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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Review of Directive 97/68/EC on emissions from engines in non-road mobile machinery in view of establishing a new legislative instrument

Disclaimer: This report commits only the Commission's services involved in its preparation and does not prejudge the final form of any decision to be taken by the Commission.

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Executive Summary Sheet

Review of the legislative instrument on emissions from engines in non-road mobile machinery

A. Need for action

Why? What is the problem being addressed?

Non-Road Mobile Machinery (NRMM) covers a large variety of combustion engines installed in machines ranging from small handheld equipment, construction machinery and generator sets, to railcars, locomotives and inland waterway vessels. These engines contribute significantly to air pollution and are accountable for roughly 15% of the nitrogen oxide (NOx) and 5% of the particulate matter (PM) emissions in the EU. The data also indicate that their relative contribution to the total NOx emissions will become bigger over time. The emissions limits for these engines are set in Directive 97/68/EC. This Directive was amended a number of times, but the technical review concluded that the current legislation has shortcomings. The scope is overly restricted, new emission stages were last introduced when the Directive was amended in 2004 and no longer reflect the current state of technology, and there is a mismatch between the emission limits for certain engine categories.

What is this initiative expected to achieve?

The initiative seeks to protect human health and the environment, and to ensure a good functioning of the internal market for NRMM engines. It also seeks to address competitiveness and compliance aspects. In line with the EU's air quality policy, the objective is to progressively reduce the emissions from new engines being brought on the market. This is expected to result in a very significant emission reduction overall, but the reduction by engine category will vary depending on how stringent the specific requirements already are. The revision is also expected to alleviate the pressure on Member States to take additional regulatory action that could hamper the internal market. Finally, the revision seeks to remove obstacles to external trade by reducing the regulatory barriers that result from diverging emission requirements.

What is the value added of action at the EU level?

The problem of air pollution has a strong transnational dimension as the effects are rarely confined to the territory of one Member State only. All EU Member States share common EU air quality goals and also have a strong interest in avoiding barriers to intra-community trade. Common rules at the EU level are, therefore, best suited to address the problem. This initiative concerns the revision of existing EU legislation and would not mean that EU legislation is established in a new area.

B. Solutions

What legislative and non-legislative policy options have been considered? Is there a preferred choice or not? Why?

Three main policy options were analysed in detail. Each consists of various sub-options for the engine categories and applications already covered by EU NRMM legislation, and for the ones that could come under its scope in the future. Alongside the no-policy change scenario, these options are:

Option 2: Alignment with US standards in scope and limit values

Option 3: Step towards road sector ambition levels, for the most relevant emission sources

Option 4: Extended level of ambition through enhanced monitoring provisions

It was already taken into account in the analytical design that the preferred option might be a combination of elements from different options. The analysis of costs and benefits was carried out in individual modules that allow for regrouping. Non-legislative options (e.g. a voluntary agreement with industry) have been considered, but the initial analysis concluded that they are unsuitable for reaching the initiative's objectives.

Who supports which option?

The need for a revision is acknowledged by Member States, industry and NGOs alike. However, the preferred level of ambition differs between stakeholders who naturally assign different weight to costs and benefits. Engine and machinery manufacturers would be most directly affected by the cost increase that could result from more stringent emission limits and stress the need for cost-effective reductions and alignment with US EPA limits. Option 2 would require limited research and development efforts from them and could strengthen their export potential, but would still result in important emission reductions. Some Member State authorities and environmental NGOs support a solution that would go one step further and bring NRMM emission legislation closer to the requirements for trucks, by inserting a particulate number (PN) limit in addition to the particulate matter mass limit (PM). Options 3 and 4 answer to this call. End customers, such as railway and inland waterway vessel operators, tend to be most cost-sensitive and stress that the environmental benefits of more stringent emission legislation will only translate into real life reductions if the operators can afford cleaner machinery.
C. Impacts of the preferred option
What are the benefits of the preferred option (if any, otherwise main ones)?
Due to the considerable diversity of engines and applications in the NRMM sector, the preferred option is a combination of elements cutting across policy options. The preferred option will lead to a significant reduction of pollutant emissions which have adverse effects on human health and the environment. The focus is on the reduction of diesel particle emissions. In addition, substantial reductions in NOx and HC emissions will be achieved. Overall, the benefit of the preferred option is expected to be in the € 26,100 to 33,300 million range until 2040. A detailed quantification of the benefits is provided for all options and engine categories. Due to the breadth of the NRMM sector and the large variety of engines and machinery covered, it was not possible to capture all relevant aspects in one study at one time. As a result, the data stem from different studies and certain concessions in terms of geographical coverage and base year had to be made to keep them comparable.
What are the costs of the preferred option (if any, otherwise main ones)?
A detailed quantification of the costs is provided for all options and engine categories. The cost of the preferred option will mainly be incurred by engine and machinery manufacturers (for development, redesign and production), but also by end-users of machinery (for additional fuel consumption and maintenance). The total cost of the preferred option will be in the range of € 5,200 to 5,800 million until 2040. Overall, the cost-benefit analysis shows important net benefits, but significant investment will be required for certain engine categories and/or sectors. The investment need will be highest in sectors which, until now, have less stringent emission requirements in relative terms; i.e. small diesel engines (19-37 kW) and engines used in the IWT sector.
How will businesses, SMEs and micro-enterprises be affected?
The result of the public consultation indicates that a large majority of businesses, including SMEs, will at least support more stringent emission limits in-line with the current US legislation. Impacts on SMEs were thoroughly assessed in a dedicated study and it is likely that the costs of more stringent emission requirements are more strongly felt by SMEs. In particular in the IWT sector, where shipbuilders, dealers and end users are often SMEs.
Will there be significant impacts on national budgets and administrations?
A significant impact on national budgets and administrations is not expected.
Will there be other significant impacts?
Reducing unequal treatment of engines inside and outside the scope of the Directive, avoids market distortions and unfair competition. Closer alignment with third country requirements emission standards, particular the US, improve cost-efficiency and competitiveness of manufacturers. This is of particular interest with regard to the possible free trade agreement (FTA) between the EU and the US, given that NRMM and their engines make up for a significant part of transatlantic trade. Further regulatory market fragmentation is avoided, with some Member States currently introducing local restrictions in order to comply with EU air quality policy.
D. Follow up
When will the policy be reviewed?
A technical review of the NRMM legislation was carried out in 2008, which triggered the development of the current initiative. Such a review could be repeated a number of years after the entry into force of the revised

NRMM legislation once sufficient evidence of the effects can be expected. This could be the case 5 years after the entry into force of new emission requirements.

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Identification

Lead DG: ENTR

Other involved DGs: SG, EMPL, MOVE, CLIMA, ENV, RTD, JRC

Agenda Planning/WP Reference: 2010/ENTR/001

1.2. Organisation and timing

Work on this impact assessment started in 2008 with a technical review of the NRMM Directive. In the following years, the review was followed-up with the commissioning of external studies and the preparation of emission inventories for various engine categories. The impact assessment report itself was drafted during the year 2013.

1.3. Consultation and expertise

An open public consultation started on 15 January 2013 and closed on 8 April 2013 (12 weeks duration). For this purpose, a dedicated consultation web-page[1] was set up and the Commission services prepared a 15 page consultation document, outlining key issues, study results and potential courses of action. 69 responses were received in total. A detailed analysis of the results is included in Annex II of this report and the individual responses can be viewed on the consultation web-page. Furthermore, a stakeholder hearing attended by approx. 80 participants took place in Brussels on 14 February 2013. The Group of Experts on Machinery Emissions (GEME), which brings together industry, NGO, Member State and Commission representatives was regularly informed on the state of the impact assessment work and actively supported the process. The position of all stakeholders was duly considered and almost unanimous agreement exists on the need to further develop NRMM engine emission legislation.

The work on the impact assessment was followed and informed by an inter-service steering group which met on 25 April, 6 June, 11 September and 17 October 2013. All relevant Commission services were invited to participate in this group and SG, EMPL, MOVE, CLIMA, ENV, RTD and JRC followed the invitation. The JRC further supported the analytical work with a research project on the effects of particulate number (PN) limits for certain engine categories.

The Commission has carried out various studies and regularly consulted stakeholders, as concerns the feasibility of new limit values and the need to include

[1] http://ec.europa.eu/enterprise/sectors/automotive/documents/consultations/2012-emissions-nrmm/index_en.htm

new stages for exhaust emissions based on technical progress. The Impact Assessment builds on the following external studies[2]:

- A Technical Review of the Directive, submitted in two parts, by the JRC, which in part 1 includes an overview of emissions inventories for NRMM. Part 2, inter alia, focuses on spark ignition engines (small petrol engines and snowmobile engines) and, among others, analyses emission inventories and market sales of construction and agricultural machinery.

- An Impact Assessment study by ARCADIS N.V. assesses the impacts of the policy options developed in the Technical Review of the JRC. A complementary study by the same contractors looked specifically at the impacts on small and medium sized enterprises (SMEs). In addition to the social and economic impact the environmental and health impact was also evaluated in this study.

- A study from Risk & Policy Analysis (RPA) and Arcadis, evaluates the current contribution of the NRMM sector to greenhouse gas (GHG) emissions. This study also examines the feasibility of extending the emission limits for variable speed engines to constant speed engines and considers the option of aligning the exhaust emission limit values to US values.

- The PANTEIA study[3] commissioned by DG MOVE analysis the situation in the inland navigation sectors and assesses specific measures for reducing emissions from inland waterway transport.

1.4. Scrutiny by the Commission Impact Assessment Board

The Impact Assessment Board of the European Commission assessed a draft version of the present impact assessment and issued its opinion on 22/11/2013. The Impact Assessment Board made several recommendations and, in the light of the latter, the final impact assessment report:

Clarifies the rationale for expanding the scope of the Directive and explains more thoroughly how regulatory shortcomings contribute to internal market distortions and air pollution problems.

Describes the structure of the NRMM sector by means of additional graphs and explains the coherence of the planned review of the NRMM Directive with other air quality related initiatives. Furthermore, it provides an overview of the positions of both Member States' authorities and different economic operators, including SMEs in Annex II and throughout the text.

2. CONTEXT

This Impact Assessment report examines options for revising Directive 97/68/EC (hereafter NRMM Directive) of 16 December 1997 on the approximation of the laws

[2] http://ec.europa.eu/enterprise/sectors/mechanical/non-road-mobile-machinery/publications-studies/index_en.htm
[3] http://ec.europa.eu/transport/modes/inland/studies/inland_waterways_en.htm

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.

