statoil
21	ES	Castellon	BP
22	ES	Tenerife	CEPSA
23	ES	Huelva (La Rabida)	CEPSA
24	ES	San Roque (Algeciras)	CEPSA
25	ES	Petronor (Bilbao)	Repsol
26	ES	Cartagena	Repsol
27	ES	La Coruna	Repsol
28	ES	Puertollano	Repsol
29	ES	Tarragona	Repsol
30	EL	Thessaloniki	Hellenic
31	EL	Aspropyrgos	Hellenic
32	EL	Elefsis	Hellenic
33	EL	Agii Theodori (Corinth)	Motor Hellas
34	FI	Naantali	Neste
35	FI	Porvoo	Neste
36	FR	Lavera	Ineos/Petrochina
37	FR	Fos	ExxonMobil
38	FR	Port-Jerome	ExxonMobil
39	FR	Donges	Total
40	FR	Feyzin	Total
41	FR	Grandpuits	Total
42	FR	Gonfreville	Total
43	FR	La Mede	Total
44	FR	SARA	SARA
45	HR	Rijeka	INA
46	HR	Sisak	INA
47	IE	Whitegate	Phillips66
48	IT	Livorno	ENI
49	IT	Sannazzaro	ENI
50	IT	Taranto	ENI
51	IT	Gela	ENI
52	IT	Falconara	API
53	IT	Augusta	ExxonMobil
54	IT	Priolo (+Melilli)	Lukoil
55	IT	RAM (Milazzo)	ENI/KPI
56	IT	Trecate	ExxonMobil/TotalERG
57	IT	Busalla	IPLOM
58	IT	Sarroch	SARAS
59	LT	Mazeikiu (Lietuva)	PKN Orlen
60	NL	Rotterdam	ExxonMobil
61	NL	Rotterdam	KPC
62	NL	NRC (Rotterdam)	BP
63	NL	Pernis	Shell
64	NL	Vlissingen (Zeeland)	Total/Lukoil
65	PT	Leca (Porto)	Petrogal
66	PT	Sines	Petrogal
67	HU	Szazhalombata (Duna)	MOL
68	PL	Gdansk	Lotos
69	PL	Plock	PKN Orlen
70	RO	Ploiesti	Petrobrazi (Petrom)
71	RO	Ploiesti	Petrotel (Lukoil)
72	RO	Navodari (Constanza)	Petromidia (Rompetrol)
73	SE	Gothenburg	Preem
74	SE	Lysekil	Preem
75	SE	Gothenburg	St1
76	SK	Slovnaft (Bratislava)	MOL
77	UK	Grangemouth	Ineos/Petrochina
78	UK	Killingholme (Humber)	Phillips66
79	UK	Fawley	ExxonMobil
80	UK	Humberside (Lindsey Oi	Total
81	UK	Stanlow	Essar
82	UK	Pembroke	Valero
	Total EU28		**82**

Mainstream refineries recently closed

	Country	Refinery name	Ownership	Year
1	DE	Wilhelmshaven	Hestya Energy BV	2011
2	DE	Harburg	Shell	2012
3	FR	Reichstett	Petroplus	2011
4	FR	Berre	LyondellBasell	2011
5	FR	Petit Couronne	Petroplus	2013
6	FR	Dunkerque	Total	2010
7	IT	Porto Marghera	ENI	2013
8	IT	Mantova (Frassino)	MOL	2014
9	IT	Roma	TotalERG	2012
10	IT	Cremona	TAMOIL	2010
11	RO	Arpechim (Pitesti)	OMV Petrom	2011
12	UK	Coryton	Petroplus	2012
13	UK	Milford Haven	Murco	2014
14	UK	Teesside	Petroplus	2009

Atypical refineries (bitumen/lubes)

	Country	Refinery name	Ownership
1	CZ	Pardubice	Paramo (PKN Orlen)
2	BE	Antwerp	APC (Vitol)
3	DE	Hamburg/Neuhoff	H&R
4	DE	Salzbergen	H&R
5	DE	Brunsbuttel	TOTAL
6	ES	ASESA	CEPSA/REPSOL
7	FR	Dunkerque	Colas
8	IT	Ravenna	ALMA
9	NL	Rotterdam	Koch
10	PL	Jedlicze	PKN Orlen
11	PL	Trzebinia	PKN Orlen
12	RO	Ploiesti (Vega)	Rompetrol
13	SE	Nynasham	Nynas
14	SE	Gothenburg	Nynas
15	UK	Eastham	Nynas/Shell
16	UK	Dundee	Nynas

