ARCADIS BELGIUM

Complementary Impact Assessment study on possible emission reduction measures for recreational marine craft engines

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EXECUTIVE SUMMARY

BACKGROUND AND GOALS OF THE PROJECT

The current European Legislation on recreational craft engines is laid down in Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft, amended by Directive 2003/44/EC. This Directive aims to harmonise the laws, regulations and administrative provisions in the Member States as regards the safety characteristics of recreational craft and their environmental characteristics and applies to three different areas:

- the design and construction of recreational craft[1], partly completed boats, personal watercraft and certain components or parts mentioned by the Directive;
- exhaust emissions produced by propulsion engines installed on or in pleasure craft and by personal watercraft;
- noise emissions produced by recreational craft with stern drive engines without integral exhausts or inboard propulsion engines, by personal watercraft and by outboard engines and stern drive engines with integral exhaust.

The Directive does not apply to craft such as racing craft, canoes, kayaks or gondolas, surfboards or sailing surfboards, original and individual replicas of historical craft, or experimental craft, nor to engines fitted, or intended to be fitted, to such craft. Also excluded are craft intended to carry passengers for commercial purposes which are covered by Council Directive 82/714/EEC of 4 October 1982 on technical prescriptions for inland waterway vessels.

In accordance with Article 2 of Directive 2003/44/EC the Commission shall submit a report on the possibilities of further improving the environmental characteristics of recreational marine engines and, if deemed appropriate, submit appropriate proposals.

In this context two studies have been carried out in the past:

- TNO for EC DG Enterprise, “Stocktaking study on the current status and developments of technology and regulations related to the environmental performance of recreational marine engines – Final Report”, January 2005. In this study four possible options for further emission reducing measures have been identified.
- European Confederation of Nautical Industries for EC DG Enterprise, “Study on The Feasibility and Impact of Possible Scenarios for Further Emission Reduction Measures for Recreational Craft Engines in the Context of Directive 94/25/EC, as Amended by Directive 2003/44/EC: Impact Assessment Report – Final Report”, 26 October 2006”. This study identified and measured in detail the impacts and distributive effects of the four possible scenarios for further emission reduction measures. It was concluded that each of the scenario options investigated would result in a relatively low emission reduction, and would entail a social cost for certain European SME’s.

The Commission submitted in response to article 2 of Directive 2003/44/EC a Communication to the Council and the European Parliament on the possibilities of further improving the environmental characteristics of recreational craft engines, submitted pursuant to Article 2 of Directive 2003/44/EC, amending Directive 94/25/EC (COM(2007)313 final; {SEC(2007)770}; {SEC(2007)819}). Further study

[1] Recreational craft: any boat of any type intended for sports and leisure purposes of hull length from 2.5m to 24m, measured according to the harmonised standard, regardless of the means of propulsion.

work was considered necessary aimed at identifying and assessing the impact of the most ambitious - but feasible - scenario to maximise the emission reduction potential of recreational craft engines and at the same time to mitigate the social and economic impact on small and medium sized enterprises.

The objectives of this complementary Impact Assessment study are:

1. To identify a scenario, based upon the most stringent exhaust emission requirements, either existing or under development, that are applied or are envisaged to be applied to recreational marine engines in other parts of the world, and
2. To assess the feasibility and impact of applying such requirements to the largest range of recreational marine engine types covered by the Directive as possible. The identified scenario has to be submitted to a detailed impact assessment, addressing technical, social, environmental, and economical aspects.
3. To identify mitigating measures to limit the negative economical and social impacts the identified scenario may have on the concerned SMEs. These have to be based on alleviating measures already proposed or applied to small volume manufacturers in Community legislation governing engine emissions, and
4. To assess the impact and effectiveness of such measures if they were to be applied to the identified scenario, and identify or develop from this analysis the most effective method for mitigating the negative economical and social impacts the identified emission reduction scenario may have on SMEs.
5. To compare the assessed impacts of the emission reduction scenario and of the mitigating measures for SMEs identified in this study with those of the scenarios assessed in the 2006 impact assessment study.

The impact assessment covers technical, social, environmental and economic aspects. The assessment is carried out in accordance with the Commission Guidelines on Impact Assessment as updated on 15 March 2006.

The study results should be presented in such a way that they can be used by the Commission services for assessing, within the context of article 2 of Directive 2003/44/EC, the appropriateness of considering the elaboration of further legislative proposals.

APPROACH OF THE IMPACT ASSESSMENT

The approach of this impact assessment combined a focused literature review with an extensive consultation process with sector organisations and individual companies potentially affected. A tight contact with the industry has been formalised and channelled via a number of official stakeholder information and consultation meetings, written questionnaires to the competent industry associations, individual engine manufacturers and marinisers and boat builders as well as the organisation of individual company meetings.

These are the most important literature sources investigated:

- Studies specified in the ToR: the TNO Stocktaking study and the ECNI Impact Assessment (2006);
- Existing legislation or legislation under development[2];
- Studies/reports supporting the development of some of these regulations e.g. US EPA RIAs.

[2] For each mentioned legislation (or proposal), the country or region where it applies is indicated between brackets in italic

Within the stakeholder consultation, three separate written questionnaires were drafted and sent out:

- A sector questionnaire dedicated to IMEC and Euromot who facilitated an integrated industry position with all of their members involved in the recreational marine craft industry. Information was asked on:
  - Technical feasibility of the exhaust emission reduction scenario,
  - Characterisation of industry (industry actors, structures, processes and importance),
  - Compliance costs of applying the basic emission reduction scenario with and without flexibilities in place,
  - Impact of applying the scenarios to the various stakeholders,
  - Likely mitigating impact of measures already proposed or applied to small volume engine manufacturers in Community legislation governing engine emissions.
- A questionnaire dedicated to individual engine manufacturers and marinisers active on the European market to ask for:
  - Company details e.g. coordinates, activities, engine families, production facilities located in Europe, employees, turnover, markets served;
  - Compliance costs:
    - ~ sunk costs;
    - ~ fixed costs related to R&D, retooling and recertification;
    - ~ variable costs;
    - ~ impact of flexibilities on compliance costs.
  - Impact of applying the basic emission reduction scenario on competition, cost-pass through percentages, the natural business cycle, the companies' engine gamma, the viability of the companies' operations;
  - Likely mitigating impact of measures already proposed or applied to small volume engine manufacturers in Community legislation governing engine emissions.
- A questionnaire dedicated to recreational marine boat builders asking for:
  - Company details, coordinates and activities;
  - Impacts of applying the emission reduction scenario on vessel redesign, cost-pass through percentages of possible vessel redesign, the viability of the companies' operations, the companies' boat gamma as well as the impact of the introduction of a flexibility scheme;
  - Likely impact of mitigating measures.

On April 9 2008, IMEC and Euromot organised two sector meetings for CI and SI engine industries. The company questionnaires were returned beforehand and acted as a starting point for the interviews with 12 companies. This enabled the contractor to further enquire the companies and interpret details about their activities, the industry structure and processes, the likely impacts of applying the emission reduction scenario as well as the likely impact of mitigating measures.

Response has been obtained from 18 companies among which:

- 10 large enterprises with more than 250 employees and more than € 50 million turnover;
- 4 medium sized companies employing between 50 and 250 employees and a turnover between € 10 million and € 50 million;
- 1 medium sized company with less than 50 employees and a turnover between € 10 million and € 50 million;
- 3 small companies with less than 50 employees and a turnover below € 10 million.

Half of the questionnaires have been completed by European companies, of which two thirds can be categorised as an SME according to the standard definition of an SME adopted by the European Commission. Three European companies do not produce for the American market at all. All European companies who replied, except one, manufacture and/or marinise CI engines. All American and Japanese companies who replied to the questionnaire produce for the European market, but only one third has a

European based production facility. These foreign companies ship large amounts of OB engines to the European market as well as a more limited number of SI IB engines and PWCs.

The companies who replied to the questionnaire represent more than 85% of European sales, assuming a European market for OB engines of between 200,000 and 220,000 units/year. Likewise, the respondents to the questionnaire provide almost the entire number of CI engines sold on the European market, assuming European demand for CI engines at 40,000 units/year. The companies who replied to the questionnaire cover about 60% of European demand for PWCs, assuming European sales of PWCs at about 10,000 units/year. The share of the respondents' SI IB engines put on the European market in the total SI IB engines sales on the European market is important, but currently still unclear. Knowing that the OB and CI engine sales are by far the most important, it can be concluded that the questionnaire provides a good coverage of the industry. This, however, does not alter the fact that the small to very small European engine manufacturers and marinisers often only selling to the EU market are underrepresented in the questionnaire.

IDENTIFICATION OF SCENARIOS TO BE ASSESSED

The first step of the analysis consisted of identifying a scenario, based upon the most stringent exhaust emission requirements, either existing or under development, applied or envisaged to be applied to recreational marine engines in other parts of the world.

In selecting the scenarios, the importance of global harmonization of regulation between EU and US was taken into account. Companies producing for several markets would not need to invest in separate R&D efforts for different markets on the one hand and would also be able to realise advantages of scale by producing the same engine for a much larger market. Due to the advantages of scale production costs would drop in relative terms.

The following basic scenarios were selected for the impact assessment and are referred to as the "basic C1 + S1 scenario":

- Compression ignition engines: USEPA final rule Tier 3 standards for marine diesel C1 recreational and commercial high power density (final rule EPA420-F-08-004, March 2008) (cf. Table 1)
- Spark-ignition engines: unpublished proposed rule Emission Standards for new non-road Spark-Ignition engines, equipment and vessels as presented in the US EPA note EPA420-F-07-032 of April 2007 (cfr. Table 2 for Outboard and Personal WaterCraft spark-ignition engines and Table 3 for Inboard and Sterndrive spark-ignition engines) (cf. below)

Table 1: Tier 3 standards for marine diesel C1 engines below 3700 kW (final rule US EPA420-F-08-004, March 2008)

Maximum Engine Power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X + HC g/bhp-hr (g/kW-hr)	Model year
<19 kW	<0.9	0.30 (0.40)	5.6 (7.5)	2009
19 to <75 kW	<0.9[a]	0.22 (0.30)	5.6 (7.5)	2009
		0.22 (0.30)[b]	3.5 (4.7)[b]	2014
75 to <3700 kW	<0.9	0.11 (0.15)	4.3 (5.8)	2012
	0.9-<1.2	0.10 (0.14)	4.3 (5.8)	2013
	1.2-<2.5	0.09 (0.12)	4.3 (5.8)	2014
	2.5-<3.5	0.09 (0.12)	4.3 (5.8)	2013
	3.5-<7.0	0.08 (0.11)	4.3 (5.8)	2012

Notes:

(a) <75kW engines at or above 0.9 L/cylinder are subject to the corresponding 75-3700 kW standards.

(b) Option: 0.15 g/bhp-hr (0.20 g/kW-hr) PM / 4.3g/bhp-hr (5.8g/kW-hr) NO_X-HC in 2014

Table 2: HC+NOx and CO exhaust emission standards for outboard and personal watercraft spark-ignition engines (pers. comm., ICOMIA, IMEC, February 2008)

Emission standards for HC+NOx (g/kW-h)		
	P < 4.3 kW	**P ≥ 4.3 kW**
Cap	81.00	$0.250\ x\left(151+\frac{557}{P^{0.9}}\right)+6.00$
Standards	30	$0.09\ x\left(151+\frac{557}{P^{0.9}}\right)+2.1$
Emission standards for CO (g/kW-h)		
	P ≤ 40 kW	**P > 40 kW**
Cap	$650-5.0\times P$	450
Standards	$500-5.0\times P$	300

Table 3: HC+NOx and CO exhaust emission standards for inboard and sterndrive spark-ignition engines (pers. comm., ICOMIA, IMEC, February 2008)

Emission standards for HC+NOx (g/kW-h)			
	P ≤ 373 kW	**373< P ≤ 485 kW**	**P > 485 kW**
Cap	16	16	22
Standards	5	- (1)	- (1)
Emission standards for CO (g/kW-h)			
	P ≤ 373 kW		**P > 373 kW**
Cap	150		350
Standards	75		- (1)

(1) only cap, no averaging

Companies placing engines on the US market can make use of ABT which gives them the flexibility to achieve the same absolute level of emission reductions at lower costs. This ABT system can, however, not be part of the regulation ruling the placing on the EU market of engines. The reason for this is that in the EU the individual Members States are responsible for the implementation of environmental regulations and they might not be in favour of a system placing an administrative burden on them. Consequently, inspiration has been sought in an alternative mechanism granting similar flexibilities to the companies but with which experience exists within the EU e.g. the flexibility scheme as it is used in the framework of the Non-Road Mobile Machinery Directive.

In this way, three scenarios with flexibilities were selected for investigation:

- Scenario C2a + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies;
- Scenario C2b + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies and additionally EU RCD stage 1 standards for all CI engines < 37 kW placed on the EU market;
- Scenario C2c + S2, being the proposed EU RCD stage 2 exhaust emission standards with flexibility scheme for all companies and additionally EU RCD stage 1 standards for CI engines < 37 kW placed on the EU market by SMEs.

The flexibility scheme referred to in the above scenarios corresponds to the industry position for what concerns CI side. This means that companies are allowed to place on the market a number of engines only complying with EU RCD stage 1 standards. This number may, over a period of seven years from the date the new standards come into effect, not exceed 50% of the company's annual sales value of engines in a predetermined year or the fixed number of engines as specified in the following table. The former was used for the environmental and socio-economic impact assessment.

Table 4: Fixed number of engines, eligible for exemption under the flexibility scheme, not to be exceeded in each engine category over a period of 7 years from the introduction date

Engine category		*Number of engines*
Disp.<0,9 l/cyl	37kW<P<75kW	500
Disp.< 0,9 l/cyl	P>75 kW	150
0,9 l/cyl <Disp.< 1,2 l/cyl	P>75kW	150
1,2 l/cyl< Disp.< 2,5 l/cyl	P>75kW	100
2,5 l/cyl <Disp.< 3,5 l/cyl	P>75kW	100
3,5 l/cyl <Disp.< 7,0 l/cyl	P>75kW	50

For the SI side companies, there was no agreed industry position and decisions to use flexibility schemes varied between individual companies. During the stakeholder consultation it became clear which manufacturers would or would not use the flexibility scheme. The environmental and socio-economic impact assessment used these individual cases for calculating impacts.

ENVIRONMENTAL IMPACT ANALYSIS

The focus of the environmental impact analysis is on the impact of the selected scenarios to the emissions of recreational craft engines and the resulting impact on the ambient air concentrations of certain pollutants. The most relevant pollutants are therefore nitrogen dioxides (NO_x), carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM). The environmental impact is assessed as follows:

- Estimate of the emission reduction potential of the scenario for the mentioned pollutants;
- Estimate of the change in ambient air concentrations due to the implementation of the selected scenario through air distribution modelling.

Since the impacts need to be comparable with the assessments in the impact assessment study carried out by ECNI (2006), the methodology for emission and emission reduction estimation is taken over from that study (e.g. fleet size, hours of operation, receiving environments, etc.).

Next to the scenarios (without and with flexibility schemes) as assessed in the current complementary impact assessment, some additional scenarios were assessed especially for the environmental impact assessment because of the fact that:

- In the ECNI study, it was assumed that, where sales weighted emissions of engines on sale today were lower than the limit values of the option then the measured emission rates were used.
- For PM and CO, measured emission rates often seem lower than the standards, meaning that no differences in scenarios can be found due to the fact that in all scenarios the same emission rates are used.
- The conservative scenarios only take into account standards and no measured emission rates, showing the real effect of the standards.

Combining all parameters (engine power, hours of operation, emission rates), results in total emissions for the three receiving environments: lake marina, coast marina and inland waterways. The total emissions for the scenarios selected in this complementary impact assessment (C1S1, C2aS2, C2bS2, C2cS2 and C1S1$_{cons}$ and C2bS2$_{cons}$[3]) are shown in the following table. Conservative scenarios for the other flexibility scenarios were not assessed since the result will be comparable with the C2bS2$_{cons}$ scenario. These results only show the 'medium' usage profiles but were deemed to be sufficient to draw conclusions for the environmental impact.

Table 5: Overview of emissions for HC+NOx, PT and CO for scenarios with flexibilities compared to RCD Stage 1

	Emmissions in tons/year		
	HC+NOx	**PT**	**CO**
Lake Marina			
Reference Scenario (Stage I)	8.97-10.83	0.12-0.18	27.99-42.98
C1S1 (Stage II)	6.80-8.03	0.06-0.10	30.30-46.72
C2aS2	7.10-8.37	0.09-0.13	30.30-46.72
C2bS2	7.13-8.39	0.09-0.13	30.30-46.72
C2cS2	7.13-8.39	0.09-0.13	30.30-46.72
C1S1cons	7.15-8.33	0.07-0.12	56.77-90.57
C2bS2cons	7.79-8.68	0.13-0.22	55.56-88.73
Coast Marina			
Reference Scenario (Stage I)	23.65-28.93	0.21-0.36	95.34-132.66
C1S1 (Stage II)	17.36-20.84	0.10-0.18	104.37-146.64
C2aS2	18.04-21.67	0.13-0.23	104.37-146.64
C2bS2	18.12-21.72	0.18-0.37	104.37-146.64
C2cS2	18.12-21.72	0.18-0.37	104.37-146.64
C1S1cons	18.16-21.44	0.12-0.23	198.81-282.55
C2bS2cons	19.59-22.73	0.20-0.43	194.85-276.55
Inland waterways			
Reference Scenario (Stage I)	0.57-0.58	0.0006-0.0008	3.12
C1S1 (Stage II)	0.36-0.37	0.0046-0.0055	4.35-4.36
C2aS2	0.38-0.39	0.0006-0.0008	4.35-4.36
C2bS2	0.38-0.39	0.0006-0.0008	4.35-4.36
C2cS2	0.38-0.39	0.0006-0.0008	4.35-4.36
C1S1cons	0.36	0.0014-0.0017	6.79
C2bS2cons	0.40-0.41	0.0046-0.0055	6.60-6.61

[3] The C1S1$_{cons}$ and C2bS2$_{cons}$ scenarios refer to conservative scenarios which were added in the environmental impact analysis and which only take into account standards and not measured emission rates, showing the real effect of the standards.

This table shows that:

- the proposed C1S1 scenario will lead to a reduction of emissions for NO_X+HC and PT and an increase in CO emissions and that for all three receiving environments. The conservative scenario ($C1S1_{cons}$) leads to higher emissions (and lower emission reductions) since only legal standards are taken into account and no measured emission rates are taken forward as emission rates in this additional conservative scenario.
- PT emissions remain the same for the three basic flexibility scenarios since measured PT emission rates are lower than standards for the <37kW engines
- CO emissions remain the same for the basic scenario C1S1 and the three basic flexibility scenarios: since measured emission rates are lower than the standards set for CO, it are always the measured emission rates C2aS2, C2bS2 and C2cS2; emissions for the conservative flexibility scenarios differ from the basic flexibility scenarios due to the fact that the measured data are not taken into account and are lower than the standards. The fact that emissions for all three basic flexibility scenarios at the one hand and all three conservative flexibility scenarios on the other hand do not differ, is due to the fact fact that these 3 scenarios only differ for CI engines, where EF remain the same in Stage I and Stage II.

Emission reductions are more comparable when expressed in percentage reduction compared to the Reference Stage I scenario, as shown the next table.

Table 6: Overview of the change in emissions for HC+NOx, PT and CO for the different scenarios with flexibilities compared to RCD Stage 1

	Average reduction (in % compared to Ref scenario)		
	HC+NOx	PT	CO
	Total	Total	Total
Lake Marina			
Reference Scenario	-	-	-
C1S1 (Stage II)	25	46	-9
C2aS2	22	29	-9
C2bS2	22	29	-9
C2cS2	22	29	-9
C1S1cons	22	33	-107
C2bS2cons	16	-18	-103
Coast Marina			
Reference Scenario	-	-	-
C1S1 (Stage II)	27	45	-10
C2aS2	24	28	-10
C2bS2	24	28	-10
C2cS2	24	-8	-10
C1S1cons	25	29	-23
C2bS2cons	19	-8	-106
Inland waterways			
Reference Scenario	-	-	-
C1S1 (Stage II)	37	0	-40

	Average reduction (in % compared to Ref scenario)		
	HC+NOx	PT	CO
	Total	Total	Total
C2aS2	34	0	-40
C2bS2	33	0	-40
C2cS2	33	0	-40
C1S1cons	36	-130	-118
C2bS2cons	30	-653	-112

This table shows that:

- Emission reductions in the basic scenario (C1S1) are most important , which is an obvious result of the permission of higher emission standard in the flexibility schemes, resulting in higher emissions for the flexibility schemes;
- The conservative scenarios result in lower emission reductions, since lower measured data are not taken into account here;
- The conservative scenario, allowing the highest flexibility ($C2bS2_{cons}$) even result in higher PT emissions than in Stage I;
- The fact that CO emissions increase is a direct result from the higher emission standards for CO for SI engines in Stage II;
- The extreme high emission reductions for PM for $C1S1_{cons}$ and $C2bS2_{cons}$ are simply due to the fact that for the inland waterway only 6-30 kW SI and <19-37kW CI engines are taken into account that that emission rates for these engines are in the mentioned scenarios 3 to 10 times higher than in the reference.

To estimate total emission reductions for HC+NOx, PT and CO, the reduction percentages as shown in the previous table for the different scenarios, are applied to the total emissions for the Reference Stage I scenario as reported in ECNI (2006). The next table gives an overview of total emissions for the different scenarios as well as total emission reductions.

Table 7: Overview of the change in total emissions for HC+NOx, PT and CO for the different scenarios compared to RCD Stage 1

	HC+NOx (tons/year)		PT (tons/year)		CO (tons/year)	
	Emissions	Emission reduction	Emissions	Emission reduction	Emissions	Emission reduction
Reference scenario (Stage I)	40907		539		153142	
C1S1 (Stage II)	30061	10846	296	243	172850	-19708
C2aS2	30074	10833	387	152	172850	-19708
C2bS2/C2cS2	31105	9802	387	152	184634	-31492

Changes in ambient air concentrations for the different scenarios are calculated based on the ECNI results and not modelled. This estimation is based on the assumption that emission and concentrations are directly proportional,

An estimation of the ambient air concentrations of NO_X+HC and PT as a result of emissions from recreational craft for the new proposed and the reference scenario are given in following table.

Table 8: Overview of the estimated concentrations for NO_X+HC and PT in the reference Stage 1 scenario and the new proposed scenario

	N0x + HC (µg/m³)		PT (µg/m³)
	Long term	Short term	Long term
EQS	40 (1)	200 (1)	40
LAKE MARINA			
Reference (ECNI, 2006)	28.78	516.29	0.27
C1S1	21.59	387.22	0.15
C2bS2	22.45	67.12	0.19
C1S1cons	22.45	402.71	0.18
C2bS2 cons	24.18	433.68	0.32
COAST MARINA			
Reference (ECNI, 2006)	44.61	1774.04	0.25
C1S1	32.57	1295.05	0.14
C2bS2	33.90	1348.27	0.18
C1S1cons	33.46	1330.53	0.18
C2bS2 cons	36.13	1436.97	0.27
INLAND WATERWAYS			
Reference (ECNI, 2006)	0.78	11.64	0.00
C1S1	0.49	7.33	0.00
C2bS2	0.52	7.80	0.00
C1S1cons	0.50	7.45	0.00
C2bS2 cons	0.55	8.15	0.00

(1) this is the EQS for NO_x only, there is no EQS for HC available

In order to correctly interpret these results, the following remarks must be considered:

- For the purpose of air quality modelling, it has been assumed that all emissions from recreational craft exhausts enter the air. This is an oversimplification, as the presence of wet exhausts on most recreational craft engines will result in the emission of exhaust pollutants directly into the water. A proportion of these emissions may remain in the water rather than entering the atmosphere, although as a result of propeller turbulence and the rate at which exhaust gas is emitted it is likely that this proportion is small.

- For the reference scenario, ambient air concentrations for NO_X and HC are summarised to show the NO_X+HC concentrations and to compare with the new scenario. EQS however are only available for NO_X.

We can conclude for PT that PT emissions in all environments remain well below the long- and short term EQS levels as well for the reference as the new proposed scenario. Since the estimated concentrations give the additional share of PT-concentrations due to emissions of the recreational craft engines, it is interesting to have a look at the ambient background concentrations (long term) of PT (PM10) in Europe. Only in those areas where concentrations approach the EQS value of 40 µg/m³, one could say that emissions from recreational craft engines could result in a exceedance of the EQS. Contributions of the scenarios calculated here are however so limited (maximum of 0.19 µg/m³(0.32 µg/m³ for a conservative scenario) tot 40 µg/m³) that recreational craft engines can hardly be pointed out as an important contributor.

For NO_X+HC the conclusion to be drawn is somewhat more complicated. Since NO_X+HC – concentrations are shown as one value and the EQS only refers to NO_X, as a 'worst-case' we assume that 50% of the NO_X+HC- air contribution is NO_X. In this case, we can estimate a long-term concentration of about 11, 17 and 0.3 µg/m³ NO_X for lake marina, coast marina and inland waterways respectively. Short-term concentrations can be estimated at approximately 194, 674 and 4 µg/m³. Only for the coast marina receiving environment a short-term exceedance of the EQS is expected. Again looking at the ambient background concentrations (long term) of NO_X in Europe: In those areas where background concentrations reach 23 µg/m³ (= EQS – contribution of recreational craft engines) it can not be excluded that recreational craft engines in a coast marina area contribute to an exceedance of the EQS. In those areas where background concentrations reach 29 µg/m³ (= EQS – contribution of recreational craft engines) it can not be excluded that recreational craft engines in a lake marina area contribute to an exceedance of the EQS.

SOCIO-ECONOMIC IMPACT ANALYSIS

Industry characterisation

The execution of a thorough impact assessment requires the mapping of industry actors, structures and processes in a comprehensive way. A sound understanding of the relations between the different actors is a prerequisite in order to be able to construct a causal model and then to assess the likely direct and indirect consequences of the proposed policy. The chapter on industry characterisation gives an overview of the market structure and actors, the number of engine families produced and company specific information of EU production facilities.

Compliance costs

Based on the technologies that would be required to achieve the emission limit values, the costs of bringing engines in compliance with the proposed environmental standards have been calculated for the selected basic scenario without flexibilities. Technical impacts linked to the application of the scenario are reflected in associated compliance costs.

A harmonisation of RCD emission standards with the proposed US EPA emission standards would mean that European based companies active both on the EU and the USA market would have limited additional compliance costs. Costs to meet the emission standards have to be made for the US market and as such can be regarded as sunk costs. Costs can be limited to re-certification costs and related testing and calibration.

However, this is conditional to the fact that the RCD Directive is aligned with the full package of the proposed US EPA emission standards, including the accompanying CO standards, same deadlines of phase in and a mechanism to allow flexibility for the industry as an equivalent to the ABT system. The latter is also the case for US based companies also serving the EU market and using the ABT system in the US. Without a flexibility scheme, these companies would face significant additional fixed costs if the RCD standards are at the same level as the proposed US EPA standards. However, at the moment only a limited amount of US companies in the recreational craft engine sector use the ABT system. For other US based companies, a flexibility schemes does not have an impact on the compliance costs as such.

For companies not serving the US market, mainly including SMEs and marinisers, the fixed compliance costs may be significantly higher, as costs to be made besides recertification cannot be regarded as sunk. It is however important to note that OEMs (boat builders) often operate globally. To meet requirements of customers all over the world, they want to be able to provide engines meeting the most stringent standards, i.e. US EPA and as such also oblige engine manufacturers and marinisers only operating in the EU market to meet these market needs. Hence, it can be stated that full fixed costs should be accounted for only those EU companies not exporting directly and indirectly to the US.

Fixed costs for engine manufacturers and marinisers

Fixed costs or investment costs are associated with the development, validation and certification of the improved engine required to meet the proposed emissions limits.

Examples of fixed costs include:

- Re-development of combustion system;
- Calibration and validation of the Fuel Injection Equipment;
- Re-certification;
- Component re-design and analysis;
- Retooling costs (adaptations to assembly line);
- Mechanical Validation Testing;
- Environmental validation tests.

RE-CERTIFICATION COST

Elements taken into account to calculate the re-certification cost are presented in the table below. These are based on the DHV study for CI engines and adapted to new insights as proposed during the CI industry group interview:

	Typical costs (EUR, 2007) for engine>18kW, per engine family
Transport engine to test location	500 €
Certification by notified body	1.500 €
Administration by manufacturer (40 hours X 200€)	8.000 €
Engine testing (40 hours X 235€/h)	9.400 €
Periodical update of certificate	500 €
	19.900 €

The total figure should be regarded for guidance only, as recertification costs differ largely according to the companies contacted during the interviews, with figures ranging between 8,000 and 27,000 EUR/engine family. For SI engines (outboard, SI inboard and PWC) and CI engines below 18kW, re-certification costs are within the same order of magnitude and therefore it is assumed to be similar as the figure presented in table above.

OTHER FIXED COSTS

Re-certification costs can be regarded as limited compared to potential costs of re-calibration, costs linked to mechanical redesign and component change, research and development and retooling of the assembly line.

For CI engines, R&D costs are negligible for the majority of engine manufacturing companies, as these costs have already been made by base engine manufacturers (industrial engines, on road engines) on which these engines are based. For marinisers, costs up to 250,000 EUR/engine family have been communicated during the interviews including calibration of fuel injection, component redesign and mechanical validation tests. Based on the results of the interview sessions retooling costs of assembly line are negligible for the majority of the engine manufacturing companies, whereas for marinisers retooling costs between 500 and 5,000 EUR/engine family have been communicated.

Besides fixed costs for engine manufacturers and marinisers additional fixed costs are expected in harbours linked to the logistics of the distribution of low sulphur oil for CI engines. However, the introduction of low sulphur oil does not entail additional costs for the engine manufacturers or marinisers.

For SI engines, *other* fixed costs can be regarded as negligible for the majority of the companies and therefore have not been taken into account. However, the technical feasibility study of the scenarios made clear that if CO standards will not be adapted to the same level of the US EPA rule, this would necessitate OB and PWC manufacturers to introduce catalyst technology which is not technically feasible yet before 2015. Apart from this remark, some SI companies are faced with significant additional fixed costs:

- SI outboard engine manufacturers which are only active on the EU market face significant R&D and testing costs: engines that have to be redesigned completely can reach up to 4 à 3 M EUR/engine family; engine adaptations of low power engines range between 200,000 and 300,000 EUR;
- For US based companies relying on ABT to meet the US EPA emission standards, a harmonisation of the RCD Directive with the proposed US EPA emissions standards without a flexibility scheme would imply significant recalibration costs and R&D costs: costs up to 1.5 M EUR/engine family have been communicated linked to adaptations of engines such as changes in injection system, changes in cylinder porting and introduction of very high pressure systems.

Variable costs for engine manufacturers and marinisers

Variable costs are costs of improved or added technology on every engine such as implementation of techniques in related to the engine management system, after treatment and exhaust components, engine management systems, etc. Typical variable costs to marinise engines include engine mounts, intake pipes and filters, sea-water cooling system, bell-housing/flywheel adaptor, cooled/insulated exhaust manifold, cooled/insulated turbocharger, sea-water charge cooler, EGR circuit insulation, etc. Next to costs related to the purchase of components, it also includes changes in labour costs and energy requirements.

Detailed information on the different variable costs items is lacking and could not be provided within the short timeframe of this project. As a second best option, variable costs estimated in terms of percentage increase in manufacturers recommended retail price (RRC) are used. Variable costs include estimated price increase for the purchase of NRMM certified base engines. Upgrade in power or torque is not included in costs as this would invalidate NRMM certification.

In general, it is stated by industry that variable costs for the CI engine manufacturers are offset by higher added values created by the newly developed engines. R&D to adapt engines to more stringent emission standards goes hand in hand with R&D to improve engines in terms of power output, torque, electronic control systems, stability, noise, etc. The added value created allows the manufacturers to increase prices in a way which largely offset the costs of adapting the engines to the new emission standards.

The variable costs can be regarded as limited in general for SI outboard and PWC. For SI Inboard engines, variable costs can be up to 6%. As these figures are based on a limited number of data, it should be regarded as for guidance only.

Discontinuation of non-compliant models

Discontinuation is often very costly in case products have not reached the end of their lifetime and especially in case of newly developed engines. The decision whether to discontinue or to comply will depend on various factors, such as gamma width, marketing policy, competition in the segment, etc. Companies often have to keep low power categories in their gamma for client attracting or binding. However, in cases where compliance costs are too high, companies will discontinue certain models.

The costs linked to discontinuation include loss of profit generated by the models to be discontinued and additionally the loss of market share by not providing a certain model in the gamma. Due to a lack of information, a second best method had to be used by expressing the costs in terms of loss of turnover generated by the models to be discontinued.

Total yearly compliance costs

Calculated compliance costs are based on the assumption of complete alignment with US EPA rules which includes next to the emission standards:

- Equal phase-in periods;
- Equivalent flexibility mechanisms to ABT for companies who will make use of it;
- Adoption of US EPA CO standards which are lower than the current RCD levels. More stringent emission standards for CO would mean additional investment costs for outboard and PWC to introduce aftertreatment technologies (catalysts) which is regarded as not feasible by the industry before 2015.

Compliance costs include costs for both EU and non-EU companies (i.e. based in Japan and USA) active on the EU market. Changes in compliance costs over the years have not been taken into account due to a lack of detailed data.

CI ENGINES

In Scenario C1 the compliance costs have been estimated for the CI engine sector to comply with the proposed EU RCD stage 2 exhaust emission standards without flexibilities. Costs for CI engines vary widely, i.e. between 5.7 MEUR and 19 MEUR per year. This range reflects the high variety in compliance costs the CI sector can be faced with. Especially the large variety in variable costs for smaller engine families contributes to this high variety. The highest burden is to be covered by small engines < 75kW.

Total costs are mainly covered by large manufacturers representing 75% of the sector, although small manufacturers and marinisers faced with temporary discontinuation of engine models also bear a substantial part of the total compliance costs.

In Scenario C2a the compliance costs have been estimated of the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies in the sector. Costs for CI engines vary between 2 MEUR and 15.3 MEUR per year. This means a cost decrease of 3.7 MEUR/year compared to the basic Scenario C1, due to the fact that some companies will not have to discontinue certain engine models and instead can rely on a flexibility scheme. However, this needs to be regarded as an underestimation of the total impact of the flexibility scheme for the CI sector as the figure does not reflect the impact of lost market share, nor additional benefits linked to the ability for companies to spread investment costs over time to meet the revised emission standards. The highest burden need to be covered by small engines < 75kW. Total costs are mainly covered by large manufacturers, representing 75% of the sector.

In Scenario C2b the compliance costs have been estimated for the CI engine sector of the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies in the sector and additionally EU RCD stage 1 standards for all CI engines < 37 kW placed on the EU market. Costs for CI engines vary between 1.2 MEUR and 8 MEUR per year. Compared to the basic Scenario C1, this would mean a cost decrease of 4.5 to 11 MEUR/year. Taking into account the lower bound of the variable costs, the highest contribution of this decrease comes from the implementation of the flexibility scheme rather than from the installation of an exemption of power ranges below 37KW. When focusing on the upper bound of the variable costs, a dominant effect of the high variable costs for the smaller power ranges prevails. This means that these costs would disappear in case of an exemption of power ranges below 37kW.

In Scenario C2c the compliance costs have been estimated for the CI engine sector of a proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies and additionally the exemption of the proposed emission standards for power ranges below 37kW for SMEs. Costs for CI engines vary between 1.8 MEUR and 15.2 MEUR per year. This means a cost decrease of around 3.85 MEUR/year compared to Scenario C1. The economic benefit of Scenario C2c is only slightly higher than the benefits of the flexibility scheme on (temporary) discontinuation of models in Scenario C2b (3.7 MEUR/year). This leads to the conclusion that the majority of the benefits linked to the exemption of the power ranges below 37kW go to large companies rather than SMEs. This is also logic, as large companies represent 75% of the units put on the market for engines with a power range below 37kW. However, this does not mean that the benefits of the exemption of power ranges below 37kW for SMEs are not substantial as 55% of the engines put by SMEs on the market are engines with a power rate below 37kW.

SI ENGINES

In the basic scenario S1 the compliance costs have been estimated for the SI engine sector to comply with the proposed EU RCD stage 2 exhaust emission standards without flexibilities. Total compliance costs vary between 5.1 MEUR and 10.6 MEUR per year:

- Compliance costs of SI <u>outboard</u> amount to around 4.7 MEUR per year. The highest burden is covered by small engines (<75kW) as these represent the highest share of the market.
- Compliance costs of SI <u>inboard</u> vary between 0.3 and 5.7 MEUR per year
- Compliance costs of <u>PWC</u> amount to around 0.2 MEUR per year.

The compliance costs for outboard engines include costs to be made by a limited number of companies facing very high compliance costs:

- EU based companies not serving the US market, with costs up to 1.8 MEUR/year reflecting the situation of one EU based SME and based on rough estimates provided by the industry. These high costs would result in the decision to discontinue particular models and would have significant social and economic indirect impacts on suppliers and costumers;
- Companies relying on ABT in the US market without having the possibility to rely on a flexibility scheme in the EU market, with additional costs up to 520.011 EUR/year reflecting the situation of one US based company[4]. In case of an adaptation of the RCD Directive without an introduction of a flexibility scheme, it would result in a discontinuation of particular models or in the decision to stop putting theses engines on the EU market.

In Scenario S2, the compliance costs have been estimated for the SI engine sector to comply with the the proposed EU RCD stage 2 exhaust emission standards combined with a flexibility scheme. Total compliance costs vary between 4.6 MEUR and 10 MEUR per year, which is only slightly lower compared to Scenario S1. This can entirely be attributed to the fact that the company relying on ABT in the US market would be able to rely on a similar flexibility scheme in the EU, in which case the additional costs of 1.8 MEUR per year to meet the RCD emission standards can be regarded as sunk. Other conclusions made for scenario S1 remain valid. The decrease in compliance costs indicates a small impact from the flexibility scheme. However, this figure does not take into account additional benefits which are linked to the ability of companies to spread investment costs over time to meet the revised emission standards.

Impact on competitiveness

Share of compliance costs in yearly turnover

The share of compliance costs in yearly turnover of engine sales on the EU market was calculated for the different scenarios and for the individual companies who have released data[5]. Results show that all SMEs (and especially the three SMEs only selling on the EU market) face a major burden and may see their competitiveness deteriorate as a result of more stringent exhaust emissions standards, even if their larger competitors are likely to have higher absolute compliance costs. The share of compliance costs for SMEs ranges between 5.75% and 67.35% of annual turnover in the basic scenario without flexibilities. Large engine manufacturers have a much more moderate ratio, varying between 0.06% and 2.76% for a scenario without flexibilities. The use of a flexibility scheme and especially a flexibility scheme in combination with EU RCD stage 1 standards for CI engines below 37 kW would potentially reduce the possible negative effects on competitiveness for most companies and particularly for SMEs.

Impact on final consumers

Cost differences between manufacturers are an important - but not the only - factor impacting competitiveness. The passing of costs on to the other actors in the supply chain is another factor. To the extent engine manufacturers and marinisers pass on compliance costs to the other actors in the supply chain, competitiveness effects extend to sub-contractors, boat builders, service providers and end consumers. Consequently, the changes may affect market structure and industry composition, functioning of markets, trade and investment flows, engine manufacturers, innovation, local economic activity and employment.

[4] During the interviews three companies have been identified stating that they rely on ABT. One of these companies focuses on the PWC market with a low sales figures in Europe and another company has decided to cease the use of ABT in the future. These two companies have therefore been left out of the analysis.

[5] The total fixed compliance costs were spread over a period of three years.