The NRMM Directive establishes the exhaust emission limits and implementation dates – divided into stages – for the various engine categories within its scope. The engines covered by the Directive include spark-ignited (petrol) engines and compression ignited (diesel) engines, both variable speed and constant speed, which are used in a wide range of applications ranging from small handheld equipment, construction and forestry machinery, generators, to railcars, locomotives and inland waterway vessels. The exhaust emission limits provided for in the Directive get progressively stricter over time in pre-defined stages, with the latest stage coming into effect in 2014. The Directive also provides the procedures for type-approving these engines before they are placed on the market and specifies the relevant test methods. Furthermore, it stipulates certain exemptions, derogations and transitional measures. It is important to note that certain engine categories are not regulated at present. Most notably compression ignited engines with less than 19kW and more than 560kW, and spark ignited engines above 19kW. This leaves important regulatory gaps, especially by comparison to the United States where these engines are regulated and the overall stringency of NRMM emission legislation is higher.

The initiative under consideration is situated in the broader context of the EU’s air quality, occupational health, energy, transport and climate protection policies. In particular, it relates to the current review of the EU’s air quality policy and the EU legislation on the prevention and control of emissions from industrial production processes (IPPC and IED Directives) and combustion plants (LCP Directive). Furthermore, there is a close link to the EU's emission legislation for heavy duty motor vehicles (i.e. trucks and busses) where similar engines and aftertreatment systems are often in use and which stipulates more stringent emission limits than the NRMM Directive in its current form. With the entry into force of the Euro VI emission limits for all new trucks and buses in 2014 this gap will widen. As the initiative under consideration would be addressed to a number of important economic sectors, it is also linked to EU industrial policy and Europe 2020, the European strategy for growth and jobs.

Since its adoption in 1997 the Directive was amended several times, with the most relevant amendments being:

– Directive 2002/88/EC extended the scope to small petrol engines (Stage I and II);

– Directive 2004/26/EC extended the scope to constant speed engines as well as to rail and inland marine engines. Stages IIIA, IIIB and IV were introduced together with certain flexibility provisions;

– Directive 2011/88/EU revised the flexibility percentage for Stage IIIB engines;

– Directive 2012/46/EU clarified certain technical issues on Stage IV engine testing.

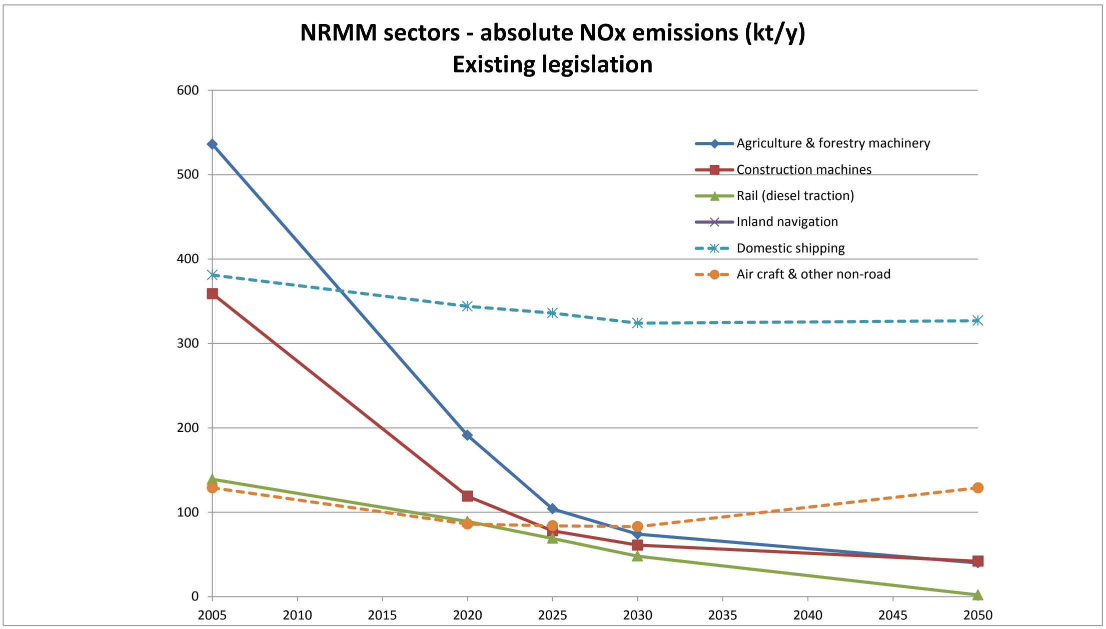
A complete overview of all amendments is available from this website[4]. Starting from the requirements already set in the amending Directives, the review will assess further reduction measures taking into account technical and economic feasibility for the manufacturers of engines and machinery.

3. PROBLEM DEFINITION

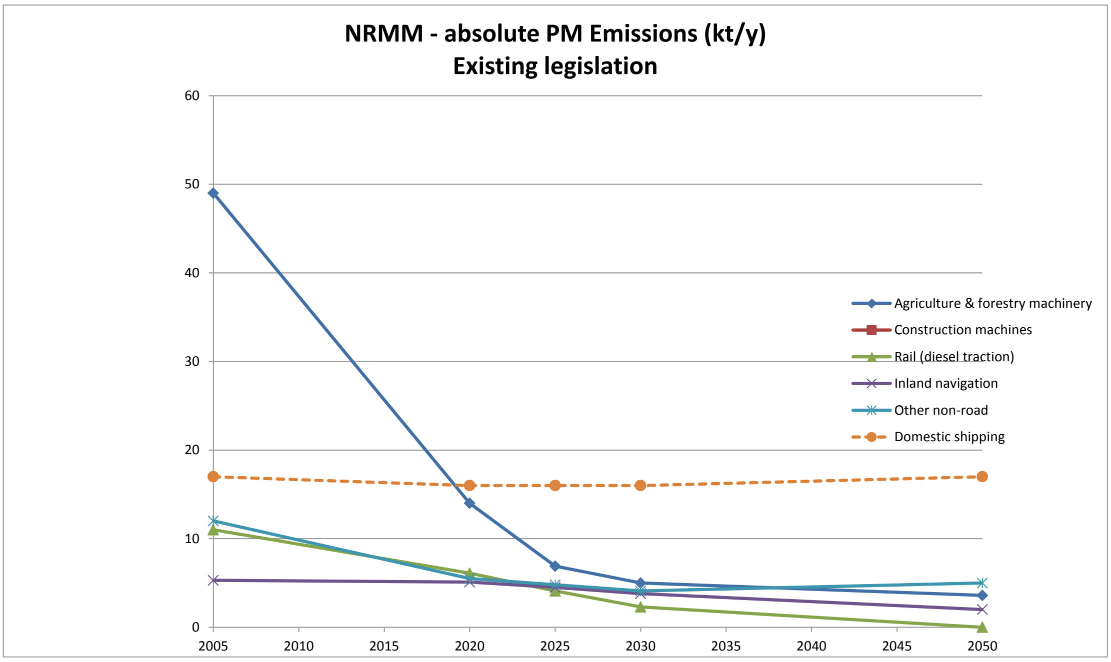
3.1. The problem that requires action

Air pollution

Combustion engines installed in NRMM are a significant source of air pollution and this is the main problem that the Directive itself and the current review seek to address. At present, many EU Member States struggle to reach their air quality objectives and a further reduction of emissions from combustion engines is an important issue in this context. Despite the limits set by the NRMM Directive and its subsequent amendments, the NRMM sector has become an increasingly important source of air pollution in relative terms, especially of nitrogen oxides (NOx) and particulate matter (PM). The NRMM sector is responsible for around 15% of the total NOx emissions and 5% of the total PM emission in the EU. While the PM share is expected to decrease, the NOx share is expected to increase up to nearly 20% in 2020. NOx emissions in absolute terms, however, will decrease in the same period. This can be explained by the faster decrease in emissions from the other sectors especially the road transport sector. The projections below are taken from the 2013 review of the EU air policy of DG ENV and provide an overview of the NOx and PM emissions from the non-road sector up to 2050 and constitute a baseline for this impact assessment. It is worthwhile noting that a number of NRMM sectors, such as domestic shipping and aircrafts (see dotted lines in the charts below), are not included in the scope of the NRMM Directive.



[4] http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/emissions-non-road/



In order to address this situation and to further decrease emissions, subsequent amendments to Directive 97/68/EC, most notably 2004/26/EC introduced further emission reduction stages for existing regulated engine categories and brought other engines into the scope. The JRC study shows that these further steps can be expected to provide a significant reduction in the overall amount of pollutants emitted from NRMM engines over the next decade. However, as the most stringent emission stage IV requirements foreseen in the current legislation will enter into force in 2014, it now appears necessary to ensure that the NRMM sector is put on a long-term emission reduction trajectory that is aligned to the EU's overall air quality policy and regulatory requirements in adjacent sectors. Due to the strong export orientation of the engine and machinery manufactures based in the EU, it is also of major importance that emission requirements, where relevant, are developed with a view to the corresponding requirements in the main third-country markets such as the United States.

Providing more long-term guidance on emission requirements than is currently the case would also give more planning certainty to industry and enable the sector to schedule the necessary investments in research and development.

Alongside the impact of NRMM engine exhaust gas on air quality, NRMM is also accountable for roughly 100 million tons of CO_2 equivalent emissions in the EU27 annually which corresponds to 2% of the EU27's total greenhouse gas emissions[5] and, therefore, contributes to global warming. It is, however, important to keep in mind that the focus of the legislation at hand is on the reduction of toxic pollutants (NOx, PM, HC, CO). The regulatory approach taken for light duty vehicles (cars and vans) where toxic pollutants and greenhouse gases are addressed in separate pieces of legislation follows the same logic.

[5] Arcadis (2010) Study in View of the Revision of Directive 97/68/EC on NRMM, Module1

Regulatory shortcomings

Despite past efforts, the legislation in its current form has specific shortcomings. Not all categories of NRMM engines are covered. More specifically, the Directive excludes:

- Compression-ignited (CI) engines with less than 19kW and more than 560kW, despite the fact that they alone represent 17% of all non-road applications and have a significant impact on the environment;

- Spark ignited engines above 19kW;

- Stationary engines;

- Engines installed in all-terrain vehicles;

- Engines installed in snowmobiles;

- Engines running on alternative fuels such as LNG.

The fact that these engines are currently unregulated means that important environmental benefits are foregone. They were excluded because of their overall low contribution at the time of the last revision in 2004 and have become more important sources of pollution in the meantime by comparison to the regulated engine categories.

Furthermore, there is a risk of market distortion due to the following effects:

- For some machinery, the producer has some choice whether to install an engine currently covered by the Directive or an unregulated one. In particular a switch from CI to SI engines could be encouraged by the present regulatory situation depending on the circumstances and fuel availability. These findings have been confirmed by the feedback received from stakeholders during the open public consultation.

- The current difference in regulatory stringency between certain categories of CI and SI engines in the Directive, in principle, also has the potential to result in a distortion of the market.

- There is also the possibility that Member States, regions or municipalities increasingly resort to local regulation restricting the use of certain NRMM in order to meet air quality requirements (see section 3.4 for examples).