APPENDIX 2: COMMON DATA AND ASSUMPTIONS

Table A2.1 General data

Exchange rates		
USD/EUR	1.4	$/€
Investment and operating costs		
Capital charge rate	15%	/a of investment
(The annual revenue necessary to cover the cost of an investment, including return on capital		
Under typical EU economic and fiscal environment 15% corresponds roughly to 8% return on capital)		
Opex (excluding energy)	5.4%	/a of investment
(includes 4% fixed costs and 1.4% variable costs)		
Marginal fuel cost (based on Nat Gas)	25	€/MWh
	292	€/toe
Barrels per tonne (crude)	7.37	bbl/t
Number of mainstream refineries in EU28	82	

Table A2.2 EU refining throughput and product yield data
(*Source Concawe report 13/1*

Year		*2005*	*2010*	*2015*	*2020*	*2025*	*2030*
Crude throughput *(Table 4.1.1)*	Mt		606	606	598	575	554
Refinery production *(Appendix 7)*							
LPG	Mt		26	24.5	24.1	24.6	24.2
Chem			54.6	57.5	58.3	59.1	59.9
Gasoline			127.4	115.2	107.2	97	90.7
Jet/Kero			41.4	48	52.8	56.8	57
Diesel			184.7	193.1	192.8	182.2	172.7
Heating oil			63.3	71.4	72.3	69.5	66.9
Distillate Marine Fuel (DMF)			6.3	20.3	25.1	26.1	27.0
Inland HFO			32.1	23.5	14.9	11.3	8.7
Res marine FO			42.1	31.1	27.6	28.4	28.9
Bitumen			19.3	19.4	18.4	17.6	16.9
Luboils			5.1	5.1	4.9	4.7	4.5
Total			602.3	609.1	598.4	577.3	557.4
Road fuels *(Table 3.4.1)*							
Gasoline demand (inc. Ethanol)	Mt	116	88	80	73	63	56
Fossil gasoline demand	Mt	115	84	73	65	55	49
Ethanol in gasoline	Mt	1.1	3.8	7.5	8	7.6	7.3
	%v/v	0.90%	4.10%	8.90%	10.40%	11.60%	12.50%
Ethanol in gasoline excluding E85	Mt	1.1	3.6	7	7	6.2	5.5
	%v/v	0.90%	3.90%	8.30%	9.30%	9.70%	9.80%
Oxygen in gasoline excluding E85	%m/m	0.30%	1.40%	3.10%	3.40%	3.60%	3.60%
Road diesel demand (inc. biofuels)	Mt	178	185	194	198	191	185
FAME in road diesel	Mt	1.7	13.5	14.2	16.6	17.8	18.4
	%v/v	0.90%	6.90%	6.90%	7.90%	8.80%	9.40%
Ethanol in road diesel (E95)	Mt	0	0	0.2	0.4	0.7	1.1
	%v/v	0.00%	0.00%	0.10%	0.20%	0.40%	0.70%
FAME+ethanol in road fuels	Mtoe	2.2	14.4	17.4	19.9	21	21.6
	%energy	0.70%	5.10%	6.20%	7.10%	7.90%	8.50%
Other non-fossil alternative fuels in road fuels	Mtoe	0	1	2.3	3.7	5.4	7.2
(HVO, BTL, DME, elec)	%energy	0.00%	0.40%	0.80%	1.30%	2.00%	2.80%
All non-fossil alternative fuels in road fuels	Mtoe	2.2	15.4	19.8	23.7	26.4	28.9
	%energy	0.70%	5.50%	7.00%	8.40%	9.90%	11.30%
Ethanol in gasoline	Mtoe	0.7	2.4	4.8	5.1	4.9	4.7
FAME+others in road diesel	Mtoe	1.5	13.0	15.0	18.6	21.5	24.2
FAME+others in road diesel (as FAME)	Mt	1.7	14.7	17.1	21.1	24.5	27.5
Road diesel imports *(Chapter 8)*	Mt		10	10	10	10	10