Manufacturers were asked to document cost-pass through possibilities to suppliers and customers. All respondents indicated that there is very limited, if any, possibility to have suppliers absorbing part of the compliance costs. The marine engine manufacturing industry is too small to put pressure on suppliers. Ideas about the possibility of passing on costs to the customers (either boat builders or end consumers) varied. Certain manufacturers were pessimistic and stated that they would need to absorb more than half of the compliance costs themselves. On the other hand certain marine engine manufacturers stated that they actively seek to offset the likely price increase resulting from stricter emissions standards by not only improving the environmental performance of the engine, but also by adding real value to the consumer e.g. more power, decreased fuel consumption, etc. US and Japanese manufacturers, both large enterprises and SMEs, generally were confident that they would be able to pass on costs to consumers.

For meeting the stricter exhaust gas emission standards for recreational marine engines, engine manufacturers and marinisers generally see their costs increase. It has been argued that because of the limited importance of the recreational marine engine industry, engine manufacturers and marinisers will hardly be able to pass part of the cost increase on to their suppliers. Consequently, companies will try to pass on compliance costs down the chain to the consumer. What percentage of the costs increase would finally be passed on to the consumer is not easy to estimate and could be the subject of a separate study. In order to ensure consistency and thus comparability of our scenarios with the TNO options investigated in the ECNI study, it was assumed that compliance costs are entirely passed on to the end consumer.

The potential price effect for CI engines ranges from 0.27% to 4.10%, depending on the scenario. For OB engines, the potential price effect amounts to around 0.5%. For SI IB engines, the potential price effect ranges from 0.5% to almost 10% and for PWC around 0.17%. The potential price increases calculated in the 2006 impact assessment are much larger compared to the current impact assessment because of the higher compliance costs.

Consumers confronted with price increases may opt to spend their resources differently, partly shifting their spending to other leisure activities that yield higher utility. Nevertheless, overall utility derived from recreational marine boating would decrease. Cost pass through to consumers is to be regarded limited, as the marine recreational craft industry has significant competition coming from other luxury items and leisure activities. When the price of boating increases, consumers may shift their spending to activities which are deemed more value for money. The relationship between changes in quantity demanded of a good and changes in its price is described as the elasticity of demand. The inelastic price elasticity of demand of marine recreational activities is likely to put increased pressure on competitiveness.

To the extent smaller undertakings would leave the market on the one hand and companies would drop models without replacing them on the other hand, this may result in a (limited) decrease in consumer choice. Together with the likely price effects the decrease in consumer choice negatively impacts consumer welfare.

Impact of price effects on the number of jobs

Based on the information on compliance costs in the ECNI study, recalculated price effects, the most recent job figures available in the sector, a number of assumptions concerning the number of direct jobs, it was possible to calculate the total job losses in the EU for the current scenarios and for the TNO options.

Results show that for CI engines, potential job losses range from 5 to approx. 70 in the scenarios assessed in the current impact assessment, whereas potential job losses resulting from the TNO scenarios amount to over 200. For OB engines, losses amount to nearly 90 jobs in the scenarios assessed in the current impact assessment, whereas in the TNO options job losses range between approx. 90 and 125 jobs. For PWC engines, losses amount to half a job in the scenarios assessed in the current impact assessment, whereas for the TNO options potential job losses range from 4 to a maximum of approx. 10 jobs. There is no considerable impact on jobs in the SI IB engine manufacturing chain

Impact on innovation and technological development

One of the arguments in favour of flexibilities according to industry consists of the fact that the ability to keep alive mechanical fuel injection engines will help European SMEs to remain competitive in price compared to large American engine manufacturers benefiting from a favourable currency exchange rate. Industry indicated that if the small European boat builders can save money on their engine supply, this will also be a factor to help them to stay competitive against US imported boats.

According to industry, as the US is the main market for PWCs, the EU market might end up with a very small product range without harmonisation. Industry indicated that the situation is similar for SI OB and IB SD engines. According to industry, the EU market is not big enough to drive new technology development, so that if standards would not be harmonised, certain engines will be driven out of the European market. Contrary to this situation, industry indicates that the development of diesel technology is driven by the European market and it is important to keep this high technological advantage to avoid import of less environmentally performing technologies.

More stringent environmental regulation may also have positive competitiveness effects through stimulating innovation, improving efficiency, creating comparative advantages and spinning off new production activities. The actual distribution of these benefits between different firms and regions may nonetheless vary largely. Certain marine engine manufacturers stated that they actively seek to offset the likely price increase resulting from stricter emissions standards by not only improving the environmental performance of the engine, but also by adding real value to the consumer e.g. more power, decreased fuel consumption, etc.

COMPARISION WITH THE 2006 IMPACT ASSESSMENT THROUGH A MULTI-CRITERIA AND COST-BENEFIT ANALYSIS

Multi-criteria analysis

The various scenarios assessed in the current impact assessment as well as the TNO (2004) options assessed in the ECNI impact assessment (2006) are presented in terms of their effectiveness, efficiency and consistency. All scenarios are compared by means of a multi-criteria analysis. By altering the weights attributed to the different scenarios, insight is provided in the sensitivity of the ranking of the scenarios.

The TNO options assessed in the ECNI impact assessment are:

- Option 1: All SI engines to comply with RCD Stage 1 limits for four-stroke SI engines. CI engines should comply with NRMM10 Stage IIIA limits specified for propulsion engines for inland waterway vessels (commercial marine engines). For CI engines with a power output of less than 37kW, RCD Stage 1 limits for CI engines would continue to apply.
- Option 2: All SI engines should comply with HC and NOx limits that lie at 75% of the RCD Stage 1 limits for four-stroke SI engines, with the limits for HC and NOx applied as HC+NOx. For CO the RCD Stage 1 limits are assumed to continue to apply. For CI engines with a power output of less than 18kW, RCD Stage 1 limits would continue to apply. For CI engines with a power output of 18 kW and more, but less than 37kW, the NRMM Stage II limits would apply. For CI engines with a power output of 37kW and above, the NRMM Stage IIIA limits for general use would apply.
- Option 2A: As for Option 2, except SI engines with a power output of less than 30kW and all PWC engines would have to comply with the Option 1 limits (RCD Stage 1, four-stroke SI limits).

- Option 2B: As for Option 2A, however CI engines would have to comply with the NRMM Stage II limits for general use. A comparison between the limit values of these four proposed options and the current RCD Stage 1 limit values (to be known as the "do-nothing scenario" and hereafter referred to as the Reference case) has been made. This has been conducted as the impact assessment study requires a multi-criteria analysis using the "do-nothing scenario" as baseline for the comparison.

The following Table demonstrates that scenarios 2A, 2 and C1 + S1 are the most effective in environmental terms. Scenarios 2 and 2A outperform the other scenarios in terms of NOx+HC reduction whereas C1+C2 performs better for PT reduction.

The scenarios assessed in the current impact assessment study realise emission reductions in a more cost-efficient way. The potential compliance costs and job losses per kiloton reduction in emissions are much lower than for the TNO (2004) options. Especially scenario C2b + S2 realises emission reductions at limited costs per kiloton emission reduction. Scenario C1 + S1 performs best on both effectiveness and cost-effectiveness criteria. Industry pointed out that the higher socio-economic impacts per kiloton reduction for the TNO (2004) scenarios relates to the technical difficulties of adopting the required technology in the short term.

Table 9: Overview of the effectiveness and (social) costs effectiveness per scenario

Scenario	*Absolute annual reduction (in kilotons)*			*Compliance costs per kiloton reduction (in € million)*		*Job losses per kiloton reduction (in number of jobs)*	
	NOx+HC	*PT*	*NOx+HC & PT (expressed in NOx equivalents)*	*min*	*max*	*min*	*max*
C1 + S1	10.85	0.24	13.03	0.83	2.27	8.49	12.43
C2a + S2	9.83	0.15	11.20	0.59	2.26	8.58	13.17
C2b + S2	9.80	0.15	11.17	0.52	1.61	8.33	10.67
C2c + S2	9.80	0.15	11.17	0.58	2.26	8.53	13.18
1	8.14	0.09	8.99	6.75	6.75	33.26	33.26
2	12.65	0.11	13.63	14.68	14.68	37.95	37.95
2A	13.39	0.11	14.37	12.44	12.44	35.00	35.00
2B	9.39	0.11	10.37	12.97	12.97	31.96	31.96

With the decision software DEFINITE the critical deliberations between the eights scenarios have been studied in more depth based upon three decision criteria (annual emission reduction, compliance costs per kiloton emission reduction and job losses per kiloton emission reduction). The scores on each criterion are standardised and a certain weight was attributed to each criterion. The standardised scores on the different criteria were weighted and summed for each scenario. Finally, the different scenarios are ranked. It is only in case the absolute annual emission reduction is attributed 90% of the overall weight that option 2A ranks first. In case a weight lower than 90% is given to environmental performance (annual emission reduction), scenario C1+S1 always ranks first.

Cost-Benefit Analysis

Weighing the cost and the benefits of the different scenarios provides an indication of the desirability of the scenarios from a welfare point of view. Below, the benefits stemming from the reduction in exhaust gas emissions have been monetized. The factors used for monetising the environmental benefits of the reduction of NOx and PT emissions are those put forward in the Netcen study and suggested in the NRMM Directive.

As can be seen from the following Table, the monetised benefits from the reduction of NOx+HC are higher than those of PT. Again scenarios 2A, 2 and C1 + S1 yield the highest benefits. However, the compliance costs of the scenarios assessed in the framework of this study are much lower.

Combining both costs and benefits, all scenarios assessed in the current study have a positive B/C ratio and are expected to increase overall welfare, contrary to the TNO (2004) options. The difference between the scenarios in this impact assessment is rather small. For the TNO options, the emission reductions are realised in a much less cost efficient manner. The harmonisation of the US and EU exhaust emission standards apparently has important advantages.

Table 10: B/C ratio of the various scenarios (in € million)

Scenario	*Environmental benefits of emission reduction*		*Compliance costs*		*B/C ratio*	
	NOx+HC	*PT*	*min*	*max*	*min*	*max*
C1+S1	45.55	8.85	10.84	29.54	5.02	1.84
C2a+S2	41.3	5.54	6.63	25.33	7.06	1.85
C2b+S2	41.17	5.54	5.83	18.03	8.01	2.59
C2c+S2	41.17	5.54	6.43	25.25	7.26	1.85
1	34.18	3.42	60.65		0.62	
2	53.13	3.97	200.16		0.29	
2A	56.24	3.97	178.71		0.34	
2B	39.43	3.97	134.44		0.32	

1 INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

The current European Legislation on recreational craft engines is laid down in Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft, amended by Directive 2003/44/EC. This Directive aims to harmonise the laws, regulations and administrative provisions in the Member States as regards the safety characteristics of recreational craft and their environmental characteristics and applies to three different areas:

- the design and construction of recreational craft[6], partly completed boats, personal watercraft and certain components or parts mentioned by the Directive;
- exhaust emissions produced by propulsion engines installed on or in pleasure craft and by personal watercraft;
- noise emissions produced by recreational craft with stern drive engines without integral exhausts or inboard propulsion engines, by personal watercraft and by outboard engines and stern drive engines with integral exhaust.

The Directive does not apply to craft such as racing craft, canoes, kayaks or gondolas, surfboards or sailing surfboards, original and individual replicas of historical craft, or experimental craft, nor to engines fitted, or intended to be fitted, to such craft. Also excluded are craft intended to carry passengers for commercial purposes which are covered by Council Directive 82/714/EEC of 4 October 1982 on technical prescriptions for inland waterway vessels.

In accordance with Article 2 of Directive 2003/44/EC the Commission shall submit a report on the possibilities of further improving the environmental characteristics of recreational marine engines and, if deemed appropriate, submit appropriate proposals.

In this context two studies have been carried out:

- TNO for EC DG Enterprise, "Stocktaking study on the current status and developments of technology and regulations related to the environmental performance of recreational marine engines – Final Report", January 2005. ("stocktaking study"). In this study four possible options for further emission reducing measures have been identified.
- European Confederation of Nautical Industries for EC DG Enterprise, "Study on The Feasibility and Impact of Possible Scenarios for Further Emission Reduction Measures for Recreational Craft Engines in the Context of Directive 94/25/EC, as Amended by Directive 2003/44/EC: Impact Assessment Report – Final Report", 26 October 2006". This study identified and measured in detail the impacts and distributive effects of the four possible scenarios for further emission reduction measures. It was concluded that each of the scenario options investigated would result in a relatively low emission reduction, and would entail a social cost for certain European SME's.

The Commission submitted in response to article 2 of Directive 2003/44/EC a Communication to the Council and the European Parliament on the possibilities of further improving the environmental characteristics of recreational craft engines, submitted pursuant to Article 2 of Directive 2003/44/EC, amending Directive 94/25/EC (COM(2007)313 final; {SEC(2007)770}; {SEC(2007)819}).

[6] Recreational craft: any boat of any type intended for sports and leisure purposes of hull length from 2.5m to 24m, measured according to the harmonised standard, regardless of the means of propulsion.

Further study work was considered necessary aimed at identifying and assessing the impact of the most ambitious - but feasible - scenario to:

- Maximise the emission reduction potential of recreational craft engines and
- To mitigate the social and economic impact on small and medium sized enterprises.

1.2 GOALS

The objectives of this complementary Impact Assessment study are:

1. To identify a scenario, based upon the most stringent exhaust emission requirements, either existing or under development, that are applied or are envisaged to be applied to recreational marine engines in other parts of the world, and
2. To assess the feasibility and impact of applying such requirements to the largest range of recreational marine engine types covered by the Directive as possible. The identified scenario has to be submitted to a detailed impact assessment, addressing technical, social, environmental, and economical aspects.
3. To identify mitigating measures to limit the negative economical and social impacts the identified scenario may have on the concerned SMEs. These have to be based on alleviating measures already proposed or applied to small volume manufacturers in Community legislation governing engine emissions, and
4. To assess the impact and effectiveness of such measures if they were to be applied to the identified scenario, and identify or develop from this analysis the most effective method for mitigating the negative economical and social impacts the identified emission reduction scenario may have on SMEs.
5. To compare the assessed impacts of the emission reduction scenario and of the mitigating measures for SMEs identified in this study with those of the scenarios assessed in the 2006 impact assessment study.

The impact assessment covers technical, social, environmental and economic aspects. The assessment is carried out in accordance with the Commission Guidelines on Impact Assessment as updated on 15 March 2006.

The study results should be presented in such a way that they can be used by the Commission services for assessing, within the context of article 2 of Directive 2003/44/EC, the appropriateness of considering the elaboration of further legislative proposals.

2 APPROACH

The approach of this impact assessment involved the following steps:

- Extensive consultation with sector organisations and companies potentially affected to gather data on impacts, costs and benefits;
- A literature review, to obtain base data on the products affected and to gather cost and benefit data as a check for the data provided during consultation;
- Calculation of the economic impacts of the scenarios.

Each of these steps is described further below.

2.1 LITERATURE REVIEW

An extensive literature review was conducted using sources identified by the contractor, the Commission and the industry stakeholders. The information assembled and analysed during this review is presented further in the report.

2.2 STAKEHOLDER CONSULTATION

Gathering opinions and information from interested parties is an essential part of the policy-development process, enhancing its transparency and ensuring that proposed policy is practically workable and legitimate. Stakeholder acceptance of the results will be highest if they are consulted from the right from the onset of the study. Stakeholders hold important information which they only provide if they are confident with the methodology of the study and feel their ideas and values will be given proper attention. Furthermore, the Commission is required by the EC Treaty to carry out wide consultations before proposing legislation. (EC, 2005b)

Stakeholders that may be affected by, or involved in, the development of more stringent exhaust emission limit values of engines used in recreational marine crafts have been actively consulted, using various methods, throughout the whole study. The consultation has proved very useful in getting to know the industry as well as the impacts of more stringent exhaust emission standards under various conditions.

2.2.1 Objectives

The objective of the stakeholder consultation has been to complement information and insights gathered through the consultation of legislative documents, impact assessments, positioning papers, technical reports, publicly available industry information and statistics. The consultation process particularly served to:

- identify the most important stakeholders;
- gather information on the most stringent exhaust emission requirements, either existing or under development, in and outside the EU;
- gather information on the feasibility of applying the most stringent exhaust emission requirements identified to the largest ranges of recreational marine engines types as possible;
- help select the scenario to be submitted to a detailed impact assessment;
- provide a broad support basis for the scenario to be submitted to the impact assessment;
- get to know and understand industry structure, processes and importance;
- collect information on compliance costs and impacts of the scenario;

- identify measures for mitigating the impact of the scenario on SMEs;
- collect information on the mitigating effect of the measures to limit the negative effects of the scenario on SMEs;
- provide background information on the methodology, assumptions, quality and outcomes of the earlier studies, in particular the impact assessment carried out by ECNI (2006).

2.2.2 Identification of the stakeholders

At the first steering committee meeting between the European Commission and the contractor on January 10 2008 it was advised to consult the following stakeholders for the economic impact analysis:

- the International Council of Marine Industry Organisations (ICOMIA) which hosts the Marine Engine Committee (IMEC);
- the European Association of Internal Combustion Engine Manufacturers (Euromot);
- European SME engine manufacturers and marinisers.

IMEC and Euromot represent the interests of the marine engine manufacturers and marinisers that are associated to their organisation. With their mandate both industry associations have already participated in the stocktaking study (TNO, 2005), identifying scenarios for further emission reductions, and the impact assessment study (ECNI, 2006), measuring the impacts and distributive effects of the scenarios put forward by the stocktaking study. Both studies have been carried out in the framework of the European Commission's obligation to report to the European Parliament and Council on the possibilities to further improve the environmental characteristics of the recreational marine craft engines.

Not all European based marine engine manufacturers and marinisers are a member of IMEC and/or Euromot. The larger, most dominant, players on the market are a member and thus have their interests represented by at least one of the two industry associations. A number of smaller, and more vulnerable, companies are not a member and therefore may be overlooked. In order to provide a forum to the smaller marine engine manufacturers and marinisers, individual companies were sent an individual company questionnaire. The questionnaire has been sent directly to the IMEC CI and SI task force members, the Euromot members involved in the marine engine industry as well as a number of additional companies of which the contact details were provided to us by the European Commission, IMEC or Euromot and/or were found on the internet. In order to reach the largest possible number of SME engine manufacturers and marinisers, contact details have also been gathered through a number of national marine industry federations besides IMEC or Euromot[7]. The associations were asked to forward the questionnaires meant for individual companies to their members. IMEC and Euromot have provided contact details of their own members and of UCINA member companies which deal with marine engines. Some effort was put in finding contact details of individual companies not represented yet. Furthermore, the questionnaire was downloadable from CIRCA.

A preliminary assessment of the impacts of new exhaust emission standards revealed boat builders may be impacted as well. Therefore a special questionnaire has been drawn up for boat builders. The national marine industry federations were asked to provide contact details of boat builders. Besides, IMEC CI and SI task force members as well as the Euromot members involved in the marine industry were also asked to express their views.

We can conclude that the questionnaire for engine manufactures and marinisers as well as the one for boat builders has been widely spread among industry associations and some 50 individual companies.

[7] E.g. ANEN Spanish association, Danboat, Finboat, Sweboat, Deutscher Boots- und Schiffbauer-Verband

2.2.3 Consultation process

The nature of the subject required the use of a combination of methods for the stakeholder consultation. A tight contact with the industry has been formalised and channelled via a number of official stakeholder information and consultation meetings, written questionnaires to the competent industry associations, individual engine manufacturers and marinisers and boat builders as well as the organisation of individual company meetings.

2.2.3.1 Stakeholder information and consultation meetings

The first contacts with the industry and government representatives were established in February 2008 in the framework of the second meeting of the Expert Group on the amended Recreational Craft Directive during which the objectives and methodology of the study have been presented by the contractor. In the margin of the expert group meeting, an informal meeting with the industry representatives took place for establishing a solid basis for cooperation between the contractor and the industry.

In order to promote transparency and ensure stakeholder acceptance, the European Commission organised two information and consultation meetings on the complementary impact assessment study on possible emission reduction measures for recreational marine craft engines. These meetings were meant as a discussion forum open to all interested stakeholders. Stakeholders consisted of the representatives of the competent industry associations (e.g. IMEC and Euromot), dominant engine manufacturers and government representatives. The first stakeholder information and consultation meeting on March 10 2008 served to present and discuss the draft first interim report, the exhaust emission reduction scenario to be submitted to the impact assessment and the content and practical organisation of the questionnaire to the stakeholders. The second stakeholder information and consultation meeting on May 15 2008 served to discuss the draft final report.

2.2.3.2 Written questionnaires

Three separate written questionnaires were drafted and sent out in March 2008 to the following stakeholders:

- a sector questionnaire dedicated to IMEC and Euromot who facilitated an integrated industry position with all of their members involved in the recreational marine craft industry;
- a questionnaire dedicated to individual engine manufacturers and marinisers active on the European market;
- a questionnaire dedicated to recreational marine boat builders.

QUESTIONNAIRE FOR THE COMPETENT INDUSTRY ASSOCIATIONS

IMEC and Euromot were asked to complete a detailed questionnaire covering:

- the technical feasibility of the exhaust emission reduction scenario submitted to the impact assessment study;
- the characterisation of the industry (industry actors, structures, processes and importance);
- compliance costs of applying the emission reduction scenario under consideration; with and without flexibilities in place;
- the impact of applying the emission reduction scenario to the various stakeholders;
- the likely mitigating impact of measures already proposed or applied to small volume engine manufacturers in Community legislation governing engine emissions.

QUESTIONNAIRE FOR ENGINE MANUFACTURERS AND MARINISERS ACTIVE ON THE EUROPEAN MARKET

The individual questionnaire for marine engine manufacturers and marinisers active on the European market was structured around the following topics:

- company details e.g. coordinates, activities, engine families, production facilities located in Europe, employees, turnover, markets served;
- compliance costs:
  - sunk costs;
  - fixed costs related to R&D, retooling and recertification;
  - variable costs;
  - impact of flexibilities on compliance costs.
- impact of applying the emission reduction scenario on competition, cost-pass through percentages, the natural business cycle, the companies' engine gamma, the viability of the companies' operations;
- the likely mitigating impact of measures already proposed or applied to small volume engine manufacturers in Community legislation governing engine emissions.

QUESTIONNAIRE FOR BOAT BUILDERS

The questionnaire for boat builders was structured around the following topics:

- company details, coordinates and activities;
- impacts of applying the emission reduction scenario on vessel redesign, cost-pass through percentages of possible vessel redesign, the viability of the companies' operations, the companies' boat gamma as well as the impact of the introduction of a flexibility scheme;
- the likely impact of mitigating measures.

2.2.3.3 Combined IMEC – Euromot task force meeting and individual company interviews

On April 9 2008, IMEC and Euromot both met with their core members involved in the marine recreational craft industry to discuss the draft first interim report and questionnaire for industry associations. Afterwards, industry provided the contractors with feedback on the industry questionnaire during two simultaneous meetings.

The company questionnaires were returned beforehand and acted as a starting point for the interviews on March 9. The contractors had individual company talks with 12 companies: Selva, Kawasaki, Yamaha, Honda, Suzuki, Volvo Penta (CI and SI), Cummins, Mercury, Nanni Diesel, Vetus, Beta Marine and Lombardini. This enabled the contractor to further enquire the companies and interpret details about their activities, the industry structure and processes, the likely impacts of applying the emission reduction scenario as well as the likely impact of mitigating measures.

2.2.4 Results of the stakeholder consultation

2.2.4.1 Questionnaire for engine manufacturers and marinisers

In total 16 companies returned the questionnaire for recreational marine engine manufacturers and marinisers. Besides, two additional companies completed the questionnaire during the individual interview. A response has thus been obtained from 18 companies among which:

- 10 large enterprises with more than 250 employees and more than € 50 million turnover;
- 4 medium sized companies employing between 50 and 250 employees and a turnover between € 10 million and € 50 million;
- 1 medium sized company with less than 50 employees and a turnover between € 10 million and € 50 million;
- 3 small companies with less than 50 employees and a turnover below € 10 million.

As can be read from Table 2.1, half of the questionnaires have been completed by European companies. Two thirds of the European respondents can be categorised as an SME according to the standard definition of an SME adopted by the European Commission. Three European companies do not produce for the American market at all. All European companies who replied, except one, manufacture and/or marinise CI engines. All American and Japanese companies who replied to the questionnaire produce for the European market, but only one third has a European based production facility. These foreign companies ship large amounts of OB engines to the European market as well as a more limited number of SI IB engines and PWCs.

The companies who replied to the questionnaire represent more than 85% of European sales, assuming a European market for OB engines of between 200,000 and 220,000 units/year. Likewise, the respondents to the questionnaire provide almost the entire number of CI engines sold on the European market, assuming European demand for CI engines at 40,000 units/year. The companies who replied to the questionnaire cover about 60% of European demand for PWCs, assuming European sales of PWCs at about 10,000 units/year. The share of the respondents' SI IB engines put on the European market in the total SI IB engines sales on the European market is important, but currently still unclear. Knowing that the OB and CI engine sales are by far the most important, it can be concluded that the questionnaire provides a good coverage of the industry. This, however, does not alter the fact that the small to very small European engine manufacturers and marinisers often only selling to the EU market are underrepresented in the questionnaire.

Table 2.1 Profile of the respondents: engine manufacturers and marinisers

Company	*Home region*	*Activity*	*Engine type*	*Company size*	*EU based production*	*Market served*
1	EU	E Mar	CI	Small	Yes	EU, US
2	EU	E Man	CI	Large	Yes	EU, US
3	EU	E Man, E Mar	CI	Large	Yes	EU, US
4	US	E Man, E Mar	SI IB	Medium	No	EU, US
5	US	E Mar	SI IB	Medium	No	EU, US
6	Japan	E Man, B Man	PWC	Large	No	EU, US
7	EU	E Man, E Mar	CI	Small	Yes	EU
8	US	E Man, E Mar, B Man	OB, SI IB	Large	Yes	EU, US
9	EU	E Mar	CI	Medium	Yes	EU, US
10	EU	E Mar	CI	Small	Yes	EU

11	Japan	E Man	OB	Large	No	EU, US
12	Japan	E Man	OB	Large	No	EU, US
13	EU	E Mar	CI	Medium	Yes	EU, US
14	EU	E Man, E Mar	CI, SI IB	Large	Yes	EU, US
15	Japan	E Man, E Mar	OB, CI, PWC	Large	Yes	EU, US
16	Japan	E Man	CI	Large	Yes	EU, US
17	EU	E Man	OB	Medium	Yes	EU
18	Japan	E Man	OB, PWC	Large	No	EU, US

Activity: **E Man** – Engine Manufacturer / **E Mar** – Engine Mariniser / **B Man** – Boat Manufacturer

Engine type: **OB** – Outboard engine / **CI** – Compression Ignition Inboard engine / **SI IB** – Spark Ignition Inboard Engine / **PWC** – Personal Watercraft

In general, the quality of the questionnaires returned can be regarded as good to very good. The individual interviews with the companies also presented a valuable opportunity to check interpretation of the response and identify further data needed.

2.2.4.2 Questionnaire for boat manufacturers

In total, 5 companies returned the questionnaire for boat builders.

Table 2.2 Profile of the respondents: boat builders

Company	*Home region*	*Activity*	*Engine type*	*EU based production*
1	EU	B Man	CI	Yes
2	EU	B Man	SI IB	Yes
3	Canada	E Man, B Man	OB, SI IB, PWC	Yes
4	US	B Man	CI	Yes
5	US	B Man	CI	Yes

Activity: **E Man** – Engine Manufacturer / **E Mar** – Engine Mariniser / **B Man** – Boat Manufacturer

Engine type: **OB** – Outboard engine / **CI** – Compression Ignition Inboard engine / **SI IB** – Spark Ignition Inboard Engine / **PWC** – Personal Watercraft

3 IDENTIFICATION OF THE MOST AMBITIOUS – BUT FEASIBLE SCENARIO

This section of the report shows how the most ambitious – but feasible - scenario to maximise the emission reduction potential of recreational craft engines is identified. The identification was performed in three steps:

- Collection of information/data
- Listing of more ambitious scenarios than in the current legislation
- Select (a) scenario'(s) to be analysed in-depth;
- Analyse the feasibility of applying such scenario to the largest range of recreational marine engine types covered by the Directive.

3.1 DATA COLLECTION

The collection of relevant information or data was performed by:

- Listing relevant legislation found in different countries, regions
- Gathering and analysing available literature, based on:
  - Reports provided by the Commission, particularly the background documents of the Impact assessment study of 2006 (ECNI)
  - Reports, notes found through an extensive internet search
- Stakeholder consultation

The result of this data collection step is listed here.

3.1.1 Literature/legislation

First of all, all scenarios found through different sources, were listed to be able to select the most ambitious one. Therefore information was gathered on existing legislation or legislation under development (in and outside the EU). Following specific sources were reviewed:

- Information of the studies specified in the ToR
  - TNO (2005), Stocktaking study on the current status and developments of technology and regulations related to the environmental performance of recreational marine engines – Final Report ("stocktaking study");
  - ECNI (2006), "Study on The Feasibility and Impact of Possible Scenarios for Further Emission Reduction Measures for Recreational Craft Engines in the Context of Directive 94/25/EC, as Amended by Directive 2003/44/EC: Impact Assessment Report – Final Report".
- Existing legislation or legislation under development[8]:
  - Recreational Craft Directive 94/25/EC, amended by Directive 2003/44/EC *(EU)*;
  - Directive on Non-Road Mobile Machinery (NRMM) 97/68/EC, amended by 2004/26/EC *(EU)*;
  - The "Emission standards for new non-road engines" regulation in the Code of Federal Regulations [40 CFR Part 89 et al.][67 FR 68241-68447, 8 Nov 2002] *(US)*

[8] For each mentioned legislation (or proposal), the country or region where it applies is indicated between brackets in italic

- Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder; Proposed Rule40, CFR Parts 92, 94, 1033, et al *(US)*
- Spark-Ignition Engines and Equipment, proposed rule, May 2007, 40 CFR Parts 60, 63, et al. *(US)*
- Proposed emission standards for new non-road spark-ignition engines, equipment, and vessels (US EPA (USEPA420-F-07-032), Office of Transportation and Air Quality, April 2007) *(US)*;
- Canadian marine spark-ignition engine and off-road recreational vehicle emission regulations (Canada Gazette Part 1, December 30, 2006) *(Canada)*
- Japanese standards for Non-road vehicles (March 28, 2006) *(Japan)*
- Korean emission standards for mobile non-road diesel engines *(Korea)*

- Studies/reports supporting the development of some of these regulations:
  - US EPA (June, 1996): Regulatory Impact Analysis on the Control of Air Pollution Emission Standards for New Non-road Spark-Ignition Marine Engines;
  - Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder (US EPA, March 2007);
  - US EPA (May, 2004): Final Regulatory Analysis on the Control of Emissions from Non-road Diesel Engines
  - US EPA (April, 2007): Draft Regulatory Impact Analysis on the Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment
  - Benchmark Research (September, 2003). Final Regulatory Analysis on the Control of Emissions from Non-road Diesel Engines
  - Environment Link and Vehicle Design and Research P/L (2007). Comparative assessment of the environmental performance of small engines, prepared for the Australian Department of the Environment and Water Resources

3.1.2 Stakeholder information

A first introductory stakeholder information was held on Wednesday, February 20, 2007 in Brussels. This stakeholder information was combined with an experts group meeting on the Recreational Craft Directive in Brussels. At this meeting, a presentation was given by Arcadis explaining:

- Background of the study
- Goals of the study
- Elements to be discussed

Also important industry stakeholders like ICOMIA, Euromot and EMA were present at this meeting on which they could provide their first comments, concerns, ideas, et.

After the experts group meeting, an informal meeting with industry representatives was held with two important goals:

- giving the industry stakeholders the opportunity to give their first ideas on the proposals shown in the presentation
- giving ARCADIS the opportunity to summarize the most important data gaps.

The result of this informal meeting was:

- a clear input of the industry for a possible ambitious scenario to be assessed;

- the agreement of the industry to give their full support to try to collect the most recent information available and to help contacting individual companies.

3.2 LIST MORE STRINGENT EXHAUST EMISSION REQUIREMENTS, EITHER EXISTING OR UNDER DEVELOPMENT

3.2.1 Spark ignition legislation

CURRENT EUROPEAN LEGISLATION

To improve clarity of this report, this chapter is introduced by showing the current European emission standards for recreational SI engines (Recreational Craft Directive 94/25/EC, amended by Directive 2003/44/EC).

Table 3.1: European emission standards for SI engines (Recreational Craft Directive 94/25/EC, amended by Directive 2003/44/EC)

			2-Stroke SI	*4-Stroke SI*
date[9] of entry in to force			1/01/2007	1/01/2006
$CO = A+B/P_N^n$	(g/kWh)	A	150	150
		B	600	600
		n	1	1
$HC = A+B/P_N^n$	(g/kWh)	A	30	6
		B	100	50
		n	0,75	0,75
$NOx = A+B/P_N^n$	(g/kWh)	A	10	15
		B	0	0
		n	0	0

CALIFORNIA CODE OF REGULATIONS (CARB)

Emission standards for Spark-Ignition (SI) Marine Engines

These standards are set in the California Code of Regulations, Chapter 9 (Off-Road Vehicles and Engines - Pollution Control Devices), sections 2440 through 2448 - Article 4.7. Spark-Ignition Marine Engines.

The legislative text indicated that: "*For model year 2001 and later model year SI personal watercraft (PWC) and outboard (OB) marine engines, exhaust emissions from new spark-ignition marine engines manufactured for sale, sold, or offered for sale in California, or that are introduced, delivered or imported into California for introduction into commerce must not exceed the hydrocarbon plus oxides of nitrogen (HC+NOx) exhaust emission standards liste*d Table 3.2";

[9] Date of placing on the market of the engine

Table 3.2: Corporate average emission standards for HC+NOx (CARB) for SI PWC/OB engines

Corporate Average Emission Standards by Implementation Date HC+NOx (g/kW-hr)			
Model Year	Max. Family Emission Limit (FEL)	$P_{tx} < 4.3$ kW	$P_{tx} \geq 4.3$ kW
2001	Not Applicable	81.00	$(0.25 \times (151+557/P_{tx}^{0.9}))+6.0$
2004	80	64.80	$(0.20 \times (151+557/P_{tx}^{0.9}))+4.8$
2008	44	30.00	$(0.09 \times (151+557/P_{tx}^{0.9}))+2.1$

P is the average power in kW (sales-weighted) of the total number of spark-ignition tx marine engines produced for sale in California in model year x.

The principle of corporate average emission standards is explained in chapter 3.2.3 of this report.

Proposed rule for SI inboard and sterndrive marine engines

The legislative text says that: "*For model year 2003 and later model years SI inboard and sterndrive marine engines, exhaust emissions from new model year 2003 and later SI inboard and sterndrive marine engines must not exceed the exhaust emission standards listed in* Table 3.3 *for the designated emission durability test period. Prior to Model Year 2007 certification, each engine manufacturer must select either Option 1 (OPT 1) or Option 2 (OPT 2) for its entire production for the 2007 and 2008 model years."*

Table 3.3: Proposed Californian rule for SI inboard/sterndrive marine engine standards

Inboard/Sterndrive Marine Engine Standards

MODEL YEAR	RATED POWER [kilowatts]	COMPLIANCE OPTION[1]	DURABILITY [hours / years]	EXHAUST STANDARD NMHC[2]+NOx [grams per kilowatt-hour]	EXHAUST STANDARD TYPE[3]	SUPPLEMENTAL MEASURE[4]
2003 - 2006	kW ≤ 373	N/A	N/A	16.0	AVE	None
2007	kW ≤ 373	OPT 1	N/A	16.0 (55%)	AVE	None
			480 / 10	5.0 (45%)	FIXED	
		OPT 2	N/A	14.0	FIXED	Low-Permeation Fuel Line Hoses
2008	kW ≤ 373	OPT 1	N/A	16.0 (25%)	AVE	None
			480 / 10	5.0 (75%)	FIXED	
		OPT 2	480 / 10	5.0	FIXED	Low-Permeation Fuel Line Hoses
2009 and later	kW ≤ 373	N/A	480 / 10	5.0[6]	FIXED	Carryover[7]
	373 < kW ≤ 485		150[5] / 3	5.0[6]	AVE	
	kW > 485		50[5] / 1	5.0[6]	AVE	

Notes:

1. Once a manufacturer has chosen an option, that option must continue to be used exclusively across product lines
2. The non-methane component of hydrocarbon
3. Corporate averaging (AVE) may be used to demonstrate compliance with the exhaust emission standard, except where a FIXED standard isrequired
4. Supplemental measures may be different than shown, but must provide equal and verifiable emission reductions to those indicated
5. For the purpose of durability testing, engine components that have been approved with an hourly warranty period shorter than the full hourly durability period per § 2445.1 (c)(3)(C)4. may be replaced at the specified warranty interval
6. All engines ≤ 373 kW must meet a 5.0 g/kW-hr NMHC+NOx capping standard. For engines > 373 kW, the standard may be met by sales-averaging with engines equal to or less than 373 kW
7. The same or better supplemental emission control hardware used to meet the standard in 2007 must be

used every model year thereafter

CANADA

The proposed Regulations would introduce Canadian emission standards and test procedures aligned with those of the EPA for marine spark-ignition engines established under Title 40, Part 91, of the *Code of Federal Regulations* (CFR). The new exhaust emission standards (using the test procedures specified in the CFR) for spark-ignition engines are presented in following table. The standards for combined HC+NOx emissions is based on the power rating of the engine.

Table 3.4: HC+NOx exhaust emission standards for marine spark-ignition engines (Canada Gazette, Part I, December 30, 2006)

	$HC+NO_X$ emission standard (g/kW-h)	
Model Year	**$P^{(1)} < 4.3$ kW**	**$P^{(1)} \geq 4.3$ kW**
2008 and later	81.00	$0.250x\left(151+\frac{557}{P^{0.9}}\right)+6.00$

(1) P is the sales-weighted average power of the engine family in kilowatts

US ENVIRONMENTAL PROTECTION AGENCY (US EPA) REGULATIONS

The exhaust emission standards for SI engines are set in Chapter 40 – Title 91 of the US EPA Federal Register, titled "Control of emissions from marine SI engines" (see http://www.access.gpo.gov/nara/cfr/waisidx_05/40cfr91_05.html). Table 3.5 gives the exhaust emission standards for outboard and personal watercraft engines.

Table 3.5: Hydrocarbon plus oxides of nitrogen exhaust emission standards for OB and PWC engines [grams per kilowatt-hour]

Model year	P < 4.3 kW $HC+NO_X$ emission standard by model year	P > 4.3 kW $HC+NO_X$ emission standard by model year
1998	278.00	$(0.917 \times (151 + 557/P^{0.9})) + 2.44$
1999	253.00	$(0.833 \times (151 + 557/P^{0.9})) + 2.89$
2000	228.00	$(0.750 \times (151 + 557/P^{0.9})) + 3.33$
2001	204.00	$(0.667 \times (151 + 557/P^{0.9})) + 3.78$
2002	179.00	$(0.583 \times (151 + 557/P^{0.9})) + 4.22$
2003	155.00	$(0.500 \times (151 + 557/P^{0.9})) + 4.67$
2004	130.00	$(0.417 \times (151 + 557/P^{0.9})) + 5.11$
2005	105.00	$(0.333 \times (151 + 557/P^{0.9})) + 5.56$
2006 and later	81.00	$(0.250 \times (151 + 557/P^{0.9})) + 6.00$

P = the average power of an engine family in kW (sales weighted).