New emission stages were last introduced when the Directive was amended in 2004. This means that emission requirements for certain engine categories are becoming outdated when compared to the state of the art of technology and recent developments in the road sector. Furthermore, conclusive evidence[6] became available in the meantime about the adverse health effects of diesel exhaust emissions and especially about particulate matter (i.e. diesel soot). One of the main

[6] In 2012, the WHO classified diesel exhaust as carcinogenic to humans (Group 1) based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

findings is that the size of the particles is a crucial factor behind the observed health effects and this can only be addressed by limit values that are based on a particle number count (i.e. PN limit). Experts concluded that even the most ambitious levels defined by Stage IV do not guarantee adequate protection from such pollutants. In line with the developments in the road sector, the introduction of a new emission stage (Stage V) targeting particle number limits in addition to particle mass limits, therefore, needs to be considered for the most relevant engine categories.

Furthermore, there is a mismatch between certain engines categories as to the stringency of the currently applicable emission limits. In particular, the emission limits for engines installed in inland waterway vessels appear to be insufficiently ambitious and require reassessment. The NAIADES II Communication[7] on inland waterway transport identifies a lack of stringency in the current emission limits as an important issue that needs to be addressed to ensure the long-term viability of inland navigation as a green mode of transport.

Exhaust emissions from constant speed engines, which represent a large part of non-road engines are regulated since 2007. The emission limits for these engines are, however, less stringent than for variable speed engines, which may encourage manufacturers to move from variable speed engines to constant speed engines with lower environmental standards. This situation needs to be reviewed as there is no technical justification for assigning less stringent limit values to constant speed engines.

Currently, the emission limits for NRMM are being tested under laboratory conditions when the engine is type approved. Whilst the Directive does require the emissions control system to correctly function under real-world conditions, it does not contain any provision to check that a properly maintained emissions control system is indeed functioning correctly when in service. It may be useful to provide measures and check whether engine emissions in-service are fulfilling the requirements set by the Directive over the prescribed useful engine life, as this is already the case for heavy duty road vehicles.

3.2. Underlying drivers of the problem

As explained in the problem description, some regulatory shortcomings hinder the effectiveness of EU NRMM emission legislation. Similarly, current emission limits do not fully reflect technical progress and public health concerns are insufficiently addressed.

Due to increasingly stringent emission requirements, NRMM within the scope of the current Directive have become cleaner over time. However, due to the late introduction of reduction efforts by comparison to the road sector and the absence of emission requirements for certain categories of NRMM engines, the resulting emissions trajectory still falls short of what is needed to deliver on the EU's air quality and occupational health objectives.

3.3. Who is affected, in what ways and to what extent?

A range of different groups are affected by the problems discussed above:

[7] COM(2013)623 of 10 September 2013

- The population of the European Union is affected by poor air quality through the acute (i.e. short-term) and chronic (i.e. long-term) effects on health. Effects can range from minor respiratory irritation to cardiovascular diseases and premature death. A number of groups within the population are particularly vulnerable. Especially workers who are directly exposed to high concentrations of NRMM engine exhaust gas over an extended period of time are at a heightened risk. Children, elderly people and those with an existing cardio-respiratory disease are also particularly vulnerable.

- Engine and machinery manufacturers including component suppliers: More stringent emission limits can be expected to require adaptation or redesign of engines, machines and their components. This may entail substantial research and development effort and increased production cost affecting manufacturers, importers and exporters of engines and non-road machinery, and their employees. A considerable number of SMEs can be expected to be affected in client sectors such as construction or inland navigation. For certain component suppliers, including the makers of after treatment systems, stricter emission limits could result in higher demand for their products.

- Operators of NRMM: An increase in the production cost of NRMM could be handed on to the operators of NRMM to a certain extent and stricter regulatory requirements could possibly also result in higher operation and maintenance costs.

- Finally, national public authorities responsible for type approval and market surveillance could be affected as they play a key role in enforcing the legislation.

- Particular attention is given to the potential effect on the SMEs amongst the manufacturers, component suppliers and operators.

3.4. Evolution of the problem

Without additional public intervention at the EU level, the evolution of the problem would be mainly determined by the legal requirements already in force, future demand for NRMM and the rate of renewal of the existing machinery stock.

In absence of EU action, Member States can also intervene themselves, as they need to comply with the limits and targets for various air pollutants set by the EU's Ambient Air Quality[8] and National Ceilings[9] Directives. Some European cities have already introduced seasonal restrictions on the use of older construction machinery (e.g. Austria and Sweden) and some public entities in the EU have tightened their public procurement rules by requiring specific low emission machinery for public works contracts (e.g. Berlin and Stuttgart). This already results in a distortion of the internal market and could become a more important barrier in the future, unless a harmonised basis for such efforts is provided in form of more stringent EU emission stages.

[8] 2008/50/EC
[9] 2001/81/EC

Additionally, if no action is taken, the misalignment with 3rd countries (e.g. US, Switzerland, Japan) would continue or could even increase. Already now, EU manufacturers have to offer substantially modified engines and machines in some of these markets to meet the applicable emission requirements. This leads to reduced scale effects, increased costs for the manufacturers and technical barriers to trade.

3.5. EU right to act

The legal basis of the NRMM Directive 97/68/EC is Article 114 of the Treaty on the Functioning of the European Union.

As this concerns amendments to existing EU legislation, only the EU can effectively address the issues. The subsidiarity principle is respected, since the policy objectives cannot be sufficiently achieved by actions of the Member States. European Union action is necessary because of the need to avoid the emergence of barriers to the single market notably in the field of NRMM engines, and because of the transnational nature of air pollution. Even though the effects of the main air pollutants are most severe close to the source, the effects on air quality are not limited to the local level and cross-border pollution is a serious environmental problem that can make national solutions ineffective. In order to solve the problem of air pollution, concerted action at the EU scale is required.

Setting up emission limits and type approval procedures at national level would potentially result in a patchwork of 28 different regimes which would represent a serious obstacle to intra Community trade. Moreover, it could impose a significant administrative and financial burden on manufacturers who are active in more than one market. Therefore, the objectives of the initiative under consideration cannot be achieved without action at the EU level.

Finally, a harmonised approach at EU level is expected to represent the most cost-efficient way for manufacturers and end-users to achieve emission reductions.

4. OBJECTIVES

The primary objective of the NRMM Directive is to reduce the emission of gaseous and particulate emissions (NOx, HC, PM, CO) from the engines incorporated in non-road mobile machinery. This is also the central objective of the review process. More specifically, the initiative under consideration pursues the following objectives.

Greenhouse gas (GHG) emissions are currently not included in the scope of the NRMM Directive. This is mainly due to the fact that the Directive targets at the emission performance of engines rather than of the machinery in which the engines are installed. Given that the GHG emission performance is, however, to a great extent influenced by the machinery (e.g. weight, design,…) as well as its actual operation, the most appropriate legislative way as to how best address GHG emissions is still to be sought.   For the considerations of the current review process, GHG emissions, therefore, remain out of scope.

4.1. General policy objectives

- *Health and environment*: Protect human health and the environment through a further reduction of toxic air pollutant emissions from NRMM engines.
- *Competitiveness*: Ensure a good functioning of the internal market and provide a reliable, long-term regulatory outlook for the relevant economic sectors.

4.2. Specific policy objectives

- *Health and environment*: Contribute to a reduction of toxic air pollutants (NOx, HC, PM, CO) with a view to the objectives of the EU's air quality policy.
- *Competitiveness:* Reduce obstacles to internal and external trade and prevent regulatory fragmentation by reducing the pressure on Member States and other public authorities to impose restrictions of the use NRMM. Furthermore, promote technical progress by providing long term guidance on emission limits. The revision also aims at increasing alignment with regulations established outside of the EU market, and the United States in particular.
- *Compliance*: Support Member States in their efforts to comply with the requirements of EU air quality policy by providing them with a supportive regulatory environment.

4.3. Operational policy objectives

- *Health and environment*: Ensure that NRMM emission limits and type approval requirements reflect technical progress and address the regulatory shortcomings that have been identified. In concrete terms, this means updating the Directive’s scope and limit values.
- *Compliance*: Support Member States, regions and cities in addressing compliance problems in the so-called urban hotspots, where air quality problems have proven to be most difficult to address.

4.4. Consistency with other policies and objectives

The initiative under consideration is aimed at improving environment and health protection by updating existing emission limits and by extending their scope where appropriate. At the same time, it is aimed at ensuring the functioning of the single market, while removing unnecessary burden on the companies operating in it and internationally. It is, therefore, entirely consistent with the Europe 2020 strategy and fully aligned to the EU's Sustainable Development Strategy.

In this context, the initiative under consideration ties in with the following more specific policies and objectives:

– The EU's 6th Environmental Action Programme[10] which proposed to attain "levels of air quality that do not give rise to significant negative impacts on, and risks to human health and the environment".

– The Thematic Strategy on Air Pollution[11] which provides a comprehensive EU policy framework for reducing the adverse impact of air pollution on human health and environment for the period up to 2020.

– The National Ceilings Directive 2001/81/EC which establishes legally binding limits for the total permissible emissions at Member State level for several air pollutants. According to the official data reported under this Directive, 12 Member States exceeded these limits in 2010 and, despite some improvements, compliance problems will likely persist.

– The Ambient Air Quality Directive 2008/50/EC which sets legally binding limits for concentrations in outdoor air of major air pollutants such as particulate matter and nitrogen dioxide.

– The 2011 White Paper on Transport[12], in particular with regard to cleaner inland waterway and rail transportation.

More stringent requirements for combustion engines in NRMM would positively contribute to the objectives of all of the above policies. In this context, it should be noted that the EU's air quality policy is currently subject to a comprehensive review as the policy efforts, at EU and national level, have not fully delivered the expected results in terms of improved air quality.

– The abovementioned review of the EU's air quality policy and the present review of NRMM legislation are closely interlinked. Among other activities, DG ENV announced its intention to carry out simulation calculations with a view to further quantifying the emission reduction effects of the preferred option in the context of the air quality review.

Furthermore, the initiative under consideration is situated in the context of:

– The Integrated Industrial Policy for the Globalisation Era[13] which calls for a strengthening of the single market and the convergence of rules and standards at the international level. The initiative under consideration also ties in with the industrial policy update of 2012[14] and could make an important contribution to technical harmonisation in the context of the EU-US trade negotiations (TTIP).

[10] Decision No 1600/2002/EC of 22 July 2002
[11] COM(2005)446 of 21 September 2005
[12] COM(2011)144 of 28 March 2011
[13] COM(2010)614 of 28 October 2010
[14] COM(2012)582 of 10 October 2012

5. POLICY OPTIONS

Building on the problem description in section 3.1, four policy options will be analysed in detail. It is important to note that a non-regulatory approach (i.e. self-regulation of industry) is already being discarded at this stage. Such an approach would mean that it would be up to industry to decide and implement new emission requirements for NRMM engines. However, in the light of past experience in other regulatory areas, it is doubtful if consensus among all relevant manufacturers could be reached on more ambitious emission limits, substantially exceeding the requirements of the current Directive. It is also questionable if all manufacturers would respect such a non-binding agreement in practice, and if a satisfactory level of environmental and health protection would result from it. Hence, it appears that emission limits for NRMM engines can only be effective and ensure a level playing field if they are legally binding. The open public consultation showed that this also corresponds to the view of the industry stakeholders who mostly spoke out in favour of the US alignment option (i.e. a regulatory approach).