APPENDIX 3: EU-ETS COST ESTIMATION

Table A3.1 Estimated cost of purchased CO_2 emissions allowances

CO_2 price	€/t		16.5	30.0
EU refineries total CO_2 emissions	Mt/a	RE	144	
Total CWT (Complexity-Weighted-Tonne) activity of EU refineries	Mt/a	CWT	3900	
CWT is a refinery activity metric that takes into account both size and complexity of a refinery and correlates with CO2 emissions				
Benchmark	t CO2/CWT	BM	0.0295	
This is the value, established in the ETS regulation, on the basis of which free allowances to refineries are calculated				
Direct v total emissions correction factor		CF	0.89	
This factor eliminates the impact of electricity generation for which no free allowances may be granted				
Gross free allowances	Mt CO2/a	GFA=CWT*BM*CF	102	
Carbon leakage exposure factor		CLEF	100%	
This factor reflects the degree of carbon leakage exposure of a certain sector				
Cross sectoral correction factor		CSCF	82.4%	
This factor, the same for all sectors, adjusts free allowances to bring the total in line with the desired emissions reduction as set by the ETS regulation				
Net free allowances	Mt CO2/a	NFA=GFA*CLEF*CSCF	84	
Purchased allowances	Mt CO2/a	RE-NFA	60	
Cost of purchased allowances	M€/a		988	1797

APPENDIX 4: IED (AIR EMISSIONS) COST ESTIMATION

Essential elements of the Concawe Cost Study: The *cost elements* of the study were based on earlier published EGTEI work[8] (circa 2000-2004) but this was extensively updated using detailed data from Concawe member companies derived from either "built and operating projects" (including US projects) or detailed "pre-budget appropriation" cost studies. The companies contributing such cost data process more than half of the crude oil refined in Europe today. Details are documented in Concawe's cost-effectiveness report 6/11 [4].

The key to a robust assessment of the cost or cost effectiveness of additional abatement measures is to have detailed data (physical and operational) on the actual situation in individual European refineries. This was provided through Concawe's four yearly "Refinery Sulphur Survey". Although NOx and Dust concentration data were not available in the sulphur survey, the cost effectiveness of further abatement measures was explored by using an appropriate range of assumed "current" NOx and Dust concentrations. In each case, the higher end of the range was used in the cost-effectiveness analysis since this yields the lowest cost per tonne of emission reduction.

To complete the assessment of the cost implications of the BAT conclusions in the final draft of the REF BREF, Concawe utilised the detailed cost data underpinning the cost-effectiveness study to undertake a bottom up assessment. For each contributing refinery, this involved determining the cost/cost effectiveness of various further abatement techniques for the FCCU, the SRU and for each individual combustion stack size category (from <50MW, 50-100MW, 100-300MW and >300MW) based on the physical/operational data from the 2010 Concawe sulphur survey responses.

The cost implications of the final draft REF BREF BAT conclusions were then determined by comparing the achieved emission/performance level in each specific situation with the upper and lower levels proposed for a given pollutant for that unit in the final draft. It is worth emphasising that this was done at the individual refinery unit level (e.g. the actual combustion stack or the actual SRU/FCCU in a particular refinery). The cost of the additional abatement measures required to be compliant with either the upper or lower level of the AEL ranges of the final draft was then determined by summing the costs for all the refineries participating in the survey and then multiplying by the ratio of crude processed in the EU in 2010 divided by the crude processed in the participating refineries (a factor of 1.5).

[8] EGTEI Synopsis Sheets for the Petroleum industry: Combustion Processes, FCC Units and Sulphur Recovery Units; November 2005

Table A4.1 Estimated investment required for meeting AELs as per Technical Working Group conclusions, upper AEL i.e. least severe
(all values in ppm except sulphur recovery)