Emission standards for Inboard Sterndrive SI engines are given in the May 18, 2007 proposed rule for "Control of Emissions from Nonroad Spark-Ignition Engines and Equipment". An extract of this proposed rule is given here:

"We (US EPA) *are proposing a more stringent level of emission standards for outboard and personal watercraft engines starting with the 2009 model year. The proposed standards for engines above 40 kW are 16 g/kW-hr for HC+NOx and 200 g/kW-hr for CO. For engines below 40 kW, the standards increase gradually based on the engine's maximum power. We expect manufacturers to meet these standards with improved fueling systems and other in-cylinder controls.*

We are proposing new exhaust emission standards for sterndrive and inboard marine engines. The proposed standards are 5 g/kW-hr for HC+NOx and 75 g/kW-hr for CO starting with the 2009 model year. For sterndrive and inboard marine engines above 373 kW with high-performance characteristics (generally referred to as "SD/I high-performance engines"), we are proposing a CO standard of 350 g/kW-hr. We are also proposing a variety of other special provisions for these engines to reflect unique operating characteristics and to make it feasible to meet emission standards using emission credits."

Credit generation and use is calculated based on the family emission limit (FEL) of the engine family and the standard. We are proposing FEL caps to prevent the sale of very-high emitting engines. For HC+NOX, the proposed FEL cap is 16 g/kW-hr for HC+NOX emissions from engines below 373 kW; this emission level is equal to the first phase of the California SD/I standards. We are proposing an FEL cap of 150 g/kW-hr for CO emissions from engines below 373 kW. These FEL caps represent the average baseline emission levels of SD/I engines, based on data described in the Draft RIA. The analogous figures for high-performance engines are 30 g/kW-hr for HC+NOX and 350 g/kW-hr for CO"

CONCLUSION FOR SPARK IGNITION LEGISLATION

A review of **existing legislation in Australia, United States and Canada** of emission standards for vessels was performed by Environment Link & Vehicle Design and Research P/L for the Department of the Environment and water Resources. Some short conclusions are:

- There are no Australian regulations or standards limiting air pollutant emissions from marine outboard engines
- The USEPA regulates emissions from outboard engines and personal watercraft (spark ignition engines) and compression ignition engines. The standards for SI engines were introduced in 1998 and have become progressively stricter up to 2006.
- CARB (Californian Air Resources Board) sets requirements for SI marine engines manufactured from 2001. CARB also has an engine labelling requirement
- Environment Canada and the Canadian Marine Manufacturers Association (CMMA) signed a Memorandum of Understanding (MOU) to voluntarily introduce cleaner outboard engines and personal watercraft into the Canadian marketplace. Under the MOU the eleven participating member companies agree to provide engines for outboards and personal watercraft that comply with USEPA emission standards, commencing with the 2001 model year. The new engines are being phased in through to 2006. Under the MOU engine labelling is also required.

Taking into account the differences between the European, US and California regulations, Figure 3.1 compares the emission limits applying to engines of two power ratings (5kW and 40kW).

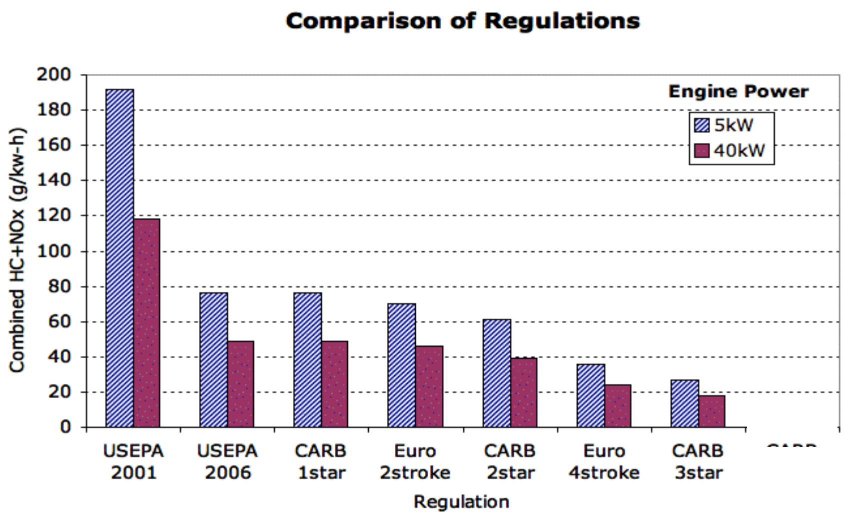


Figure 3.1: Comparison of regulations for vessel engines (Environment Link & Vehicle Design and Research P/L, 2007[10])

Following conclusions were drawn from this figure in the report:

- European requirements for two stroke engines are similar to the USEPA 2006 requirements but European four stroke requirements are substantially more stringent (about half the emissions)
- USEPA 2006 requirements, which are the same as CARB (Californian Air Resources Board) Tier 1, are substantially more stringent than the USEPA 2001 requirements
- European four stroke requirements are between the CARB Tier 2 and 3 requirements and are more stringent than the US standards.

Looking at the **proposed rules**, it can be concluded that:

- Canadian proposal for SI Personal watercraft and Outboard engines is in alignment with the US EPA legislation
- The US EPA proposal for SI Inboard sterndrive engines is consistent with the requirements adopted by California ARB

3.2.2 Compression Ignition legislation

CURRENT EUROPEAN LEGISLATION

As for SI engines, to improve clarity of this report, this chapter is introduced by showing the current European emission standards for recreational CI engines (Recreational Craft Directive 94/25/EC, amended by Directive 2003/44/EC).

[10] The original figure form Environment Link & Vehicle Design and Research P/L include a CARB 4star scenario. Since this scenario is left out by CARB in de meanwhile (ICOMIA, personal communication, March 2008, it was deleted from this figure)

Table 3.6: European emission standards for CI engines (Recreational Craft Directive 94/25/EC, amended by Directive 2003/44/EC)

			Compression Ignition (CI)
date[11] of entry in to force			1/01/2006
$CO = A+B/P_N^n$	(g/kWh)	A	5
		B	0
		n	0
$HC = A+B/P_N^n$	(g/kWh)	A	1,5
		B	2
		n	0,5
$NOx = A+B/P_N^n$	(g/kWh)	A	9,8
		B	0
		n	0
PT	(g/kWh)		1

US EPA RULE FOR MORE STRINGENT EMISSION STANDARDS FOR MARINE CI ENGINES

This refers to the following rule:

“Control of Emissions of Air Pollution from Locomotives and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder” (signed March 14, 2008). The final rule consists of a three-part emission control strategy:

- First, the final standards for existing locomotives and marine diesel engines when they are remanufactured. These standards take effect as soon as certified remanufacture systems are available, as early as 2008.
- Second, the rule sets near-term emission standards, referred to as Tier 3 standards, for newly-built locomotive and diesel marine engines. These standards reflect the application of currently available technologies to reduce engine-out PM and NOx emissions and phase-in starting in 2009. The rule also creates new idle reduction requirements for new and remanufactured locomotives and establishes a new generation of clean switch locomotives, based on clean nonroad diesel engine standards.
- Third, the final long-term emissions standards, referred to as Tier 4, apply to newly-built locomotives and marine diesel engines. These standards are based on the application of high-efficiency catalytic aftertreatment technology and would phase-in beginning in 2014 for marine diesel engines and 2015 for locomotives. These standards are enabled by the availability of ultra-low sulfur diesel fuel with sulfur content capped at 15 parts per million, which will be available by 2012. These marine Tier 4 engine standards apply only to commercial marine diesel engines above 600kW(800hp) and not recreational marine CI engines.

The standards are given in Table 3.7.

[11] Date of placing on the market of the engine

Table 3.7: Tier 3 standards for marine diesel C1 engines below 3700 kW (final rule US EPA420-F-08-004, March 2008)

Maximum Engine Power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X + HC g/bhp-hr (g/kW-hr)	Model year
<19 kW	<0.9	0.30 (0.40)	5.6 (7.5)	2009
19 to <75 kW	<0.9[a]	0.22 (0.30)	5.6 (7.5)	2009
		0.22 (0.30)[b]	3.5 (4.7)[b]	2014
75 to <3700 kW	<0.9	0.11 (0.15)	4.3 (5.8)	2012
	0.9-<1.2	0.10 (0.14)	4.3 (5.8)	2013
	1.2-<2.5	0.09 (0.12)	4.3 (5.8)	2014
	2.5-<3.5	0.09 (0.12)	4.3 (5.8)	2013
	3.5-<7.0	0.08 (0.11)	4.3 (5.8)	2012

Notes:

(a) <75kW engines at or above 0.9 L/cylinder are subject to the corresponding 75-3700 kW standards.

(b) Option: 0.15 g/bhp-hr (0.20 g/kW-hr) PM / 4.3g/bhp-hr (5.8g/kW-hr) NO_X-HC in 2014

JAPANESE AND KOREAN LEGISLATION

A description of the existing regulation in Japan and Korea were added:

- Current regulations for Motor Vehicle Exhaust Emission Reduction only applies to special vehicles on public roads (CEMA (Japan Construction Equipment Manufacturers Association, April, 4 2004)
- In Korea, the gas emission regulation only applies for excavators, loaders, forklifts, dozers, rollers, mobile cranes as from January 2005.

Conclusions for these standards are:

- Korean limits (as from January 2005) are more or less comparable with current US EPA legislation for NOx, HC and PM; the CO limits are more stringent and are in line with option 2B limits (ECNI, 2006)
- The Japanese regulation focuses on the reduction of PM emission, and therefore has more stringent limit values for PM than in the EU (cf Table 3.8)

Table 3.8: Target levels for permissible limits (3rd level emission regulation)

• • • • • • • • • • • (kw)		• PM • (g/kwh)	NOx	HC	First Year
			(g/kwh) (NOx + HC)		
19 • P<37		0.4	6	1	2007
		[0.6]	7 [7.5]		[2007]
37 • • P<75	37 • • P<55	0.3	4	0.7	2008
		[0.4]	4.7 [4.7]		[2008]
	55 • • P<75	0.25			
		[0.4]			
75 • P<130		0.2	3.6	0.4	2007
		[0.3]	4.0 [4.0]		[2007]
130• P• 560		0.17	3.6	0.4	2006
		[0.2]	4.0 [4.0]		[2006]
[ ];EU Emission Standards					

Conclusion is that existing legislation concerning emissions from mobile engines does not go further than the options assessed in the ECNI study (2006). Therefore, in a next step, all relevant legislation under development is analysed.

Ongoing discussions to amend Directive 97/68/EC (amended by 2004/26/EC) on Non-Road Mobile Machinery (NRMM)

Also the NRMM Directive was re-examined to be able to identify more stringent measures proposed in that Directive for other non-road mobile machinery. This step is quite straightforward, meaning that the Directive was screened in order to identify more stringent limit values set for non-road mobile machinery, potentially applicable to recreational marine craft engines. Since this Directive is in the progress of being reviewed, the documents already available in the framework of this reviewing process were taken into account, being:

- a presentation on the review of NRMM Directive given by the IES Transport and Air Quality Unit to the European engine emissions experts group (GEME) (17/12/2007)
- all available information on http://ec.europa.eu/enterprise/mechan_equipment/emissions/

Table 3.9Table 3.9 gives an overview of the proposed Stage IIIB standards to be taken up in de review of the NRMM Directive. Table 3.10 gives an overview of the proposed Stage IIIB standards to be taken up in de review of the NRMM Directive. Table 3.11 and Table 3.12 give the EMA-Euromot IIIB and IV Proposal for Harmonised Next Stage Emission Standards, as presented on 14/12/2007 to the GEME. These standards are proposed, taken into account that they should be accompanied by an Averaging, Banking and Trading system (ABT)

Table 3.9: Proposal Stage IIIB (1 January 2012) (IES Transport and Air Quality Unit, European, 17/12/2007)

Category: swept volume/net power (SV/P) (litre per cylinder/kW)	carbon monoxide (CO) (g/kWh)	hydro-carbons (HC) (g/kWh)	nitrogen oxides (NOx) (g/kWh)	particulates (PT) (g/kWh)	Remarks
V1:1: SV < 0.9 and P ≥ 37 W	3.5	1.0	4.0	0.14	
V1:2: 0.9 ≤ SV < 1.2	2.5		4.0	0.12	possibly 1.1.2013
V1:3: 1.2 ≤ SV < 2.5		0.8	4.2	0.11	possibly 1.1.2013
V1:4: 2.5 ≤ SV < 5			4.8	0.11	
V2:1: 5 ≤ SV < 15			5.0	0.14	
V2:2: 15 ≤ SV < 20 and P < 3300 kW			5.2	0.20	possibly 1.1.2013
V2:3, V2:4, V2:5			5.9/6.6	0.20	possibly to be regulated by IMO

Table 3.10: Proposal Stage IV (1 January 2016) for all engines (IES Transport and Air Quality Unit, European, 17/12/2007)

CO [g/kWh]	HC [g/kWh]	NO_x [g/kWh]	PT [g/kWh]
2.5	0.19	0.4	0.025

Table 3.11: EMA-Euromot Stage IIIB Proposal for Harmonised Next Stage Emission Standards (IES Transport and Air Quality Unit, European, 17/12/2007)

Displacement L/Cyl		2011	2012	2013	2014	eng. No	CCNR	Year
<0.9	PM	0.40	0.14				0.14	
(>75kW)	NOx+HC	7.5	5.4			4	4 + 1	2012
	CO		3.5				3.5	
0.9 - <1.2	PM	0.30		0.12			0.12	
	NOx+HC	7.2		5.4		1	4 + 1	2013
	CO			3.5			2.5	
1.2 - <2.5	PM	0.20			0.11		0.11	
	NOx+HC	7.2			5.6	19	4.2 + 0.8	2013
	CO				3.5		2.5	
2.5 - <3.5	PM	0.20		0.11			0.11	
	NOx+HC	7.2		5.6		9	4.8 + 0.8	2012
	CO			3.5			2.5	
3.5 - <7.0	PM	0.20	0.11				0.14	
	NOx+HC	7.2	5.8			81	4.8 + 0.8	2012
	CO		3.5				2.5	
7.0 - <15.0	PM	0.27		0.14			0.14	
	NOx+HC	7.8		6.2		4	5.0 + 0.8	2012
	CO			3.5			2.5	
15.0 - <20.0	PM	0.50			0.34		0.2	
<3300kW	NOx+HC	8.7			7.0		5.2 + 0.8	2013
	CO				3.5		2.5	
15.0 - <20.0	PM	0.50			0.27		0.20	
>3300kW	NOx+HC	9.8			8.7		5.9 + 0.8	
	CO				3.5		2.5	
20.0 - <25.0	PM	0.50			0.27	12	0.2	
	NOx+HC	9.8			9.8		5.9 + 0.8	IMO
	CO				3.5		2.5	
25.0 - <30.0	PM	0.50			0.27		0.2	
	NOx+HC	11.0			11.0		6.6 + 0.8	
	CO				3.5		2.5	

Table 3.12: EMA-Euromot Stage IV Proposal for Harmonised Next Stage Emission Standards (IES Transport and Air Quality Unit, European, 17/12/2007)

Rating	L/Cyl		PM [g/kWh]	NOx [g/kWh]	HC [g/kWh]
600 ≤ kW < 3700 (all below 3300 kW)	all		0.04 (0.025)	1.8 (0.4)	0.19 (0.19)

(in blue the proposed data from CCNR)

CONCLUSION FOR COMPRESSION IGNITION LEGISLATION

- the proposal for NRMM is more stringent than current legislation specifically for recreational craft engines
- Japanese standards are more stringent than the US EPA proposal (earlier implementation of more stringent standards)

3.2.3 Important differences between EU and US/Canadian legislation

A first difference between current EU legislation and US/Canadian legislation is the fact that in current EU legislation for recreational craft engines, emission standards are set for NOx and HC separately, while the emissions standards in the current or proposed US/Canadian legislation are <u>combined standards</u> for NOx+HC.

It is of extreme importance that US/Canada regulations allow <u>corporate averaging</u>, banking and trading to meet the emission standards. The ABT provision is an integral part of the US EPA and CARB compliance programmes. Therefore, even if emission standards are assessed to be feasible in the US and California, these feasibility conclusions cannot be automatically adopted in the current assessment. A general description of the ABT provision is given here.

An important difference with the US EPA standards is the fact that the US EPA considers an ABT (Averaging, Banking and Trading) program for recreational marine engines. This is a voluntary program which would allow a manufacturer to certify one or more engine families at emission levels above the applicable emission standards, provided that the increased emissions are offset by one or more engine families certified below the applicable standards. The average of all emissions for a particular manufacturer's production would have to be at or below the level of the applicable emission standards. In addition, credits could be traded with other companies or banked for future use. ABT would allow us to consider a lower emissions standard, or one that otherwise results in greater emissions reductions, because ABT reduces the cost and improves the technological feasibility and cost effectiveness of achieving a standard. For example, it could help to ensure the attainment of the standards earlier than would otherwise be possible. Manufacturers gain flexibility in product planning and the opportunity for a more cost-effective introduction of product lines meeting a new standard. ABT also creates an incentive for the early introduction of new technology, which allows certain engine families to act as trail blazers for new technology. This can help provide valuable information to manufacturers on the technology before manufacturers need apply the technology throughout their product line. This early introduction of clean technology improves the feasibility of achieving the standards and can provide valuable information for use in other regulatory programs that may benefit from similar technologies. For recreational marine diesel engines, an ABT program would be similar to the one for commercial marine engines. US EPA is concerned that an ABT program may not be appropriate for SI SD/I marine engines for three primary reasons. First, there are many small businesses which produce SI engines for the recreational marine market. There are also very few large businesses producing SI engines for this market. While the large businesses tend to have broad product offerings and could readily take advantage of the provisions of an ABT program, the small businesses tend to have much narrower product lines and would therefore be unlikely to benefit from ABT provisions. A concern is that this situation would allow the large businesses a competitive advantage. Similarly, another concern is that most manufacturers of recreational SI engines do not have a broad enough product line to take advantage of an ABT program. Therefore, it may not be useful to the majority of businesses. Third, the emission control technology discussed above appear to be equally applicable to all engines. Therefore, an ABT program may not be necessary except, perhaps, as a tool to help phase-in new technology. Adopting an ABT program in the long term may make sense if we were to conclude that a more stringent standard is feasible at least for some engines. Figure 3.2 gives a general overview of an ABT system and how it should be applied by manufacturers.

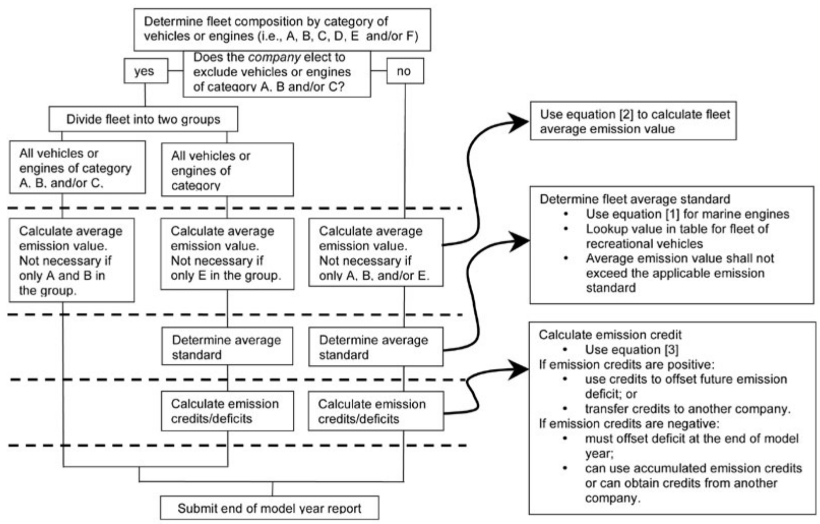


Figure 3.2: Overview of the Averaging, Banking and Trading system (CARB)

Note:

Directive 2004/26/EC, amending the NRMM Directive (97/68/EC) includes provisions for engines placed on the market under a "flexible scheme". As the ABT system, this scheme provides an engine manufacturer some flexibility on how to reach limit values within the targeted period of compliancy in the sense that an engine manufacturer during the period between two successive stages of limit values has the possibility to place a limited number of engines on the market that only comply with the previous stage of emission limit values. The flexible scheme and conditions of application are described in Annex III of Directive 2004/26/EC.

3.2.4 View of industry stakeholders

3.2.4.1 Compression ignition engines

The combined Recreational Marine Diesel Engine Task Force of IMEC (ICOMIA's Marine Engine Committee) and EUROMOT (European Association of Internal Combustion Engine Manufacturers) represent the interests of the majority of recreational marine diesel engine manufacturers in Europe. Their position on future emission requirements, as expressed in desired amendments to limit values in EU Directive 2003/44/EC, is given here. The primary objectives of the recreational marine diesel engine industry are:

- Global alignment for exhaust emission regulations over 37 kW and
- Flexibility provisions for SMEs

Therefore they propose and alignment with current proposals in the US for diesel engines. The proposed emission limits and timing by industry are given in Table 3.13.

Table 3.13: Proposed emission limits and timing for marine diesel engines (Combined industry position – EU stage 2)

			PM in g/kWh	HC+Nox in g/kWh
	disp.<0,9 l/cyl	P<18 kW	RCD stage 1	RCD stage 1
	disp.<0,9 l/cyl	18kW<P<37kW	RCD stage 1	RCD stage 1
2012	disp.<0,9 l/cyl	37W<P<75kW	0,3	7,5
2014 [1]	disp.<0,9 l/cyl	37W<P<75kW	0,3	4,7
2014 [1]	disp.<0,9 l/cyl	37W<P<75kW	0,2	5,8
2012	disp.<0,9 l/cyl	P>75kW	0,15	5,8
2013	0,9 l/cyl < Disp. < 1,2 l/cyl	P>75kW	0,14	5,8
2014	1,2 l/cyl < Disp. < 2,5 l/cyl	P>75kW	0,12	5,8
2013	2,5 l/cyl < Disp. < 3, l/cyl	P>75kW	0,12	5,8
2012	3,5 l/cyl < Disp. < 7,0 l/cyl	P>75kW	0,11	5,8

(1) Engines with 2014 model year, a displacement below 0.9L/cyl and maximum engine power above 19 kW and at or below 75 kW may be certified to either PM 0.3 g/kWh and HC+NOx 4.7 g/kWh or PM 0.2 g/kWh and HC+NOx 5.8 g/kWh.

3.2.4.2 Spark-ignition engines

Industry has long favoured alignment between US and EU Regulations. However SI engine manufacturers believe this must be implemented at a major change in technology. Since the current SI scenarios, in their view, offer little or no overall benefit, they favour remaining with the current Stage 1 USEPA officially published the proposed rule Emission Standards for new non-road Spark-Ignition engines, equipment and vessels as presented in the US EPA note EPA420-F-07-032 of April 2007 (www.epa.gov/otaq/regs/nonroad/marinesi-equipld/420f07032.htm) and described in chapter 3.2.1. In summary, official US EPA emission standards proposed for SI engines are as follows:

Table 3.14: Proposed Emission Standards for SI engines (US EPA, May 2007)

Proposed Outboard/PWC Exhaust Emission Standards [g/kW-hr] for model year 2009		
Pollutant	*Power*	
	P\a\ <= 40 kW	**P\a\ > 40 kW**
HC+NOX	28-0.3 x P	16
CO	500-5.0 x P	300
Proposed Inboard and Sterndrive Exhaust Emission Standards [g/kW-hr] for model year 2009		
Pollutant	*Power*	
	P\a\ <= 373 kW	**P\a\ > 373kW (SD/I high performance engines**
HC+NOX	5	5
CO	75	350

a\ P = maximum engine power in kilowatts (kW)

Above mentioned proposed US EPA emission standards for SI engines are the official, publicly announced figures.

According to ICOMIA and IMEC, the official proposal needs to be replaced by an updated version which is negotiated in the period this study is executed: $HC+NO_X$ and CO exhaust emission standards for outboard and personal watercraft spark-ignition engines and $HC+NO_X$ and CO exhaust emission standards for inboard and sterndrive spark-ignition engines. For SI OB and PWC engines, the official proposed emission standards have been established by US EPA as a simplification of the CARB rules.

Proposed emission standards as provided by personal communication by industry in February 2008 are presented in Table 3.15 for outboard and personal watercraft engines and in Table 3.16 for spark ignition inboards and sterndrives.

Table 3.15: HC+NOx and CO exhaust emission standards for outboard and personal watercraft spark-ignition engines (pers. comm., ICOMIA, IMEC, February 2008)

Emission standards for HC+NOx (g/kW-h)		
	P < 4.3 kW	**P ≥ 4.3 kW**
Cap	81.00	$0.250\ x\left(151+\frac{557}{P^{0.9}}\right)+6.00$
Standards	30	$0.09\ x\left(151+\frac{557}{P^{0.9}}\right)+2.1$
Emission standards for CO (g/kW-h)		
	P ≤ 40 kW	**P > 40 kW**
Cap	$650-5.0\times P$	450
Standards	$500-5.0\times P$	300

Table 3.16: HC+NOx and CO exhaust emission standards for inboard and sterndrive spark-ignition engines (pers. comm., ICOMIA, IMEC, February 2008)

Emission standards for HC+NOx (g/kW-h)			
	P ≤ 373 kW	**373< P ≤ 485 kW**	**P > 485 kW**
Cap	16	16	22
Standards	5	- (1)	- (1)
Emission standards for CO (g/kW-h)			
	P ≤ 373 kW		**P > 373 kW**
Cap	150		350
Standards	75		- (1)

(1) only cap, no averaging

Above mentioned figures on Outboard/PWC SI engines differ with the official US EPA note on proposed emission standards both on emission standards and engine power distribution.

The following concerns were expressed by the European Commission towards this unofficial proposal:

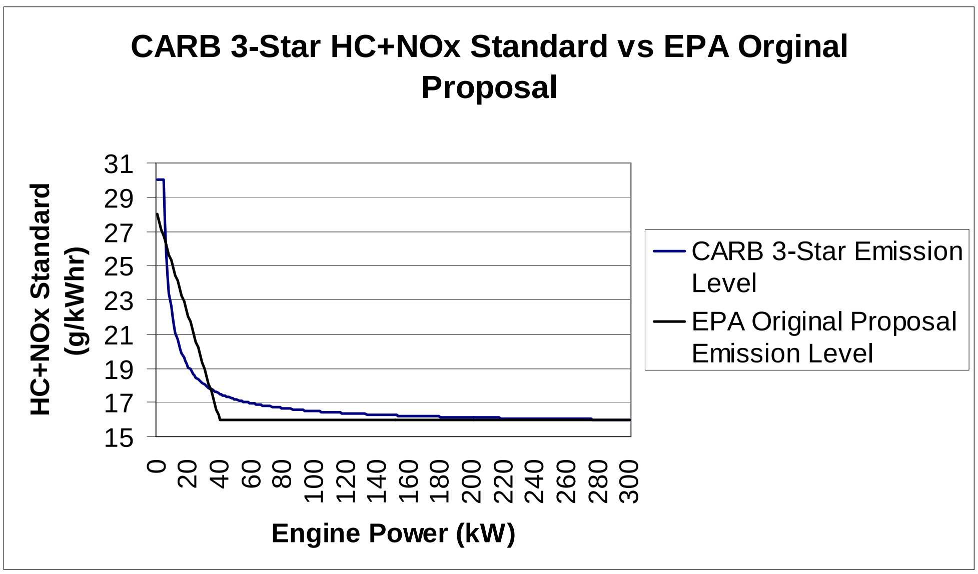
- there have been no signals from US EPA that changes are expected in the content of the official USEPA proposal
- there seems to be a lack of consistency between the HC+NO_X emission standards for outboard and personal watercraft engines on the one hand, which is based on an equation, and on the other hand the emission standards for inboard and sterndrive engines, based on fixed emission limits. In the official USEPA proposal, fixed emission limit values have been specified both for outboard/PWC and inboard/sterndrive engines
- there is a risk that the link is cut between this impact assessment and the former ECNI (2006) impact assessment as well as the USEPA Regulatory Impact Assessment and any previous community legislation preparation work.

Furthermore, in both cases corporate averaging is allowed, which has not been accepted in EU emission legislation so far. Therefore, a flexibility scheme based on the scheme used in the framework of the NRMM Directive (now under review) could be developed as an alternative to the ABT-system.

According to industry however, the officially proposed rule was changed in view of alignment with the Proposed Californian rule for SI inboard/sterndrive marine engine standards (CARB). For inboard and sterndrive engines, catalyst based standards were set. However, it was regarded technically not feasible yet to install catalysts on outboard engines. Therefore, the emission limits have been split up between outboard/PWC and SD/I.

In the figure below, a comparison is given of the emission limits in the USEPA proposal (April 2007) and the calculated values of the negotiated proposal per power band of outboard and PWC engines. The graph shows that below 6 kW, the official USEPA proposal is slightly more stringent. Between 6 kW and 34 kW, the official USEPA proposal is slightly less stringent. For engines above 35 kW, the official USEPA proposal is slightly more stringent, becoming equal for engines above 100 kW.

Figure 3.3: Difference between the CARB 3-Star HC+NOx standard and the USEPA original proposal



Based on these clarifications, the EC accepted the above scenario put forward by industry as a basis for the Impact Assessment.

3.3 SELECTION OF THE BASIC SCENARIOS TO BE ANALYSED IN-DEPTH

To select the final basic scenarios, the following was taken into account:

- Input/remarks by industry on the one hand and concerns from the European Commission on the other hand
- The importance of global harmonization of regulation
- An indication of the technical feasibility of the scenario

Input from industry and concerns from the European Commission were already indicated in the previous chapter. The concept of global harmonization and the technical feasibility are explained in detail below. Finally, in paragraph 0 the selected scenarios for this complementary impact assessment are given.

3.3.1 Importance of harmonisation today

First of all, industry stated that harmonisation is especially important for the CI Sector.

According to industry, the manufacturing cost of engines to meet separate standards for different parts of the world would be reduced if only one standard would be applicable in Europe as well as in the US (or even other parts of the world e.g. Japan, Canada). A harmonisation between US and EU standards is a very important step towards global harmonization as the EU and US markets are most important for marine engines manufacturers. If the EU and US are not able to agree on common set of marine engine exhaust emission standards, it is unlikely that the rest of the world will be able to. Since Europe is the leader in Recreational CI engines there are risks if the home market does not reflect state of the art for both environmental and economical demands.

The fact that costs are reduced by harmonisation of standards might imply that more stringent emission standards can be achieved. The reduction of costs could broaden emission reduction investments, which is beneficial for the environment. This is however a general statement and of course the aim of this impact assessment to examine whether the environmental benefits can be shown.

According to industry, the benefits for companies producing for several markets are also clear, as they do not need to invest in separate research and development efforts for different markets and they are able to realise advantages of scale by producing the same engine for a much larger market. Due to the advantages of scale production costs may drop in relative terms and have an impact in many stages of production:

- One production line,
- More efficient calibration
- Development
- Purchase at reduced rate due to higher quantities
- Although 2 certificates have to be issued the testing procedure is cheaper

Another aspect is the fact that there is a very active second hand market, which means that import from the US will need to comply with EU legislation. Global harmonisation would benefit this situation.

Industry also wants to point out that, while there is much focus on US-EU alignment, internal alignment between EU Directives is equally important. Marinisers automatically benefit from engines, which have been developed from NRMM or Automotive base engines. Therefore gaps left by a less stringent limit can be an invitation to less qualitative imports with higher emissions. New basic engines (automotive or industrial) can be seen as a consequence of the development of the emissions for on road and non-road. Older versions will not stay in production as the marine volumes are too small to justify further lifecycle.

Since Europe is the leader in sectors of Recreational engine Manufacturing (CI) there are risks if the home market does not reflect state of the art. Continuing an obsolete RCD Stage I limit might can lead to fragmentation and result in creating diverse regionally limited regulations (e.g. as seen on Lake Constance) that force manufacturers to comply and thus add development, certification and variant cost. A RCD limit coherent in technical feasibility and stringency being the reference can prevent such tendencies.

3.3.2 Technical feasibility of the scenarios

A next question to be answered is whether it is technically feasible to apply the identified scenario to the full range of recreational marine engine types or whether a division in classes in necessary. This can be translated in: "Which specific measures need to be taken to reduce the emissions to the proposed limit values and are they feasible to the largest range of recreational marine engine types covered by the Directive ?"

The technical feasibility study answered the following questions:

- Which measures need to be taken to reach the required limit values in the scenario, e.g.:
  - Modification of engine types (new engines)
  - End of pipe measures to new engines (e.g. dust filter already implemented in new engines);
- To which type of recreational crafts are these measures applicable?
- What is the share of these crafts types in all existing crafts – is it the largest range?

The technical feasibility of the proposed scenarios is based on the ECNI (2006) study and the impact assessments for proposed regulation by US EPA. The information was checked with industry.

3.3.2.1 For compression ignition engines

Considering the fact that:

- we take forward the industry proposals to submit to an impact assessment,
- this proposal for CI engines closely resembles to the US EPA agreed rule on CI engines less than 30 L/cylinder (40 CFR Parts 9,85, et al. Control of Emissions of Air Pollution From locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder; Final Rule dt. May 6, 2008), and thus leads to global harmonisation;

and comparing the proposed emission limits for CI in the scenario taken forward in this assessment with the emission standards given in the assessment report of 2006 (ECNI), it can be concluded that for engines >37kW:

- For PM, emission standards are less stringent in the options 2, 2A and 2B (0,3-0,4 g/kW-hr) than for the scenario, assessed in this report (0,12-0,3 g/kW-hr);
- For HC+NOx, standards from option 2B (about 7–8,4 g/kW-hr)[12] are less stringent than for the scenario assessed in this report (5,4-5,8 g/kw-hr)

As a first indication and only on a qualitative basis we could assume that, measures that were assessed as needed in the 2006 impact assessment for PM in the scenarios 2, 2A and 2B and for NOx+HC in the scenario 2B, will be needed to comply with the standards, proposed in the current complementary impact assessment. Only the measures indicated as "prime route" in the IA (ECNI, 2006) were taken over here. "*Prime route" measures were considered the best commercial/technical solution to meet the exhaust*

[12] This is a calculated standard for the sum of HC and NOx

emissions requirements. These are assumed to be the technology adopted by the majority of the industry, however some organisations may choose to adopt alternative solutions which better fit their commercial position. The costs for this solution has been included as additional variable costs. Note that the choice of "Prime Route" is influenced by legislative requirements of other major markets such as the USA".

Figure 3.4 gives an overview of the main emission development challenges for CI engines to comply with the standards proposed in options 1, 2, 2A and 2B of the ENCI (2006) study.

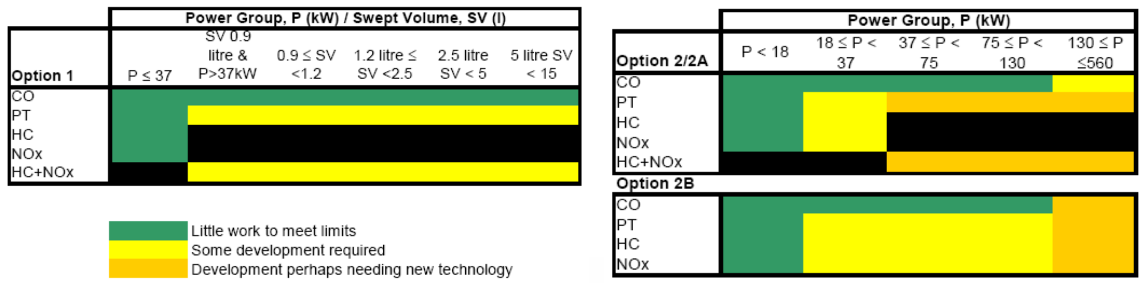


Figure 3.4: Main Emission Development Challenges for CI Engines by Swept Volume for Option 1 (left) and by Power Groupings for Options 2, 2A and 2B (right)

This implies that following measures should be considered here:

- Basic Engine Components: Fuel injectors with VCO nozzles
- Fuel Injection System: Mechanically controlled moderate pressure FIE rotary pump or electronically controlled high pressure FIE
- Added Engine Hardware: Internal EGR or Cooled External EGR

It was indicated in the 2006 assessment that exhaust aftertreatment measures like, oxidation catalyst, SCR Catalyst and diesel particulate filter (DPF) were considered not to be necessary to comply with the propped scenarios.

The following description of possible measures to be implemented to comply these standards are taken over from the Draft Regulatory Impact Analysis (RIA) report from US EPA.

To meet the proposed standards, following technologies could be used (RIA, 2007):

- Incremental improvements to existing engine components:
- Catalytic exhaust treatment technologies for new engines

More detailed information on these techniques is given below.

Incremental improvements to existing engine components

In almost all instances, marine diesel engines are derivative of land based nonroad engines. This implies that the marinisers will benefit from the technologies used to meet the nonroad emission standards. To meet the lower NO_x standards, improvements in fuel system design and engine calibration will be necessary. An example of this is the use of high-pressure, common-rail fuel injection systems or improvements in unit injector design. Such fuel system improvements in conjunction with engine mapping and calibration optimization, will enable manufacturers to meet the proposed standards. For the marine engines derived from nonroad applications, these technologies probably can be applied as early as 2009. Because some marine engines are not as similar to on-highway, nonroad engines, a full implementation of these technologies from marine engines cannot be accomplished until 2012.

As for PM, a combination of fuel injection improvements, plus the use of existing low-oil-consumption piston ring-pack designs and improved closed crankcase ventilation systems will provide significant PM reductions. The use of ultra low sulphur diesel fuel in the marine sector will assist in meeting the proposed standards.

Catalytic exhaust treatment technologies for new engines

The RIA indicates that for marine diesel engines that are either used in recreational vessels or are rated to produce less than 600 kW of power, the proposed emission standards would likely not require the use of catalytic exhaust treatment technologies. Since this should be validated based on stakeholder information, at present, we summarize the possible exhaust treatment technologies to be complete:

- Oxidation catalyst
- SCR catalyst
- Diesel particulate filter

3.3.2.2 For spark ignition engines

In the framework of an impact assessment of a proposed rule on *"Control of Emissions From Nonroad Large Spark Ignition Engines, Recreational Engines (Marine and Land-Based), and Highway Motorcycles*", the US EPA (40 CFR Parts 86, 94, 1048 and 1051 [FRL–6907–6]) indicates that at least three primary technologies could be used by marinisers to reduce emissions from SD/IB engines: (1) electronic fuel injection, (2) exhaust gas recirculation, and (3) two-way or three-way catalysts.

Electronic control gives manufacturers more precise control of the air/fuel ratio in each cylinder thereby giving them greater flexibility in how they calibrate their engines. With the addition of an oxygen sensor, electronics give manufacturers the ability to use closed loop control which is especially valuable when a catalyst is used. Threeway catalysts operate best near stoichiometric conditions in the exhaust. Industry noted that, on average, this technology is expected to reduce emissions by about 20% compared to a carburetted engine, but that catalyst technology is expected to yield higher benefits. (IMEC , 2008). It is also indicated by industry that electronic control is not practical on small OB engines due to significant costs.

Exhaust gas recirculation can be used for meaningful reductions in NO_x. The recirculated gas acts as a diluent in the fuel-air mixture which reduces combustion temperature. These lower temperatures significantly reduce formation rate of NOx, but HC is increased slightly due to lower temperatures for HC burn-up during the late expansion and exhaust strokes. Depending on the burn rate of the engine and the amount of recirculated gases, EGR can improve fuel consumption. Although EGR slows the burn rate (which tends to decrease peak power), it can offset this effect with some benefits for engine efficiency. EGR reduces pumping work since the addition of recirculated gas increases intake pressure. Because the burned gas temperature is decreased, there is less heat loss to the exhaust and cylinder walls. In effect, EGR allows more of the chemical energy in the fuel to be converted to useable work. Most SD/I engines sold to the marine market are primarily designed for automotive use. Marinizers then take the basic engine blocks and adapt them to be better suited for the marine engines. However, EGR has been used as an effective NOx control strategy in automotive applications for more than 20 years. Today's automotive applications use levels of 15–17 percent EGR. Through the use of high swirl, high turbulence combustion chambers, manufacturers could increase the burn rate of the engine. By increasing the burn rate, the amount of EGR could be increased to 20–25 percent. In the US EPA lab, they calibrated a heavy-duty highway gasoline engine for emissions over the ISO E4 marine duty cycle. They achieved a 47 percent reduction in NO_x without significantly changing HC or CO emissions.