The effect of variations in implementation dates has the same effect across options and is therefore not reflected as a parameter in the design of the individual policy options. However, the need for sufficiently long lead times for industry to re-design and adapt their engines and machinery to the new technological requirements is an important consideration within the overall context of the review. Tools which proofed to be effective in the current Directive such as, for instance, the granting of a certain degree of flexibility throughout the transition period between two emission stages will be maintained and are, therefore, also not included in the assessment of individual options.

Option 1: Business as usual – applying the existing legislation (Baseline)

The NRMM Directive would continue to apply in its current form and no new emission stage would follow on Stage IV, which enters into force from 2014 onwards. Engine types outside of the current scope would continue to be unregulated, unless Member States decide to act themselves.

Option 2: Alignment with US standards in scope and limit values

The revision would seek to achieve alignment with US-EPA standards where feasible. As today's US-EPA standards are generally stricter than current EU standards, this approach would have the effect of both extending the scope of regulated engines and introducing stricter emission limit values. For engine categories where a meaningful correspondence between the EU and the US limits cannot be established, or where less stringent standards apply in the US than in the EU, notably for railcars which do not exist as a distinct category in the US, no alignment would be sought. Instead, an appropriate level of ambition would be applied with a view to ensuring consistency across engine categories. It is also important to note that this option would target particle mass limits rather than particle number limits.

Option 3: Step towards road sector ambition levels, for the most relevant emission sources

The Euro VI emission standard for heavy duty vehicles (i.e. trucks and buses) would be used as the main point of orientation. This would notably include the issue of particulate matter number limits which currently do not exist in NRMM legislation. However, the technical and regulatory differences between heavy duty vehicles and NRMM would be taken into account when defining limit values. With regard to the definition of limit values, this option is more ambitious than Option 2 and would seek a coherent and comparable reduction across the most relevant engine categories. It would allow for some limited differentiation among the different power classes in accordance with the results of cost-benefit analyses.

As for engines for the IWV transport sector, two options are studied: Option 3A being inspired by alignment with future US standards on NOx and HC yet introducing PN emission limits, Option 3B setting in addition also very ambitious emission reduction targets for NOx and HC. In a similar manner, two options are being studied for rail applications, i.e. the introduction of PN emission limits only (Option 3A) respectively PN emission limits in combination with more stringent NOx/HC limits (Option 3B).

Option 4: Extended level of ambition through enhanced monitoring provisions

Under this option, the revision would seek to combine the more stringent emission limits resulting from Option 2 and/or Option 3 with enhanced monitoring provisions.

These provisions would mainly be aimed at monitoring the in-service conformity of NRMM engines. In-service conformity means compliance of the engine with the type approval requirements during the product's 'normal life'. For this reason, legislation has been developed in the heavy duty sector which is aimed at monitoring, via limited sampling, the emission performance of engines once installed in vehicles and in service life. Similar procedures would be introduced for the non-road sector. This could also serve as a first step towards controlling real world (so-called off-cycle) emissions.

Furthermore, with a view to obtaining a more accurate picture of the specific greenhouse gas emissions and fuel consumption of NRMM engines, information on these emissions could be used to label engines to better inform buyers and users. If deemed necessary at a later point of time, the results from the monitoring and reporting of the specific greenhouse gas engine emissions could possibly be used for further measures in the future.

The open public consultation showed that most industry stakeholders have a strong preference for Option 2, as US alignment would result in reduced emissions without imposing new development costs on industry. The producers of aftertreatment systems (catalytic converters and particle filters) are a notable exception to this and expressed a strong preference for more regulatory ambition. Environmental NGOs and some public authorities also favour Option 3 and spoke out in favour of close alignment with Euro VI limit values and procedures.

6. ANALYSIS OF IMPACTS

Given the diversity of the non-road sector and the wide range of engines and applications within the potential scope of the initiative under consideration, the results of the different studies listed in section 1.3 had to be combined and adjusted for the purpose of the impact analysis. The objective was to ensure comparability and to quantify the expected impacts in monetary terms across engine categories.

Despite far reaching efforts, a number of limitations remain however. All relevant studies work with EU 15 data and calculations are mostly based on machinery park and fuel consumption data from 2005. To address this situation, complementary data and information was obtained from stakeholders in 2013 which, by and large, confirmed the validity of the study results. It was also one of the stated objectives of the public consultation to enable stakeholders to comment on the findings of the background studies and the feedback received did not indicate that any of the respondents had serious doubts about their overall validity.

The types of costs and benefits covered by the analysis are the following:

- *Compliance costs* are the development and production costs imposed on the engine manufacturers and the machinery manufacturers who integrate the engines into their products. They also include the operational costs imposed on the end user that, for example, stem from more costly maintenance requirements or the fact that an aftertreatment system requires consumables, such as urea.

- *Benefits* are analysed on the basis of the expected reduction of PM and NOx emissions (for snowmobiles and ATVs also HC), as these are the most important pollutants in the given context. The total impact of the expected reduction during the period under review is then monetised by establishing the mass of pollution avoided (in tonnes) and multiplying it with a specific pollution factor[15] that stands for the monetary health benefits per unit avoided. In some cases, the underlying studies have a shorter time horizon than our own calculations which reach to 2040 in Option 2 and 2050 in Option 3. These could not be aligned as the models used for the studies were no longer accessible. However, this does not have a discernible effect on the overall trends.

An annual discount rate of 4% was applied to all costs and benefits in line with the Commission's Impact Assessment Guidelines. Where different analytical scenarios were assessed for one option, the relevant range is reproduced in the overview tables (base case, lower estimate etc.). The concrete limit values for the various engine categories, on which the analysis of the regulatory options is based, can be found in an overview table Annex I.

1.1. Option 1: Business as usual – applying the existing legislation

If the NRMM Directive would continue to apply in its present form, important benefits would be foregone. In the public consultation, a large majority of stakeholders acknowledged that the current regulatory situation is unsatisfactory with

[15] CE Delft (2008) Handbook on estimation of external costs in the transport sector.

a view to its medium- to long term effects. Significant emission reduction potential that could otherwise be realised would remain unexploited and a further increase in the adverse environmental impact of non-regulated machinery would be likely. The data and projections available on air pollution in Europe and the specific role of NRMM emissions (presented in section 3.1) support this view.

Maintaining the present regulatory situation would mean that no long-term regulatory perspective is available for the relevant economic sectors. The unequal treatment of engines inside and outside the scope of the Directive could also lead to a distortion of the market and unfair competition. Furthermore, the chance for closer alignment with third country requirements would be forgone. It is important to recall at this point that negotiations on a possible free trade agreement (FTA) between the EU and the US have started and that NRMM and their engines make up for a significant part of transatlantic trade. All of the above issues indicate that the problems described in section 3 of this report will likely persist if no regulatory action is taken.

On the positive side, no new regulatory burden would be imposed on engine and equipment manufacturers at EU level. However, in absence of EU action, this may happen through Member State legislation.

1.2. Option 2: Alignment with US standards

Most engine manufacturers and many equipment manufacturers are selling their products on the global market and would, therefore, benefit from harmonised emission limits and test procedures which would bring down their development, production and certification costs. With this option, barriers to trade with the United States and a number of other trading partners that have aligned their legislation to US standards would be reduced to a minimum. However, the emission limits for certain engine categories would remain less ambitious than might be technically and economically feasible. This option would target limit values for particle mass rather than particle numbers.

In accordance with the description of this option in section 5, no US alignment would be sought for the engines used in locomotives and railcars. US emission limits for locomotives are less stringent than the limits already in force in the EU and the testing procedures differ considerably. Therefore, the current EU emission limits for railcars and locomotives would continue to apply under this option.

1.2.1. US alignment of CI engines <19kW

	Option 2 – US alignment CI < 19 kW
Compliance costs	
Development and production costs	€ 6.8 m
Operational costs	€ 6.8 m
Total costs	€ 13.6 m
Benefits	
Reduction of PM emissions	- 75%
Reduction of NOx emissions	- 45%
Monetised impact for PM	€ 388 m
Monetised impact for NOx	€ 276 m

Total benefits	€ 664 m
Benefit-cost calculations	
Net impact on society	€ 650.4
Benefit/cost ratio	48.8

Source: ARCADIS Impact Assessment Study (2009), Reference period: 2005-2030

1.2.1.1. Socio-economic impacts

Although diesel engines below 19 kW are currently not subject to emission regulation in the EU, their emissions are already regulated in important third-countries, such as the United States and Japan. Due to the overall size of the US market and in the absence of EU regulation, the US EPA standards have become a global benchmark for this engine category and all major manufacturers produce compliant engines and machinery. As a result, the research and development costs for their products to meet identical limits in the EU can be assumed to border on zero. Additional research and development costs would occur almost exclusively in the small market segment of diesel engines with less than 8 kW. These engines exist in the EU market, but are not present in the US and other third-country markets where this segment is exclusively populated by petrol engines. As a result, manufactures have not developed diesel engines and machinery meeting US EPA requirements and would need to do so if equivalent EU standards were to be introduced. The introduction of EU limits would also impose certain type approval costs, but these are likely to be offset by the benefits that internationally harmonised limits would create for EU manufacturers.

Overall, this option would lead to compliance costs of roughly 13.6 million euros until 2030. For the purpose of this impact assessment it is assumed that these costs are equally split between development and production, and operational costs (6.8 million euro each). From an international competitiveness perspective the new limits could be beneficial for European manufacturers. When engines and machines sold in the EU market have to meet US equivalent standards, more polluting machines designed for unregulated markets would face higher entry barriers. This could increase the sales of EU manufacturers in their home market.

The Arcadis background study found that the number of SMEs manufacturing diesel engines and machinery with less than 19 kW is limited and that the SMEs active in this market segment would not to be disproportionally affected by the new emission limits. However, there are many SMEs among the end users which could be affected by an increase in the price of certain types of machinery.

1.2.1.2. Environmental & health impacts

Small diesel engines below 19kW are currently not subject to NOx and PM emission limits. However, the annual sales for this category are around 17% of total NRMM sales and the total emissions for this category are 12 kilo tonne (kt) NOx and 1.7 kt PM. Alignment with US EPA limits would significantly decrease the emissions of NOx and PM and therefore improve the air quality in Europe.

The monetised environmental gains that would result from this option are estimated at € 388 million from reduced PM emissions and € 276 million from reduced NO_X emissions, leading to total benefits of € 664 million. Since the compliance costs are only estimated at 13.6 million euro, the environmental gains clearly outweigh the costs of including the whole category below 19 kW in the scope of the NRMM emission legislation.