Installation/ Type of emission		AEL	Required Technology	Number of refineries affected	Total estimated investment (M€)
Sulphur recovery					
Sulphur		98.5%	SuperClaus	26	280
Fluid Catalytic Cracking					
SO_2	Partial burn Full burn	1200 800	Sulphur Reducing Additives/Limited Wet Gas Scrubbing (WGS)	14	910
NOx	Partial burn Full burn	400 300	Base/SNCR/ Very Limited SCR		
Dust	Partial burn Full burn	50	Base/Limited Further 3 Field ESP		
Fired Heaters					
SO2	Multi fuel Gas only	600 55	Fuel switch	51	3,100
NOx	Multi fuel Gas only	300 150	Low NOx Burner (LNB)/Some SCR		
Dust	Multi fuel	50	Base/Limited Further 3 Field ESP		
Total estimated investment (extrapolated to all EU refineries)					**6,600**

Table A4.2 Estimated investment required for meeting AELs as per Technical Working Group conclusions, lower AEL i.e. most severe (all values in ppm except sulphur recovery)

Installation/ Type of emission		AEL	Required Technology	Number of refineries affected	Total estimated investment (M€)
Sulphur recovery					
Sulphur		99.9%	Amine TGTU	55	3,160
Fluid Catalytic Cracking					
SO2	Partial burn Full burn	100 100	Comprehensive WGS	33	2,950
NOx	Partial burn Full burn	100 100	SNCR/Significant Increase in SCR		
Dust	Partial burn Full burn	10	Comprehensive 4 Field ESP		
Fired Heaters					
SO2	Multi fuel Gas only	35 55	FGD scrubber	62	8,500
NOx	Multi fuel Gas only	30 30	Comprehensive SCR		
Dust	Multi fuel	5	Comprehensive 4 Field ESP		
Total estimated investment (extrapolated to all EU refineries)					**22,000**

Table A4.3 Estimated cost of IED

IED estimated costs: Air

Abatement cost scenario		Low	High
BAT-AEL level applied		**Upper**	**Lower**
Cumulative estimated investment 2010-2020	M€	6600	22000
Capital charge	M€/a	990	3300
Operating cost increase	M€/a	356	1188
Total estimated cost	M€/a	1346	4488
	$/bbl	0.43	1.43

IED estimated costs: Water

Abatement cost scenario		Low	High
BAT-AEL level applied		**Upper**	**Lower**
Estimated investment	M€	150	not estimated
Capital charge	M€/a	22.5	
Operating cost increase	M€/a	2.5	
Total estimated cost	M€/a	25	
	$/bbl	0.01	

Estimated costs associated with Water Framework Directive:

Water consumption	m^3/t crude	7.2
	Mm^3/a	4306
Additional water cost	€/m^3 water	0.3
	M€/a	1292
	$/bbl	0.41

APPENDIX 5: SLFD (MARINE FUELS) COST ESTIMATION

Data from **Appendix 1**

Estimated refining Investment to year		**2015**	**2020**			
ECA 0.1%S	G$	14.0				
All bunker 0.5%S	G$		21.0			
Assumed % bunker for EU waters			Low 50%		High 100%	
Net refining investment		14.0	10.5		21.0	
			0.5% only	**Total**	0.5% only	**Total**
Capital charge	G€/a	1.50	1.13	**2.63**	2.25	**3.75**
Additional variable costs						
Maintenance	G€/a	0.54	0.41	**0.95**	0.81	**1.35**
Energy	Mtoe/a	1.44	0.53	**1.97**	1.06	**2.50**
	G€/a	0.42	0.15	**0.57**	0.31	**0.73**
CO_2 emissions	Mt/a	8.9	3.9	**12.8**	7.8	**16.7**
	G€/a	0.05	0.03	**0.09**	0.05	**0.12**
Total		1.01	0.59	**1.61**	1.17	**2.19**
Total estimated cost	G€/a	2.51	1.71	**4.23**	3.42	**5.94**

APPENDIX 6: RED COST ESTIMATION

Year		*2010*	*2015*	*2020*
Fossil gasoline produced by EU refineries	Mt/a	127.4	115.2	107.2
Covered by alternative fuels	Mt/a	3.8	7.5	8.0
		3.0%	6.5%	7.5%
% Gasoline in refinery production		21.0%	19.0%	17.9%
Refinery production	Mt/a	606.0	606.0	598.0
Lost crude throughput	Mt/a	18.1	39.5	44.6
	%	3.0%	6.5%	7.5%
Estimated lost margin	G€/a	0.29	0.62	0.70

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