It should, however, be noted that for recreational marine purposes exhaust gas recirculation is not practical on small OB engines and that a 3 way catalyst is only applicable to SD and IB engines and not reasonable for OB engines and PWCs. Besides, industry noted applying exhaust gas recirculation on any marine engine would require a complete redesign. Moreover, this technology has never been used, even never really been tested, on marine SI engines (IMEC 2008).

With regard to emissions reductions through catalytic control, US EPA is considering various designs that involve packaging small catalysts in the exhaust manifold with changes in the size of the exhaust manifold. By placing the catalysts here, costs to the manufacturer may be reduced compared to a large catalyst downstream especially when considering the packaging of the system in a boat. Engine manufacturers water jacket the exhaust manifold to meet temperature safety protocol then mix the water into the exhaust to protect the exhaust couplings and muffle noise. By placing the catalyst in the exhaust manifold, it is upstream of where the water and exhaust mix. However, placing the catalyst in the exhaust manifold limits the catalyst size. Using a small catalyst, in turn, limits potential emissions reductions. It is not clear what the potential emission reductions are by a small catalyst placed in or directly adjacent to the exhaust manifold. There have been concerns that aspects of the marine environment could result in unique durability problems for catalysts. The primary aspects that could affect catalyst durability are sustained operation at high load, salt water effects on catalyst efficiency, thermal shock from cold water coming into contact with a hot catalyst, engine vibration, and shock effects in rough water associated with marine applications. Three-way catalysts may be an effective control strategy for gasoline marine engines. Three-way catalysts act as both an oxidation catalyst to reduce HC, CO and as a reduction catalyst to control NOx. They are most effective when coupled with an oxygen sensor and a feedback loop to maintain a stochiometric exhaust mixture. As an alternative, a two-way oxidation catalyst could be used effectively with less precise control of the air fuel ratio in the exhaust.

The US EPA expects manufacturers to meet the standards for sterndrive and inboard engines with three-way catalysts and closed-loop fuel injection. To ensure proper functioning of these emission control systems in use, the US EPA proposes a requirement that engines have a diagnostic system for detecting a failure in the emission control system.

A study on the catalytic reduction of marine sterndrive engine (General Motors 4.3 liter V-6) emissions (Southwest Research Institute and US EPA, 2002), shows that:

- In baseline configuration, the engine produced 16.6 g HC+NO_X/kW-hr, and 111 g CO/kW-hr.
- In closed loop control with catalysts, HC+NOX emissions were reduced by 75 percent to 4.1 g/kW-hr and CO emission were reduced by 36 percent to 70 g/k-hr of CO
- The catalyzed engine operates satisfactorily in on-water operations

It is already mentioned that, according to industry, there is a risk of not aligning the full package of the proposed US EPA emission standards, including the accompanying CO standards, same deadlines of phase in and a mechanism to allow flexibility for the industry as an equivalent to the ABT system. If the full EPA rule is adopted by the EU, a serious relaxation of EU CO standards is required (unless engines have a catalyst -from 2005 and later). Industry stresses that, if CO standards are not raised to the same level of the EPA rule, this would necessitate OB and PWC to introduce catalyst technology which is not technically feasible yet the forthcoming years before 2015. OB and PWC engines are close to the water, lack space and need to be kept from overheating.

In the Californian State Implementation Plan, the preparation of new emission standards for recreational boats is put forward as an action. The new standards would necessitate catalysts on OB and these should be implemented by 2013. Industry points out that, although put forward in the SIP, the feasibility of fitting catalysts to outboard engines has yet to be demonstrated. This was already indicated in the ECNI study.

3.3.2.3 Changes in boat design

In the responses to the questionnaire sent to boat builders, four companies indicated that vessel redesign may be required because of potential engine modifications stemming from the new exhaust emission standards for engines. In the US, the boat sector is given the time to make adaptations by means of a time lag foreseen in the US EPA rule.

The questionnaire was also discussed during a meeting between ECNI and technical managers of boat builders. It seemed that at this stage, without being sure of the changes to the engines, it is hard to give a precise answer on the consequences. Generally speaking, the three most important aspects for boat builders are the engine dimensions, its weight and the price.

Most boats are designed to accept a variety of engines; the choice is given to the customer. In a limited number of cases, boat designs will need to be modified as a result of the scenario. Generally, this situation occurs specifically in case of aftertreatment for large marine engines or for twin engine installations. Aftertreatment systems may increase the dimensions of the engine itself and its total weight. Such physical changes of the engines need be taken into consideration at the design and conception stage of the boat. Communication from engine manufacturers indicated that for sterndrive SI engines, 5 to 6 boat hull) designs would need to be modified. Catalysts on IB SI engines should not imply any problem for boat builders.

The following elements were raised during the ECNI meeting with boat builders:

- Integration or not of the aftertreatment system will have an impact on the engine installation. If not integrated, some special skills are needed at the boatyard to install the new engine and exhaust system.
- Impact on the fuel consumption. As already mentioned, reducing the emission limits (especially for NOx) might lead to increased fuel consumption.
  - For the boat builder, it means that fuel tanks would have to be bigger to offer the same autonomy (but it also requires rethinking the layout of the boat cabins, floors, etc).
  - For the customer, increased fuel consumption is not attractive$µ
  - Average usage of a boat engine is less than 100 hrs/year, which makes the replacement of an engine less "economic" on the financial side
- Impact on the boat design and conception in order to adapt to the new engine models and characteristics (weight and dimensions). This impact will vary between companies, depending whether it is an SME or large company with different production facilities, on the number of models which need be adapted, etc.

3.3.3 Basic scenarios selected for the impact assessment

COMPRESSION IGNITION ENGINES

Regarding the scenarios for compression ignition engines, the USEPA final rule Tier 3 standards for marine diesel C1 recreational and commercial high power density (final rule EPA420-F-08-004, March 2008) is selected (cfr Table 3.7).

SPARK IGNITION ENGINES

The unpublished proposed rule Emission Standards for new non-road Spark-Ignition engines, equipment and vessels as presented in the US EPA note EPA420-F-07-032 of April 2007 (cfr. Table 3.15 for Outboard and Personal WaterCraft spark-ignition engines and Table 3.16 for Inboard and Sterndrive spark-ignition engines).

4 SELECTION OF ADDITIONAL SCENARIOS INCLUDING MITIGATING MEASURES

In the previous chapter the most ambitious – but feasible – scenario has been selected for both CI and SI engines. Industry indicated that a number of companies may find it hard to align with the US EPA based emission standards, including the accompanying CO standards, if not the full US EPA package would be adopted.

Companies placing engines on the US market can make use of ABT which gives them the flexibility to achieve the same absolute level of emission reductions at lower costs. This ABT system can, however, not be part of the regulation ruling the placing on the EU market of engines. The reason for this is that in the EU the individual Members States are responsible for the implementation of environmental regulations and they might not be in favour of a system placing an administrative burden on them. Consequently, inspiration has been sought in an alternative mechanism granting similar flexibilities to the companies but with which experience exists within the EU e.g. the flexibility scheme as it is used in the framework of the Non-Road Mobile Machinery Directive for small volume manufacturers. The combination of the most ambitious scenario with this flexibility scheme will form the basis of other scenarios of which the impact is analysed.

The approach followed in this chapter consists of a literature review of alleviating measures already proposed or applied to small volume manufacturers in EU and US legislation governing engine emissions. Next, the sector has been consulted to provide its opinion on the likely mitigating impact of the alleviating measures identified. The results of this consultation process are analysed and discussed, after which the final scenarios with mitigation measures are assessed in this impact assessment study.

4.1 LITERATURE REVIEW

4.1.1 SMEs and (environmental) regulation[13]

The impact assessments carried out by ECNI, Dti and US EPA clearly reflect that ambitious emission reduction scenarios will in particular place an important burden on small and medium sized engine manufacturers, marinisers as well as boat builders (US EPA, 2007; ECNI, 2006 and Dti, 2004).

Having adopted a new, SME-friendly, approach to law-making, the Commission now systematically screens new EU rules in order to assess the impact they will have on small companies. In order to get the balance right, the Commission is involved in an active dialogue with the people concerned. It consults extensively, most recently with SME Panels – composed of entrepreneurs and operating within the Euro Info Centres network – to allow a proposed policy or law to be tested and evaluated by those it would affect.

In the US the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), generally requires an agency to prepare a regulatory flexibility analysis of any rule unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. The purpose of the RFA is to ensure that small entities have a voice when an agency like USEPA makes policy determinations in shaping its rules on the one hand and to fit regulatory and informational requirements to the scale of the businesses, organizations and governmental jurisdictions subject to the regulation an the other hand.

[13] (USEPA, 2006)

To achieve this goal, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration. The RFA does not require an agency to necessarily minimize a rule's impact on small entities if there are legal, policy, factual or other reasons for not doing so. The RFA only requires that agencies determine, to the extent feasible, the rule's economic impact on small entities, explore regulatory options for reducing any significant economic impact on a substantial number of such entities, and explain their ultimate choice of regulatory approach.

For any rule which is believed to have a significant economic impact on a substantial number of small entities, a regulatory flexibility analysis has to be made, comprising the organisation of a Small Business Advocacy Review Panel (SBAR Panel), for the analysis of the potential adverse economic impacts on small entities and the identification of mitigating measures. In addition to a regulatory flexibility analysis, the agency is required to prepare a small entity compliance guide as well as to provide informal advice in the post-promulgation stage and to review these rules within a certain period after promulgation.

4.1.2 Legislation reviewed

The legislation reviewed for the identification of mitigation measures already proposed or applied to small volume manufacturers in legislation governing engine emissions are:

- Non-Road Mobile Machinery Directive 97/68/EC and amending acts;
- US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels (US EPA (EPA420-F-07-032), Office of Transportation and Air Quality, April 2007);
- US EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel. This rule sets out new emission standards for non-road diesel engines mainly used in construction, agricultural, industrial and mining operations. Consequently, companies will have to go through test procedures and to fulfil information requirements.

A description of this legislation is already given in paragraph 3.2.

4.1.3 Measures proposed and/or installed in EU and US rulemaking

In what follows, we discuss the several flexibilities identified. The discussion will provide a general definition of the measures as wells as a description of the problem they try to tackle.

In the small-business flexibility analysis of the draft regulatory impact analysis of the US EPA proposed regulation concerning emission standards for new non-road spark-ignition engines, equipment and vessels it was argued by the USEPA that a complete exemption from the upcoming standards (assuming that such an exemption could be justified legally) would not be a panacea as it would put small business engine manufacturers at a competitive disadvantage. In the end, the rest of the market would be producing engines that are compliant with these new standards and the equipment producers would only be able to accommodate these compliant engines.

OVERVIEW

Table 4.1: Overview mitigation measures identified in legislation governing engine emissions already proposed or applied to small volume manufacturers

Measures	*Regulation*		
	*EU**	*US**	*US***
Additional lead time	x	x	x
Flexibility scheme for engine or equipment manufacturers	x	x	x
Averaging, banking and trading provisions		x	x
Hardship relief and provisions		x	x
Simplified engine certification for small business equipment manufacturers		x	
Broader definition of engine family		x	
Allow the use of assigned deterioration factors		x	
Production line testing exemption		x	
Simplified test procedures for high performance engines		x	
Adapt Eligibility of small business flexibilities		x	

EU* - Non-road mobile machinery Directive 97/68/EC and amending acts

US* - EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels

US** - EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel

ADDITIONAL LEAD TIME

All regulations reviewed stipulated or proposed, in some way or another, to introduce additional lead time before certain standards take effect for small businesses.

In the framework of Directive 2002/88/EC, amending Directive 97/68/EC concerning emissions of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery, small volume engine manufacturers are granted three more years for getting type-approval of their engine types or families if they fail to meet the imposed requirements concerning emission limit values and the placing on the market of these engines.

A similar provision was elaborated for non-handheld engine manufacturers in the US EPA proposed regulation concerning emission standards for new non-road spark-ignition engines, equipment and vessels. Small volume equipment manufacturers, possibly using these engines in their equipment, would also be granted extra time beyond the implementation dates to continue using non-compliant engines. It has been argued that in case just a portion of the production would be attributed additional lead time, engine manufacturers could sell engines that meet the standards on some product lines while delaying the introduction of emission control technology on more challenging product lines.

Additional lead time for SMEs has also been accorded in the framework of the US EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel. For all power categories small business engine manufacturers may elect to delay compliance with the standard for up to three year for both PM and NOx provided there is a change in the level of existing standards. For engines in the 25-50 hp category small business engine manufacturers must comply with the interim standards for PM on time, and may elect to delay compliance with the 2013 Tier 4 0.02 g/bhp-hr standard requirements for up to three years. For engines in the 50-75 hp category small business engine manufacturers may delay compliance with the 2013 Tier 4 requirement of 0.02 g/bhp-hr PM for up to three years provided that they comply with the interim Tier 4 requirements on time, without the use of credits. Alternatively, a manufacturer may elect to skip the interim standard completely. Manufacturers choosing this option will receive only one additional year for compliance with the 0.02 g/bhp-hr standard.

There are a number of advantages of according additional lead time for complying with certain standards. In the first place this measure gives more time to small volume manufacturers to redesign their products. Second, small enterprises would be able to take advantage of the experiences by other – larger – manufacturers. Third, it helps to limit and spread out the compliance efforts and costs. In the stocktaking study it has been argued that the cost of the introduction of certain abatement technology is decisively dependant on the time available to develop and introduce it (TNO, 2004).

FLEXIBILITY SCHEME FOR ENGINE OR EQUIPMENT MANUFACTURERS

Directive 2004/26/EC of 21 April 2004 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery, amending Directive 97/68/EC concerning emissions of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery introduces a flexibility scheme. Such a flexibility scheme is defined as the procedure by which an engine manufacturer is allowed, on request of an equipment manufacturer and permission being granted by the approval authority, to place on the market, during the period between two successive stages of limit values, a limited number of engines, to be installed in non-road mobile machinery, that only comply with the previous stage of emission limit values.

An equipment manufacturer that wishes to make use of the flexibility scheme shall request permission from any approval authority to purchase a limited number of engines from his engine suppliers that only comply with the previous stage of emission limit values in the period between two emissions stages. The number of engines placed on the market under a flexibility scheme shall, in each engine category, not exceed 20 percent of the equipment manufacturers' annual sales on the EU market of equipment with engines in that engine category. As an alternative the equipment manufacturer may seek permission for his engine suppliers to place on the market a fixed number of engines under the flexibility scheme. The number of engines in each engine category shall not exceed the values in Table 4.2.

Table 4.2 Number of engines in each engine category eligible for the flexibility scheme

Engine category	*Number of engines*
19-37 kW	200
37-75 kW	150
75-130 kW	100
130-560 kW	50

Equipment manufacturers are required to affix a label on the machines, indicating the type approval and one indicating that the engine is placed on the market under the flexibility scheme. Engine manufacturers are required to affix a label on the engines, indicating that the engine is placed on the market under the flexibility scheme.

In the framework of the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels the rule makers proposed to provide small-volume manufacturers of non-handheld equipment with additional flexibilities. In the context of the flexibility programme for small-volume equipment manufacturers the US EPA proposed that small-volume manufacturers may use Phase 2 engines at a level of 200 percent of their average annual production level of Class II equipment over a period of four years beyond the implementation date for the Phase 3 standards. Therefore, small-volume equipment manufacturers could potentially use Phase 2 engines on all their Class II equipment for two years or they might, for example, sell half their Class II equipment with Phase 2 engines for four years. This flexibility scheme completes the two year lead time, beyond the implementation dates for the Phase 3 standards to continue using Phase 2 engines in their Class II equipment, which was already awarded to small-volume equipment manufacturers.

In the US EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel business equipment manufacturers have the opportunity to choose between the following two exemptions or flexibility options:

- manufacturers would be allowed to exempt 700 pieces of equipment over seven years, with one engine family; or,
- manufacturers using the small volume allowance programme could exempt:
    - 525 pieces of equipment over seven years (with a maximum of 150 in any given year) for each of the three power category below 175 horsepower, and
    - 350 pieces of equipment over seven years (with a maximum of 100 in any given year) for the two power categories above 175 horsepower.

The US EPA believes these transition provisions could allow small business equipment manufacturers to postpone any redesign needed on low sales volume or difficult equipment packages, thus saving and/or decreasing the strain on financial resources and – in many cases, limited – engineering personnel. Manufacturers would be able to continue to use their current engine/equipment configuration and avoid out-of-cycle equipment redesign until the allowances are exhausted or the time limit passes.

AVERAGING, BANKING AND TRADING PROVISIONS (ABT PROVISIONS)

US EPA has included averaging, banking, and trading (ABT) programs in almost all of its recent mobile source emissions control programs. Such a program generally applies to all companies covered by the rulemaking. In some cases SMEs have been awarded special ABT provisions. In other cases the SBAR panel has highlighted unfair situations because of larger enterprises benefiting more from ABT programs, putting SMEs at a competitive disadvantage.

Averaging means the exchange of emission credits between engine families within a given engine manufacturer's product line for a specific model year. Engine manufacturers divide their product lines into engine families that are comprised of engines expected to have similar emission characteristics throughout their useful life. Averaging allows a manufacturer to certify one or more engine families at levels above the applicable emission standard, but below a set upper limit. This level then becomes the applicable standard for all of the engines in that engine family, for purposes of certification, in-use testing, and the like. However, the increased emissions must be offset by one or more engine families within that manufacturer's product line that are certified below the same emission standard, such that the average standard from all the manufacturer's engine families, weighted by engine power, regulatory useful life, and production volume, is at or below the level of the emission standard.

Banking means the retention of emission credits by the engine manufacturer for use in future model year averaging or trading.

Trading means the exchange of emission credits between engine manufacturers which can then be used for averaging purposes, banked for future use, or traded to another engine manufacturer.

In the framework of the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels the rule makers incorporated some recommendations of the SBAR Panel in the legislative proposal. The proposed legislation comprises an early banking program in which sterndrive inboard engine manufacturers could earn bonus for certifying early. This program, combined with the additional lead time for small businesses, would give small volume engine manufacturers ample opportunity to bank emission credits prior to the proposed implementation date of the standards. It was believed an early banking program with bonus credits would provide greater incentive for more small business engine manufacturers to introduce advanced technology earlier across the nation than would otherwise occur.

Small businesses, however, expressed concern that the generally proposed ABT system in the framework of the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels could give a competitive advantage to large businesses. Specifically, there was an equity concern that if credits generated by engines below a certain power category could be used for high performance engines, that a large manufacturer could use these credits to meet the high performance engine standards without making any changes to their engines. This concern led US EPA to investigate the desirability of credit trading between high-performance and other marine engines and the impact it could have on small businesses.

Although the SBAR panel recommended small engine manufacturer specific ABT provisions in the framework of the US EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel, it was not believed a different ABT programme would be appropriate for small engine manufacturers. The main conclusion of the US EPA was that small volume manufacturers would particularly need extra time to comply due to cost and personnel constraints.

HARDSHIP RELIEF AND PROVISIONS

In the framework of the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels the US EPA rule makers proposed two hardship programmes: unusual hardship circumstances hardship and economic hardship.

Under the proposed unusual circumstances hardship provision, manufacturers would be able to apply for hardship relief if circumstances outside their control (i.e. a fire at the manufacturing plant or the unforeseen shut down of a supplier with no alternative available) cause the failure to comply and if failure to sell the subject engines or equipment would jeopardize the company's solvency. The terms and time frame of the relief would depend on the specific circumstances of the company and the situation involved. As part of its application for hardship, a company would be required to provide a compliance plan detailing when and how it would achieve compliance with the standards. This hardship provision would be available to all business engine manufacturers, equipment manufacturers, vessel manufacturers, and fuel system component manufacturers, regardless of size.

Under the proposed economic hardship provision, small business manufacturers would be able to petition US EPA for limited additional lead time to comply with the standards. A manufacturer would have to make the case that it has taken all possible business, technical, and economic steps to comply, but the burden of compliance costs would have a significant impact on the company's solvency. Hardship relief could include requirements for interim emission reductions and/or purchase and use of emission credits. The length of the hardship relief would be established during the initial review and would likely need to be reviewed annually thereafter. As part of its application for hardship, a company would be required to provide a compliance plan detailing when and how it would achieve compliance with the standards. This hardship provision would be available only to engine manufacturers, equipment manufacturers, vessel manufacturers, and fuel system component manufacturers that are small businesses.

The US EPA final rule concerning the control of emissions of air pollution from non-road diesel engines and fuel also comprises two types of hardship provisions for small engine manufacturers. First, for the case of a catastrophic event or other extreme unforeseen circumstances beyond the control of the manufacturer that could not have been avoided with reasonable discretion (such as fire, tornado, or supplier not fulfilling contract). Second, for the cases in which a manufacturer has taken all reasonable business, technical, and economic steps to comply but cannot do so. The hardship relief provision could provide lead time for up to 2 years- in addition to the additional lead time small businesses already received. The manufacturer would, however, have to demonstrate to the Agency's satisfaction that failure to sell the noncompliant engines would jeopardize the company's solvency. In this rule hardship provisions have also been adopted for small non road diesel equipment manufacturers and diesel fuel refiners.

SIMPLIFIED ENGINE CERTIFICATION FOR SMALL BUSINESS EQUIPMENT MANUFACTURERS

Generally, it has been engine manufacturers who certify with US EPA for the exhaust emission standards, where the standards are engine standards. However, a number of *equipment* manufacturers, especially those making low volume models, believe it may be necessary for equipment manufacturers to certify their own unique engine/muffler designs with US EPA (but using the same catalyst substrate already used in a muffler certified by the engine manufacturer).

In the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels, a simplified engine certification process for small business equipment manufacturers is proposed for such situations. Under such a simplified certification process, the equipment manufacturer would need to demonstrate that it is using the same catalyst substrate as the approved engine manufacturer's family, provide information on the differences between their engine/exhaust system and the engine/exhaust system certified by the engine manufacturer, and explain why the deterioration data generated by the engine manufacturer would be representative for the equipment manufacturer's configuration.

BROADER DEFINITION OF ENGINE FAMILY

Typically in US EPA engine and equipment programs, manufacturers are able to group their engine lines into engine families for certification to the standards. Engines in a given family must have many similar characteristics including the combustion cycle, cooling system, fuel system, air aspiration, fuel type, aftertreatment design, number of cylinders and cylinder bore sizes. A manufacturer would then only perform emission tests on the engine in that family that would be most likely to exceed an emission standard.

In the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels it has been proposed that small volume engine manufacturers may use a broader definition of engine family for certification purposes. In this way, small volume engine manufacturers are allowed to group all of their small SI engines into a single engine family for certification by engine class and useful life category, subject to good engineering judgment. Similarly small volume sterndrive inboard engine manufacturers are allowed to group all of their high performance engines into a single engine family for certification, subject to good engineering judgment.

ALLOW THE USE OF ASSIGNED DETERIORATION FACTORS

Deterioration factors, which represent the expected deterioration in emissions over an engine's full useful life, need to be determined in order to compare emission levels from the emission data engine with the applicable emission standards.

In the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels it has been stipulated that small volume engine manufacturers may rely on an assigned deterioration factor to demonstrate compliance with the standards rather than doing service accumulation and additional testing to measure deteriorated emission levels at the end of the regulatory useful life (see §1054.240). US EPA intends to analyse emissions deterioration information which becomes available over the next few years to determine what deterioration factors would be appropriate for non-handheld engines. Prior to the implementation date, US EPA would provide guidance to small volume engine manufacturers specifying the levels of the assigned deterioration factors.

This flexibility would relieve concerned manufactures of additional testing to measure deteriorated emission levels at the end of the regulatory useful life.

PRODUCTION LINE TESTING EXEMPTION

Manufacturers are required to test production samples to ensure engines are produced as described in the application for certification. Manufacturers must provide records of this verification to the US EPA upon request.

In US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels is has been stipulated that small-volume engine manufacturers would be exempt from the production-line testing requirements. However, the US EPA believes requiring limited production-line testing could be beneficial to remind manufacturers they have an ongoing obligation to assure production engines are complying with the standards. Therefore, US EPA still requests comment on the alternative of applying limited production-line testing to small volume engine manufacturers with a requirement to test one production engine per year.

SIMPLIFIED TEST PROCEDURES FOR HIGH PERFORMANCE ENGINES

The test procedures provide an objective measurement for establishing whether engines comply with emission standards.

Existing testing requirements include detailed specifications for the calibration and maintenance of testing equipment and tolerances for performing the actual tests. For high performance sterndrive inboard engines it may be difficult to hold the engine at idle or high power within the tolerances currently specified by US EPA in the test procedures. Therefore, the US EPA proposed emission standards for new non-road spark-ignition engines, equipment, and vessels we suggest less restrictive specifications and tolerances, for small businesses testing high performance sterndrive inboard engines, which would allow the use of portable emission measurement equipment. This would facilitate less expensive testing for these small businesses without having a negative effect on the environment.

ADAPT ELIGIBILITY OF SMALL BUSINESS FLEXIBILITIES

Although the European commission adopted a definition of an SME, each rule may define an SME or small entity differently according to the particularities of the sector considered and the vulnerabilities encountered.

4.2 CONSULTATION OF THE SECTOR

In order to develop alternative scenarios that provide the engine manufacturers and marinisers with companies were asked to give their opinion on the likely mitigating impact on SMEs of a number of alleviating measures already proposed or applied to small volume manufacturers in legislation governing engine emissions. The focus, however, was on the potential impact of a flexibility scheme similar to that in place in the NRMM Directive. The idea is that a flexibility scheme could be used as an alternative for the US ABT systems and would therefore apply to all manufacturers and not only to SMEs.

The companies had the opportunity to share their ideas on the likely mitigating impact of various measures by answering the questionnaire. Besides this, mitigation measures were also discussed during the combined IMEC – Euromot task force meeting in the beginning of April as well as during the individual company talks with the companies present at the task force meeting. On the basis of the group sessions and individual contacts, the CI side designed a recreational marine diesel engine task force industry position on stage 2 of the EU RCD.

4.2.1 Marine diesel engine task force industry position

In its industry position paper of 8 April 2008, which can be consulted in ANNEX 1, the recreational marine diesel engine task force explicitly admits that manufacturers exclusively trading on the EU market may have no economic benefit from alignment. As a general rule, these enterprises have a significant amount of their production at the smaller engine size. In order to ensure that these firms remain competitive there is a need to protect them by means of specific provisions such as maintaining current EU RCD stage 1 emission levels for engines below 37kW. Besides this, industry also points out that the timing of the EU legislative process is important to industry. Sensible entry dates are required to allow for a feasible phase in of the requirements by SMEs.

In addition to this, industry developed a proposal of how the flexibility scheme should look like for the SME manufacturers and marinisers of CI engines. To this end, industry decided about certain parameters. Each SME manufacturer of CI engines would be allowed to place a limited number of EU RCD Stage 1 engines on the market; the number of which would not exceed:

- 50% of the manufacturer’s annual sales in a specific base year in each engine category, which can than be spread over a period of seven years[14] or
- a fixed number of engines, as stipulated in Table 4.3 not to be exceeded in each engine category over a period of 7 years from the introduction date.

[14] In the NRMM Directive the number of engines placed on the market under a flexibility scheme shall, in each engine category, not exceed 20% of the OEM's annual sales of equipment with engines in that engine category (calculated as the average of the latest 5 years sales on the EU market). Where an OEM has marketed equipment in the EU for a period of less than 5 years the average will be calculated based on the period for which the OEM has marketed equipment in the EU. As the revision process of the NRMM Directive is looking into replacement of the 20% rule by a higher percentage up till 50%, 50% has been put forward here.

Table 4.3 Fixed number of engines, eligible for exemption under the flexibility scheme, not to be exceeded in each engine category over a period of 7 years from the introduction date

Engine category		*Number of engines*
Disp.<0,9 l/cyl	37kW<P<75kW	500
Disp.< 0,9 l/cyl	P>75 kW	150
0,9 l/cyl <Disp.< 1,2 l/cyl	P>75kW	150
1,2 l/cyl< Disp.< 2,5 l/cyl	P>75kW	100
2,5 l/cyl <Disp.< 3,5 l/cyl	P>75kW	100
3,5 l/cyl <Disp.< 7,0 l/cyl	P>75kW	50

Additionally the CI engine manufacturers feel that it would be valuable if they could simplify emission compliance by allowing the use of assigned deterioration factors as well as an exemption of production line testing. Both measures are expected to significantly lower the administrative burden. Finally, additional lead time ranks also high, as it would allow small companies to spread certification in time. However, additional lead time would not significantly reduce costs but would allow spreading them.

4.2.2 Spark-ignition engine sector

Information on the OB, SI IB and PWC engine manufacturers' position has been gathered through the questionnaire and the individual company talks in the framework of the combined IMEC-Euromot task force meeting.

The companies generally welcomed a flexibility scheme as an alternative to ABT. If properly designed the scheme would allow companies to continue with some smaller volume engines and engines approaching their end of life without either having to drop these engines earlier than planned or having to make disproportioned costs.

One manufacturer of OB engines tried to quantify the flexibility needs of the OB engine manufacturers: per engine family 20% of engine sales should ideally not be required to meet future EU RCD stage 2 standards and this for an unlimited number of engine families. This means that up to 20% of engine sales in Europe would be allowed to only comply with old standards, and more specifically those OB engines which are averaged in the US.

The sole European manufacturer of OB engines, however, indicated a flexibility scheme, even complemented with other flexibilities, would be of little help. The only measure that would really help this company to continue its operations are exemptions. In Annex 2, the agreed IMEC letter is attached proposing that EU SI Outboard engine manufacturers be exempted any new emissions regulations if their sales remain below 5% of the EU total.

4.2.3 General insights gained through stakeholder consultation

In the questionnaire for engine manufacturers and marinisers, SME engine manufacturers were asked to rank the alleviating measures already proposed or applied to small volume manufacturers in legislation governing engine emissions from "likely to have the highest mitigating impact" to "likely to have the lowest mitigating impact". Besides this, SMEs were also asked to score the mitigating impact of the different measures on technical as well as administrative costs. Several non-SME engine manufacturers also expressed their opinion on the likely mitigating impact of the different measures. In total 7 SMEs and

5 larger companies replied to this part of the ranking and scoring exercise in the questionnaire. The answers on the flexibility scheme need to be interpret in the light of the industry proposals, both from the CI and SI side, on the design of the scheme as presented above.

Looking at the average rank respondents attributed to the various mitigating measures (see Table 4.4) it strikes that manufacturers do not have a clear preference for many measures. The flexibility scheme is the most preferred both by the entire sample and the sample with only SMEs. Four companies ranked the flexibility scheme to be very likely to have the highest mitigating impact and 2 others ranked it as their second best measure, among them 4 SMEs. Besides the flexibility scheme, the exemption of production line requirements and additional lead time are also perceived as important measures. The latter measure is especially valued by SMEs who stated they would otherwise have difficulties to have all their engines certified on time.

Table 4.4 Results ranking exercise of possible mitigation measures

Measures	*Average rank of the respondents having answered to this section of the questionnaire**	
	All	*SMEs only*
Additional lead time	5.1	4.4
Flexibility scheme for engine and/or equipment manufacturers	3.8	4.0
Averaging, banking and trading provisions	5.5	5.3
Hardship relief and provisions	5.9	6.0
Simplified engine certification for small business equipment manufacturers	5.5	5.0
Broader definition of engine family	5.1	4.7
Allow the use of assigned deterioration factors	4.8	5.6
Production line testing exemption	4.0	4.6
Simplified test procedures for high performance engines	5.0	6.4

* (1 = highest and 10 lowest mitigating impact)

The benefits of the **flexibility scheme** are multiple. First, flexibilities are regarded as an aid to keep on producing small volume engines for which adaptation would be particularly costly or engines which approach the end of their life cycle. According to one US based company, for 15 to 20% of the companies a flexibility scheme is indispensable since they would not be able to comply because of the high compliance costs.

Some - especially larger - companies either active on the CI and on the SI market state that they expect to be able to comply without making us of the flexibility scheme. However, they stress that the flexibility scheme would allow them to cope with unforeseen situations. Companies see it as a way to bridge sudden problems with the supply of base engines and/or components by their suppliers, unintentional delays in production lines, etc. Two large US based manufacturers of SI IB engines were confronted with supply problems. Their automotive base engine manufacturer unilaterally decided to stop production of one of the engines they marinise and this on a very short notice. This illustrates the difficult position the marine sector is in because of its limited economic importance. For the future such situations can not be ruled out and may give rise to important difficulties for which flexibilities prove helpful.

In case SMEs would not be allowed additional lead time, they will have problems to have all of their engines certified on time. Assuming an SME would not be able to benefit from a flexibility scheme it may have to discontinue certain engines for a certain period, as the administrative work is costly and SMEs often do not have enough manpower to speed up certification. In a situation without lead time and flexibilities an SME may at least temporarily loose market share as certain engines cannot be sold. On average an SME can only have about 2 engine families tested a year. Many SME CI engine manufacturers or marinisers would be in this situation.

Flexibilities offer a reasonable way out in each of the situations referred to above. Besides a tool for simply limiting the risk of non-compliance a flexibility scheme would also be beneficial for limiting the risks of non-compliance to the image of the industry.

Another argument in favour of flexibilities is the fact that the ability to keep alive mechanical fuel injection engines will help European SMEs to remain competitive in price compared to big American engine manufacturers benefiting from a favourable currency exchange rate. If the small European boat builders can save money on their engine supply, this will also be a factor to help them to stay competitive against US imported boats. It has been pointed out that a good RCD emission strategy regarding the practical elaboration of the flexibilities may favour EU based operations and companies.

As already mentioned **additional lead time** would allow smaller SMEs to spread their certification rather than having to fund and administer certification and related testing for multiple families at the same time. It thereby avoids having high compliance costs concentrated over a very short period. A split and a better scheduling of investments over time will be allowed. One of the larger European marinisers indicated that if 3 years additional lead time could be attributed to SMEs, this would allow CI engine manufacturers and marinisers to avoid investments on products coming close to their end of life and would allow to keep them alive until the new common rail products are ready.

Certain companies indicated that they actively try to limit the number of engine families they place on the market by grouping engines as much as possible. Allow for more a **broader engine definition** and thus flexibility for what concerns the grouping of engines would be a great help to certain SME manufactures. This would necessitate tight control but would save considerable cost and time whenever an existing family could be grouped with another. A larger EU based SME mariniser of CI engines indicated that in case 2 engine families could be merged into 1 family this would lead to a reduction of one seventh of its homologation costs.

One of the problems SME engine producers have found is actually determining deterioration factors. If the **use of assigned deteriorating factors** were adopted it could be beneficial as it would imply a significant saving in endurance test costs. According to a large SI IB manufacturer this however is only helpful to certain market segments (e.g. high performance engines) and for small scale marinisers.

The same applies to **production line testing exemptions** which would be a valuable support for small unit producers. An agreement could be reached that a company is not required to do the testing as long as onboard diagnostics guarantee the same results.

Hardship relief might be useful but it is very likely that this will be only helpful under unfortunate circumstances. Considering possible supply problems with base engines hardship relief, which may be attributed under the form of temporary exemptions, may be especially valuable to marinisers buying engines from other markets.

The mitigation measures considered tackling the impacts of the proposed emission standards on companies' operations in different ways. Although the net effect of mitigation measures should be positive, its potential cost reducing effects may be (partly) wiped out by potentially more stringent administrative requirements. Table 4.5 comprises an overview of the scores the respondents to the questionnaire gave to the possible impact of measures on technical and administrative costs. On the basis of the scoring exercise the manufacturers indicated that technical costs are reduced the most through additional lead time and production line testing exception. The flexibility scheme has not been put forward as an important measure for mitigating technical costs, especially among SMEs, which does not correspond with the observations based on the ranking exercise. The scoring of the mitigation measures' likely impact on administrative costs is more in line with what could be reasonable expected. Companies, and especially SMEs, believe that the flexibility scheme, the ABT system, hardship relief, and simplified test procedures for high performance engines would add to an important extent to the administrative burden of a company.

Table 4.5 Results of the scoring exercise of possible mitigating impact of measures on technical and administrative costs related to emission standards

Measures	*Average score of the respondents having answered to this section of the questionnaire**			
	Technical costs		*Administrative costs*	
	All	*SMEs only*	*All*	*SMEs only*
Additional lead time	2.6	2.7	1.8	2.3
Flexibility scheme for engine and/or equipment manufacturers	2.3	1.9	1.7	1.3
Averaging, banking and trading provisions	2.0	1.9	2.0	1.4
Hardship relief and provisions	1.5	1.3	1.1	1.0
Simplified engine certification for small business equipment manufacturers	1.6	1.7	1.1	1.3
Broader definition of engine family	2.1	2.4	1.8	2.1
Allow the use of assigned deterioration factors	2.3	1.7	2.0	1.9
Production line testing exemption	2.8	2.4	3.1	2.7
Simplified test procedures for high performance engines	2.0	1.5	1.7	1.0

* (4= highest and 0 = lowest mitigating impact on technical or administrative costs)

Three major CI engine marinisers, active on both the US and the EU market, explicitly indicated they never used **ABT** because of the important administrative costs involved. The companies fear the additional administration this measure would bring and expect this would undue its potential advantages. Communication with US authorities has proved very difficult and time-consuming. The use of the ABT system is complicated as IB engines are built into boats that can end up anywhere in the world which makes it difficult to trace them. This has also been a key reason for a larger IB manufacturer not to make use of ABT.

Because of their reluctance towards the use of ABT, a **flexibility scheme**, being the EU alternative to ABT, is also regarded with certain scepsis. It is clear that the use of a flexibility scheme would require some administration work. Companies state the flexibility scheme should be designed in a way that it does not place too much of a burden on companies wanting to make use of it.

Although the **grouping of engine families** is welcomed by SME engine manufacturers, one company believes doing so would necessitate tight control and therefore would bring an extra burden. The mitigation measure is, however, expected to yield positive benefits. The selection of engine families can be done on the basis of good engineering judgement which would imply a specific approval process in order to avoid any future contesting.

Hardship relief will require a company to document the particular situation it is in and prove how certain provisions can help the company to get a way out of that situation. Providing proof of the particularity of the situation and the effectiveness of certain provisions for tackling the unforeseen challenges is often very hard and certainly a time consuming task. The competent administrations, having to judge about the issue, will certainly have a tough job with scanning, tracing the validity of the arguments and taking a decision.

4.3 SCENARIOS WITH FLEXIBILITIES SELECTED FOR THE IMPACT ASSESSMENT

In the previous chapter the most ambitious – but feasible – scenario has been selected for both CI and SI engines. This is the basic scenario and will be referred to as the 'C1 + S1' scenario, being the proposed EU RCD stage 2 exhaust emission standards without a flexibility scheme.

Besides the basic C1 + S1 scenario, three scenarios with flexibilities were selected:

- Scenario C2a + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies;
- Scenario C2b + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies and additionally EU RCD stage 1 standards for all CI engines < 37 kW placed on the EU market;
- Scenario C2c + S2, being the proposed EU RCD stage 2 exhaust emission standards with flexibility scheme for all companies and additionally EU RCD stage 1 standards for CI engines < 37 kW placed on the EU market by SMEs.

The flexibility scheme referred to in the above scenarios corresponds to the industry position for what concerns the CI side (see Annex 1). This means that companies are allowed to place on the market a number of engines only complying with EU RCD stage 1 standards. This number may, over a period of seven years from the date the new standards come into effect, not exceed 50% of the company's annual sales value of engines in a predetermined year or the fixed number of engines as specified in Table 4.3. The former was used for the environmental and socio-economic impact assessment.

For the SI side companies, there was no agreed industry position and decisions to use flexibility schemes varied between individual companies. During the stakeholder consultation it became clear which manufacturers would or would not use the flexibility scheme. The environmental and socio-economic impact assessment used these individual cases for calculating impacts.