1.2.2. EPA alignment of CI engines 19-37kW

	Option 2 – US alignment CI 19-37 kW
Compliance costs	
Development and production costs	€ 153.8 m
Operational costs	€ 421.6 m
Total costs	€ 575.5 m
Benefits	
Reduction of PM emissions	- 94%
Reduction of NOx emissions	- 37%
Monetised impact for PM	€ 707 m
Monetised impact for NOx	€ 440 m
Total benefits	€ 1147 m
Benefit-cost calculations	
Net impact on society	572 €
Benefit/cost ratio	2.0

Source: NOx and PM emissions of machinery on the market per equipment category as per JRC Report - Part II (2008) Reference period: 2015-2040

1.2.2.1. Socio-economic impacts

While for the NRMM engine categories between 37-560kW stage IIIB and even stage IV limits were set, the engines between 19-37kW stayed with the IIIA limits that were introduced in 2007. In contrast to this, new, more stringent emission limits for this category come into force from 2013 onwards in the US. This situation is evidence that it is technically feasible to offer similar performing engines in the EU market. Most companies active in this market segment produce for the European, American and Japanese markets anyway and would be largely unaffected in terms of R&D effort if the EU aligned its limits to the US.

As concerns production costs, it is expected that the mechanical injection equipment currently used on stage IIIA engines will be gradually replaced by electronically controlled injection systems. This kind of equipment has become widely available at relatively low cost in recent years and enables improved emission performance. The overall compliance costs of this option are estimated at € 575.5 million. At € 421.6 million, operational costs account for the biggest part of these costs. This is due to additional fuel, service and maintenance expenditure which is expected to result from fitting aftertreatment systems

There are no SMEs among the engine manufacturers in this segment. Although many machinery manufacturers are SMEs, no problems are expected given the limited impact on engine prices and presumably very limited installation challenges.

1.2.2.2. Environmental & health impacts

The new limits would lower the NOx and PM emission and improve the air quality. Estimation showed that this would result in a 37% decrease in total emissions of

NOx and a 94% decrease of the PM emissions from this engine category. In monetary terms, this corresponds to benefits of € 856 million.

1.2.3. EPA alignment of CI engines >560kW

	Option 2 – US alignment CI > 560 kW		
	Base case		Lower estimate
Compliance costs			
Development and production costs	€ 150 m		€ 150 m
Operational costs	€ 231 m		€ 112 m
Total costs	€ 381 m		€ 262 m
Benefits			
Reduction of PM emissions		- 94%	
Reduction of NOx emissions		- 65%	
Monetised impact for PM		€ 1,076 m	
Monetised impact for NOx		€ 1,588 m	
Total benefits		€ 4,664 m	
Benefit-cost calculations			
Net impact on society	€ 4,283 m		€ 4,402 m
Benefit/cost ratio	12.2		17.8

Source: ARCADIS Impact Assessment Study (2009), chapter 3.4 pp. 84, Reference period 2005-2030

1.2.3.1. Socio-economic impacts

NRMM engines above 560kW are almost exclusively used in heavy construction equipment (~440 EU sales annually) and heavy mining equipment (~220 EU sales annually). The number of engines of this category produced in the EU is, however, larger. According to industry estimates only 15-20% of the engines produced stay in the EU while the rest is exported.

When exporting to the US, EU manufacturers already have to meet EPA emission limits, but in most other export markets no emission limits for this category exist as yet. Manufacturers exporting to the US, therefore, already have the technology and capability to produce engines and machinery complying with these limits. Due to the strong international presence of the main manufacturers and the overall importance of the US market, it can be assumed that the bulk of the necessary investment in R&D has already been made.

Meeting the new limits may require aftertreatment systems like a Selective Catalytic Reduction (SCR) system or a Diesel Particulate Filter (DPF). The SCR reduces the NOx, while the DPF prevents PM emissions. This leads to a cost increase for each engine where these systems need to be fitted. Furthermore, these systems may also entail additional operational costs for the end user. The SCR system requires a supply of urea to work which needs to be regularly refilled and more complex after treatment systems may also require more maintenance and can reduce fuel efficiency. Overall, the costs of aligning with the US are estimated between € 262 and 381 million, depending on the assumptions made on after treatment system costs.

From an international perspective, the new limits could put the incumbents in the EU market at an advantage. Market entry by firms who design their products for sale in unregulated markets could potentially become harder, since they would require significant and potentially costly upgrades. Furthermore, alignment with the US standards will reduce barriers to trade for EU firms that do not export their products to the US market at present due to the difference in emission requirements.

According to the Arcadis study, no SMEs are expected to be among the engine or machinery manufactures in this category. However, some of the end users will be SMEs. They will likely be affected by the new requirements which can be expected to result in higher machinery prices. According to industry, this price increase can be expected to be relatively small in relation to the total machinery price however. Overall, there is no indication that this price increase would disproportionally affect SMEs.

1.2.3.2. Environmental & health impacts

The environmental impact is mainly due to the reduction of NOx and PM emissions and the resulting improvement of the air quality in the European Union. PM emission from large diesel engines could be reduced by 94% and NOx emission by 65%. This corresponds to monetised benefits of € 4,664 million. One indirect effect of the potential price increase of machines in this power category, that is not included in the analysis, is the possible postponement of the purchase of new machines. Older and more polluting versions could be kept in use longer which could delay the projected emissions reduction. The potential magnitude of this effect is, however, very difficult to estimate and not included in the calculation of the environmental and health benefits as a result.

1.2.4. US alignment of CI constant speed engines

	Option 2 – US alignment CI CS
Compliance costs	
Development and production costs	€ 1,417 m
Operational costs	(not considered in the study)
Total costs	€ 1,417 m
Benefits	
Reduction of PM emissions	- 41%
Reduction of NOx emissions	- 37%
Monetised impact for PM	€ 1,065 m
Monetised impact for NOx	€ 2,085 m
Total benefits	€ 3,150 m
Benefit-cost calculations	
Net impact on society	€ 1,733 m
Benefit/cost ratio	2.2

Source: RPA & ARCADIS Study in view of the revision of Directive 97/68, Final report - Module 2 (2010), pp.54 Reference period: 2015-2040

1.2.4.1. Socio-economic impacts

Constant speed (CS) engines are mainly used in generators sets. These devices are exclusively powered by this type of engines and generate electricity from diesel fuel. The power spectrum of generator sets reaches from small (<19kW) to very large (>560kW). The use of CS engines in other machine categories is limited to small construction and agricultural machinery, such as cement mixers. Constant speed engines account for roughly 15% of the land-based engine inventory and contribute significantly to air pollution.

The NRMM Directive already sets emission limits for constant speed engines (Stage IIIA). These are, however, less stringent than the limits for equivalent variable speed engines. There is no obvious technical reason for this difference because, in principle, it is easier to reach a low and stable emission performance on a constant speed engine than on an engine running at variable speeds.

The background study found that, in the lower power bands, manufacturers are likely to achieve, or already have achieved the US limits due to their presence in the US market. The potential scale of the costs to be incurred across all power bands as a result of the US alignment is estimated at € 1,417 million.

It proofed difficult to find information on the number of SMEs in this market segment, but after consultation with industry it can be assumed that a significant number of OEMs are SMEs. It is likely that the costs of more stringent emission requirements are more strongly felt by SMEs as their development costs can be spread over fewer machines.

1.2.4.2. Environmental & health impacts

A reduction of PM and NOx emissions by 41% and 37% respectively is expected from US alignment. The corresponding environmental gains are estimated at € 3,150 million euro until 2040.

1.2.5. EPA alignment of SI engines <19kW

	Option 2 – US alignment SI engines <19kW
Compliance costs	
Development and production costs	(no cost data available)
Operational costs	(no cost data available)
Total costs	€ -- m
Benefits	
Reduction of HC emissions	- 44%
Reduction of NOx emissions	- 44%
Monetised impact for HC	€ 63.66 m
Monetised impact for NOx	€ 31.12 m
Total benefits	€ 94.79 m
Benefit-cost calculations	
Net impact on society	€ -- m
Benefit/cost ratio	--

Sources: JRC report, p 83; data for EU15 in 2005 / ARCADIS Impact Assessment Study (2009), chapter 3.4 pp.84
Reference period: 2020-2040

1.2.5.1. Socio-economic impacts

Spark ignited (i.e. petrol) engines below 19kW are predominantly installed in handheld equipment such as chainsaws and hedge trimmers, and wheeled applications such as lawn mowers. The emissions of these engines are already regulated in the NRMM Directive, but the level of stringency of the EU legislation is lower than in important third country markets (e.g. US and Japan). It is important to note that the weight and size limitation of handheld equipment sets limits to installing aftertreatment systems to clean the exhaust gas.

As is the case for all SI engines, no reliable cost data could be obtained for this engine category, but it is clear that market forces and third-country legislation (US, Japan) have already led to a shift towards lower emission engines. It can thus be assumed that am alignment with US EPA limits could be achieved at low cost, as the necessary R&D activities have already been carried out. Production costs could increase to a certain extent as engines may need to be fitted with an oxidation catalyst to meet US EPA standards. This would mostly affect products at the low end of the market which are predominantly imported from Southeast Asia. There is no information pointing towards an increase in the operational costs incurred by the users. Should this option result in additional costs to engine and equipment manufacturers, these costs are likely to be outweighed by the benefits that internationally harmonised limits would create for EU manufacturers.

1.2.5.2. Environmental & health impacts

The total monetised environmental gain resulting from a decrease in NOx and HC emissions under this option is expected at € 94.79 million euro. It should be noted that PM emissions do not play a significant role in spark ignited engines in this power band. Instead, focus is on hydrocarbon emissions (HC) which can reach high levels in this type of engine.

1.2.6. EPA alignment of SI engines >19kW

	Option 2 – US alignment SI engines >19kW
Compliance costs	
Development and production costs	(no cost data available)
Operational costs	(no cost data available)
Total costs	€ -- m
Benefits	
Reduction of HC emissions	- 70%
Reduction of NOx emissions	- 70%
Monetised impact for HC	€ 283.27 m
Monetised impact for NOx	€ 138.48 m
Total benefits	€ 421.75 m
Benefit-cost calculations	
Net impact on society	€ -- m
Benefit/cost ratio	

Source: JRC report, p 83; data for EU15 in 2005 as per ARCADIS Impact Assessment Study (2009), chapter 3.4 pp.84
Reference period: 2020-2040

1.2.6.1. Socio-economic impacts

Spark ignited engines (i.e. petrol and LPG engines) above 19kW are currently not regulated by NRMM emission legislation. However, such engines are used in a number of industrial applications such as forklifts. The socio-economic impacts of introducing emission requirements would be relatively limited as this power category is dominated by CI (diesel) engines and SI engines are mostly imported from abroad. Leaving them unregulated, however, risks creating an incentive for users to move from regulated CI to unregulated SI engines and also for manufacturers to move across the 19 kW border to evade the emission requirements on smaller SI engines.

As most producers of these engines are located outside the EU, an increase in compliance costs would have limited effect on EU based engine manufacturers. However, some European car manufacturers also sell variants of their engines for use in applications such as forklifts. They and their customers, including the end-users, could be affected by higher production costs for machines meeting US EPA limits.

1.2.6.2. Environmental & health impacts

If calculated on the basis of the current stock of SI engines above 19kW on the EU market, the environmental impact of this option would be limited. There are only an estimated 80,000 engines of this category in operation the EU and more stringent limits would therefore decrease the HC and NOx emissions from these machines by a relatively small total amount. The sizeable environmental benefits (€ 421.75 million) that are expected to result from this option are mostly a consequence of the avoided increase in HC and NOx emissions that could result from a shift in demand. Such a shift is expected if new emission limits for CI engines between 19-37kW are introduced while SI engines in that same power band stay unregulated.

1.2.7. EPA alignment of SI engines for ATVs and SbS

	Option 2 – US alignment of SI engines for ATVs & SbS
Compliance costs	
Development and production costs	(no cost data available)
Operational costs	(no cost data available)
Total costs	€ -- m
Benefits	
Reduction of HC emissions	- 50%
Reduction of NOx emissions	- 2%
Monetised impact for HC	€ 6.86 m
Monetised impact for NOx	€ 1.59 m
Total benefits	€ 8.45 m
Benefit-cost calculations	
Net impact on society	€ -- m
Benefit/cost ratio	

Source:
Reference period: 2020-2040

1.2.7.1. Socio-economic impacts

All-Terrain Vehicles (ATVs) and Side-by-Side (SbS) vehicles are primarily designed for off-road use for recreational and utility purposes, including for agriculture and forestry. They are almost exclusively powered by petrol engines. If used on public roads, these vehicles are either subject to L-Category (i.e. motorcycle) or T-Category (i.e. agricultural tractor) rules. While the EU legislation on L-Category vehicles sets emission limits for ATVs and SbS, the T-Category legislation refers to the NRMM Directive where these vehicles are currently exempt from emission requirements. ATVs and SbS also fall into the scope of NRMM legislation if these vehicles are not approved for use on public roads. This means that ATV and SbS engine emissions are factually unregulated in the EU unless these vehicles are type-approved as L-Category vehicles.

Due to the central importance of the US market for global ATV and SbS sales and the fact that emission limits took effect there in 2006, it can be assumed that no additional research and development would be necessary if the EU aligned its legislation to the US. Overall, there is also no indication that US alignment would lead to significantly higher production or operational costs.

1.2.7.2. Environmental & health impacts

Due to the relatively small population of these vehicles in the EU and assuming that a large share of the ATV and SbS engines on the EU market are technically identical to the ones sold on the US market, where US EPA limits already have to be met since the model year 2006, the environmental effect of US alignment are relatively limited (€ 8.45 million). However, when assuming that the EU market could increasingly be accessed by low cost products that do not comply with US EPA standards in the future, the environmental effects of leaving this engine category unregulated would become more severe.

1.2.8. EPA alignment of SI engines for snowmobiles

	Option 2 – US alignment of SI engines for snowmobiles	
	Least favourable	Most favourable
Compliance costs		
Development and production costs	€ 0.8 m	
Operational costs		
Total costs	€ 0.8 m	
Benefits		
Reduction of PM emissions	- 14%	- 40%
Reduction of NOx emissions	85%	42%
Reduction of HC emissions	- 14%	- 40%
Monetised impact for PM	€ 8 m	€ 22 m
Monetised impact for NOx	€ - 8 m	€ - 17 m
Monetised impact for HC	€ 16 m	€ 44 m
Total benefits	€ 16 m	€ 49 m
Benefit-cost calculations		
Net impact on society	€ 15.2 m	€ 48.2 m
Benefit/cost ratio	20	61.3

Source: ARCADIS Impact Assessment Study (2009), chapter 3.2 p.53ff, Reference period 2005-2040

1.2.8.1. Socio-economic impacts

Almost all snowmobiles in the EU/EEA are sold and operated in Sweden, Finland and Norway. They are mainly used for leisure purposes and in the winter season. In contrast to the US – the world's biggest market for snowmobiles – current EU legislation does not set emission limits for snowmobile engines. However, the snowmobiles sold on the European market are technically very similar, if not identical, to the ones sold in the US, where US-EPA emission limits must be met.

Still there are two reasons to include snowmobile engines in the scope of NRMM legislation and to align the relevant emission limits to the US. Firstly, the current regulatory gap between the EU and the US poses a certain risk that more polluting and cheaper machines with basic 2-stroke engine designs could increasingly be put on the European market in the future if no limits are set. Secondly, Member States in Northern Europe may feel the need to introduce their own legislation in absence of EU action. This could harm the internal market.

Since most snowmobiles already meet the currently applicable US limits, alignment is likely to involve little to no R&D effort and limited additional production costs. The overall costs are, therefore, estimated below € 1 million.

The snowmobile market is strongly dominated by North American and Japanese companies and there is no indication that European SMEs would be negatively affected by introducing emission limits that are aligned to the US.

1.2.8.2. Environmental & health impacts

The number of snowmobiles operated in the EU is relatively low (roughly 315,000) and their contribution to atmospheric pollution is limited. Due to their geographical concentration in Northern Europe, seasonal use and the absence of emission limits, air pollution from snowmobile engines is nonetheless of concern for some Member States. The Swedish Ministry of the Environment, for example, explicitly called for including snowmobile engines in the scope of NRMM emission legislation in its contribution to the public consultation.

Most snowmobiles are still powered by relatively basic 2-stroke engines which tend to have elevated hydrocarbon (HC) and carbon monoxide (CO) emissions. However, in the last decade several manufacturers have been successful in designing less polluting 2-stroke engines in response to US regulation.

The total environmental benefit of this option is estimated at € 15.2 – 48.2 million. The projected increase in NOx emissions is due to the fact that a shift from 2-stroke to 4-stroke technology could potentially increase NOx emissions, depending on whether a carburettor or direct injection is used. However, NOx emissions are not the focus of the environmental concerns surrounding snowmobile emissions. US legislation, for example, does not set NOx emission limits because snowmobiles are operated in winter when tropospheric ozone formation is not considered a problem.

1.2.9. US alignment of IWV engines

Option	Option 2 - US alignment
Category	**IWV**
Reference period	2012-2050
COMPLIANCE COSTS	
Investment costs for IWT industry [1)]	211,0 m€
Costs of ownership for IWT industry [2)]	296,0 m€
BENEFITS	
Reduction of PM emissions, in 2040 vs. BAU	-3 299 t/y (-70%)
Reduction of NOx emissions, in 2040 vs. BAU	-60 273 t/y (-62%)
Monetised impact for PM	4.523 m€
Monetised impact for NOx	8.928 m€
Total benefits	13.451 m€
BENEFIT-COST CALCULATIONS	
Net impact for society (NPV)	**13.155 m€**
Benefit/Cost ratio	**44,4**
Benefit/Investment ratio	**62,3**
[1)] Marginal investment costs for the entire IWT sector	
[2)] Marginal investment costs + operational costs for the IWT sector over 20 years	

Source: PANTEIA, Reference period: 2012-2050

1.2.9.1. Socio-economic impacts

The European IWT sector is concentrated in the Netherlands, France, Belgium and Germany. 95% of the total fleet is registered in one of these countries with the Dutch fleet making up for the biggest share. As a result, the socio-economic impacts will be focussed on these countries.

Since 2007, the engines used in inland waterway vessels are subject to Stage IIIA emission requirements in the EU. This option would go one step further and align the EU requirements to the more stringent emission limits applicable in the US, as described in Annex I. From a socio-economic standpoint, US alignment would have its merits as the European market, with sales of around 200 engines a year, is relatively small and most engine manufacturers are active in both the EU and the US. Going beyond US EPA limits could result in engine manufacturers leaving the EU market as the expected market size could be too small to justify the necessary R&D investment to comply with EU limits that exceed US EPA limits.

The marginal investment costs for the IWV transport sector for aligning the EU to the US limits are expected to be moderate (€ 211 million) because compliant engines are already available. The costs of ownership amount to € 296 million. These figures include the investment costs and the operational costs for the entire sector over a period of 20 years and assume the use of diesel engines with SCR after-treatment. Moreover, it is assumed that diesel engines used for complying with standards under Option 2 have a slightly better fuel consumption performance than the ones under the BAU scenario, with a relative saving of 2% on fuel consumption.

SMEs play an important role in the IWT sector. While most engines are produced by large companies, the shipbuilders, dealers and end users are often SMEs. Among the end users single vessel enterprises, where the captain is also the owner, are commonplace. Therefore, it is important to take into account the ability of end user to invest in new engines and vessels and, in particular, their access to financing.

However, it is also important to consider that some Member States may feel forced to take restrictive measures if the emission requirements at the EU level are not tightened. The access regime of the port of Rotterdam, for example, will only allow Stage IIIA engines to operate in the port as of 2025. To prevent restrictions that would negatively affect the internal market by going beyond EU emission limits, the introduction of a new emission stage for IWV appears necessary. This could either happen by aligning to the US EPA limits, or by introducing more ambitious limits which will be discussed under Option 3.

1.2.9.2. Environmental & health impacts

At present, the atmospheric pollution from inland shipping is significant with 17 % of the overall non-road emissions. The main impact of the new more stringent limits is better air quality as a result of the less polluting engines on the market and the environmental effects will be most directly felt in the vicinity of the main inland waterways and, in particular, along the Rhine. Improving the environmental performance of this transport mode is a priority for EU transport policy. This ambition is formulated in the NAIADES II package, adopted on 10 September 2013.

With a view to allowing the direct comparison of this Option with the more ambitious ones presented under 6.3.4 (Options 3A and 3B), slightly differing assumptions were made on the underlying shadow prices for the PM and NOx damage costs, respectively: these were lined up with the values consistently used throughout the study of Options 3A and 3B, i.e. 104 291 €/t for PM and 11 252 €/t for NOx. Moreover, calculations were carried out on the basis of the medium damage cost scenario only given that emissions form IWV transport are expected to happen predominantly in countries and areas with fairly high population densities, as pointed out above.

The EPA alignment option for IWVs would bring down PM emissions by 70% and NOx emissions by 62%. The corresponding environmental gains are estimated at € 13,451 million in the period up to 2040. However, the average lifetime of an engine is 10 to 12 years, and with an overhaul it can be extended to 25 years and more. Therefore, it takes a long time before all vessels are equipped with new engines and the benefits of more stringent emission limits for IWV would only become apparent with considerable time lag after their entry into force.

1.3. Option 3: Step towards road sector ambition levels

This option takes the most recent limit values applicable to the road sector (i.e. Euro VI for heavy duty vehicles) as the point of reference for determining the level of ambition for the non-road sector. Technical solutions for complying with these limits have been developed and are now on the market for heavy duty vehicles. However, they would need to be adapted to the different equipment types in the non-road sector and this can be expected to lead to additional development and production costs for engine and equipment manufacturers. For certain types of equipment the use of technology from the heavy duty motor vehicles may not be economically or technically feasible. The level of ambition pursued for different engine types would take this and also past reduction efforts into account.