Table 4.6 provides an overview of the maximum flexibility in the various scenarios. This, however, is only a theoretical situation. During the stakeholder consultation a number of manufacturers indicated that they would not use the flexibility scheme and provided compliance costs accordingly. In order to ensure consistency between the socio-economic and environmental impact assessment, this real situation will also be conducted taking into account the companies' position towards the potential use of flexibilities. By doing so, the percentage of OB engines, CI engines and PWCs that would only comply with EU RCD stage 1 exhaust emission standards is reduced to 5%, 19.8% and 0% respectively for the three scenarios with flexibilities.

Table 4.6 Overview of the share of companies in Stage 1 and Stage 2 with companies making maximum use of the flexibilities in the different scenarios

Scenario	CI IB*						OB		SI IB		PWC	
	< 37 kW**				> 37 kW							
	SME		non-SME		Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
	Stage I	Stage II	Stage I	Stage II								
C1 + S1	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%
C2a + S2	7%	93%	7%	93%	7%	93%	20%	80%	20%	80%	20%	80%
C2b + S2	100%	0%	100%	0%	7%	93%	20%	80%	20%	80%	20%	80%
C2c + S2	100%	0%	7%	93%	7%	93%	20%	80%	20%	80%	20%	80%

* For the calculation of the approximate maximal number of CI IB engines that can be placed on the EU market under a flexibility scheme (and consequently only need to meet the EU RCD stage 1 standards) it has been assumed that all companies would make use of the 50% of annual sales rule and equally spread the number of engines over a period of seven years.

** Under 37 kW about 56% of the engines is placed on the EU market by a SME.

The following Table gives an overview of the approximate maximum number of engines that could be placed on the EU market which does not comply with the proposed EU RCD stage 2 exhaust emissions standards.

Table 4.7 Maximum annual number of engines that could be placed on the EU market under EU RCD Stage 1 exhaust emission standards in the different scenarios

Scenario	*CI**		*OB*		*SI IB*		*PWC*	
	Stage I	*Stage II*	*Stage I*	*Stage II*	*Stage I*	*Stage II*	*Stage I*	*Stage II*
C1 + S1	0	40,000	0	210,829	0	10,182	0	9,038
C2a + S2	2,857	37,143	42,166	168,663	2,036	8,146	1,808	7,230
C2b + S2	23,286	16,714	42,166	168,663	2,036	8,146	1,808	7,230
C2c + S2	13,606	26,394	42,166	168,663	2,036	8,146	1,808	7,230

* For the calculation of the approximate maximum number of CI engines that can be placed on the EU market under a flexibility scheme (and consequently only needs to meet the EU RCD stage 1 standards) it has been assumed that all companies would make use of the 50% of annual sales rule and equally spread the number of engines over a period of seven years.

5 ENVIRONMENTAL IMPACT ANALYSIS

The focus of the environmental impact analysis is on the impact of the selected scenarios to the emissions of recreational craft engines and the resulting impact on the ambient air concentrations of certain pollutants. The most relevant pollutants are therefore nitrogen dioxides (NO_x), carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM). The environmental impact is assessed as follows:

- Estimate of the emission reduction potential of the scenario for the mentioned pollutants;
- Estimate of the change in ambient air concentrations due to the implementation of the selected scenario through air distribution modelling.

Since in a next step of the study, the impacts need to be compared with the assessments in the impact assessment study carried out by ECNI (2006), the methodology for emission and emission reduction estimation is taken over from that study. Adjusted emission factors (g/kWh), representative for the selected scenario are used as input for the emission calculation and ambient air concentration modelling. The two steps in the environmental impact assessment are worked out in more detail in the following chapters.

5.1 EMISSION REDUCTION POTENTIAL

As already indicated, to assess the current environmental impact of the defined scenario, the emissions of HC, CO, NO_X and PT into the following receiving environments are calculated:

- lake marina;
- coastal marina area;
- Linear waterway (river or canal).

Emissions are calculated per engine type (SI and CI) and per engine power range. Emissions for a parameter A are calculated based on following general formula:

$$\text{Emission of A} = \sum_{t,p} (\text{Emission factor for A (in g/kWh)} \times \text{Engine Power (kW)} \times \text{engine power used (\%)} \times \text{hours of operation (h)})$$

where A = parameter (NO_X, HC, PT, CO)
t = the engine type (SI or CI)
p = the power range (<3kW; 3-6 kW; 6-20 kW; ...)

To be able to estimate total emissions, defining a representative fleet of recreational crafts for each environment, is necessary. This representative fleet is taken over from ECNI (2006). Fleets are characterised by:

- size of fleet
- size of type of craft present
- engine types and powers present
- usage profiles of engines

All this information is taken over from the ECNI (2006) study. Note that for each scenario, a “worst-case” fleet size was modelled. Engine power was chosen as the median of the range, e.g. in the range 3-6 kW the engine power was set at 4.5 kW. The percentage of the engine power used was taken over from ECNI (2006), being 20.7% for SI and 34% for CI. Also the hours of operation are taken over.

An important issue in the ECNI emission calculations, is the fact that it was assumed that engines on sale today which exceeded any maximum limit allowed under the options would be modified to give sales weighted emissions which were equal to the limit value. Where sales weighted emissions of engines on sale today were within the limit values of the option then the current values for emissions were used.

The scenarios to be assessed are described in detail in chapter 3 and 4. However, to have an idea of the impact of not using measured emission rates, in the following chapter, some extra scenarios are defined.

5.1.1 Impact without flexibilities

Since an environmental impact of the chosen scenario needs to be calculated, the emission factors to be used in the formula need to reflect the emission standards as shown in Table 3.7 for Compression Ignition engines and Table 3.15 and Table 3.16 for Spark Ignition engines. Proposed emission standards are not defined in the ranges as the ranges for which data on fleet, hours of operation etc… are available. Therefore, emission rates (EF) per power range are defined as the emission rate, calculated with the median engine power within each engine range. An overview of the used emission factors per type of engine and power range is given in Table 5.1. As a comparison, the emission factors used in the ECNI (2006) study to calculate emissions for the Reference Stage 1 scenario, as well as the measured emission rates are also shown in the Table below.

Table 5.1 Overview of the assumed emission factors per power range (kW) for Stage 1 (reference scenario)[(1)] and Stage II (C1S1 scenario) and the measured data (ECNI, 2006)

	SI Emissions (g/kWh)							
		<3kW	3kW - 6kW	6kW - 20kW	20kW - 30kW	30kW - 75kW	75kW - 150kW	>150kW
CO	Measured	346.4	265.8	335.0	211.5	132.3	125.4	109.3
	Stage I	450.0	283.3	196.2	174.0	161.4	155.3	153.3
	Stage II	490.0	477.5	435.0	375.0	300.0	300.0	300.0
		<3kW	3kW - 6kW	6kW - 20kW	20kW - 30kW	30kW - 75kW	75kW - 150kW	>150kW
HC+NOx	Measured	125.8	126.5	160.9	66.9	29.4	23.4	12.3
	Stage I	70.9	50.9	42.4	35.8	30.4	28.7	30.5
	Stage II	30.0	28.6	20.7	18.5	17.1	16.4	16.2
		<3kW	3kW - 6kW	6kW - 20kW	20kW - 30kW	30kW - 75kW	75kW - 150kW	>150kW
		2.0	4.5	13.0	25.0	52.5	112.5	180.0
PM	Measured	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stage I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Stage II	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	CI Emissions (g/kWh)							PWC Emissions (g/kWh)
		<18kW	18kW - <37kW	37kW - <56kW	56kW - <75kW	75kW - <130kW	130kW - 560kW	75-150kW
CO	Measured	0.0	3.3	2.7	1.4	1.6	1.4	113.6
	Stage I	5.0	5.0	5.0	5.0	5.0	5.0	155.3
	Stage II	5.0	5.0	5.0	5.0	5.0	5.0	155.3
		<18kW	18kW - <37kW	37kW - <56kW	56kW - <75kW	75kW - <130kW	130kW - 560kW	75-150kW
HC+NOx	Measured	0.0	8.5	5.3	8.7	7.9	7.4	15.5
	Stage I	12.0	11.7	11.6	11.5	11.5	11.4	25.6
	Stage II	7.5	7.5	7.5	7.5	5.8	5.8	14.0
		<18kW	18kW - <37kW	37kW - <56kW	56kW - <75kW	75kW - <130kW	130kW - 560kW	75-150kW
		9.0	27.5	46.5	65.5	102.5	345.0	112.5
PM	Measured	0.0	0.1	0.3	0.2	0.4	0.3	0.0
	Stage I	1.0	1.0	1.0	1.0	1.0	1.0	0.0
	Stage II	0.4	0.3	0.3	0.3	0.1	0.1	0.0

(1) these data are those used to calculate emissions for the Reference Stage 1 scenario in ECNI (2006)

Table 5.1 shows that for PT, Stage II emission rates are lower than Stage I emission rates for all engine power ranges. Measured PT emission rates seem to be lower however than Stage I and Stage II emission rates, except for CI engines between 75kW and 560 kW. For HC+NOX, standards in the new proposal are lower for all power ranges. Measured CO rates of CI engines are lower than Stage I and Stage II standards. Only for SI engines between 20-30kW, CO Stage I standards are lower than measured rates.

The scenarios which are examined here were described in chapters 3 and 4. As already indicated, for the environmental impact however, an extra conservative scenario is added as an alternative for the scenario's already indicated. The following bullet points explain the reason for adding those conservative scenarios:

- To guarantee comparability with the ECNI (2006) results, the scenarios examined in the underlying study also take into account the measured emission rates and use these wherever they are below the standards;
- For PM and CO, measured emission rates often seem lower than the standards, meaning that no differences in scenarios can be found due to the fact that in all scenarios the same emission rates are used.
- The conservative scenarios only take into account standards and no measured emission rates, showing the real effect of the standards.

These conservative scenarios are indicated with "cons" as subscript. Conservative scenarios are worked out for the basis scenario C1S1 ($C1S1_{cons}$) and for the flexibility scenario with most flexibility and thus highest emissions C2bS2 ($C2bS2_{cons}$).

Combining all described parameters in the abovementioned formula, results in total emissions for the three receiving environments: lake marina, coast marina and inland waterways. The total emissions for the scenarios selected in this complementary impact assessment (C1S1 and $C1S1_{cons}$) and the reference Stage 1 scenario are shown in Table 5.2. These results only show the 'medium' usage profiles. In the ECNI study, emissions were modelled under conditions of 'high', 'medium' and 'low' usage in order to account for possible inaccuracies in usage data. Since we are looking for the difference in environmental impact between the reference and new scenario, limiting the modelling to one usage profile was deemed to be sufficient to draw conclusions for the environmental impact.

Table 5.2 Overview of the emissions for NO_X+HC, PT and CO in the reference Stage 1 scenario and the new proposed scenarios C1S1 and $C1S1_{cons}$

	Emissions in tons/year		
	HC+NOx	**PT**	**CO**
Lake Marina			
Reference scenario (Stage I)	8.97 - 10.83	0.12 - 0.18	27.99 - 42.98
C1S1 (Stage II)	6.80 - 8.03	0.06 - 0.10	30.30 - 46.72
$C1S1_{cons}$	7.15 - 8.33	0.07 - 0.12	56.77 - 90.57
Coast Marina			
Reference scenario (Stage I)	23.65 - 28.93	0.21 - 0.36	95.34 - 132.66
C1S1 (Stage II)	17.36 - 20.84	0.10 - 0.18	104.37 - 146.64
$C1S1_{cons}$	18.16 - 21.44	0.12 - 0.23	198.81 - 282.55
Inland waterways			
Reference scenario (Stage I)	0.57 - 0.58	0.0006 - 0.0008	3.12
C1S1 (Stage II)	0.36 - 0.37	0.0006 - 0.0008	4.35 - 4.36
$C1S1_{cons}$	0.36 - 0.37	0.0014 - 0.0017	6.79

Table 5.2 shows that the proposed C1S1 scenario will lead to a reduction of emissions for NO_X+HC and PT and an increase in CO emissions and that for all three receiving environments. As indicated already, the conservative scenario ($C1S1_{cons}$) leads to higher emissions (and lower emission reductions) since only legal standards are taken into account and no measured emission rates are taken forward as emission rates in this additional conservative scenario.

5.1.2 Impact with flexibilities

The results of the emissions per receiving environment for the scenarios, where flexibilities are allowed, are shown in Table 5.3.

Table 5.3 Overview of emissions for HC+NOx, PT and CO for scenario's with flexibilities compared to RCD Stage 1

	Emissions in tons/year		
	HC+NOx	**PT**	**CO**
Lake Marina			
Reference scenario (Stage I)	8.97 - 10.83	0.12 - 0.18	27.99 - 42.98
C1S1 (Stage II)	6.80 - 8.03	0.06 - 0.10	30.30 - 46.72
C2aS2	7.10 - 8.37	0.09 - 0.13	30.30 - 46.72
C2bS2	7.13 - 8.39	0.09 - 0.13	30.30 - 46.72
C2cS2	7.13 - 8.39	0.09 - 0.13	30.30 - 46.72
$C1S1_{cons}$	7.15 - 8.33	0.07 - 0.12	56.77 - 90.57
$C2bS2_{cons}$	7.79 - 8.68	0.13 - 0.22	55.56 - 88.73
Coast Marina			
Reference scenario (Stage I)	23.65 - 28.93	0.21 - 0.36	95.34 - 132.66
C1S1 (Stage II)	17.36 - 20.84	0.10 - 0.18	104.37 - 146.64
C2aS2	18.04 - 21.67	0.13 - 0.23	104.37 - 146.64
C2bS2	18.12 - 21.72	0.18 - 0.37	104.37 - 146.64
C2cS2	18.12 - 21.72	0.18 - 0.37	104.37 - 146.64
$C1S1_{cons}$	18.16 - 21.44	0.12 - 0.23	198.81 - 282.55
$C2bS2_{cons}$	19.59 - 22.73	0.20 - 0.43	194.85 - 276.55
Inland waterways			
Reference scenario (Stage I)	0.57 - 0.58	0.0006 - 0.0008	3.12
C1S1 (Stage II)	0.36 - 0.37	0.0046 - 0.0055	4.35 - 4.36
C2aS2	0.38 - 0.39	0.0006 - 0.0008	4.35 - 4.36
C2bS2	0.38 - 0.39	0.0006 - 0.0008	4.35 - 4.36
C2cS2	0.38 - 0.39	0.0006 - 0.0008	4.35 - 4.36
$C1S1_{cons}$	0.36	0.0014 - 0.0017	6.79
$C2bS2_{cons}$	0.40 - 0.41	0.0046 - 0.0055	6.60 - 6.61

The data, shown in Table 5.3 need some clarification:

- PT emissions remain the same for the three basic flexibility scenarios since measured PT emission rates are lower than standards for the <37kW engines
- CO emissions remain the same for the basic scenario C1S1 and the three basic flexibility scenarios: since measured emission rates are lower than the standards set for CO, it are always the measured emission rates C2aS2, C2bS2 and C2cS2; emissions for the conservative flexibility scenarios differ from the basic flexibility scenarios due to the fact that the measured data are not taken into account and are lower than the standards. The fact that emissions for all three basic flexibility scenarios at the one hand and all three conservative flexibility scenarios on the other hand do not differ, is due to the fact fact that these 3 scenarios only differ for CI engines, where EF remain the same in Stage I and Stage II

Table 5.3 shows that the C1S1 scenario in most cases has a positive impact on the emissions, except for CO emissions. Emission reductions are more comparable when expressed in percentage reduction compared to the Reference Stage I scenario, as shown in Table 5.4.

Table 5.4 Overview of the change in emissions for HC+NOx, PT and CO for the different scenario's with flexibilities compared to RCD Stage 1

	Average reduction (in % compared to Ref scenario (Stage I))		
	HC+NOx	**PT**	**CO**
	Total	Total	Total
Lake Marina			
Reference scenario (Stage I)	-	-	-
C1S1 (Stage II)	25	46	-9
C2aS2	22	29	-9
C2bS2	22	29	-9
C2cS2	22	29	-9
$C1S1_{cons}$	22	33	-107
$C2bS2_{cons}$	16	-18	-103
Coast Marina			
Reference scenario (Stage I)	-	-	-
C1S1 (Stage II)	27	45	-10
C2aS2	24	28	-10
C2bS2	24	28	-10
C2cS2	24	-8	-10
$C1S1_{cons}$	25	29	-23
$C2bS2_{cons}$	19	-8	-106
Inland waterways			
Reference scenario (Stage I)	-	-	-
C1S1 (Stage II)	37	0	-40
C2aS2	34	0	-40
C2bS2	33	0	-40
C2cS2	33	0	-40
$C1S1_{cons}$	36	-130	-118
$C2bS2_{cons}$	30	-653	-112

Table 5.4 shows that:

- Emission reductions in the basic scenario (C1S1) are most important , which is an obvious result of the permission of higher emission standard in the flexibility schemes, resulting in higher emissions for the flexibility schemes;
- The conservative scenarios result in lower emission reductions, since lower measured data are not taken into account here;
- The conservative scenario, allowing the highest flexibility ($C2bS2_{cons}$) even result in higher PT emissions than in Stage I;
- The fact that CO emissions increase is a direct result from the higher emission standards for CO for SI engines in Stage II;
- The extreme high emission reductions for PM for $C1S1_{cons}$ and $C2bS2_{cons}$ are simply due to the fact that for the inland waterway only 6-30 kW SI and <19-37kW CI engines are taken into

account that that emission rates for these engines are in the mentioned scenarios 3 to 10 times higher than in the reference.

5.1.3 Total emission reductions

To estimate total emission reductions for HC+NOx, PT and CO, the reduction percentages as shown in Table 5.4 for the different scenarios, are applied to the total emissions for the Reference Stage I scenario as reported in ECNI (2006). The following Table gives an overview of total emissions for the different scenarios as well as total emission reductions.

Table 5.5 Overview of the change in total emissions for HC+NOx, PT and CO for the different scenario's compared to RCD Stage 1

	HC+NOx (tons/year)		PT (tons/year)		CO (tons/year)	
	Emissions	Emission reduction	Emissions	Emission reduction	Emissions	Emission reduction
Reference scenario (Stage I)	40907		539		153142	
C1S1 (Stage II)	30061	10846	296	243	172850	-19708
C2aS2	30074	10833	387	152	172850	-19708
C2bS2/C2cS2	31105	9802	387	152	184634	-31492

To be able to estimate the impact of the different scenarios on CI and SI engines separately, total emissions for CI and SI engines were estimated. The result is shown in Table 5.6.

Table 5.6 Estimation of the change in total emissions for HC+NOx, PT and CO, shown separately for CI and SI engines

	Stage I Reference	C1S1		C2bS2	
	Emissions (tons)	Emission reduction (%)	Emission reduction (tons)	Emission reduction (%)	Emission reduction (tons)
CI					
HC+NOx	15149	19%	2857	14%	2103
PT	539	45%	243	28%	152
CO	3726	0%	0	0%	0
SI					
HC+NOx	25758	34%	8792	31%	8095
PT	0	0%	0		
CO	149417	-15%	-22429	-15%	-22429

Note that the total emission reductions (as sum of CI and SI), as reported in Table 5.6, sometimes differ from the total emission reductions reported in Table 5.5, due to rounding up of the data and the fact that the CI/SI comparison is only based on the 'coast marina" scenario. Difference in terms of percentages of reductions for CI on the one hand and SI on the other, are therefore more important to assess than real emission reduction data.

Table 5.6 shows that:

- For HC+NOX, emission reductions are most important for SI engines;
- Emission reductions for PT are only from CI engines, which is a logical result from the assumption that diesel SI engines do not emit PT;
- Emission increase for CO is only due to for SI engines, since emission rates for CO for CI engines do not change in the different scenarios.

5.2 CHANGE IN AMBIENT AIR CONCENTRATIONS

Because of the fact that compared to the ECNI study:

- the impact on the same environments are estimated without changing the conditions: linear waterways, coastal areas, lakes
- the same methodology is used to estimate the environmental impact and only emissions will change in the modelling;
- all other conditions and parameters like, amount of boats, amount of kilometres, … stay unchanged,

changes in ambient air concentrations for the different scenarios are calculated with a more simplified method and not modelled. This estimation is based on the assumption that emission and concentrations are related linear, which implies that air concentrations will not be calculated by modelling the concentrations from scratch, but by in-/decreasing the calculated air concentrations resulting from the ECNI as follows:

$$\text{Concentration new scenario} = \text{Concentration old scenario} \times \frac{\text{emission new scenario}}{\text{emission old scenario}}$$

Following reasons underpin the acceptance of using this simplified method:

- In the ECNI study, AERMOD was used for the atmospheric dispersion modelling. AERMOD is based on atmospheric boundary layer turbulence structure and scaling concepts, including treatment of multiple ground-level and elevated point, area and volume sources. It handles flat or complex, rural or urban terrain and includes algorithms for building effects and plume penetration of inversions aloft. It uses Gaussian dispersion for stable atmospheric conditions (i.e., low turbulence).
- the Gaussian model is perhaps the oldest and perhaps the most commonly used model type. It assumes that the air pollutant dispersion has a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution. Gaussian models are most often used for predicting the dispersion of continuous, buoyant air pollution plumes originating from ground-level or elevated sources. Gaussian models may also be used for predicting the dispersion of non-continuous air pollution plumes (called puff models). The primary algorithm used in Gaussian modeling is the Generalized Dispersion Equation For A Continuous Point-Source Plume
- For a Gaussian-type dispersion model, the ambient concentration will be directly proportional to the emission rate (USEPA, description of air quality modelling – AERMOD model http://www.epa.gov/ttn/fera/data/risk/vol_1/chapter_09.pdf).

An estimation of the ambient air concentrations of NO_X+HC and PT as a result of emissions from recreational craft for the new proposed and the reference scenario are given in Table 5.7.

Table 5.7 Overview of the estimated concentrations for NO_X+HC and PT in the reference Stage 1 scenario and the new proposed scenario

	NO_X +HC (µg/m³)		PT (µg/m³)
	Long term	Short term	Long term
EQS	40 (1)	200 (1)	40
LAKE MARINA			
Reference (ECNI, 2006)	28.78	516.29	0.27
C1S1	21.59	387.22	0.15
C2bS2	22.45	67.12	0.19
$C1S1_{cons}$	22.45	402.71	0.18
$C2bS2_{cons}$	24.18	433.68	0.32
COAST MARINA			
Reference (ECNI, 2006)	44.61	1774.04	0.25
C1S1	32.57	1295.05	0.14
C2bS2	33.90	1348.27	0.18
$C1S1_{cons}$	33.46	1330.53	0.18
$C2bS2_{cons}$	36.13	1436.97	0.27
INLAND WATERWAYS			
Reference (ECNI, 2006)	0.78	11.64	0.00
C1S1	0.49	7.33	0.00
C2bS2	0.52	7.80	0.00
$C1S1_{cons}$	0.50	7.45	0.00
$C2bS2_{cons}$	0.55	8.15	0.00

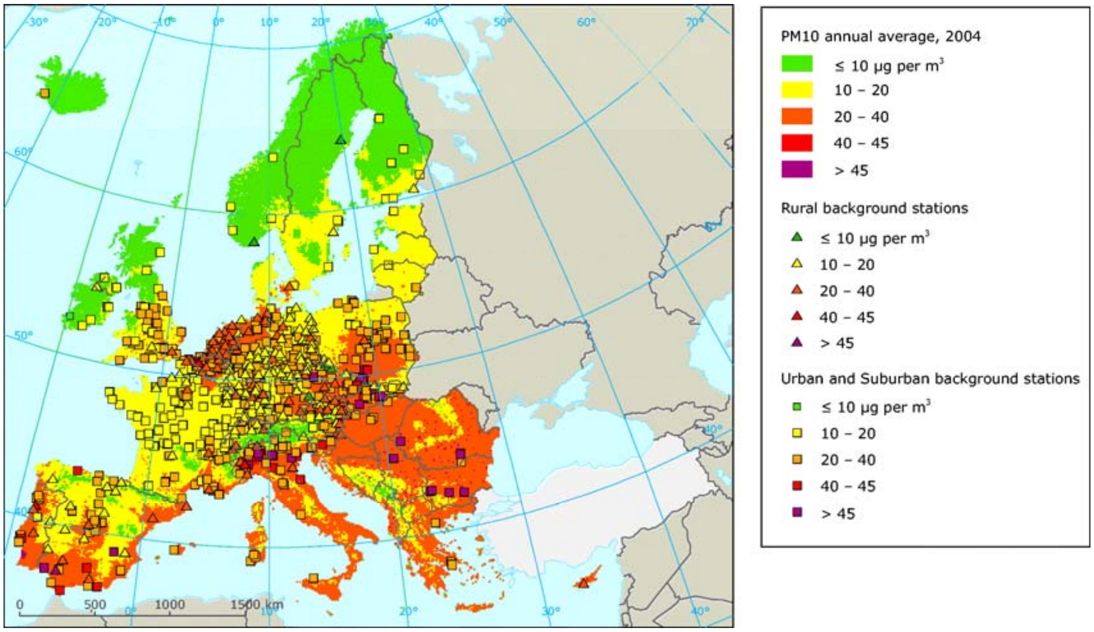
(1) this is the EQS for NO_X only, there is no EQS for HC available

To correctly interpret the results in Table 5.7 following remarks must be considered:

- For the purpose of air quality modelling, it has been assumed that all emissions from recreational craft exhausts enter the air. This is an oversimplification, as the presence of wet exhausts on most recreational craft engines will result in the emission of exhaust pollutants directly into the water. A proportion of these emissions may remain in the water rather than entering the atmosphere, although as a result of propeller turbulence and the rate at which exhaust gas is emitted it is likely that this proportion is small.
- For the reference scenario, ambient air concentrations for NO_X and HC are summarised to show the NO_X+HC concentrations and to compare with the new scenario. EQS however are only available for NO_X.

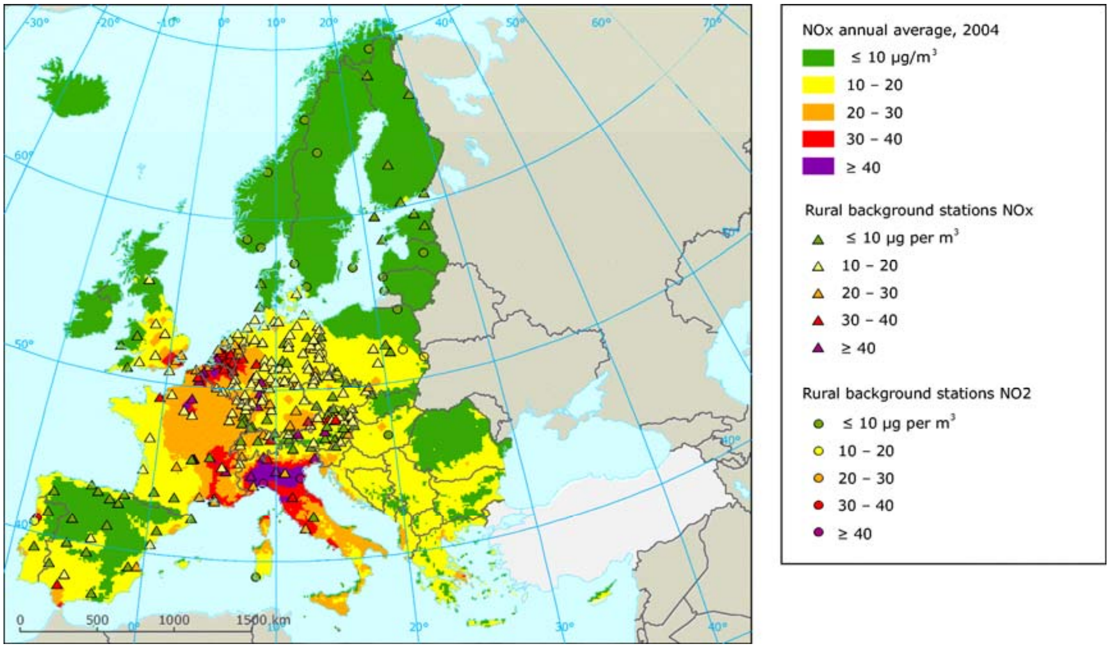
From Table 5.7 we can conclude for PT that PT emissions in all environments remain well below the long- and short term EQS levels as well for the reference as the new proposed scenario. Since the concentrations in Table 5.7 give the additional share of PT-concentrations due to emissions of the recreational craft engines, it is interesting to have a look at the ambient background concentrations (long term) of PT (PM10) in Europe (Figure 5.1). Only in those areas where concentrations approach the EQS value of 40 µg/m³, one could say that emissions from recreational craft engines could result in a exceedance of the EQS. Contributions of the scenarios calculated here are however so limited (maximum of 0.15 µg/m³ tot 40 µg/m³) that recreational craft engines can hardly be pointed out as an important contributor.

Figure 5.1 Annual average PM10 air concentrations in Europe (EMEP, http://www.eea.europa.eu)



For NO_X+HC the conclusion to be drawn is somewhat more complicated. Since NO_X+HC – concentrations are shown as one value and the EQS only refers to NO_X, we should try to make an estimation of the amount of NO_X in NO_X+HC. The ECNI study shows a NO_X-contribution of 31-41% for short term concentrations and 34-46% for long term concentrations. As a 'worst-case' we assume that 50% of the NO_X+HC- air contribution is NO_X. In this case, we can estimate a long-term concentration of 11, 16 and 0.23 µg/m³ NO_X for lake marina, coast marina and inland waterways respectively. Short-term concentrations can be estimated at respectively 201, 634 and 3.43 µg/m³. Only for the coast marina receiving environment a short-term exceedance of the EQS is expected. Again looking at the ambient background concentrations (long term) of NO_X in Europe (Figure 5.2). In those areas where background concentrations reach 24 µg/m³ (= EQS – contribution of recreational craft engines) it can not be excluded that recreational craft engines in a coast marina area contribute to an exceedance of the EQS. In those areas where background concentrations reach 29 µg/m³ (= EQS – contribution of recreational craft engines) it can not be excluded that recreational craft engines in a lake marina area contribute to an exceedance of the EQS.

Figure 5.2 Annual average NO_X air concentrations in Europe (EMEP, http://www.eea.europa.eu)



Besides emission reductions resulting from the decrease of emission standards, also potential indirect impacts e.g. fuel savings/increase of fuel consumption (and as a result emission reductions/increase) due to implementation of certain measures are considered here qualitatively.

For outboard engines, a new EU rule without flexibilities would require additional calibration for the EU market. Whereas the USEPA rule is NOx oriented, the EU RCD Directive could be regarded HC oriented. In the US in order to live up to the EPA rule, engines would have to be made richer so NOx decreases. At the same time HC and CO emissions increase and fuel economy would be worse off, which means an increase in greenhouse gas emissions (CO2). For small engines, it would reduce fuel economy with 1-2%. For larger engines it would reduce fuel economy with 7-8%. For 2-stroke DI engines 200 and 250 HP it would reduce fuel economy with 4-5% (OB producers, stakeholder meetings). Because of this worse fuel economy, the engines are averaged in the US. For the same reason, flexibilities would be used for those engines in the EU too. Without flexibilities, greenhouse gas emissions would increase during the use of the engine.

It was already indicated in the beginning of this chapter that, since the new proposal doesn't include standards for CO, the impact on CO emissions will be assessed qualitatively. In a first approach, one could assume that the situation after implementation of the new proposal remains the same as in the reference Stage 1 situation. This means that in none of the receiving environments, the EQS will be exceeded. The same remark as indicated above about the requirement for extra calibration, it was indicated by the OB producers that the engines are made richer so NO_X decreases, but HC and CO emissions increase.

ECNI (2006) concludes that the environmental impact on the aquatic environment is likely to be small. Since emissions form the new proposed scenario decrease compared to the reference stage 1 scenario, it is not deemed necessary to work out the environmental impact to the aquatic environment in the current impact assessment.

6 SOCIO-ECONOMIC IMPACT ANALYSIS

6.1 INDUSTRY CHARACTERISATION

The execution of a thorough impact assessment requires the mapping of industry actors, structures and processes in a comprehensive way. A sound understanding of the relations between the different actors is a prerequisite in order to be able to construct a causal model and then to assess the likely direct and indirect consequences of the proposed policy.

The manufacture of marine engines is a small industry. The largest producers of engines are Sweden, Germany, Italy and the UK. In 2004 the sector showed a trade deficit of € 121 Million, largely reflecting the dominance of non-EU based outboard manufacturers on the EU market. (ECNI, 2006) Based on the information gathered from the companies that replied to our questionnaire and/or were interviewed the number of direct jobs provided by the EU manufacturers and marinisers of recreational marine engines amounts to about 2,300.

The recreational marine engine manufacturing and marinising industry is embedded in the wider supply chain of boats for recreational purposes – encompassing component and service suppliers, boat manufacturers, dealers and consumers – which may be impacted as well by the regulations under consideration. Table 6.1 provides an overview of the importance of the marine industry in those European countries where the sector is most important. Although this table goes beyond the recreational marine industry, it does provide an idea of the stakeholders involved and of the importance of the marine industry of which the marine engine manufacturers take part.

Table 6.1 Number of companies in the European (recreational) marine industry chain (ICOMIA, 2007)

Nation	*Boat builders*	*Engine manufacturers / marinisers*	*Equipment/ Accessory Manufacturers*	*Trade & Service Providers*
Croatia	65	1	45	98
Denmark	30	1	25	130
Finland	58	0	19	175
France	156	7	956	2.200
Germany	412	11	205	3.200
Greece	87	0	4	1.500
Ireland	4	0	1	60
Italy	800	10	150	3000
Netherlands	450	1	25	870
Norway	95	2	30	350
Portugal	55	0	N/K	N/K

Nation	*Boat builders*	*Engine manufacturers / marinisers*	*Equipment/ Accessory Manufacturers*	*Trade & Service Providers*
Spain	25	3	30	2100
Sweden	50	3	40	400
Switzerland	18	7	N/K	226
Turkey	300	0	70	2.000
UK	500	5	300	3.500

Although the recreational marine industry is present almost everywhere and is an important economic sector in specific regions, its overall importance is limited compared to e.g. the motorcycle and car business. This is an important observation for the impact assessment. Because of the relatively limited size of the sector far less capital is circulating in the sector which might limit investment opportunities and thereby also the sectors' capacity to respond to and cope with major challenges like new ambitious emission standards.

The recreational marine engine industry itself consists of several branches which may themselves be either more or less able to benefit from advantages of scale and evolutions on other engine markets. Sales of outboard engines e.g. far outnumber sales of inboard engines. About 80 percent of engines sold on the EU market are outboard engines. The ratio outboard / inboard engines sold is similar on the US market. The composition of the EU and US market of inboard engines is, however, very different. Where the EU market is in favour of diesel engines, as can be seen from Figure 6.1, consumers on the US market favour engines on gasoline. (TNO Automotive, 2004)

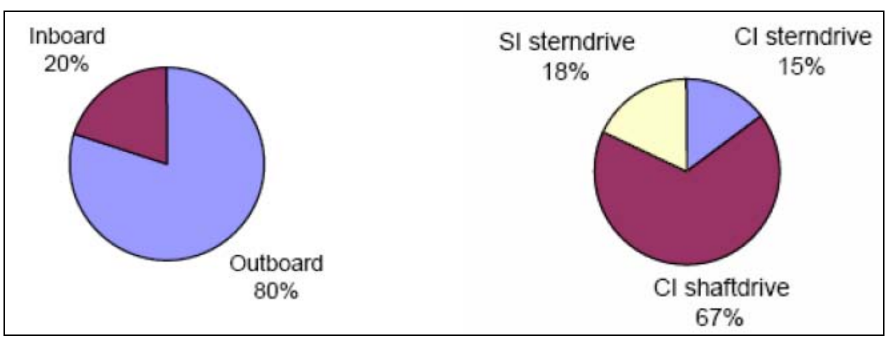


Figure 6.1: Estimated share inboard / outboard engines on EU market and share inboard engine types on EU market

Another major difference between the EU and US market concerns the power of the engines sold. On average, consumers on the EU market prefer engines of a low power category where boats on the US market, compared with the situation on the EU market, rather tend to have higher performance engines installed.

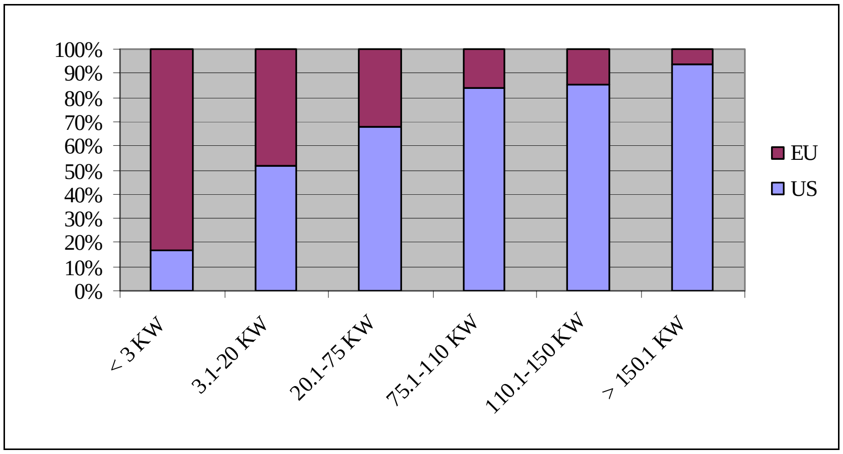


Figure 6.2: Outboard engine sales in the EU and US per power category

The market for marine engines is small. Consequently, engine designs are marked by a slow development and renewal rate. The renewal of engines designs is – in most cases – limited to the updating of existing designs rather than launching completely new ones. Any new engine design will not only be tomorrow's engine, but to a large extent also of the generation after that. Engine development (at least for outboard) is driven by the US. (TNO Automotive, 2004)

There are two kinds of manufacturers involved in the production of marine engines: original engine manufacturers and engine marinisers. Original engine manufactures either produce engines that are specifically designed for marine use or base engines that are designed for general machinery or automotive use. Engine marinisers buy engines from engine manufacturers who produce engines for other markets (both for general machinery use and automotive use) and convert or adapt them for marine use. The contribution of marinisers is usually limited to the mounting of external parts and changing the settings. Some original engine manufacturers produce marinised versions of their own base engines. (TNO Automotive, 2004)

OUTBOARD ENGINES

Production, import-export and sales

Annually about 823,000 outboard engines are sold worldwide. Sales of outboard engines in the EU amount to about 210,829 units. With about 301,701 units sold a year, the US market is the most important. As can be seen from the following Table, the US market is marked by a preference for more powerful and thus more expensive engines. For drawing up this overview it has been assumed that the distribution of unit sales per engine category for ROW is similar to that on the EU market. (IMEC, 2008 and ICOMIA, 2006)

Table 6.2 Overview of unit sales and sales value of OB engines in the EU, US and ROW

Engine category (in kW)	*Unit sales*			*RRP (in €)*	*Sales value (in million €)*		
	EU	*US*	*ROW*		*EU*	*US*	*ROW*
< 3	49,608	7,596	71,017	791	39.2	6.0	57.8
3 - 20	84,652	74,168	121,186	2,050	173.5	152.0	255.5
20 - 75	54,242	98,550	77,652	6,590	357.5	649.4	526.4
75 - 110	10,524	36,235	15,066	10,743	113.1	389.3	166.5
110 - 150	7,684	37,082	11,000	13,919	107.0	516.1	157.5
> 150	4,119	48,070	5,896	19,421	80.0	933.6	117.8
Total	210,829	301,701	301,818		870.2	2,646.4	1,281.5

The following Figure completes this Table concerning production data and import-export flows. It is clear from this figure that the EU is a net importer of OB engines.