When proceeding by analogy on the basis of EURO VI standards for the definition of limit values for NRMM, however, account must be taken of some fundamental and structural differences that exist between those two sectors:

- *Test cycles for type approval*: These are different, both for the steady state and transient test cycles as they are supposed to reflect in a most realistic manner representative load cycles for HD vehicles and NRMM, respectively

- *Power range*: Engines used for HD vehicles are typically in the range between 100 kW to 400 kW, whereas engines for NRMM can typically also be found in smaller power bands (0-100 KW) and significantly higher power bands (up to 3000kW)

Considering the above and in absence of further scientific and empiric evidence, limit values for NRMM can certainly not be defined by literally using identical numerical values as in Euro VI for the very wide band of power categories in NRMM .

The approach chosen under the current option is therefore guided by the following principles:

- Including the same pollutant types;

- Targeting at limit values that are comparable yet taking account of NRMM specificities;

– Focussing on those power ranges that make the most relevant contribution to overall emissions from NRMM whilst at the same time providing sufficient evidence for proceeding by analogy with standards for EURO VI engines and PN limits in the Swiss legislation.

1.3.1. Introducing standards for particulate numbers (PN)

The introduction of PN limits in the EU legislation on NRMM will have a number of costs and benefits. In order to quantify these, the EC JRC Sustainable Transport Unit was asked gather, to the best extent possible on the basis of information available up-to-date, data that are needed to carry out a cost-benefit analysis (CBA). Table 6.1 presents the data sources used for that purpose.

Table 6.1: Data Sources for the Cost Benefit Analysis of a introducing a PN limit

Parameter	Source	Comments
Engine Sales	Euromot (2005)	No up-to-date engines sales were available. Therefore the Euromot (2005) sales data were used. It was assumed that sales remain constant over time.
PM Emission	JRC (2008)	The spread sheets used to provide an inventory of emission for the NRMM sector were adapted to estimate PM emissions for each engine category and expected life of engine and hours used.
PM Damage Costs	CE Delft – Handbook on estimation of external costs in the transport sector	Low and medium EU wide damage cost figures per tonne of PM2.5 emitted were adjusted for inflation (2015 costs) and used to assess the benefits of reductions in PM emissions.
DPF technology costs	USEPA (2003)	The USEPA costs estimated for the installation of DPF were used. These were adjusted for inflation and converted to Euros.

As of today, the available and limited information on cost to society effects resulting from particle sizes is inadequate to establish a coherent direct damage cost value that is linked to the number count of particles (PN). As a recent EPA literature review suggests[16], the determination of causality for adverse health impacts is as of today still best linked to the mass of particles with a size <2.5 micro-m ($PM_{2.5}$) for short-term and long-term exposures.

Against this background, the quantitative analysis steps put forward here below for assessing the socio-economic and environmental and health impacts, respectively, in the context of introducing a PN limit, are essentially based on considerations and correlations with PM.

1.3.2. Determining a limit value for particle numbers in the NRMM legislation

In order to determine a limit value for particle number in the NRMM legislation, a literature review of experimental data for particle numbers measured on engines used in the NRMM sector has been performed.

In this context, it is worthwhile mentioning that as of today available empiric information and data relating to the size rather than the mass of particles in engine exhaust gases is limited – data sources for engines that are used in the NRMM sector are even scarcer.

Therefore, the main data source turned out to be the set of measurement data from engines that were certified by the Swiss Federal Office for Environment (FOEN/BAFU)[17] in the context of their type approval procedure (see Annex III, Table III.1). Indeed, the Swiss legislation is – as of today – the only legislation that sets a PN limit, namely for construction machinery engines in the power range from 18 to 560kW.

The Swiss measurement data are available for both legislative emission cycles, i.e. the Non-Road Steady State Cycle (NRSC) and the Non-Road Transient Cycle (NRTC). A thorough statistical analysis of these data performed by JRC yielded the following results:

[16] EPA (2009). *Integrated Science Assessment for Particulate Matter (Final Report).* U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009.

[17] In its most recent update, smaller engines with an output ranging from 19 to 37 kW that meet the limit of 1×10^{12} particles/kWh have been included for the first time. The first engine families listed in this range are equipped with a DOC and DPF. www.bafu.admin.ch/partikelfilterliste/11647/index.html?lang=en

For the <u>NRSC cycle</u>, it seems reasonable to propose a PN limit of **$1.0 \cdot 10^{12}$ #/kWh** for the three categories of engines (100% of the tested engines within the limit). This will be in line with the Swiss federal legislation.

For the <u>NRTC cycle</u>, it seems reasonable to propose a PN limit using the NRTC cycle a value of **$8.0 \cdot 10^{11}$ #/kWh** for the three categories of engine (97% of the tested engines within the limit).

Further data sources have been studied, e.g. from the Swedish Transport Administration[18] or from AECC[19]. These could, however, only be used to a limited extent for the purpose of determining a PN limit value for a wider spectrum of power ranges of NRMM engines.

1.3.3. CI engines in general NRMM applications (other than IWV and rail): Introducing PN limits

The table below shows the monetised impacts of introducing PN limits for the following engine categories: 19 – 37 kW, 37 – 56 kW and 56 - 560 kW.

The choice of this categorisation was motivated by the fact that different standards apply for these three categories under the current legislation, namely Stage IIIA (19-37 kW), Stage IIIB (37-56 kW) and Stage IV (56-560 kW). Given that the (incremental) costs for the introduction of PN standards are directly dependent of

[18] http://www.trafikverket.se/PageFiles/65300/delrapport_emissionsmatning_arbetsmaskiner.pdf

[19] www.aecc.eu/content/NRMM_Seminar/09%20%20AECC%20Raimund%20Mueller.pdf

Option	Option 3		Option 3		Option 3		Option 3	
Category	**19 - 37 kW**		**37 - 56 kW**		**56 - 560 kW**		**TOTAL: 19 - 560 kW**	
Reference period	2020-2050		2020-2050		2020-2050		2020-2050	
	LOW	MEDIUM	LOW	MEDIUM	LOW	MEDIUM	LOW	MEDIUM
INCREMENTAL COMPLIANCE COSTS								
Development and production costs (engine mfct)	455 m€		73 m€		371 m€		899 m€	
Redesign and adaptation costs (machinery mfct)	361 m€		67 m€		332 m€		760 m€	
Operational costs (user)	908 m€						908 m€	
Total costs	**1.724 m€**		**140 m€**		**703 m€**		**2.567 m€**	
INCREMENTAL BENEFITS								
Reduction of PM emissions, in 2040 vs. BAU	-1.370 t/y (-98%)		-180 t/y (-61%)		-1.380 t/y (-60%)		-2.930	
Reduction of NOx emissions, in 2040 vs. BAU	-		-		-		-	
Monetised impact for PM	661 m€	2.455 m€	45 m€	167 m€	617 m€	2.294 m€	1.323 m€	4.916 m€
Monetised impact for NOx	-		-		-		-	
Total benefits	**661 m€**	**2.455 m€**	**45 m€**	**167 m€**	**617 m€**	**2.294 m€**	**1.323 m€**	**4.916 m€**
BENEFIT-COST CALCULATIONS								
Net impact for society (NPV)	**-1.063 m€**	**731 m€**	**-95 m€**	**27 m€**	**-86 m€**	**1.591 m€**	**-1.244 m€**	**2.349 m€**
Benefit/Cost ratio	-62%	42%	-68%	19%	-12%	226%	-48%	92%

current ambition levels, cost-benefit effects for these three categories, respectively, needed to be analysed separately.

1.3.3.1. Socio-economic impacts

Referring to today's state of the art of available technologies, it is assumed that the introduction of a PN limit of **$1.0 \cdot 10^{12}$ #/kWh** (see chapter …) will require the installation of a Diesel Particle Filter (DPF) for all new engines.

The economic cost impact of introducing PN limits in NRMM legislation is therefore calculated on the basis of costs for implementing the DPF technology for all NRMM power categories concerned.

In a first step, the unitary incremental costs for installing and using a DPF in a NRMM were determined. These are, in most general terms, composed of three cost elements:

(a) Costs for the engine manufacturer (material, component, labour)

(b) Costs for the machinery manufacturer

(c) Costs for the end-user (incremental operational costs)

(a) Costs for the engine manufacturer

For the estimation of costs associated with the installation of the DPF technology at the level of the engine manufacturer, indicative cost estimates provided by the United States Environmental Protection Agency (US-EPA) were used. Figures used in this study were adjusted to 2012 values, converted to Euros and grouped according to NRMM engine categories (see Annex III, Table III.2).

Further assumptions made:

- The marginal cost for the manufacturer for achieving the additional marginal emission reductions resulting from the PN legislation is assumed to amount, as an average:
  - 100% of the 2012 DPF unit costs in the power category 19-37 kW (as DPFs currently not used)
  - 20% of the 2012 DPF unit costs for the power categories 37-560 kW (assuming that DPFs are currently already predominantly used)
- The cost of the DPF decreases by 20% every four years

(b) Costs for the machinery manufacturer

For the calculation of costs that incur to machinery manufacturers, it was assumed that these relate mostly to engineering work for redesign and adaptation so as to fit the new engines and after-treatment devices to the machinery. These costs were therefore considered to represent one-off investment costs which, in the calculations, were evenly spread over the first 4 years following the entry into force of the new emission standards (regarded as common practice in industry).

Cost assumptions were made for the three power categories as outlined above, taking notably account of the incremental technological gap to be overcome with regard to technologies that are used as of today to comply with existing legislation.

Against this background, most significant costs incur for the engine power category 19-37 kW as engines in this category are assumed not to dispose of DPF after-treatment technologies for complying with today's applicable Stage IIIA emission standards and hence require significant adaptation and redesign. Engines in the power ranges 37-56 kW (predominantly expected to already dispose of DPF after-treatment technology) and 56-560 kW (predominantly expected to already dispose of DPF and SCR after-treatment technology to comply with current Stage IV standards) would only require limited extra efforts for constant speed engines and, in some cases, adaptation to more stringent PM limits.

The cost assumptions were, moreover, cross-checked with data provided to the Commission most recently by a number representative industrial stakeholder associations[20], following a survey which was conducted amongst their member companies, respectively, on the basis of questionnaires.

(c) Costs for the end-user (incremental operational costs)

Additional costs for end-users were assumed to originate, where applicable, mostly from additional diesel costs resulting from the use of DPF after-treatment technology.

Again, this does mostly affect the engine power category 19-37 kW which is assumed not to dispose of DPF after-treatment technologies for complying with today's applicable Stage IIIA emission standards: these engines are expected to have a 3% higher fuel consumption.