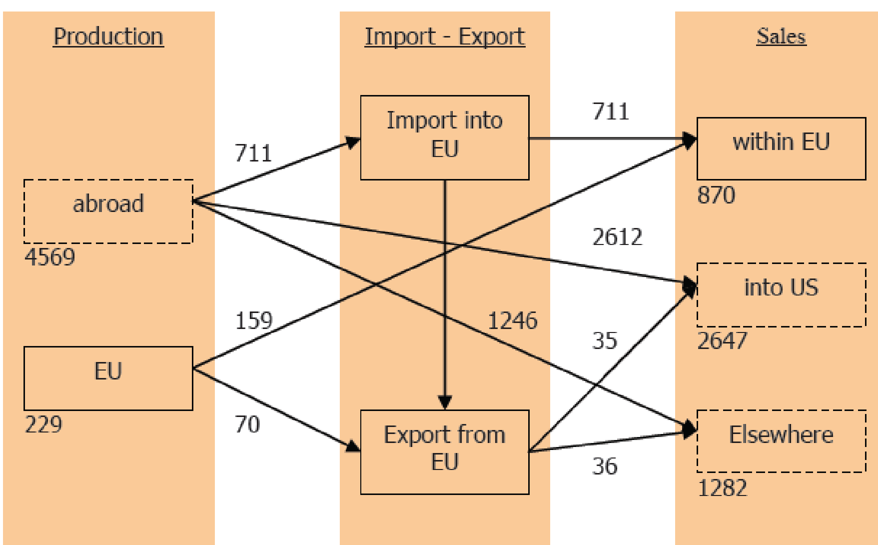


Figure 6.3 Sales value of the production, import-export and sales of OB engines in the EU, US and ROW

Market structure and actors

There are only 9 manufacturers of outboard engines worldwide. The market is dominated by Yamaha and Mercury. Bombardier, Suzuki, Honda and Tohatsu are medium to small players. Two Chinese manufacturers Sail and Parsun recently entered the market. Finally, there is Selva, the only European owned company of outboard engines, which is by far the smallest manufacturer with a share of less than

0.5 % of the world market and less than 5% of the EU market. All manufacturers sell to the European market. (ECNI, 2006)

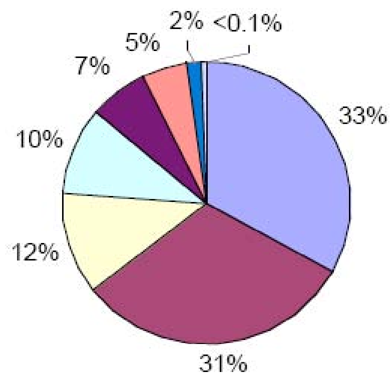


Figure 6.4 Distribution of market shares over the manufacturers of outboard engines (here eight producers instead of seven)

The engines produced are – in most cases - either sold directly to the consumer as loose engines or to equipment manufacturers who integrate them in their boats. Some engine manufacturers also produce boats and equip them with their own engines. Although most outboard engines are dedicated designs, some bigger outboard engines are sometimes based on existing automotive engines. To a large extent the market for outboard engines is a business to consumer market. A large number of outboard engines are imported from outside Europe. (US EPA, 2007; ECNI, 2006 and TNO Automotive, 2004)

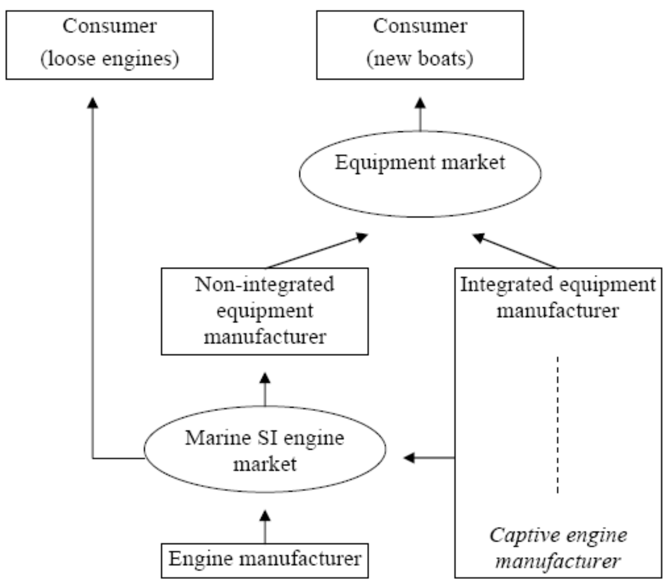


Figure 6.5 Industry structure outboard engines

Number of engine families produced

On average a manufacturer produces 2 x 15 engine families which comes down to 3900 units per family per manufacturer (IMEC, 2008). In the ECNI study it was assumed that outboard engine manufacturers produced on average 2 two stroke engine families and 5-7 four stroke engine families for the EU market (ECNI, 2006). The outboard engine manufacturers having replied to the questionnaire produce on average about 10 engine families for the European market. The lowest number of engine families produced for the European market by a manufacturer is 7, the highest is 13.

Company specific information of EU production facilities

The only European owned company of outboard engines, Selva, is an Italian based company. It produces about 4,000 engines annually, directly employs about 80 people and has a turnover of about € 20 million. Yamaha has an engine manufacturing plant in France employing about 106 people. Mercury has an engine customisation plant in Belgium. The total number of employees that is directly involved in the manufacture and customisation of OB engines in the European Union is slightly over 400.

CI ENGINES

Production, import-export and sales

Annually about 65,000 CI engines are sold worldwide. Sales of CI engines on the EU market amount to about 40,000 units and sales to the US market to about 9,128 units. The EU thus is the most important market for CI engines. Information in the following Table illustrates that diesel engines are much more popular in the EU and in the US. As has been observed for the OB engines the US engine market as a clear preference for the larger engines. (IMEC, 2008, DHV, 2007 and ECNI, 2006)

Table 6.3 Overview of unit sales and sales value of CI engines in the EU, US and ROW (DHV, 2007)

Engine category (in kW)	*Unit sales*			*RRP (in €)*	*Sales value (in million €)*		
	EU	*US*	*ROW*		*EU*	*US*	*ROW*
< 18	12,800	865		4,753	60;8	4.1	
18 - 37	9,200	622		8,962	82.5	5;6	
37 - 75	7,600	514		12,021	91.4	6.2	
75 - 130	3,600	1,147		16,892	60.8	19.4	
130 - 560	6,800	5,980		24,523	166.8	146.6	
Total	40,000	9,128	15,872		462.2	181.9	107.0

The following Figure shows that the EU is not only the most important market for CI engines but also that most CI engines are produced in the EU. An important share of the EU production of CI engines is exported to the US and ROW. Overall, the trade balance of the EU is in equilibrium meaning the EU also imports important numbers of engines.

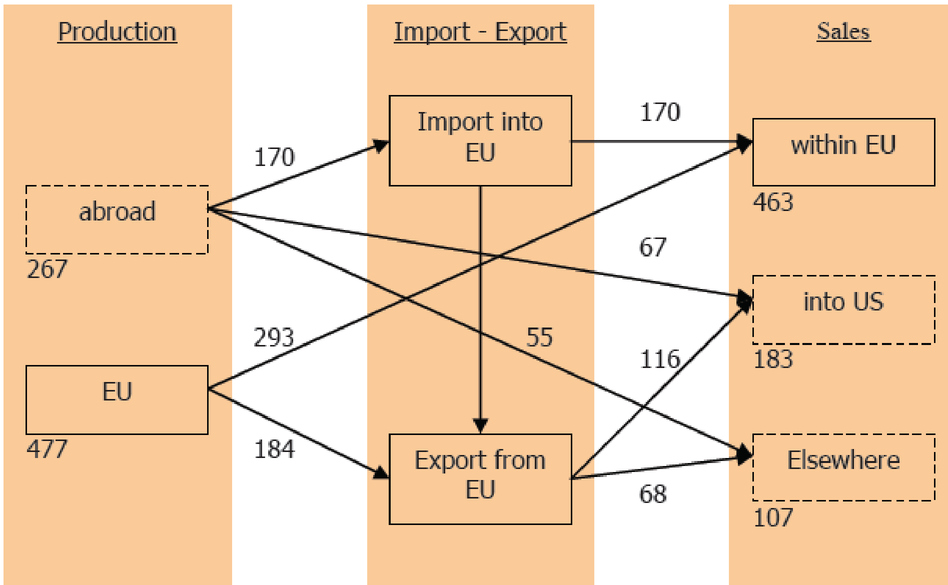


Figure 6.6 Sales value of the production, import-export and sales of CI engines in the EU, US and ROW (DHV, 2007)

Market structure and actors

There are about 10 original CI marine engine manufacturers among which Volvo Penta, Yanmar, Cummins, Volkswagen and Yamaha (IMEC, 2008). Most engines produced by these companies are sold on the marinised engine market. About half of the CI marine engines sold in the EU, either directly or already integrated in a boat, are marinised versions of engines developed for automotive or industrial applications. Marinisers either only marinise the engine and put them on the marinised engine market or integrated them in the boats they produce. A small number is sold to the consumer market as replacement engines. A lot of SME CI engine marinisers are located in Europe. The larger ones do, either directly or indirectly, put their engines on the US market. (Nanni, 2008; EPA, 2007; ECNI, 2006 and TNO Automotive, 2004)

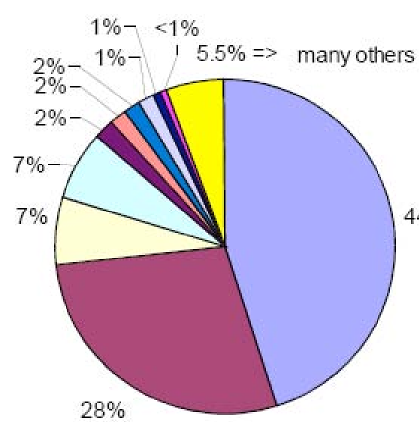


Figure 6.7 Estimated distribution of market shares over the manufacturers of CI engines

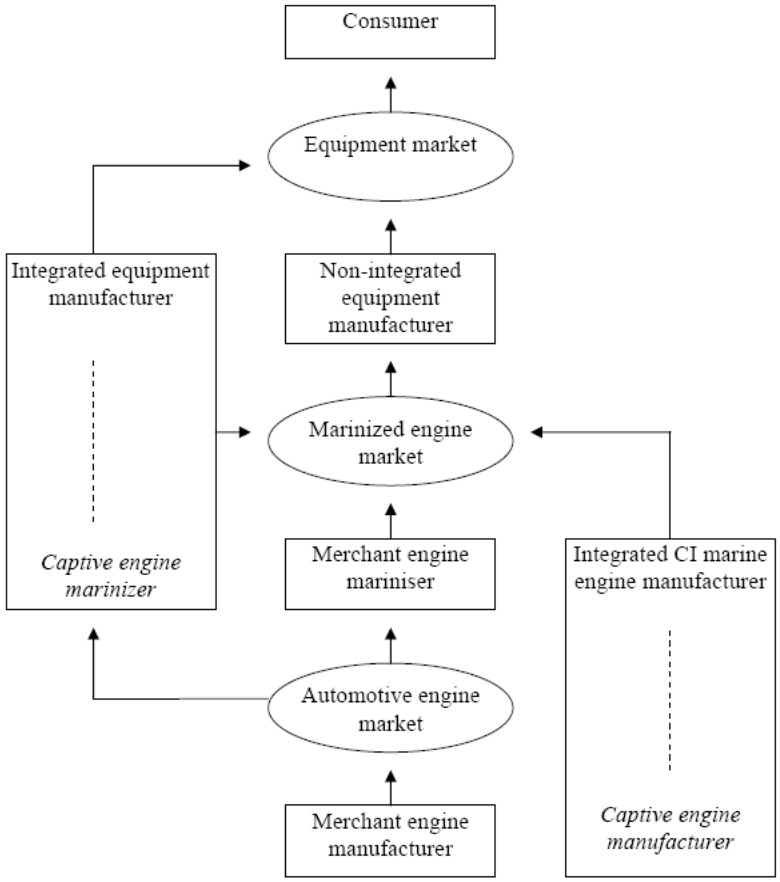


Figure 6.8 Industry structure CI engines

Number of engine families produced

In the ECNI study it was assumed that original CI engine manufacturers produce on average 5 engine families for the EU market, while marinisers produce on average 3 engine families for the EU market (ECNI, 2006). The original CI engine manufacturers having replied to the questionnaire produce on average about 4 engine families for the European market. The lowest number of engine families produced for the European market by a manufacturer of original CI engines is 2, the highest is 6. The marinisers of CI base engines having replied to the questionnaire put on average about 8 engine families on the European market. The lowest number of engines put on the European market by a mariniser is 6, the highest is 12.

Company specific information of EU production facilities

The market of CI engines is largely a European market. Consequently, production facilities are often located in the EU. There are about 15 EU based marinisers. The largest marinise about 3000 units a year and employ about 60 people. The majority produces between 500 and 1000 units a year and employs around 25 people. The smallest marinisers have an output of about 200 engines a year and employ about 20 people. Volvo Penta, the most important manufacturer and mariniser of CI engines, produces all its diesel engines in Europe. Volvo Penta hereby builds on a joint venture with an UK based firm and a thorough cooperation with the wider Volvo system. Yanmar, the second largest manufacturer of CI engine has the lion part of its production based in Europe. Only taking into account those companies having replied to the questionnaire and/or been interviewed the number of employees involved in the production of CI engines in the European Union amounts to 1,600 people.

SI INBOARD ENGINES

Production, import-export and sales

Annually about 130,000 SI inboard engines are sold on the US and EU market. Sales of SI inboard engines to the EU amount to about 10,183 units. As can be seen from Table 6.4 most SI IB engines are sold on the US market. Sales figures for ROW have been based on information gathered via the questionnaire and the individual company interviews. (IMEC, 2008 and ECNI, 2006)

Table 6.4 Overview of unit sales and sales value of SI IB engines in the EU, US and ROW

Engine category (in kW)	*Unit sales*			*RRP (in €)*	*Sales value (in million €)*		
	EU	*US*	*ROW*		*EU*	*US*	*ROW*
< 110	1,918	24,002	581	3,979	7.6	95.5	2.3
110 - 147	2,214	21,897	670	5,609	12.4	122.8	3.8
147 - 184	3,015	24,785	913	6,305	19.0	156.3	5.8
184 - 220	1,018	23,614	308	7,715	7.9	182.2	2.4
220 - 274	1,722	15,317	521	9,050	15.6	138.6	4.7
> 274	296	10,204	90	13,449	4.0	137.2	1.2
Total	10,182	119,818	3,083		66.5	832.6	20.1

EU sales of SI IB engines are almost all imports. The respondents to the questionnaire covered up to 85% of world SI IB engine production. None of these companies produced a single SI IB engine in Europe. We assumed EU production and exports of SI IB engines to be neglictable.

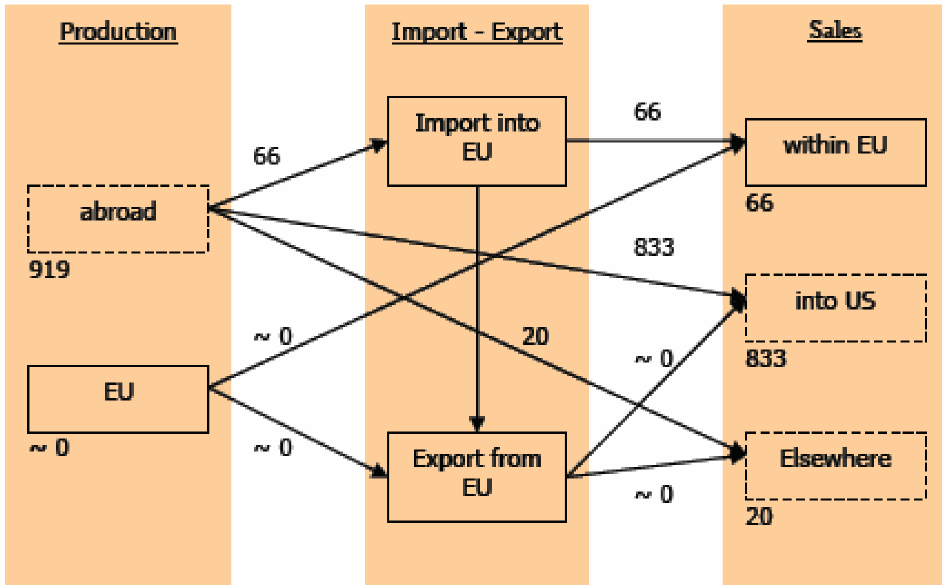


Figure 6.9 Sales value of the production, import-export and sales of CI engines in the EU, US and ROW

Market structure and actors

No engines are specifically designed and built for these applications. Particularly in Europe sterndrive petrol engines are marinised versions of engines designed for other primary applications, such as industrial and automotive use. As in the CI engine market, marinisers of SI inboard engines either only marinise the engine and put them on the marinised engine market or integrated them in the boats they produce (EPA, 2007 and TNO Automotive, 2004).

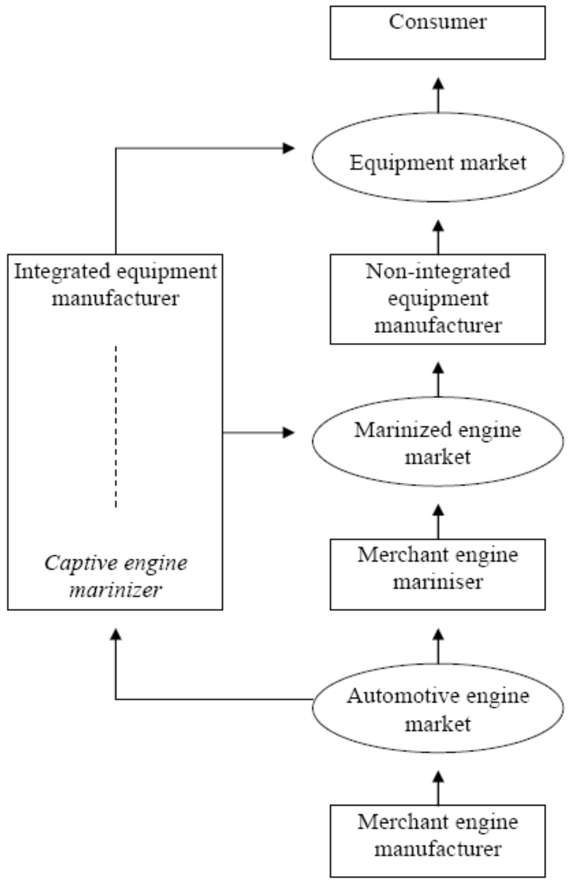


Figure 6.10 Industry structure SI inboard engines

Number of engine families produced

According to IMEC the major manufacturers of SI inboard engines, on average, produce about 7 engine families which comes down to 2,300 units per family per manufacturer (IMEC, 2008). The information on engine families gathered through the questionnaire indicated marinisers of SI inboard engines on average produce about 9 engine families for the European market. The lowest number of engines put on the European market by a mariniser is 3, the highest is 17. One small US based company, being an original SI IB manufacturer, only produced one engine family.

PERSONAL WATERCRAFTS

Production, import-export and sales

Annually about 110,000 PWCs are sold worldwide. Sales of PWCs on the EU market amount to about 9,043 units. It has been stated during the individual company interviews that the US market is by far the main market for PWCs, see Figure 6.11 and the Table below. Sales of PWCs are relatively non-existing out of the EU and the US. Because only two companies provided information to us about their sales of PWCs, production and import-export data could not be established. (IMEC, 2008 and ECNI, 2006)

Table 6.5 Overview of unit sales and sales value of PWCs in the EU, US and ROW

Engine category	*Unit sales*			*RRP (in €)*	*Sales value (in million €)*		
	EU	*US*	*ROW*		*EU*	*US*	*ROW*
All	9,034	100,966	~ 0	11,500	103.9	1,161.1	~ 0

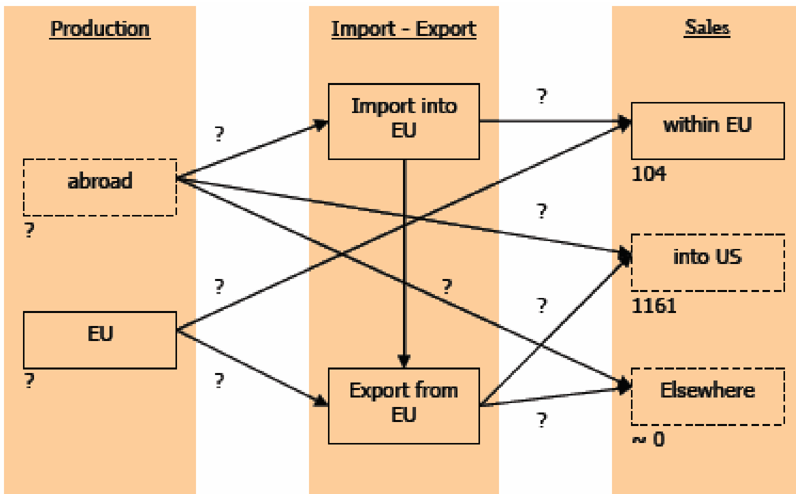


Figure 6.11 Sales value of the production, import-export and sales of PWCs in the EU, US and ROW

Market structure and actors

Like the market for outboard engines, the market for PWCs is a business to consumer market. There are 5 manufacturers of PWCs worldwide producing the engines and putting them in the PWC. These companies are Yamaha, Kawasaki, BRP (Seadoo), Honda and Hydrospace. Honda currently does not produce for the European market. (IMEC, 2008; ECNI, 2006 and TNO Automotive, 2004).

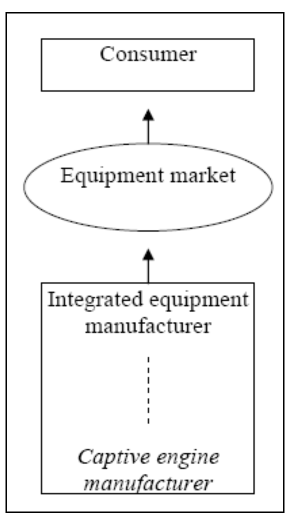


Figure 6.12 Industry structure personal watercraft

Number of engine families produced

On average a manufacturer of PWCs produces 4 engine families (IMEC, 2008). In the ECNI study, an average of 3 engine families was assumed. Half of the PWCs sold on the EU market have a two stroke engine installed while the other half is equipped with a four stroke engine. (ECNI, 2006) The manufacturers of PWCs having replied to the questionnaire indicate to either produce 3 or 4 engine families.

Company specific information of EU production facilities

On its Austrian plant, Bombardier manufactures engines and engines parts for PWCs, providing work to some 300 employees. Besides, Hydrospace is also manufacturing its PWCs in Austria.

6.2 COMPLIANCE COSTS

6.2.1 Concept and information sources

Based on the technologies that would be required to achieve the emission limit values, the costs of bringing engines in compliance with the proposed environmental standards have been calculated for the selected basic scenario without flexibilities. Technical impacts linked to the application of the scenario are reflected in associated compliance costs. The level of costs to become compliant with the emission limit values set in the scenario depends on a set of factors:

- The level of technology currently used by the manufacturer and level of technology used by the manufacturer to be compliant with other regulations in markets outside the EU;
- The sources of the engine and if applicable its original application;
- Engine families and needs for simultaneous up-grading for the full engine range to continue component sharing;
- The emission reduction technologies already available for the engine in other applications;
- The production volumes between manufacturers and their suppliers;
- The development and certification costs;
- Tooling costs;
- Component cost per engine.

Note: compliance costs are purely related to costs to be made by engine manufacturers and marinisers and do not include downstream economic impacts related to competitiveness, changes in the market structure, changes in fuel economy, etc.

Time aspects

Compliance costs should be evaluated in the scope of the time horizon within which these costs are made. **Fixed costs** occur the first years after which they are fully amortized. After a particular period of time, some fixed costs will appear again (e.g. renewable of certificate). **Variable costs** remain a cost item in the long run but will probably decrease as manufacturers learn over time to produce the engines with the new technologies or after treatment at a lower cost.

Main information sources consulted

The main sources for compliance costs consist of:

- Results of the ECNI study which used data from industry (basic data could not be released for reasons of confidentiality).
- Accurate estimates delivered by the sector and by individual companies during the interviews or in their response to the questionnaires.
- Results of the study performed by DHV for IMEC "*Cleaner engines for recreational craft – Industry proposals for future engine exhaust emissions for diesel (CI) engines*" (version 21, March 2007).
- Data of the USEPA RIAs. However according to industry, some data used are outdated or do not reflect reality. They replaced these data by more realistic data.

6.2.2 Fixed costs for engine manufacturers and marinisers

Fixed costs or investment costs are associated with the development, validation and certification of the improved engine required to meet the proposed emissions limits.

Examples of fixed costs include:

- Re-development of combustion system;
- Calibration and validation of the Fuel Injection Equipment;
- Re-certification;
- Component re-design and analysis;
- Retooling costs (adaptations to assembly line);
- Mechanical Validation Testing;
- Environmental validation tests.

A harmonisation of RCD emission standards with the proposed US EPA emission standards would mean that European based companies active both on the EU and the USA market would have limited additional compliance costs. Costs to meet the emission standards have to be made for the US market and as such can be regarded as sunk costs. Costs can be limited to re-certification costs and related testing and calibration.

However, this is conditional to the fact that the RCD Directive is aligned with the full package of the proposed US EPA emission standards, including the accompanying CO standards, same deadlines of phase in and a mechanism to allow flexibility for the industry as an equivalent to the ABT system. The latter is also the case for US based companies also serving the EU market and using the ABT system in the US. Without a flexibility scheme, these companies would face significant additional fixed costs if the RCD standards are at the same level as the proposed US EPA standards. However, at the moment only a limited amount of US companies in the recreational craft engine sector use the ABT system. For other US based companies, a flexibility schemes does not have an impact on the compliance costs as such.

For companies not serving the US market, mainly including SMEs and marinisers, the fixed compliance costs may be significantly higher, as costs to be made besides recertification cannot be regarded as sunk. It is however important to note that OEMs (boat builders) often operate globally. To meet requirements of customers all over the world, they want to be able to provide engines meeting the most stringent standards, i.e. US EPA and as such also oblige engine manufacturers and marinisers only operating in the EU market to meet these market needs. Hence, it can be stated that full fixed costs should be accounted for only those EU companies not exporting directly and indirectly to the US.

6.2.2.1 Costs of re-certification

Elements taken into account to calculate the re-certification cost are presented in the table below. These are based on the DHV study for CI engines and adapted to new insights as proposed during the CI industry group interview:

Table 6.6 Cost of re-certification

	Typical costs [EUR, 2007] for engine >18kW, per engine family
Transport engine to test location	500 €
Certification by notified body	1.500 €
Administration by manufacturer [40hours x 200€]	8.000 €
Engine testing [40 hours x 235€/h]	9.400 €
Periodical update of certificate	500 €
	19.900 €

The total figure should be regarded for guidance only, as recertification costs differ largely according to the companies contacted during the interviews, with figures ranging between 8,000 and 27,000 EUR/engine family. For SI engines (outboard, SI inboard and PWC) and CI engines below 18kW, re-certification costs are within the same order of magnitude and therefore it is assumed to be similar as the figure presented in table above.

6.2.2.2 Other fixed costs

Re-certification costs can be regarded as limited compared to potential costs of re-calibration, costs linked to mechanical redesign and component change, research and development and retooling of the assembly line.

For CI engines, R&D costs are negligible for the majority of engine manufacturing companies, as these costs have already been made by base engine manufacturers (industrial engines, on road engines) on which these engines are based. For marinisers, costs up to 250,000 EUR/engine family have been communicated during the interviews including calibration of fuel injection, component redesign and mechanical validation tests. Based on the results of the interview sessions retooling costs of assembly line are negligible for the majority of the engine manufacturing companies, whereas for marinisers retooling costs between 500 and 5,000 EUR/engine family have been communicated.

Besides fixed costs for engine manufacturers and marinisers additional fixed costs are expected in harbours linked to the logistics of the distribution of low sulphur oil for CI engines. However, the introduction of low sulphur oil does not entail additional costs for the engine manufacturers or marinisers.

For SI engines, *other* fixed costs can be regarded as negligible for the majority of the companies and therefore have not been taken into account.

In paragraph 3.3.2.2 it was explained that if CO standards will not be adapted to the same level of the US EPA rule, this would necessitate OB and PWC manufacturers to introduce catalyst technology which is not technically feasible yet. The development of a new OB engine can run up to 30 million EUR.

Apart from this remark, some SI companies are faced with significant additional fixed costs:

- SI outboard engine manufacturers which are only active on the EU market face significant R&D and testing costs: engines that have to be redesigned completely can reach up to 4 à 3 M EUR/engine family; engine adaptations of low power engines range between 200,000 and 300,000 EUR;

- For US based companies relying on ABT to meet the US EPA emission standards, a harmonisation of the RCD Directive with the proposed US EPA emissions standards without a flexibility scheme would imply significant recalibration costs and R&D costs: costs up to 1.5 M EUR/engine family have been communicated linked to adaptations of engines such as changes in injection system, changes in cylinder porting and introduction of very high pressure systems.

6.2.3 Variable costs of engine manufacturers and marinisers

Variable costs are costs of improved or added technology on every engine such as implementation of techniques in related to the engine management system, after treatment and exhaust components, engine management systems, etc. Typical variable costs to marinise engines include engine mounts, intake pipes and filters, sea-water cooling system, bell-housing/flywheel adaptor, cooled/insulated exhaust manifold, cooled/insulated turbocharger, sea-water charge cooler, EGR circuit insulation, etc. Next to costs related to the purchase of components, it also includes changes in labour costs and energy requirements.

Detailed information on the different variable costs items is lacking and could not be provided within the short timeframe of this project. As a second best option, variable costs estimated in terms of percentage increase in manufacturers recommended retail price (RRC) are used. Variable costs include estimated price increase for the purchase of NRMM certified base engines. Upgrade in power or torque is not included in costs as this would invalidate NRMM certification.

RRC and expected % increases in RRC for CI engines are taken from the DHV study (2007):

Table 6.7 Variable costs CI engines based on DHV (2007)

Maximum Engine Power	L/cylinder	Average engine RRP for a typical engine [EUR, 2007]		Typical variable cost (% increase in RRP)		Remarks
		Min	Max	Min	Max	
<19 kW	<0.9	4.753	4.753	0,0%	0,0%	*common rail probably not implemented yet*
19 to <75 kW	<0.9	7.153	12.027	0,2%	4,0%	
75 to <3700 kW	<0.9	16.829	16.829	0,2%	0,2%	*costs are minor, these engines are already common-rail: variable costs are related to marinising activities*
	0.9-<1.2	16.829	16.829	0,2%	0,2%	
	1.2-<2.5	24.623	24.623	0,2%	0,2%	
	2.5-<3.5	25.534	25.534	0,2%	0,2%	
	3.5-<7.0	54.143	54.143	0,2%	0,2%	

For 2.5 up to 7.0 l/cylinder engines, RRC has been extrapolated and the expected % price increase has been assumed to be similar to 1.2 – 2.5 l/cylinder engines.

In general, it is stated by industry that variable costs for the CI engine manufacturers are offset by higher added values created by the newly developed engines. R&D to adapt engines to more stringent emission standards goes hand in hand with R&D to improve engines in terms of power output, torque, electronic control systems, stability, noise, etc. The added value created allows the manufacturers to increase prices in a way which largely offset the costs of adapting the engines to the new emission standards.

For SI engines, a similar approach has been followed based on the ECNI study and the outputs of the interviews with the industry:

Table 6.8 Variable cost SI engines based on ECNI study and interviews with the industry

	Maximum Engine Power	L/cylinder	Average engine RRP for a typical engine [EUR, 2007]		Typical variable cost (% increase in RRP)	
			Min	Max	Min	Max
SI Outboard	< 3	< 4	779	779	0,1%	0,1%
	< 20	< 27	2713	2713	0,1%	0,1%
	< 75	< 110	8024	8024	0,1%	0,1%
	< 110	< 150	13886	13886	0,1%	0,1%
	< 150	< 230	16629	16629	0,1%	0,1%
	> 150	> 230	16629	16629	0,1%	0,1%
SI Inboard	< 110	< 150	3979	5038	0,1%	6,0%
	< 147	< 200	5609	7101	0,1%	6,0%
	< 184	< 250	6305	7982	0,1%	6,0%
	< 220	< 300	7715	9767	0,1%	6,0%
	< 274	< 373	9050	11458	0,1%	6,0%
	> 274	> 373	13449	17027	0,1%	6,0%
PWC			11500	11500	0,1%	0,1%

In general, the variable costs can be regarded as limited for SI outboard and PWC. For SI Inboard engines, variable costs can be up to 6%. As these figures are based on a limited number of data, it should be regarded as for guidance only.

6.2.4 Compliance costs in terms of unit cost per engine

6.2.4.1 Fixed costs per engine

Fixed costs have been calculated per engine family and should be recalculated in terms of costs per engine as an input to calculate the total compliance costs per engine.

A number of assumptions have been taken into account based on literature and interviews with companies, EUROMET and ICOMIA. The following general assumptions were taken into account in calculating fixed costs in terms of costs per engine:

- Figures provided in USD have been recalculated in EUR prices using an exchange rate USD/EUR of 1,266 which is the average daily exchange rate between 01/01/2003 and 29/04/2008 (source ECB, 2008);
- Engine families and engines sold on the EU market have been taken split up according to the size of the companies (small, medium, large) and based on:
  - For CI engine families: results of DHV study, combined with CI industry group interview

Table 6.9 Assumptions made on units put on EU market and number of engine families per company size for CI engines

Manufacturer OEM or Mariniser	# engines/3 years	# engine families	
		min	max
Large	9000	5	7
Medium	3000	7	12
Small	600	1	2

- For SI engines: results are based on individual interviews with SI engine manufacturers

Table 6.10 Assumptions made on units put on EU market and number of engine families per company size for SI engines

Manufacturer OEM or Mariniser	# engines/3 years	# engine families	
		min	max
Outboard			
Large	150000	8	12
Small	12000	7	7
SI Inboard			
Large	15000	8	17
Small	600	1	3
Range testing and certification costs			
PWC			
Large	9000	3	4

6.2.4.2 Unit compliance costs per CI engine

Unit compliance costs for CI engines are presented in the table on following page. Figures are for guidance only. The assumptions made for calculating unit compliance costs per CI engine (*cf.* Table 6.11) include following:

- **(1)** *Units put on the market*:
  - sources of information:
    - ~ ECNI study updated with IMEC presentation 20 Feb 2008 and ICOMIA statistics
    - ~ Estimates on share below 37kW based on interviews executed in April 2008
  - 75 to 3700kW range: equal distribution between power ranges
  - Distribution between small manufacturers + marinisers and large manufacturers is based on the assumption that 75% of market is covered by large companies. This is assumed to be equal for all engine power ranges
- **(2)** and **(3)** Fixed costs large manufacturers: Depreciation of fixed costs per engine over 3 years which is conservative
- **(4)** Variable costs : see previous paragraph below
- **(5)** Cost linked to temporary discontinuation of engine models: the CI engine industry clearly formulated a unified proposal to introduce a flexibility scheme. A selection of companies also indicated the actual need to discontinue (temporarily) some of their models in case a flexibility scheme would not be installed. All of these companies are small to medium sized manufactures and marinisers. To estimate the costs linked to discontinuation, the loss of profit generated by the models to be discontinued and the accompanying loss of market share should be estimated. Due to a lack of information, a second best method had to be used by expressing the costs in terms of loss of turn-over generated by the models to be discontinued.

Fixed costs for small manufacturers and marinisers vary largely, between 31 to 664 EUR/engine. The lower bound reflects a situation in which these companies only have to cope with (re)certification costs and related testing, the upper bound a situation in which other fixed costs related to R&D, additional testing and retooling of assembly lines should be taken into account. The latter is the case for companies which only serve the EU market and have no indirect exports to the US via boats in which their marinised engines are mounted. For large manufacturers, the fixed costs can be assumed as limited, basically reflecting costs for recertification.

Variable costs can be high compared to fixed costs. The range of variable costs is largest for small engines (< 75kW), i.e. 14 to 384 EUR/engine.

For the small engine manufacturers and marinisers mainly focusing on the small engine power ranges that are only sold directly and indirectly in the EU, the high fixed and variable costs can result in significant high compliance costs that can result in a decision to discontinue engine models.

Unit costs per engine for CI and SI engines are presented in Table 6.11.

Table 6.11 Unit costs per engine for CI engines

Maximum Engine Power	**L/cylinder**	**Units put on the market (1)**			**Fixed costs large manufacturers /engine (2)**		**Fixed costs small manufacturers & marinisers/engine (3)**		**Variable costs/engine (4)**		**Costs linked to temporal discontinuation of engine models (5)**
		total	large manufacturers	small manufacturers & marinisers	min	max	min	max	min	max	
<19 kW	<0.9	12.800	9.600	3.200	30 €	54 €	31 €	664 €	- €	- €	
19 to <75 kW	<0.9a	16.800	12.600	4.200	30 €	54 €	31 €	664 €	14 €	384 €	
19-37		*9.200*	*6.900*	*2.300*	*30 €*	*54 €*	*31 €*	*664 €*	*14 €*	*384 €*	
37-75		*7.600*	*5.700*	*1.900*	*30 €*	*54 €*	*31 €*	*664 €*	*14 €*	*384 €*	
75 to <3700 kW	<0.9	2.080	1.560	520	30 €	54 €	31 €	664 €	34 €	34 €	
	0.9-<1.2	2.080	1.560	520	30 €	54 €	31 €	664 €	34 €	34 €	
	1.2-<2.5	2.080	1.560	520	30 €	54 €	31 €	664 €	49 €	49 €	
	2.5-<3.5	2.080	1.560	520	30 €	54 €	31 €	664 €	51 €	51 €	
	3.5-<7.0	2.080	1.560	520	30 €	54 €	31 €	664 €	108 €	108 €	
		40.000	30.000	10.000							3.689.250 €

Table 6.12 Unit costs per engine for SI engines

Maximum Engine Power	L / cylinder	Units put on the market (1)	Fixed costs/engine linked to recertiication (2) min	Fixed costs/engine linked to recertiication (2) max	Other fixed costs/ engine (3)	Variable costs/engine (4) min	Variable costs/engine (4) max
SI Outboard							
< 3	< 4	49.608	6 €	7 €		1 €	1 €
< 20	< 27	84.652	6 €	7 €		3 €	3 €
< 75	< 110	54.242	6 €	7 €		8 €	8 €
< 110	< 150	10.524	6 €	7 €		14 €	14 €
< 150	< 230	7.684	6 €	7 €		17 €	17 €
> 150	> 230	4.119	6 €	7 €		17 €	17 €
		210.829					
	Large companies using US ABT system				1.688 €		
	Small companies without export to US market				3.092 €		
SI Inboard							
< 110	< 150	1.918	22 €	61 €		4 €	302 €
< 147	< 200	2.214	22 €	61 €		6 €	426 €
< 184	< 250	3.015	22 €	61 €		6 €	479 €
< 220	< 300	1.018	22 €	61 €		8 €	586 €
< 274	< 373	1.722	22 €	61 €		9 €	687 €
> 274	> 373	296	22 €	61 €		13 €	1.022 €
		10.182					
PWC		**9.034**	7 €	9 €		11 €	11 €
		230.045					

6.2.4.3 Unit compliance costs per SI engine

Unit compliance costs for SI engines are presented in the table on previous page. Figures are for guidance only. The assumptions made for calculating unit compliance costs per CI engine (cf. Table 6.12) include following:

- **(1)** *Sources of information:* ECNI study updated with IMEC presentation 20 February 2008 and ICOMIA statistics
- **(2)** *Fixed costs large manufacturers:* Depreciation of fixed costs per engine over 3 years which is conservative
- **(3)** A selection of companies in the outboard sector face significant high fixed costs other than the re-certification costs:
  - Based on rough guidance figures provided by the industry, fixed costs can amount up to approximately 3.100EUR per engine related to R&D costs of completely redesigning engines from scratch. This is the case for **EU based companies not serving the US market**. Based on the available information, this would be the case for one SME. These high costs would result in the decision to discontinue the particular models and would have significant social and economic indirect impacts on suppliers and costumers.
  - Based on guidance figures provided by the industry, fixed costs can amount to approximately 1.688 per engine related to costs of R&D, testing of new technology and validation for **companies relying on ABT in the US market without having the possibility to rely on a flexibility scheme in the EU market**. Based on the available information, the number of companies relying on ABT in the US is limited to one (non-EU) company[15] and the volume of engines sold in the EU market is limited compared to the global market. In case of an adaptation of the RCD Directive without an introduction of a flexibility scheme, it would result in a discontinuation of particular models or in the decision to stop putting these engines on the EU market.
- **(4)** *Variable costs* : see paragraph above on variable costs

Variable costs vary largely and are highest for SI inboard. Unit fixed costs are limited compared to the upper bound of potential variable costs. Unit compliance costs for SI engines are presented in Table 6.12.

[15] During the interviews three companies have been identified stating that they rely on ABT. One of these companies focuses on the PWC market with a low sales figures in Europe and another company has decided to cease the use of ABT in the future. These two companies have therefore been left out of the analysis.

Case Study – SME Outboard and boat manufacturer

Company profile

Since about 15 years, this company is the only European manufacturer of OB engines. With a production of about 4,000 OB engines a year, equalling 0.5% of worldwide OB engine unit sales, the Italian company is by far the smallest manufacturer of OB engines. This company's product range includes 30 models in more than 100 versions from 3.5 to 100 HP. Besides, the company manufactures different types of boats as well as engine components and sail drive units of other engine manufacturers. This company realises a turnover of about 20 million €, 30% of which is realised in Italy.

This company directly employs about 80 employees of which part is on an interim basis for coping with the seasonality of the business. Indirect employment by this company is, however, several times larger. The company has about 60 EU based suppliers. On average, there are about 3 to 4 employees per supplier exclusively involved in the producing for this company, meaning that the company supports 180 to 240 indirect jobs. Part of this, however, should be attributed to the boat manufacturing activities of this company. About 80% of the components used by this company are bought from Italian suppliers. Besides, this company has an extensive European distributor and dealer network for marketing engines which, according to this company, is good for a few hundred additional positions. The company has about 20 national distributors, each employing about 3 people, almost exclusively distributing the company's engines. In each of these countries, the company has on average 15 dealers, each representing about 1.5 full time equivalents. In Italy alone the company has 120 dealers. Adding up all indirect employment the company supports about 830 – 890 indirect jobs.[16]

Impact of the proposed emissions standards on competitiveness

Making abstraction of minor changes, which may occur about every 5 years, average engine life used to be 20 years, but this cycle is getting ever shorter. In 2007, this company for the first time sold its new 2 stroke direct injection 40-80 HP engine which was designed from scratch. This engine, however, would be dropped from the market as it will not be able to comply with the proposed emissions standards. Compliance costs for certain engines may be up to € 5 million as a quasi complete redesign would be needed. The cost for adapting the 4-6 HP engine would be in the range of 200,000 to 300,000 €. This is a very substantial amount, as actually no company sells such small engines with profit. They usually need to make part of the gamma of a producer client binding (client often starts with a small engine).

This company designs and produces its own engines, but unlike the Japanese OB engine producers it can not benefit from experiences and synergies with the technological developments in the car and motorcycle business. Because of this, this company is at a disadvantage for what concerns R&D expenses, by far the most important fixed costs for complying with the proposed emission standards. As this company is not active on the US market all compliance costs need to be attributed to the EU RCD standards, whereas its competitors need to make these costs for meeting the US requirements anyway. The competitors of this company, all active on both US and EU market, have a clear competitive advantage over this company as apart from recertification costs they do not incur major additional costs for complying with the proposed RCD standards. In addition, being the smallest manufacturer of OB engines on the market, this company can only spread fixed costs over a very limited number of engines.

Besides the important financial burden and the resulting competitive disadvantage, this company has to face other challenges. Assuming the company can handle the financial and competitive challenge, the proposed emissions standards will require major redesign of numerous engines. This requires a strong team of designers and administrative forces to cope with the required adaptations.

[16] In case the company would cease operation, the loss of indirect employment, supported by the company's distributor and dealer network, would (only) be partly compensated for by a more extended network on behalf of the company's competitors. The company's competitors already have their own sales network and can benefit from advantages of scale.

<u>Conclusion</u>

Because of the specific situation the only European OB engine manufacturer is in, the proposed emissions standards would place an excessive burden on the company's operations. Because of this, this company does not believe in a mitigating measure of any kind to ease this situation. Only complete exemption may guarantee survival of this company as well as many others both up and downstream the supply chain. In Annex 2, the agreed IMEC letter is attached proposing that EU SI Outboard engine manufacturers be exempted any new emissions regulations if their sales remain below 5% of the EU total.

6.2.5 Discontinuation of non-compliant models

Discontinuation is often very costly in case products have not reached the end of their lifetime and especially in case of newly developed engines. The decision whether to discontinue or to comply will depend on various factors, such as gamma width, marketing policy, competition in the segment, etc. Companies often have to keep low power categories in their gamma for client attracting or binding. However, in cases where compliance costs are too high, companies will discontinue certain models (see also the case described above).

As indicated above, the costs linked to discontinuation include loss of profit generated by the models to be discontinued and additionally the loss of market share by not providing a certain model in the gamma. Due to a lack of information, a second best method had to be used by expressing the costs in terms of loss of turnover generated by the models to be discontinued.

6.2.6 Administrative burden for engine manufacturers and marinisers

The cost of certifying an improved engine is the most important administrative burden for companies. Companies hired zero or one employee for compliance, relying instead on internal resources by reassigning existing personnel. This would mean that companies incur opportunity costs, as employees are given up for more essential activities, potentially leading to increased pressure on a company's normal operations.

6.2.7 Compliance costs for engine manufacturers and marinisers

In the following paragraphs an overview is given of the total compliance costs *per year*.

These figures are for guidance only and should be regarded as orders of magnitude rather than absolute figures.

Calculated compliance costs are based on the assumption of *complete* alignment with US EPA rules which includes next to the emission standards:

- Equal phase-in periods;
- Equivalent flexibility mechanisms to ABT for companies who will make use of it;
- Adoption of US EPA CO standards which are lower than the current RCD levels. More stringent emission standards for CO would mean additional investment costs for outboard and PWC to introduce aftertreatment technologies (catalysts) which is regarded as not feasible by the industry before 2015.

Compliance costs include costs for both EU and non-EU companies (i.e. based in Japan and USA) active on the EU market.

Changes in compliance costs over the years have not been taken into account due to a lack of detailed data.

6.2.7.1 CI engines

BASIC SCENARIO C1

In Scenario C1 the compliance costs have been estimated for the CI engine sector to comply with the proposed EU RCD stage 2 exhaust emission standards without flexibilities.

Costs for CI engines vary widely, i.e. between **5.7 MEUR and 19 MEUR per year**. This range reflects the high variety in compliance costs the CI sector can be faced with. Especially the large variety in variable costs for smaller engine families (14 to 384 EUR/engine) contributes to this high variety.

The highest burden is to be covered by small engines < 75kW (20%-66%). Total costs are mainly covered by large manufacturers representing 75% of the sector, although small manufacturers and marinisers faced with temporary discontinuation of engine models also bear a substantial part of the total compliance costs (19-64%).

Table 6.13 Total compliance costs (EUR per year) - Scenario C1

Maximum Engine Power	L/cylinder	Units put on the market (1) total	large manufacturers	small manufacturers & marinisers	Total costs per year min		max	
<19 kW	<0.9	12.800	9.600	3.200	389.997 €	7%	2.640.328 €	14%
19 to <75 kW	<0.9a	16.800	12.600	4.200	752.212 €	13%	9.909.910 €	52%
19-37		*9.200*	*6.900*	*2.300*	*411.926 €*	*7%*	*5.426.856 €*	*29%*
37-75		*7.600*	*5.700*	*1.900*	*340.286 €*	*6%*	*4.483.055 €*	*24%*
75 to <3700 kW	<0.9	2.080	1.560	520	133.383 €	2%	499.062 €	3%
	0.9-<1.2	2.080	1.560	520	133.383 €	2%	499.062 €	3%
	1.2-<2.5	2.080	1.560	520	165.806 €	3%	531.485 €	3%
	2.5-<3.5	2.080	1.560	520	169.594 €	3%	535.273 €	3%
	3.5-<7.0	2.080	1.560	520	288.609 €	5%	654.288 €	3%
		40.000	30.000	10.000	2.032.984 €		15.269.408 €	
	Costs linked to temporal discontinuation of engine models				3.689.250 €	64%	3.689.250 €	19%
					5.722.234 €	100%	**18.958.658 €**	100%

SCENARIO C2A

In Scenario C2a the compliance costs have been estimated of the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies in the sector.

Costs for CI engines vary between **2 MEUR and 15.3 MEUR per year**. Compared to the basic Scenario C1, this means a cost decrease of 3.7 MEUR/year compared to the basic Scenario C1, due to the fact that some companies will not have to discontinue certain engine models and instead can rely on a flexibility scheme. However, this needs to be regarded as an underestimation of the total impact of the flexibility scheme for the CI sector as the figure does not reflect the impact of lost market share, nor additional benefits linked to the ability for companies to spread investment costs over time to meet the revised emission standards.

The highest burden need to be covered by small engines < 75kW (46%-82%). Total costs are mainly covered by large manufacturers, representing 75% of the sector.

Table 6.14 Total compliance costs (EUR per year) - Scenario C2a

Maximum Engine Power	L/cylinder	Units put on the market (1) total	large manufacturers	small manufacturers & marinisers	Total costs per year min		max	
<19 kW	<0.9	12.800	9.600	3.200	389.997 €	19%	2.640.328 €	17%
19 to <75 kW	<0.9a	16.800	12.600	4.200	752.212 €	37%	9.909.910 €	65%
19-37		9.200	6.900	2.300	*411.926 €*	*20%*	*5.426.856 €*	*36%*
37-75		7.600	5.700	1.900	*340.286 €*	*17%*	*4.483.055 €*	*29%*
75 to <3700 kW	<0.9	2.080	1.560	520	133.383 €	7%	499.062 €	3%
	0.9-<1.2	2.080	1.560	520	133.383 €	7%	499.062 €	3%
	1.2-<2.5	2.080	1.560	520	165.806 €	8%	531.485 €	3%
	2.5-<3.5	2.080	1.560	520	169.594 €	8%	535.273 €	4%
	3.5-<7.0	2.080	1.560	520	288.609 €	14%	654.288 €	4%
		40.000	30.000	10.000	**2.032.984 €**	100%	**15.269.408 €**	100%

SCENARIO C2B

In Scenario C2b the compliance costs have been estimated for the CI engine sector of the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies in the sector and additionally EU RCD stage 1 standards for all CI engines < 37 kW placed on the EU market. No distinction is made between small or large companies.

Costs for CI engines vary between **1.2 MEUR and 8 MEUR per year**. Compared to the basic Scenario C1, this means a cost decrease of 4.5 to 11 MEUR/year. Taking into account the lower bound of the variable costs, the highest contribution of this decrease comes from the implementation of the flexibility scheme rather than from the installation of an exemption of power ranges below 37KW. When focusing on the upper bound of the variable costs, a dominant effect of the high variable costs for the smaller power ranges prevails. This means that these costs would disappear in case of an exemption of power ranges below 37kW.

Other conclusions made for scenario C2a remain valid.

Table 6.15 Total compliance costs (EUR per year) - Scenario C2b

Maximum Engine Power	L/cylinder	Units put on the market (1) total	large manufacturers	small manufacturers & marinisers	Total costs per year min		max	
<19 kW	<0.9	12.800	9.600	3.200				
19 to <75 kW	<0.9a	16.800	12.600	4.200				
19-37		9.200	6.900	2.300				
37-75		7.600	5.700	1.900	339.653 €	28%	5.249.449 €	66%
75 to <3700 kW	<0.9	2.080	1.560	520	133.383 €	11%	499.062 €	6%
	0.9-<1.2	2.080	1.560	520	133.383 €	11%	499.062 €	6%
	1.2-<2.5	2.080	1.560	520	165.806 €	13%	531.485 €	7%
	2.5-<3.5	2.080	1.560	520	169.594 €	14%	535.273 €	7%
	3.5-<7.0	2.080	1.560	520	288.609 €	23%	654.288 €	8%
		40.000	30.000	10.000	**1.230.428 €**	100%	**7.968.619 €**	100%

SCENARIO C2C

In Scenario C2c the compliance costs have been estimated for the CI engine sector of a proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies and additionally the exemption of the proposed emission standards for power ranges below 37kW for SMEs.

Costs for CI engines vary between **1.8 MEUR and 15.2 MEUR per year**. This means a cost decrease of around 3.85 MEUR/year compared to Scenario C1. The economic benefit of Scenario C2c is only slightly higher than the benefits of the flexibility scheme on (temporary) discontinuation of models in Scenario C2b (3.7 MEUR/year). This leads to the conclusion that the majority of the benefits linked to the exemption of the power ranges below 37kW go to large companies rather than SMEs. This is also logic, as large companies represent 75% of the units put on the market for engines with a power range below 37kW. However, this does not mean that the benefits of the exemption of power ranges below 37kW for SMEs are not substantial as 55% of the engines put by SMEs on the market are engines with a power rate below 37kW.

Table 6.16 Total compliance costs (EUR per year) - Scenario C2c

Maximum Engine Power	L/cylinder	**Units put on the market**			**Total costs per year**			
		total	large manufacturers	small manufacturers & marinisers	min		max	
<19 kW	<0.9	12.800	9.600	3.200	290.098 €	16%	4.199.076 €	28%
19 to <75 kW	<0.9a	16.800	12.600	4.200				
19-37	0	9.200	6.900	2.300	307.219 €	17%	3.018.086 €	20%
37-75	0	7.600	5.700	1.900	339.653 €	19%	5.249.449 €	35%
75 to <3700 kW	<0.9	2.080	1.560	520	133.383 €	7%	499.062 €	3%
	0.9-<1.2	2.080	1.560	520	133.383 €	7%	499.062 €	3%
	1.2-<2.5	2.080	1.560	520	165.806 €	9%	531.485 €	3%
	2.5-<3.5	2.080	1.560	520	169.594 €	9%	535.273 €	4%
	3.5-<7.0	2.080	1.560	520	288.609 €	16%	654.288 €	4%
		40.000	**30.000**	**10.000**	**1.827.745 €**	100%	**15.185.780 €**	100%

6.2.7.2 SI engines (outboard, SI inboard, PWC)

BASIC SCENARIO S1

In the basic scenario S1 the compliance costs have been estimated for the SI engine sector to comply with the proposed EU RCD stage 2 exhaust emission standards without flexibilities.

Total compliance costs vary between **5.1 MEUR and 10.6 MEUR per year**:

- Compliance costs of SI outboard amount to around **4.7 MEUR** per year. The highest burden is covered by small engines (<75kW) as these represent the highest share of the market.
- Compliance costs of SI inboard vary between **0.3 and 5.7 MEUR** per year
- Compliance costs of PWC amount to around **0.2 MEUR** per year.

The compliance costs for outboard engines include costs to be made by a limited number of companies facing very high compliance costs:

- **EU based companies not serving the US market**, with costs up to 1.8 MEUR/year reflecting the situation of one EU based SME and based on rough estimates provided by the industry. These high costs would result in the decision to discontinue particular models and would have significant social and economic indirect impacts on suppliers and costumers;
- **Companies relying on ABT in the US market without having the possibility to rely on a flexibility scheme in the EU market**, with additional costs up to 520.011 EUR/year reflecting the situation of one US based company[15]. In case of an adaptation of the RCD Directive without an introduction of a flexibility scheme, it would result in a discontinuation of particular models or in the decision to stop putting theses engines on the EU market.

Table 6.17 Total compliance costs (EUR per year) - Scenario SI1

Maximum Engine Power	L/cylinder	Units put on the market	Total costs per year min		Total costs per year max	
SI Outboard						
< 3	< 4	49.608	352.902 €	15%	367.189 €	15%
< 20	< 27	84.652	765.919 €	32%	790.299 €	32%
< 75	< 110	54.242	778.853 €	33%	794.475 €	33%
< 110	< 150	10.524	212.807 €	9%	215.838 €	9%
< 150	< 230	7.684	176.455 €	7%	178.668 €	7%
> 150	> 230	4.119	94.581 €	4%	95.768 €	4%
		210.829	**2.381.517 €**	100%	**2.442.237 €**	100%
	Large companies using US ABT system		520.011 €		520.011 €	
	Small companies without export to US market		1.766.667 €		1.766.667 €	
			4.668.194 €		**4.728.914 €**	
SI Inboard						
< 110	< 150	1.918	49.608 €	17%	696.673 €	12%
< 147	< 200	2.214	60.879 €	21%	1.078.359 €	19%
< 184	< 250	3.015	85.002 €	29%	1.627.794 €	29%
< 220	< 300	1.018	30.136 €	10%	658.649 €	12%
< 274	< 373	1.722	53.266 €	18%	1.288.563 €	23%
> 274	> 373	296	10.467 €	4%	320.677 €	6%
		10.182	**289.358 €**	100%	**5.670.716 €**	100%
PWC		**9.034**	**163.817 €**		**183.792 €**	
		230.045	**5.121.368 €**		**10.583.422 €**	

SCENARIO S2

In Scenario S2, the compliance costs have been estimated for the SI engine sector to comply with the the proposed EU RCD stage 2 exhaust emission standards combined with a flexibility scheme.

Total compliance costs vary between **4.6 MEUR and 10 MEUR per year**, which is only slightly lower compared to Scenario S1. This can entirely be attributed to the fact that the company relying on ABT in the US market would be able to rely on a similar flexibility scheme in the EU, in which case the additional costs of 1.8 MEUR per year to meet the RCD emission standards can be regarded as sunk. Other conclusions made for scenario S1 remain valid.

The decrease in compliance costs indicates a small impact from the flexibility scheme. However, this figure does not take into account additional benefits which are linked to the ability of companies to spread investment costs over time to meet the revised emission standards.

Table 6.18 Total compliance costs (EUR per year) - Scenario SI2

Maximum Engine Power	L/cylinder	Units put on the market	Total costs per year			
			min		max	
SI Outboard						
< 3	< 4	49.608	352.902 €	15%	367.189 €	15%
< 20	< 27	84.652	765.919 €	32%	790.299 €	32%
< 75	< 110	54.242	778.853 €	33%	794.475 €	33%
< 110	< 150	10.524	212.807 €	9%	215.838 €	9%
< 150	< 230	7.684	176.455 €	7%	178.668 €	7%
> 150	> 230	4.119	94.581 €	4%	95.768 €	4%
		210.829	**2.381.517 €**	100%	**2.442.237 €**	0%
	Small companies without export to US market		1.766.667 €		1.766.667 €	
			4.148.184 €		**4.208.904 €**	
SI Inboard						
< 110	< 150	1.918	49.608 €	17%	696.673 €	12%
< 147	< 200	2.214	60.879 €	21%	1.078.359 €	19%
< 184	< 250	3.015	85.002 €	29%	1.627.794 €	29%
< 220	< 300	1.018	30.136 €	10%	658.649 €	12%
< 274	< 373	1.722	53.266 €	18%	1.288.563 €	23%
> 274	> 373	296	10.467 €	4%	320.677 €	6%
		10.182	**289.358 €**	1 €	**5.670.716 €**	100%
PWC		**9.034**	**163.817 €**		**183.792 €**	
		230.045	**4.601.358 €**		**10.063.411 €**	

6.2.8 Compliance costs for boat builders (OEMs)

The boat building sector consists of approximately five large boat manufacturers and a large amount of very small ones (e.g. producing 1 boat per type per year).

It was not possible for boat builders to estimate adaptation costs because of the uncertainty of the changes in engines in terms of dimensions and weight (see also paragraph 3.3.2.3). These adaptation costs, together with the increase in price of the engine, would result in a price increase of the boat (passed on to the customer or partly integrated).

6.3 IMPACT ON COMPETITIVENESS

6.3.1 Share of compliance costs in turnover

The economic impact assessment and the competitiveness test are complimentary analyses and are largely based on the same information. In this way, the competitiveness test complements the economic impact assessment. As environmental regulations become increasingly stringent, concerns over the competitiveness of the affected industries and the influence of competitiveness on the macro-economic level (affecting economic growth and unemployment) become ever more a preoccupation of policy makers. The enforcement of more stringent emission limit values on recreational craft engines has a direct influence on the production costs of these engines. Therefore the manufacturing and marinising companies are at the centre of analysis in the competitiveness test.

Table 6.19 gives, for the different scenarios considered, an overview of the share of yearly compliance costs as a percentage of yearly turnover of engine sales on the EU market.[17] The companies in the table are only those for which information on both the compliance costs and the yearly turnover of engine sales on the EU market was available. Background information about the different companies is limited for reasons of confidentiality.

All SMEs for which the share of compliance costs in yearly turnover of engine sales on the EU market could be calculated will – at least in relative terms – face much higher compliance costs than their larger competitors. Although larger engine manufacturers and marinisers are likely to have higher absolute compliance costs, the burden on SMEs is likely to be substantially higher. The compliance costs/sales ratio offers a better indication of the impact higher emission standards may have on a companies' operations and, when considering the ratio for a series of companies, the impact higher emission standards may have on the company's competitiveness.

The ratio in Table 6.19 reveals that SMEs (and especially the three SMEs only selling on the EU market) face a major burden and may see their competitiveness deteriorate as a result of higher exhaust emissions standards. Compliance costs of SMEs for the proposed emissions standards range between 5.75% and 67.35% of annual turnover in the basic scenario without flexibilities. Large engine manufacturers have a much more moderate ratio, varying between 0.06% and 2.76% for a scenario without flexibilities. However, among these companies there is a large Japanese company, active on both the CI and SI side, which will see its competitiveness deteriorate on the market for CI engines. In the basic scenario without flexibilities this company has a ratio of around 16%. The company is only marginally involved in the CI sector and will not see its overall competitiveness affected. The use of a flexibility scheme and especially a flexibility scheme in combination with EU RCD stage 1 standards for CI engines below 37 kW could potentially reduce the possible negative effects on competitiveness for most companies and particularly for SMEs.

In the questionnaire companies were asked whether they expect their company to be exposed to higher competition because of the proposed harmonisation of standards on the EU and US and whether they expect their company to be able to take advantage of this. Two of the three SMEs which are solely EU oriented indicated that they fear increased competition and do not think they will be able to take advantage of more harmonised standards. The third company did not answer these particular questions. Besides these, only one other company indicated that it expected competition to increase as a result of the new standards.

[17] The total fixed compliance costs were spread over a period of three years.

Table 6.19 Share of compliance costs as a percentage of yearly engine sales on the EU market for the various scenarios

Company	*Markets served*	*Activity*	*Engine*	*Company size*	*C1 + S1*		*C2a + S2*		*C2b + S2*		*C2c + S2*	
					Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
1	EU, US	E Mar	CI	Small	67.35	67.35	7.35	7.35	6.13	6.13	6.13	6.13
2	EU, US	E Man, E Mar	CI	Large	0.60	2.49	0.60	2.49	0.60	2.49	0.60	2.49
3	EU, US	E Mar	SI IB	Medium	8.20	15.40	8.20	15.40	8.20	15.40	8.20	15.40
4	EU, US	E Man, B Man	PWC	Large	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
5	EU	E Man, E Mar	CI	Small	13.11	64.25	13.11	64.25	6.56	12.85	6.56	12.85
6	EU, US	E Man, E Mar, B Man	OB, SI IB	Large	0.16	0.16	0.02	0.02	0.02	0.02	0.02	0.02
7	EU, US	E Mar	CI	Medium	2.22	7.67	2.22	7.67	2.22	7.67	2.22	7.67
8	EU	E Mar	CI	Small	37.26	41.92	23.68	28.35	4.74	22.68	4.74	22.68
9	EU, US	E Man	OB	Large	0.06	0.11	0.06	0.11	0.06	0.11	0.06	0.11
10	EU, US	E Man	OB	Large	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
11	EU, US	E Mar	CI	Medium	5.75	5.75	5.75	5.75	2.88	2.88	2.88	2.88
12	EU, US	E Man, E Mar	CI, SI IB	Large	0.64	0.96	0.64	0.96	0.41	0.61	0.64	0.96
13	EU, US	E Man, E Mar	OB, CI, PWC	Large	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
14	EU, US	E Man	CI	Large	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
15	EU, US	E Man	OB, PWC	Large	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

16	EU	E Man	OB	Medium	10.37	13.09	10.37	13.09	10.37	13.09	10.37	13.09

Activity: **E Man** – Engine Manufacturer / **E Mar** – Engine Mariniser / **B Man** – Boat Manufacturer

Engine type: **OB** – Outboard engine / **CI** – Compression Ignition Inboard engine / **SI IB** – Spark Ignition Inboard Engine / **PWC** – Personal Watercraft

Table 6.20 provides an overview of how engine manufacturers and marinisers may be affected by the level of expenditure they incur in meeting the proposed EU RCD stage 2 standards. Previous analysis has shown that the extent of the competitiveness impact a company may experience is closely related to the relative level of compliance costs and the ability to pass these costs on to other actors. The possible consequences resulting from changed competitiveness are indicated in the table.

Table 6.20: Relationship between the level of compliance costs and competitiveness effects

Significance of compliance costs	Possible actions	Possible consequences for competitiveness
Insignificant	No action	Business as usual
Significant	Increase the selling price	Decrease in sales, shrinking market*
	Absorb the compliance costs	Decrease in profits, less investments
	Modify production function	Depending on how the new combination of inputs affects the selling price
Very significant	Increase the selling price**	Decrease in sales, shrinking market*
	Shift the focus of the business	Survival as a niche player
	Cease operation	Out of market

* The actual effect depends on the price elasticity of demand for recreational craft engines.

** A further increase of the selling price will only be possible if the price elasticity of demand for recreational craft engines is very inelastic.

An individual company has little, if any, ability to pass on a price increase if it is the only entity affected by the price increase. In such a case, boat manufacturers, retailers and consumers would have a clear incentive to purchase comparable engines from companies that are not negatively affected by the regulation. Thus, a clear price increase would place the affected firm at a competitive disadvantage, reducing its market share. The ratios in Table 6.19 indicate that SMEs face a much larger challenge to pass costs on to the other actors in the chain. Smaller companies only have a limited production and therefore fewer possibilities to offset fixed costs which will weaken their competitive position. Companies that are active on both the EU and US market generally accommodate the new requirements more easily than those only producing for the EU market. (TNO Automotive, 2004)

Companies were enquired about whether their natural business cycle (e.g. the timing and level of investments) would be affected. Most SMEs indicated that this would be the case, potentially leading to surplus costs. Larger manufacturers answered that this is not a major issue as long as harmonisation is guaranteed.

A flexibility scheme is expected to mitigate the potential negative effects on the SMEs involved in the production and/or marinisation of engines. However, certain companies indicated that keeping EU RCD stage 1 standards for CI engines below 37 kW may attract import of less environmentally performing technologies.

6.3.2 Impact on final consumers

Cost differences between manufacturers are an important - but not the only - factor impacting competitiveness. The passing of costs on to the other actors in the supply chain is another factor. To the extent engine manufacturers and marinisers pass on compliance costs to the other actors in the supply chain, competitiveness effects extend to sub-contractors, boat builders, service providers and end consumers. Consequently, the changes may affect market structure and industry composition, functioning of markets, trade and investment flows, engine manufacturers, innovation, local economic activity and employment.

Manufacturers were asked to document cost-pass through possibilities to suppliers and customers. All respondents indicated that there is very limited, if any, possibility to have suppliers absorbing part of the compliance costs. The marine engine manufacturing industry is too small to put pressure on suppliers. Ideas about the possibility of passing on costs to the customers (either boat builders or end consumers) varied. Certain manufacturers were pessimistic and stated that they would need to absorb more than half of the compliance costs themselves. A striking observation is that US and Japanese manufacturers, both large enterprises and SMEs, were confident that they would be able to pass on costs to consumers.

However, more stringent environmental regulation may also have positive competitiveness effects through stimulating innovation, improving efficiency, creating comparative advantages and spinning off new production activities. The actual distribution of these benefits between different firms and regions may nonetheless vary largely. Certain marine engine manufacturers stated that they actively seek to offset the likely price increase resulting from higher emissions standards by not only improving the environmental performance of the engine, but also by adding real value to the consumer e.g. more power, decreased fuel consumption, etc.

For meeting the higher exhaust gas emission standards for recreational marine engines, engine manufacturers and marinisers generally see their costs increase. It has been argued that because of the limited importance of the recreational marine engine industry, engine manufacturers and marinisers will hardly be able to pass part of the cost increase on to their suppliers. Consequently, companies will try to pass on compliance costs down the chain to the consumer. What percentage of the costs increase would finally be passed on to the consumer is not easy to estimate and could be the subject of a separate study. In order to ensure consistency and thus comparability of our scenarios with the TNO options investigated in the ECNI study, it was assumed that compliance costs are entirely passed on to the end consumer.

In the former 2006 impact assessment, compliance costs per unit have been calculated for determining the percentage increase in selling price. In order to ensure comparability of the scenarios assessed in the current impact assessment and those of the ECNI study, a number of issues need to be discussed in more detail:

- Number of engines placed on the EU market;
- Amortisation period of the fixed compliance costs;
- Average recommended retail price (RRP);
- Marked up factor.

Based on a number of assumptions concerning the above issues, the price effects, as assessed for the TNO scenarios in the ECNI report, have been recalculated to match the results of the current impact assessment. The different assumptions are outlined below.

The number of engines placed on the EU market corresponds to the numbers specified in paragraph 6.1. For OB engines and PWCs these numbers do not correspond with those of the ECNI assessment. In the

ECNI impact assessment compliance costs for OB engines have been calculated on the basis of 150,000 units[18]. In order to ensure consistency with the current impact assessment, the total fixed compliance costs for OB engines have been kept constant, but have been spread over 210,829 units. Total yearly variable costs were increased but kept constant on a unit basis. ECNI impact assessment compliance costs for PWCs have been calculated on the basis of 5,000 units[19]. Total fixed compliance costs for PWCs have been kept constant, but spread over 9,034 units; total yearly variable costs were decreased from 5,000 units to 4,517 (being 50% of 9,034) units, but kept constant on a unit basis.

In the ECNI impact assessment fixed compliance costs have been amortised over a ten year period. The decision to do so has been based on an assumption in the TNO calculations and the idea that ten years can be considered as the useful economic life of an engine model. Based on information gathered during the individual company interviews carried out in the framework of the combined IMEC – Euromot stakeholder meeting in April some manufacturers and marinisers indicated that the lifecycle of an engine model is decreasing. During the second stakeholder information and consultation meeting organised by the European Commission on May 15 2008 is has been decided to use a less optimistic three year depreciation period. In order to facilitate the comparison of the scenarios assessed in the current impact assessment with those assessed in the ECNI study, the compliance costs of the ECNI study are recalculated as to match a three year depreciation period for the fixed compliance costs.

The average RRP for the different engine types has been calculated on the basis of the number of engines sold per engine category and their corresponding RRP as specified in paragraph 6.1. The RRPs are only slightly different from those specified in the ECNI study and used for the recalculation of the price effects assessed for the TNO scenarios in the ECNI assessment.

No marked up factor will be applied to the compliance costs that will be passed on to the consumers. During the individual company interviews it was stated that the consumer price of an engine is typically two times higher than the ex-factory cost due to expenses and margins in the distribution chain. In the economic impact analysis of the Draft Regulatory Impact Analysis on the Control of Emissions from Marine SI and Small SI Engines, Vessels, and equipment the EPA also marked up compliance costs. Variable costs were marked up at a rate of 29 percent to account for the engine or equipment/vessel manufacturers' overhead and profit (EPA, April 2007). Both references call for the use of a positive marked up factor for calculating the likely price effect for the consumers. The estimated price effect may therefore be an underestimation of the real price effect. The possible underestimation may, however, be partly annulled. First, if part of the compliance costs is not passed on, as the engine manufacturers'/marinisers' suppliers and/or engine manufacturers/marinisers themselves take responsibility for part of the compliance costs. Second, if the actors in the supply chain do not take their standard margin on the price increase that will result from the higher exhaust emission standards.

Based on the above assumptions and the total compliance costs presented in paragraph 6.2 the derivation of the % increase in average RRP or price effect for the scenarios developed and assessed in the current impact assessment are shown in the Tables below.

[18] The remainder are two-stroke spark ignition engines < 30 kW that are unlikely to remain in the market after RCD stage I and for which consumers are assumed to switch to similar existing engines.

[19] The other half of the engines sold on the EU market does already comply with the TNO options.

Table 6.21 Potential price effect for CI engines

Scenario		*Units placed on the EU market*	*Total yearly compliance costs*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
C1	min	40,000	5,722,234	143	11,555	1.24%
	max		18,958,658	474		4.10%
C2a	min		2,032,984	51		0.44%
	max		15,269,408	382		3.30%
C2b	min		1,230,428	31		0.27%
	max		7,968,619	199		1.72%
C2c	min		1,827,745	46		0.40%
	max		15,185,780	380		3.29%

Table 6.22 Potential price effect for OB engines

Scenario		*Units placed on the EU market*	*Total yearly compliance costs*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
S1	min	210,829	4,668,194	22	4,127	0.54%
	max		4,728,914	22		0.54%
S2	min		4,148,184	20		0.48%
	max		4,208,904	20		0.48%

Table 6.23 Potential price effect for SI IB engines

Scenario		*Units placed on the EU market*	*Total yearly compliance costs*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
S1	min	9,034	289,358	28	6,529	0.49%
	max		5,670,716	557		9.61%
S2	min		289,358	28		0.49%
	max		5,670,716	557		9.61%

Table 6.24 Potential price effect for PWC

Scenario		*Units placed on the EU market*	*Total yearly compliance costs*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
S1	min	9,034	163,817	18	11,500	0.16%
	max		183,792	20		0.18%
S2	min		163,817	18		0.16%
	max		183,792	20		0.18%

Based on the information on compliance costs in the ECNI study is was possible to recalculate the average annual compliance costs per unit for the TNO scenarios. The general assumptions worked with were outlined earlier in this section. The last column of Table 6.25, Table 6.26 and Table 6.27 provide the recalculated price effect for CI engines, OB engines and PWCs respectively. There is no price effect for SI IB engines as the ECNI study concluded that on the basis of the data supplied by the manufacturers all engines would be capable of meeting the emission requirements of the TNO scenarios considered without compliance costs. The results show that the impact on the final price is much larger in the ECNI impact assessment compared to the current impact assessment.

Table 6.25 Potential price effect TNO (2004) options for CI engines

Scenario	*Units placed on the EU market*	*Yearly fixed compliance costs (in € Million)*	*Yearly variable compliance costs (in € Million)*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
1	40,000	47.07	6.10	1,329	11,555	11.50%
2		73.57	24.50	2,452		21.22%
2A		73.57	24.50	2,452		21.22%
2B		48.20	5.60	1,345		11.64%

Table 6.26 Potential price effect TNO (2004) options for OB engines

Scenario	*Units placed on the EU market*	*Yearly fixed compliance costs (in € Million)*	*Yearly variable compliance costs (in € Million)*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
1	210,829	0.87	5.34	29	4,127	0.71%
2		20.9	78.01	469		11.37%
2A		20.9	58.47	376		9.12%
2B		20.9	58.47	376		9.12%

Table 6.27 Potential price effect TNO (2004) options for PWC

Scenario	*Units placed on the EU market*	*Yearly fixed compliance costs (in € Million)*	*Yearly variable compliance costs (in € Million)*	*Yearly compliance costs / unit*	*Average RRP*	*% increase in average RRP*
1	9,034	0.33	0.94	141	11,500	1.23%
2		0.83	2.35	352		3.06%
2A		0.33	0.94	141		1.23%
2B		0.33	0.94	141		1.23%

Consumers will be confronted with price increases and may therefore opt to spend their resources differently, partly shifting their spending to other leisure activities that yield higher utility. Nevertheless, overall utility derived from recreational marine boating would decrease. Cost pass through to consumers is to be regarded limited, as the marine recreational craft industry has significant competition coming from other luxury items and leisure activities. When the price of boating increases, consumers may shift their spending to activities which are deemed more value for money. The relationship between changes in quantity demanded of a good and changes in its price is described as the elasticity of demand. Based on source data from 1958-1996, Bartlesman et al. (2000) estimated the elasticity of demand of recreational boats to be -2 (US EPA, April 2007). This means that when the price of boat will go up by 1% e.g. because of the more costly engine, demand will go down by 2%. This is a reality engine manufacturers need to take into account when considering increasing the selling price of their engines. The elastic price elasticity of demand of marine recreational activities is likely to put increased pressure on competitiveness.

To the extent smaller undertakings would leave the market on the one hand and companies would drop models without replacing them on the other hand, this may result in a (limited) decrease in consumer choice. Together with the likely price effects the decrease in consumer choice negatively impacts consumer welfare.

6.3.3 Impact of price effects on the number of jobs

The number of jobs in the recreational marine engine manufacturing and marinising industry in Europe on which the ECNI study is based for deriving the likely number of job losses is listed in the following Table. To our knowledge the number of employees directly involved in the manufacture and marinisation of CI and OB engines in the EU is somewhat higher than the number of jobs indicated in the following Table. Only taking into account those companies having replied to the questionnaire and/or being interviewed the number of employees involved in the production of CI engines in the European Union amounts to 1,600 people. The total number of employees directly involved in the manufacture and customisation of OB engines in the European Union is slightly over 400. The numbers of 1,600 and 400 FTEs will be used for quantifying job losses in the EU based CI and OB engine manufacturing/marinising chain respectively. In order to ensure comparability with the ECNI study, the TNO options used in this study will be recalculated for these new figures using the adapted price effect.

Table 6.28 Number of jobs in the EU recreational marine engine manufacturing and marinising industry

Engine type	*Number of jobs ECNI (2006) impact assessment*	*Number of jobs current impact assessment*
CI	750	1,600
OB	200	400
SI IB	-	-
PWC	300	300

The assumptions concerning the price elasticity of demand, employment elasticity and the multiplier for assessing the indirect employment effects in the supply chain are borrowed from the ECNI impact assessment. The elasticity of demand for marine engines, which is a derived demand of the elasticity of demand for boats, is set at -2. This means that for every 1% price increase the quantity demanded would fall by 2%. Similarly, the employment elasticity provides an indication of the percentage change in direct employment that is associated with a change in output. The employment elasticity is set at 0.35. Finally, the multiplier for assessing the overall (direct and indirect) employment effect is 1.6 meaning the indirect employment effect amounts to 60% of indirect employment effect.

The only European manufacturer of OB engines has indicated (see paragraph 6.2.4.3) that it would be particularly hit by each of the policy scenarios assessed in the current study and may even go out of business. This has also been stipulated in the framework of the 2006 impact assessment: it was assumed that this manufacturer would go out of business, causing 90 direct jobs to be lost (ECNI, 2006). However, some 40% of the jobs within this firm are expected to disappear as a result of simply complying with the EU RCD stage I limits (= No policy scenario). The net effect of the policy scenarios studied on employment in that company is thus a loss of 54 jobs. Moreover, 32 indirect jobs will be lost, applying a factor of 1.6 for assessing the overall effect on employment.

Currently, about 400 people are directly employed in the EU based OB engine manufacturing chain, 80 of which are working for the above mentioned European manufacturer.[20] The potential job losses among the 320 direct jobs in the EU based OB engine manufacturing companies, not considering the only European manufacturer of OB engines, were calculated based on the same assumptions as for calculating the potential job losses in the CI engine and PWC manufacturing chain.

Based on the above assumptions Table 6.29, Table 6.30 and Table 6.31 provide the potential job losses in the EU CI IB engine, OB engine and PWC manufacturing chain. No job losses in the EU SI IB engine manufacturing chain as we assumed production of SI IB engines in the EU to be negligible.

[20] We assume 10 jobs have already been lost in that company (since the ECNI (2006) was carried out) as a result of the company having to comply wit the EU RCD stage I limits.

Table 6.29 Potential job losses in the CI engine manufacturing chain

Scenario		*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs*	*Direct job losses*	*Indirect job losses*	*Total job losses*
C1	min	1,600	1.24%	2.48%	0.87%	13.9	8.3	22.2
	max		4.10%	8.20%	2.87%	45.9	27.6	73.5
C2a	min		0.44%	0.88%	0.31%	4.9	3.0	7.9
	max		3.30%	6.61%	2.31%	37.0	22.2	59.2
C2b	min		0.27%	0.53%	0.19%	3.0	1.8	4.8
	max		1.72%	3.45%	1.21%	19.3	11.6	30.9
C2c	min		0.40%	0.79%	0.28%	4.4	2.7	7.1
	max		3.29%	6.57%	2.31%	36.8	22.1	58.9

Table 6.30 Potential job losses in the OB engine manufacturing chain

Scenario		*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs non Selva*	*Job losses*				
						Direct		*Indirect*		*Total*
						Selva	*Non Selva*	*Selva*	*Non Selva*	
S1	min	400	0.54%	1.07%	0.38%	54	1.2	32	0.7	87.9
	max		0.54%	1.09%	0.38%	54	1.2	32	0.7	87.9
S2	min		0.48%	0.95%	0.33%	54	1.1	32	0.6	87.7
	max		0.48%	0.97%	0.34%	54	1.1	32	0.7	87.8

Table 6.31 Potential job losses in the PWC manufacturing chain

Scenario		*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs*	*Direct job losses*	*Indirect job losses*	*Total job losses*
S1	min	300	0.16%	0.32%	0.11%	0.3	0.2	0.5
	max		0.16%	0.32%	0.12%	0.4	0.2	0.6
S2	min		0.18%	0.35%	0.11%	0.3	0.2	0.5
	max		0.18%	0.35%	0.12%	0.4	0.2	0.6

Based on the information on compliance costs in the ECNI study, the recalculated price effects as well as the above assumptions concerning the number of direct jobs, it was possible to recalculate the total job losses for the TNO scenarios. The last column of Table 6.32, Table 6.33 and Table 6.34 provide the recalculated potential job losses in the CI engine, OB engines and PWC manufacturing chain respectively. There is no considerable impact on jobs in the SI IB engine manufacturing chain.

Table 6.32 Potential job losses TNO (2004) scenarios CI engine manufacturing chain

Scenario	*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs*	*Direct job losses*	*Indirect job losses*	*Total job losses*
1	1,600	11.50%	23.01%	8.05%	128.8	77.3	206.1
2		21.22%	42.43%	14.85%	237.6	142.6	380.2
2A		21.22%	42.43%	14.85%	237.6	142.6	380.2
2B		11.64%	23.28%	8.15%	130.4	78.2	208.6

Table 6.33 Potential job losses TNO (2004) scenarios OB engine manufacturing chain

Scenario	*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs non Selva*	*Job losses*				
					Direct		*Indirect*		*Total*
					Selva	*Non Selva*	*Selva*	*Non Selva*	
1	400	0.71%	1.43%	0.50%	54	1.6	32	1.0	88.6
2		11.37%	22.73%	7.96%	54	25.5	32	15.3	126.8
2A		9.12%	18.24%	6.38%	54	20.4	32	12.3	118.7
2B		9.12%	18.24%	6.38%	54	20.4	32	12.3	118.7

Table 6.34 Potential job losses TNO (2004) scenarios PWC manufacturing chain

Scenario	*Number of direct jobs*	*% increase in average RRP*	*% decrease in demand*	*% decrease in direct jobs*	*Direct job losses*	*Indirect job losses*	*Total job losses*
1	300	1.23%	2.45%	0.86%	2.6	1.5	4.1
2		3.06%	6.13%	2.14%	6.4	3.9	10.3
2A		1.23%	2.45%	0.86%	2.6	1.5	4.1
2B		1.23%	2.45%	0.86%	2.6	1.5	4.1

Results show that for CI engines, potential job losses range from 5 to approx. 70 in the scenarios assessed in the current impact assessment, whereas potential job losses resulting from the TNO scenarios amount to over 200. For OB engines, losses amount to nearly 90 jobs in the scenarios assessed in the current impact assessment, whereas in the TNO options job losses range between approx. 90 and 125 jobs. For PWC engines, losses amount to half a job in the scenarios assessed in the current impact assessment, whereas for the TNO options potential job losses range from 4 to a maximum of approx. 10 jobs.

6.4 IMPACT ON INNOVATION AND TECHNOLOGICAL DEVELOPMENT

One of the arguments in favour of flexibilities according to industry consists of the fact that the ability to keep alive mechanical fuel injection engines will help European SMEs to remain competitive in price compared to large American engine manufacturers benefiting from a favourable currency exchange rate. Industry indicated that if the small European boat builders can save money on their engine supply, this will also be a factor to help them to stay competitive against US imported boats.

According to industry, as the US is the main market for PWCs, the EU market might end up with a very small product range without harmonisation. Industry indicated that the situation is similar for SI OB and IB SD engines. According to industry, the EU market is not big enough to drive new technology development, so that if standards would not be harmonised, certain engines will be driven out of the European market. Contrary to this situation, industry indicates that the development of diesel technology is driven by the European market and it is important to keep this high technological advantage to avoid import of less environmentally performing technologies.

More stringent environmental regulation may also have positive competitiveness effects through stimulating innovation, improving efficiency, creating comparative advantages and spinning off new production activities. The actual distribution of these benefits between different firms and regions may nonetheless vary largely. Certain marine engine manufacturers stated that they actively seek to offset the likely price increase resulting from higher emissions standards by not only improving the environmental performance of the engine, but also by adding real value to the consumer e.g. more power, decreased fuel consumption, etc.

7 COMPARISION WITH THE 2006 IMPACT ASSESSMENT THROUGH A MULTI-CRITERIA AND COST-BENEFIT ANALYSIS

In this chapter the various scenarios assessed in the current study as well as the TNO (2004) options assessed in the ECNI impact assessment (2006) are presented in terms of their effectiveness, efficiency and consistency. All scenarios are compared by means of a multi-criteria analysis. By altering the weights attributed to the different scenarios, insight is provided in the sensitivity of the ranking of the scenarios. Finally, the environmental benefits are compared to the corresponding compliance costs. In this way, the scenarios can be ranked on the basis of their likely contribution to overall welfare.

The impact assessment study has been carried out in such a way as to facilitate the comparison of the impacts of the scenarios assessed in this report as well as those assessed in the ECNI study on a consistent basis. When calculating the impacts it has been sought to tune the assumptions made in the 2006 impact assessment to those of the current impact assessment and vice versa, depending on which ones are the most realistic. As in the 2006 impact assessment, the risk associated with this impact assessment relates to the assumptions made when calculating the impacts. The crucial factors are the expected compliance costs, emission reductions and socio-economic impacts associated with each regulatory scenario. These risks have been addressed by a thorough and transparent stakeholder consultation.

7.1 PRESENTATION OF THE SCENARIOS

Table 7.1 to Table 7.9 present the no policy scenario as well as the major environmental and socio-economic impacts of the scenarios assessed in this impact assessment as well as the TNO (2004) options assessed in the 2006 impact assessment.

The scenarios in this impact assessment are:

- The basic C1 + S1 scenario:
  - Compression ignition engines: USEPA final rule Tier 3 standards for marine diesel C1 recreational and commercial high power density (final rule EPA420-F-08-004, March 2008) (cfr Table 3.7)
  - Spark-ignition engines: unpublished proposed rule Emission Standards for new non-road Spark-Ignition engines, equipment and vessels as presented in the US EPA note EPA420-F-07-032 of April 2007 (cfr. Table 3.15 for Outboard and Personal WaterCraft spark-ignition engines and Table 3.16 for Inboard and Sterndrive spark-ignition engines)
- Scenario C2a + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies;
- Scenario C2b + S2, being the proposed EU RCD stage 2 exhaust emission standards with a flexibility scheme for all companies and additionally EU RCD stage 1 standards for all CI engines < 37 kW placed on the EU market;
- Scenario C2c + S2, being the proposed EU RCD stage 2 exhaust emission standards with flexibility scheme for all companies and additionally EU RCD stage 1 standards for CI engines < 37 kW placed on the EU market by SMEs.

The TNO options assessed in the ECNI impact assessment are:

- Option 1: All SI engines to comply with RCD Stage 1 limits for four-stroke SI engines. CI engines should comply with NRMM10 Stage IIIA limits specified for propulsion engines for inland waterway vessels (commercial marine engines). For CI engines with a power output of less than 37kW, RCD Stage 1 limits for CI engines would continue to apply.

- Option 2: All SI engines should comply with HC and NOx limits that lie at 75% of the RCD Stage 1 limits for four-stroke SI engines, with the limits for HC and NOx applied as HC+NOx. For CO the RCD Stage 1 limits are assumed to continue to apply. For CI engines with a power output of less than 18kW, RCD Stage 1 limits would continue to apply. For CI engines with a power output of 18 kW and more, but less than 37kW, the NRMM Stage II limits would apply. For CI engines with a power output of 37kW and above, the NRMM Stage IIIA limits for general use would apply.
- Option 2A: As for Option 2, except SI engines with a power output of less than 30kW and all PWC engines would have to comply with the Option 1 limits (RCD Stage 1, four-stroke SI limits).
- Option 2B: As for Option 2A, however CI engines would have to comply with the NRMM Stage II limits for general use. A comparison between the limit values of these four proposed options and the current RCD Stage 1 limit values (to be known as the “do-nothing scenario” and hereafter referred to as the Reference case) has been made. This has been conducted as the impact assessment study requires a multi-criteria analysis using the “do-nothing scenario” as baseline for the comparison.

Figure 3.4 gives an overview of the technical feasibility of the TNO options. This shows that options 2, 2A and 2B may require new technology development[21].

The impacts have been grouped in terms of their:

- Effectiveness – how well does each of the scenarios achieve the objectives (reducing exhaust emissions)?
- Efficiency – the level of resources needed to achieve the stated objectives (impacting technical, economic and social
- Consistency – the balance, trade-offs and synergies of positive and negative (un)intended (in)direct effects on economic, social and environmental systems

[21] The technical feasibility is also included in the level of compliance costs.

Table 7.1 No policy scenario: keep EU RCS stage 1 exhaust emission standards

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
No policy scenario	The no policy scenario assumes no further changes (above current EU RCS stage 1 standards) in the environmental characteristics of engines used in marine recreational craft in the EU. This scenario has no technical, environmental, economic or social effects beyond the regulation already in force.		

Table 7.2 Overview of the impacts of the proposed EU RCD stage 2 exhaust emission standards, without a flexibility scheme

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario C1 + S1	Emission reduction • NOx+HC: -10,846 tons (-26.51%) • PT: -243 tons (-45.05%) • CO: +22,430 tons (+21%)	Yearly compliance costs • CI IB: € 5.7 - 19.0 million • SI OB: € 4.7 - 4.7 million • SI IB: € 0.3 - 5.7 million • PWC: € 0.2 - 0.2 million • Total: € 10.8 - 29.5 million Price effects • CI IB: +1.24% - +4.10% • CI OB: +0.54% - +0.54% • SI IB: +0.94% - +9.61% • PWC: +0.16% - +0.18% Jobs losses • Total: 110.6 - 162.0 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 1.0 - 2.7 million Compliance cost for the reduction in PT per kiloton per annum: € 44.6 - 121.6 million Social cost for reduction in NOx+HC per kiloton per annum: 10.2 - 14.9 jobs Social cost for reduction in PT per kiloton per annum: 455.3 - 666.9 jobs

Table 7.3 Overview of the impacts of the proposed EU RCD stage 2 exhaust emission standards, with a flexibility scheme

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario C2a + S2	Emission reduction • NOx+HC: -9,833 tons (-24.04%) • PT: -152 tons (-28.02%) • CO: +22,430 tons (+21%)	Yearly compliance costs • CI IB: € 2.0 - 15.3 million • SI OB: € 4.1 - 4.2 million • SI IB: € 0.3 - 5.7 million • PWC: € 0.2 - 0.2 million • Total: € 6.6 - 25.3 million Price effects • CI IB: +0.44% - +3.30% • CI OB: +0.48 - +0.48% • SI IB: +0.49% - +9.61% • PWC: +0.16% - +0.18% Job losses • 96.1 - 147.5 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 0.7 - 2.6 million Compliance cost for the reduction in PT per kiloton per annum: € 43.6 - 166.7 million Social cost for reduction in NOx+HC per kiloton per annum: 9.8 - 15.0 jobs Social cost for reduction in PT per kiloton per annum: 632.4 - 970.6 jobs

Table 7.4 Overview of the impacts of the proposed EU RCD stage 2 exhaust emission standards, with a flexibility scheme and with EU RCD stage 1 standards for CI engines < 37 kW

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario C2b + S2	Emission reduction • NOx+HC: -9,802 tons (-23.96%) • PT: -152 tons (-28.02%) • CO: +22,430 tons (+21%)	Yearly compliance costs • CI IB: € 1.2 - 8.0 million • SI OB: € 4.1 - 4.2 million • SI IB: € 0.3 - 5.7 million • PWC: € 0.2 - 0.2 million • Total: € 4.1 - 18.0 million Price effects • CI IB: +0.27% - +1.72% • CI OB: +0.48% - +0.48% • SI IB: +0.49% - +9.61% • PWC: +0.16% - +0.18% Job losses • 93.0 - 119.2 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 0.6 - 1.8 million Compliance cost for the reduction in PT per kiloton per annum: € 38.4 - 118.6 million Social cost for reduction in NOx+HC per kiloton per annum: 9.5 - 12.1 jobs Social cost for reduction in PT per kiloton per annum: 611.9 - 784.4 jobs

Table 7.5 Overview of the impacts of the proposed EU RCD stage 2 exhaust emission standards, with a flexibility scheme and with EU RCD stage 1 standards for CI engines < 37 kW put on the market by SMEs

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario C2c + S2	Emission reduction • NOx+HC: -9,802 tons (-23.96%) • PT: -152 tons (-28.02%) • CO: +22,430 tons (+21%)	Yearly compliance costs • CI IB: € 1.8 - 15.2 million • SI OB: € 4.1 - 4.2 million • SI IB: € 0.3 - 5.7 million • PWC: € 0.2 - 0.2 million • Total: € 6.4 - 25.2 million Price effects • CI IB: +0.40% - +3.29% • CI OB: +0.48% - +0.48% • SI IB: +0.49% - +9.61% • PWC: +0.16% - +0.18% Job losses • 95.3 - 147.2 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 0.7 - 2.6 million Compliance cost for the reduction in PT per kiloton per annum: € 42.3 - 166.1 million Social cost for reduction in NOx+HC per kiloton per annum: 9.7 - 15.0 jobs Social cost for reduction in PT per kiloton per annum: 627.1 - 968.4 jobs

Table 7.6 Overview of the impacts of the EU RCD stage 2 exhaust emission standards as analysed in the 2006 impact assessment, option 1

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario 1 (TNO, 2004)	Emission reduction • NOx+HC: -8,139 tons (-19.90%) • PT: -94 tonnes (-17.44%)	Yearly compliance costs • CI IB: € 53.3 million • SI OB: € 6.2 million • SI IB: € ~0 million • PWC: € 1.3 million • Total: € 60.6 million Price effects • CI IB: +11.5% • CI OB: +0.7% • SI IB: ~0% • PWC: +1.23% Job losses • 298.9 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 7.5 million Compliance cost for the reduction in PT per kiloton per annum: € 645.2 million Social cost for reduction in NOx+HC per kiloton per annum: 36.7 jobs Social cost for reduction in PT per kiloton per annum: up to 3,178 jobs

Table 7.7 Overview of the impacts of the EU RCD stage 2 exhaust emission standards as analysed in the 2006 impact assessment, option 2

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario 2 (TNO, 2004)	Emission reduction • NOx+HC: -12,650 tons (-30.92%) • PT: -109 tonnes (-20.22%)	Yearly compliance costs • CI IB: € 98.1 million • SI OB: € 98.9 million • SI IB: € ~0 million • PWC: € 3.2 million • Total: € 200.2 million Price effects • CI IB: +21.2% • CI OB: +11.4% • SI IB: ~0% • PWC: +3.1% Job losses • 517.2 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 15.8 million Compliance cost for the reduction in PT per kiloton per annum: € 1,836.3 million Social cost for reduction in NOx+HC per kiloton per annum: 40.9 jobs Social cost for reduction in PT per kiloton per annum: up to 4,745 jobs

Table 7.8 Overview of the impacts of the EU RCD stage 2 exhaust emission standards as analysed in the 2006 impact assessment, option 2a

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario 2a (TNO, 2004)	Emission reduction • NOx+HC: -13,390 tons (-32.73%) • PT: -109 tonnes (-20.22%)	Yearly compliance costs • CI IB: € 98.1 million • SI OB: € 79.4 million • SI IB: € ~0 million • PWC: € 1.3 million • Total: € 178.7 million Price effects • CI IB: +21.2% • CI OB: +9.1% • SI IB: ~0% • PWC: +1.2% Job losses • 503.0 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 13.3 million Compliance cost for the reduction in PT per kiloton per annum: € 1639.5 million Social cost for reduction in NOx+HC per kiloton per annum: 37.6 jobs Social cost for reduction in PT per kiloton per annum: up to 4,614 jobs

Table 7.9 Overview of the impacts of the EU RCD stage 2 exhaust emission standards as analysed in the 2006 impact assessment, option 2b

Scenario	Effectiveness criteria	Efficiency criteria	Consistency criteria
Scenario 2b (TNO, 2004)	Emission reduction • NOx+HC: -9,387 tons (-22.95%) • PT: -109 tonnes (-20.22%)	Compliance costs • CI IB: € 53.8 million • SI OB: € 47.9 million • SI IB: € ~0 million • PWC: € 1.3 million • Total: € 133.4 million Price effects • CI IB: +11.6% • CI OB: +9.1% • SI IB: ~0% • PWC: +1.2% Job losses • 331.4 jobs	Compliance cost for the reduction in NOx+HC per kiloton per annum: € 14.3 million Compliance cost for the reduction in PT per kiloton per annum: € 1233.4 million Social cost for reduction in NOx+HC per kiloton per annum: 35.3 jobs Social cost for reduction in PT per kiloton per annum: up to 3,040 jobs

7.2 MULTI-CRITERIA ANALYSIS

In the following Table the environmental and socio-economic impact of the various scenarios are presented through a number of synthetic indicators. The second and third columns present the absolute annual reduction of NOx+HC and PT emissions. TNO options 2A and 1 respectively are the most and the least effective from an environmental point of view. However, (social) cost-efficiency should also be considered, as the means by which the environmental objectives are realised should be proportionate to the benefits. Therefore, the reduction in NOx+HC and PT emissions is compared to the expected compliance costs and job losses faced by industry. The reduction in NOx+HC and PT emissions was added up, accounting for the higher social costs of PT emissions compared to NOx+HC emissions.

A factor 9 was used to convert PT emissions into NOx equivalents. This factor has been derived from the study "Estimates of the marginal external costs of air pollution in Europe" by Netcen which has been referred to in the NRMM Directive. Moreover, the following factors are used as proxies of the marginal external costs of NOx and PT:

- NOx - 4200 €/tonne
- PT - 36420 €/tonne

As it is not known how the reduction in NOx+HC emissions is split up between NOx and HC, we only rely on the NOx marginal external costs as a proxy for the social benefits of the reduction in NOx+HC emissions.

The following Table demonstrates that scenarios 2A, 2 and C1 + S1 are the most effective. Scenario C1 + S1 outperforms the other scenarios in terms of PT reduction whereas 2 and 2A are performing better for NOx+HC.

The scenarios assessed in the current impact assessment study realise emission reductions in a more cost-efficient way. The potential compliance costs and job losses per kiloton reduction in emissions are much lower than for the TNO (2004) scenarios. Especially scenario C2b + S2 realises emission reductions at limited costs per kiloton emission reduction. Scenario C1 + S1 performs best on both effectiveness and cost-effectiveness criteria. Industry pointed out that the higher socio-economic impacts per kiloton reduction for the TNO (2004) scenarios relates to the technical difficulties of adopting the required technology in the short term.

Table 7.10 Overview of the effectiveness and the (social) costs effectiveness per scenario

Scenario	*Absolute annual reduction (in kilotons)*			*Compliance costs per kiloton reduction (in € million)*		*Job losses per kiloton reduction (in number of jobs)*	
	NOx+HC	*PT*	*NOx+HC & PT (expressed in NOx equivalents)*	*min*	*max*	*min*	*max*
C1 + S1	10.85	0.24	13.03	0.83	2.27	8.49	12.43
C2a + S2	9.83	0.15	11.20	0.59	2.26	8.58	13.17
C2b + S2	9.80	0.15	11.17	0.52	1.61	8.33	10.67
C2c + S2	9.80	0.15	11.17	0.58	2.26	8.53	13.18
1	8.14	0.09	8.99	6.75	6.75	33.26	33.26
2	12.65	0.11	13.63	14.68	14.68	37.95	37.95
2A	13.39	0.11	14.37	12.44	12.44	35.00	35.00
2B	9.39	0.11	10.37	12.97	12.97	31.96	31.96

With the decision software DEFINITE the critical deliberations between the eights scenarios have been studied in more depth. As in the Table, three decision criteria (annual emission reduction, compliance costs per kiloton emission reduction and job losses per kiloton emission reduction) have been used and were scored for each scenario. The scores on each criterion are standardised and a certain weight was attributed to each criterion. The standardised scores on the different criteria were weighted and summed for each scenario. Finally, the different scenarios are ranked.

Applying an equal weight (0.5 – 0.5) for the effectiveness and cost-effectiveness (job losses has been attributed one forth of the weight of the compliance costs) ranks scenario C1 +S1 first, see the following Figure. The three other scenarios with flexibilities, put forward in this study, are very close in terms of their overall score. The TNO (2004) options are not preferable when attributing equal weights to the effectiveness and cost-effectiveness criteria.

Figure 7.1 Weighing exercise (0.5; 0.375 and 0.125)

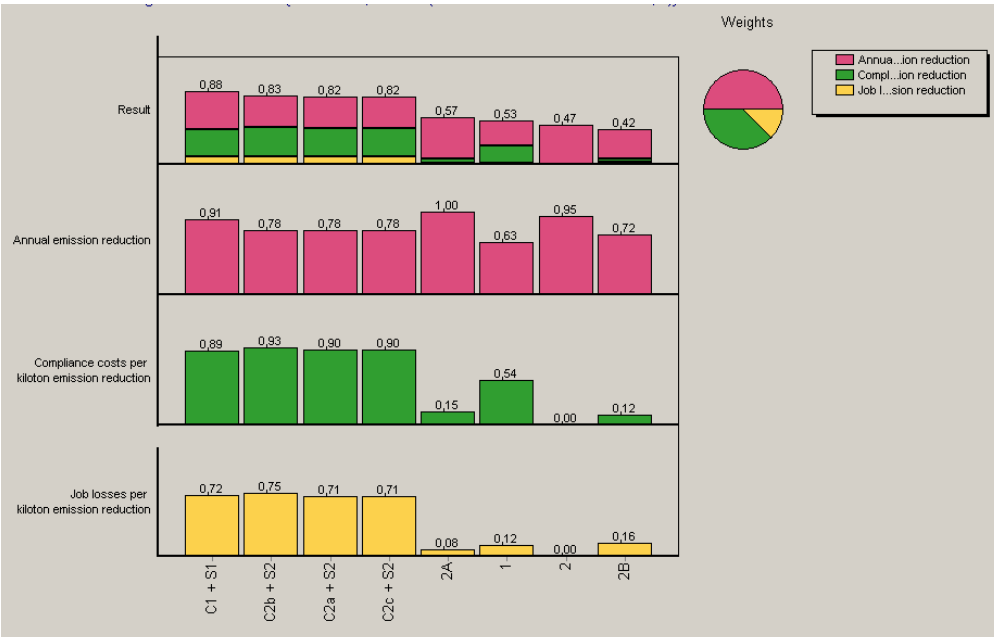
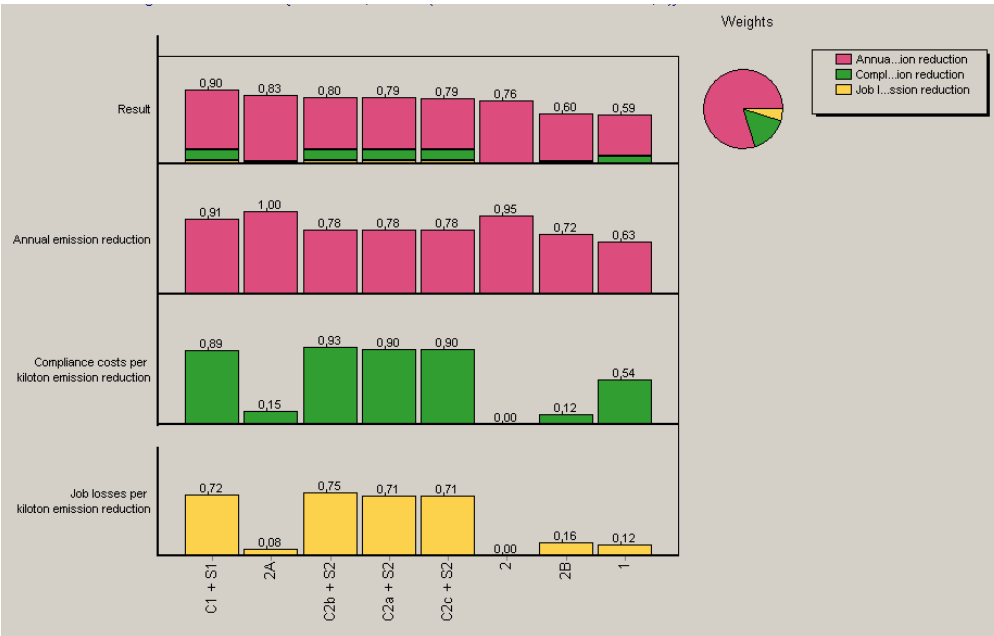


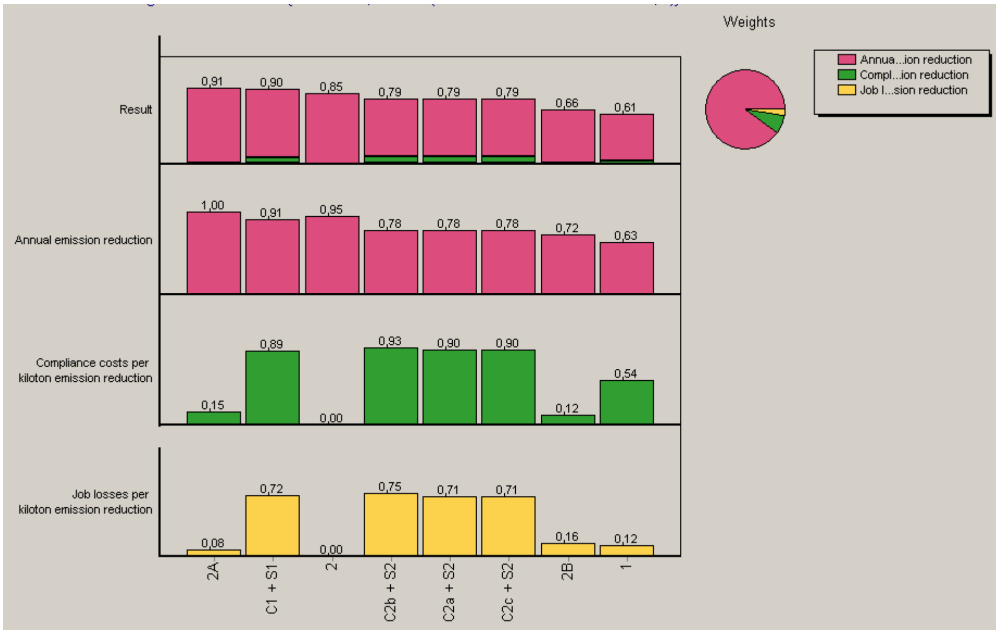
Figure 7.2 shows that drastically increasing the weight attributed to the effectiveness criterion emission reduction (the effectiveness criteria is given a four times higher weight than cost-effectiveness) scenario 2A ranks higher than the scenarios with flexibilities, developed and assessed in this study. However, scenario C1+S1 still ranks first.

Figure 7.2 Weighing exercise (0.8; 0.15 and 0.05)



It is only in case the absolute annual emission reduction is attributed 90% of the overall weight attributed to the three decision criteria, that one of the TNO (2004) options ranks first, see Figure 7.3. Given these weights, scenario 2A is the most preferred before scenario C1 +S1 and scenario 2.

Figure 7.3 Weighing exercise (0.9; 0.075 and 0.025)



7.3 COST-BENEFIT ANALYSIS

Weighing the cost and the benefits of the different scenarios provides an indication of the desirability of the scenarios from a welfare point of view. Below, the benefits stemming from the reduction in exhaust gas emissions have been monetized. The factors used for monetising the environmental benefits of the reduction of NOx and PT emissions are those put forward in the Netcen study and suggested in the NRMM Directive.

As it is not known how the reduction in NOx+HC emissions is split up between NOx and HC, we have relied on the NOx marginal external costs to monetize the environmental benefits of the reduction in NOx+HC emissions. This implies that the absolute monetized environmental benefit in terms of NOx+HC emission reduction are likely to be overestimated. However, the aim of this exercise is to compare the various scenarios, which is not endangered as long as the same factor is used for all scenarios. Consequently, the ranking of the scenarios on the basis of their Cost/Benefit ratio (B/C ratio) will provide a useful insight for deciding about the scenario to be put forward from a welfare point of view.

As can be seen from Table 7.11, the monetised benefits from the reduction of NOx+HC are higher than those of PT. Again scenarios 2A, 2 and C1 + S1 yield the highest benefits. However, the compliance costs of the scenarios assessed in the framework of this study are much lower.

Combining both costs and benefits, all scenarios assessed in the current study have a B/C ratio higher than one and are expected to increase overall welfare, contrary to the TNO (2004) options. The difference between the scenarios in this impact assessment is rather small. For the TNO options, the emission reductions are realised in a much more cost inefficient manner. The harmonisation of the US and EU exhaust emission standards apparently has important advantages.

Table 7.11 B/C ratio of the different scenarios (in € million)

Scenario	*Environmental benefits of emission reduction*		*Compliance costs*		*B/C ratio*	
	NOx+HC	*PT*	*min*	*max*	*min*	*max*
C1 + S1	45.55	8.85	10.84	29.54	5.02	1.84
C2a + S2	41.3	5.54	6.63	25.33	7.06	1.85
C2b + S2	41.17	5.54	5.83	18.03	8.01	2.59
C2c + S2	41.17	5.54	6.43	25.25	7.26	1.85
1	34.18	3.42	60.65		0.62	
2	53.13	3.97	200.16		0.29	
2A	56.24	3.97	178.71		0.34	
2B	39.43	3.97	134.44		0.32	

The factors used for assessing the marginal external costs of environmental improvements are still somewhat uncertain. This uncertainty is often expressed by means of a range. In order to limit uncertainty, the Netcen estimate is complemented by the marginal external costs estimate for NOx+HC and PT by AEA Technology (2005), as presented in Table 7.12. The estimates by AEA Technology were developed in the framework of their work in the Clean Air for Europe (CAFE) Programme. The range put forward, which is clearly in line with the Netcen estimate, accounts for various uncertainties. Besides, a number of effects are excluded from the AEA Technology estimates like the impact ton ecosystems and cultural heritage. The inclusion of these effects would further increase benefits.

Table 7.12 Average damages per tonne of emissions of NOx and PT for the EU25 (excluding Cyprus) and surrounding sea areas (in ton)

	Lower bound	*Upper bound*
EU 25 average - NOx	4,400	12,000
EU 25 average - PT	26,000	75,000
Seas average - NOx	2,500	6,900
Seas average - PT	13,000	36,000

The emission calculations carried out in the environmental impact assessment show that about 57% of NOx+HC and 53% of PT emissions take place in coastal areas. Applying the AEA Technology (2005) average marginal external cost estimates for the surrounding sea areas to the emissions from marine recreational craft in coastal areas the following ranges are derived:

- NOx: 3,317 – 9,093 €/ton
- PT: 19,110 – 54,330 €/ton

By applying these benefit ranges, the net benefits of the scenarios developed and assessed in the current impact assessment clearly outperform those of the TNO (2004) options, see Table 7.13. In case the lower bound benefit estimates for NOx and PT are most likely, the scenario C2b + S2 is expected to contribute most to welfare. In case the upper bound benefit estimates are applied, the scenario C1+S1 is expected to contribute most to overall welfare. This additional analysis confirms the findings from **Table 7.11**. Even in case the benefits to society would be at the lower bound, the implementation of the scenarios of the current impact assessment are beneficial to society as a whole.

Table 7.13 Net benefits calculated with the adapted lower and upper bound ranges put forward in the AEA Technology (2005) study (in € million)

Scenario	*Lower bound*		*Upper bound*	
	min	*max*	*min*	*max*
C1 + S1	11.08	29.78	82.28	100.98
C2a + S2	10.19	28.89	72.34	91.04
C2b + S2	17.39	29.59	79.36	91.56
C2c + S2	10.17	28.99	72.14	90.96
1	-31.85		18.47	
2	-156.11		-79.21	
2A	-132.21		-51.03	
2B	-101.22		-43.16	

ANNEXES

ANNEX 1 Combined Recreational Marine Diesel Engine Task Force Industry Position – EU Stage 2

April 08, 2008

Introduction

The Combined Recreational Marine Diesel Engine Task Force of IMEC (ICOMIA's Marine Engine Committee) and EUROMOT (European Association of Internal Combustion Engine Manufacturers) represent the interests of the majority of recreational marine diesel engine manufacturers in Europe. This paper outlines their position on future emission requirements, as expressed in desired amendments to limit values in EU Directive 1994/25/EC amended by 2003/44/EC.

Objectives

The primary objectives of the recreational marine diesel engine industry are:

- Global alignment for exhaust emission regulations (including test cycle protocol and procedures) for engines over 37kW and
- Flexibility provisions for SME's.

Alignment

The European diesel engine industry for recreational craft is the world leader. The export ratio of these engines is 3:1 in favour of European based companies in trans-Atlantic trade. The industry is highly internationalised and continues to grow. Aligned exhaust emission requirements on both sides of the Atlantic reduce technical barriers to trade, which will promote the growth of the industry. The Progress Report on Economic Initiative at the EU – US Summit in Vienna on 21 June 2006 states: "*US and European authorities aim to build effective mechanisms to promote better quality regulation, minimize unnecessary regulatory divergences to facilitate transatlantic trade and investment and increase consumer confidence in the transatlantic market."* In support of this initiative, international alignment is the highest priority objective of our industry.

Mitigation measures for small manufacturers

Some manufacturers exclusively trading on the EU market may not gain from the economical benefit of alignment. Such enterprises have a significant amount of their production at the smaller engine size. In order to ensure competitiveness, provisions need to be established that protect them from unnecessary burden.

Proposal

Emission limits

We envisage alignment being achieved through the limit values in table 1 below, which are derived from US EPA's **Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder** Final Rule, passed on March 14, 2008. This table takes account of mitigation measures for SME's by maintaining current EU emission levels for engines below 37kW and the timing of the EU legislative process.

Table 1 – Industry proposed emission limits and timing

Year	Engine category		**PM in g/kWh**	**HC+NOx in g/kWh**
	Disp.<0,9 l/cyl	P<18kW	RCD stage 1	RCD stage 1
	Disp.<0,9 l/cyl	18kW<P<37kW	RCD stage 1	RCD stage 1
2012	Disp.<0,9 l/cyl	37kW<P<75kW	0.3	7.5
2014[1]	Disp.<0,9 l/cyl	37kW<P<75kW	0.3	4.7
2014[1]	Disp.<0,9 l/cyl	37kW<P<75kW	0.2	5.8
2012	Disp.< 0,9 l/cyl	P>75 kW	0.15	5.8
2013	0,9 l/cyl <Disp.< 1,2 l/cyl	P>75kW	0.14	5.8
2014	1,2 l/cyl< Disp.< 2,5 l/cyl	P>75kW	0.12	5.8
2013	2,5 l/cyl <Disp.< 3,5 l/cyl	P>75kW	0.12	5.8
2012	3,5 l/cyl <Disp.< 7,0 l/cyl	P>75kW	0.11	5.8

[1]: Engines with 2014 model year, a displacement below 0.9 L/cyl and maximum engine power above 19kW and at or below 75kW may be certified to **either** PM 0.3 g/kWh and HC+NOx 4.7 g/kWh **or** PM 0.2 g/kWh and HC+NOx 5.8 g/kWh.

Equivalent certificates

Certificates for engines complying with the Non-Road Mobile Machinery Directive 97/68/EC as amended referring to Stage III A (industrial engines) – or On-Road Directive 2005/55/EC Row A or later and valid at the date when the marinised engine is placed on the market, shall be recognised to demonstrate conformity under EU stage 2.

Flexibility

To ensure competitiveness of all concerned Enterprises on the market, but especially protection of SME's, our proposal to maintain EU Stage 1 below 37 kW. Additionally we propose flexibilities adapted from the EU's Non Road Machinery Directive (NRMM) but applied to engine manufacturers. This flexibility scheme limits the number of Stage I engines placed on the market to:

- 50% of the manufacturer annual sales in each engine category or
- a fixed number of engines not exceeding in each engine category the number of engines specified in table 2 below.

Table 2 – Fixed number of stage I engines to be placed on the market

Engine category		Number of engines
Disp.<0,9 l/cyl	37kW<P<75kW	500
Disp.< 0,9 l/cyl	P>75 kW	150
0,9 l/cyl <Disp.< 1,2 l/cyl	P>75kW	150
1,2 l/cyl< Disp.< 2,5 l/cyl	P>75kW	100
2,5 l/cyl <Disp.< 3,5 l/cyl	P>75kW	100
3,5 l/cyl <Disp.< 7,0 l/cyl	P>75kW	50
Over a period of seven years from introduction date		

Additionally to simplify the emission compliance by allowing the use of assigned deterioration factors as well as exemption of production line testing will significantly lower the administrative burden.

Conclusion

Alignment is the highest priority of the international marine diesel engine manufacturing industry, of which the majority is located within the European Union. However, European SMEs require protection from additional burden. Therefore, IMEC and EUROMOT proposing provision which will align with EPA but at the same time will protect SMEs through maintaining current emission limits below 37 kW in combination with flexibility provisions.

ANNEX 2: IMEC letter proposing that EU SI Outboard engine manufacturers be exempted any new emissions regulations if their sales remain below 5% of the EU total

MARINE PROTECTION
IMEC

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21 March 2005

Mr J Renders
DG Enterprise and Industry
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Dear Mr Renders

Directive 2003/33/EC: Special Treatment for EU SME Outboard Manufacturers[22]

IMEC, at its last meeting, unanimously agreed that I request special treatment be given to EU SME outboard manufacturers when the proposals are drafted for Stage 2 of Directive 2003/44/EC. The SME outboard motor manufacturers do not market their products in the USA and consequently do not benefit from the economies of scale that large market provides. Consequently the costs for development of engines to meet likely Stage 2 emission limits are wholly unaffordable by such small enterprises.

The specific proposal is that the outboard engines of such manufacturers are required to comply solely with the requirements of Stage 1 of the said Directive providing the following constraints are applied:

1. Such manufacturers remain within the EU criteria for SME.
2. The median value of their engine emissions does not exceed 5% of outboard segment's total emissions.

Yours sincerely

[22] An SME outboard manufacturer must produce the main engine components at their manufacturing facility or facilities. They shall not fall under the definition of a mariniser.

H Kleyn Van Willigen
Chairman

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