In a second step, the sales volumes of NRMM engines for the period 2020 to 2050 needed to be determined. The latest sufficiently reliable data base was established back in 2005 when the European engine manufacturer's association, Euromot, provided sales figures for the EU15 in the context of a major data collection

[20] Replies received from the following European manufacturer's associations: CEME, CECE, FEM

exercise[21]. Ever since, sales data were not updated so that an assumption needed to be made as regards the likely future trends of sales figures.

After consultation with a number of stakeholders and considering the difficulty to provide reliable market forecasts for a product spectrum that is very wide, it was eventually proposed to carry out calculations under the assumption of constant sales volumes over the period 2015-2050 for the EU-28, with figures corresponding to the ones of the year 2005. This resulted in assumptions on market data and the market structure as laid down in Annex III, for NRMM with SI engines (Tables III.3a and III.3b) and land-based NRMM with CI engines (Tables III.4a and III.4b) respectively.

A recent study by Integer (see Annex III, Figure III.5) tends to confirm that sales figures for NRMM declined sharply as a result of the economic crisis in 2008, with pre-crisis levels (i.e. before 2009) expected to be reached again not before the end of this decade.

The calculations confirm a substantial potential for PM emission reductions: for the entire power range (19-560 kW), these would for instance reach an amount of -2 930 t/y in the year 2040 compared to emission under the BAU scenario. A look into the breakdown for the three power categories shows, in relative terms, the biggest saving potential in the 19-37 kW power range which is due to the fact that this category needs to comply with Stage IIIA standards only. The contributions of the other categories in which higher standards apply are, as expected, relatively lower.

1.3.3.2. Environmental & health impacts

With a view to assessing the environmental and health benefits of a PN limit in NRMM legislation, an approach by analogy has been chosen which compares the effect of $PM_{2.5}$ emissions avoided resulting from a PN limit with the base case where $PM_{2.5}$ emissions remain unaltered (corresponding to the case where no new PN limits are introduced). For determining the resulting effect of a PN limit on $PM_{2.5}$ emissions in the absence of a scientifically substantiated correlation, the assumption was made that the introduction of a PN limit of 1×10^{-12} will bring down the level of $PM_{2.5}$ emissions to an actual level of 0.01 g/kWh. This is supported by a recent publication[22] and corresponds to assumptions already made in the field of legislation for HD vehicles (Euro VI).

Figure 6.1 presents the resulting effect of this estimation in terms of total $PM_{2.5}$ emissions for the entire NRMM engine stock, with and without a PN limit respectively. For these calculations, the introduction of a PN limit was assumed to come into effect in 2020.

[21] JRC: 2007 Technical Review of the NRMM Directive 97/68/EC – Part II (2008)
[22] B. Giechaslkiel et al (2012): Measurement of Automotive Nonvolatile Particle Number Emissions within the European Legislative Framework: A Review

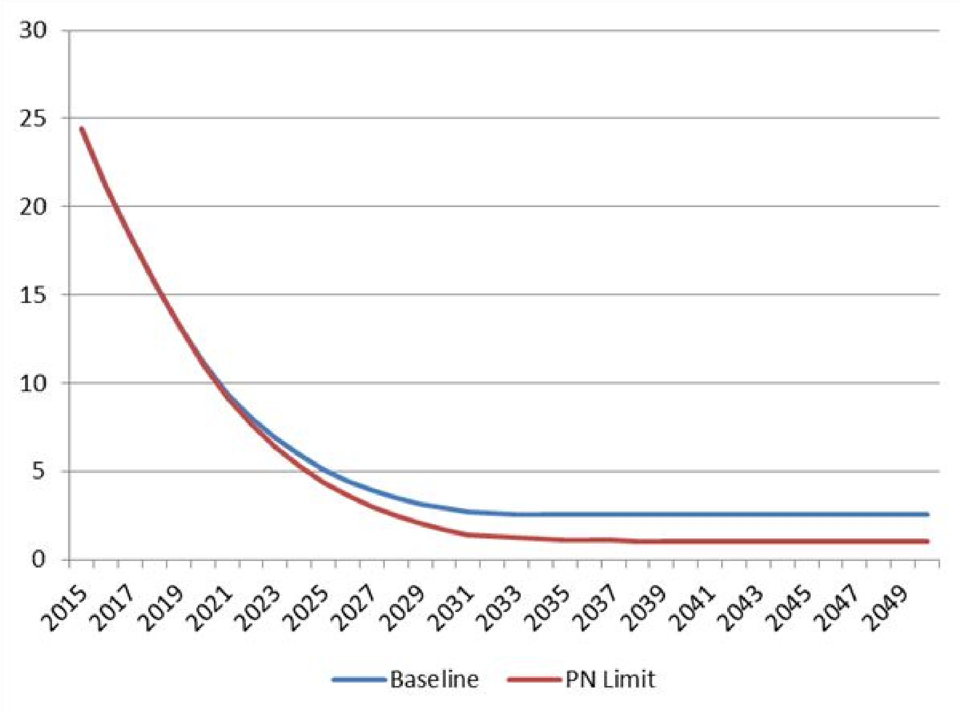


Figure 6.1: Total estimated $PM_{2.5}$ emissions (in tonnes) with and without the PN limit (2015-2050)

In order to assess the impact of the above $PM_{2.5}$ emission reductions, an economic value for the damage cost avoided was determined on the basis of the CE Delft study[23]. The study shows a significant spread in the damage cost values, depending on whether emissions occur in urban metropolitan, urban or outside built-up areas.

As it proved difficult to determine the exact location of the emissions considered, cost-benefit calculations under Option 3 were systematically carried out on the basis of two damage cost values for $PM_{2.5}$ emissions according to the following scenario assumptions:

- 'Low': $PM_{2.5}$ emission damage costs of 35 000 €/t
- 'Medium': $PM_{2.5}$ emission damage costs of 130 000 €/t

The low damage cost value corresponds to the very lowest estimate for an average EU-25 value referred to in this study, whereas the medium damage cost has been determined as a typical EU-25 average value which is representative for urban areas, indexed to 2015 prices respectively. The study mentions, in addition, significantly higher cost damage values for urban-metropolitan areas[24] which were however not been used in the current calculations.

[23] CE Delft (2008) Handbook on estimation of external costs in the transport sector
[24] Urban metropolitan: cities with > 0.5 million inhabitants

Against this background and considering, moreover, the fact that direct damage costs based on an PN approach - once such information will be actually available – would most probably demonstrate by tendency higher cost impacts than the chosen PM-based approach, it appears reasonable to consider as of today the 'medium' cost assumption as the basis for the most suitable reference scenario.

The calculations show that the introduction of PN limit values implies by far the highest incremental compliance costs for the smallest engine category (19-37 kW); this holds both for engine and machinery manufacturers, but also for end users in form of increased fuel consumption. Market players in this category might face particular difficulties with regard to financing. The entire segment might therefore be ultimately exposed to the risk of a serious loss of competitiveness, the latter aspect being of particular relevance in the light of the possible shift towards spark-ignited engines which is a genuine alternative in this specific power range.

Though significantly less pronounced, the 37-56 kW power range too has to cope with a considerable financial burden relative to its size and overall contribution, as reflected by a merely positive net benefit value for the medium damage cost assumption.

Overall, the calculations yield a positive net benefit of € 2 349 million over the period 2020-2050 for the medium PM damage cost scenario and hence confirm the financial viability of Option 3 from a global perspective.

Negative values for the net benefits throughout the three power categories for the low PM damage cost scenario highlight the dependency of the overall viability of more stringent PM and PN emission limits on the underlying assumptions for the actual damage costs: Though there are good reasons to use the medium cost assumption as most suitable reference scenario as deemed to represent best an 'EU-wide average population density pattern', these results clearly put in evidence that the effectiveness of a harmonised EU-wide approach varies across the EU according to the actual repartition of areas with lower and higher population densities.

1.3.3.3. CI engines in general NRMM applications (other than IWV and rail): Complementary introduction of new limit values for NOx and HC

As an additional step beyond the introduction of PN limits and more stringent PM limits for CI engines in general NRMM applications as outlined above, the option of adapting NOx and HC limits to levels corresponding to the ones of Stage IV (i.e. NOx: 0.4 g/kWh, HC: 0,19 g/kWh) was planned to be studied in further detail for the engine power categories 19-37 kW and 37-56 kW. Likewise, for engines >560 kW, the option of a harmonised NOx limit value at the level of the one for generator-sets (i.e. 0,67 g/kWh) was considered.

For the 19-37 kW and 37-56 kW engine power categories, the expectation was that cost synergies could be achieved in conjunction with the introduction of the stringent PN and PM limits (requiring DPF after-treatment) that were significant enough to justify, in parallel, the introduction of lower NOx and HC limit values.

However, the results obtained in chapter 6.3.3.2 as well as further preliminary analyses including careful examination of further cost data provided by a number of engine and machinery manufacturers at the request of the Commission, confirmed the in-appropriateness of such a step so that these options were not being put forward any longer: As a matter of fact, for the 19-37 kW and 37-56 kW engine power categories, the introduction of SCR after-treatment technology in order to meet the stringent NOx and HC limits would have caused further considerable additional operational and investment costs which – given the need for over-proportionate efforts for coping with extreme space limitations inherent to these very power categories – clearly would have proved to be excessive.

As for the >560 kW engine power category, the very limited number of engines not used for generator-set, rail or inland waterway vessel applications is far from justifying the significant extra-costs that the installation (equipment, R&D, redesign) and operation of SCR after-treatment technology would generate in this very specific engine segment.

1.3.4. CI engines in IWV applications: Introducing more stringent emission limits, including PN limits

With a view to examining the possibility of introducing emission limit standards in the IWV sector which go beyond the ones of the US-EPA legislation, reference is made to an exhaustive study[25] - hereafter referred to as the “PANTEIA study” - which was carried out very recently in the context of the preparatory work for the Commission’s Communication on NAIADES II[26].

One of the options investigated in this study is being retained for the purpose of this impact assessment, hereafter referred to as ‘Option 3B’. This option, denoted as the ‘Innovation Option –Efficiency’ option in the study, sets very ambitious emission reduction targets for the IWV sector and is based on the principle of a staggered effort profile: very stringent emission standards for vessels with very big engines (i.e. above 981 kW), less stringent yet still demanding standards for vessels with engines in the mid-size range (304 – 981 kW) and least stringent standards for engines in the lowest size range (75 – 304 kW).

Option 3A examined under this scenario is an alternative option which does also introduce particle number emission limits for engines of the IWV sector, yet allowing for NOx and HC emission levels which are aligned with the ones of future US legislation for engines above 600 kW.

[25] PANTEIA, 2013: Contribution to impact assessment of measures for reducing emissions of inland navigation, http://ec.europa.eu/transport/modes/inland/studies/doc/2013-06-03-contribution-to-impact-assessment-of-measures-for-reducing-emissions-of-inland-navigation.pdf

[26] European Commission, September 2013: The NAIADES II package "Towards quality inland waterway transport". http://ec.europa.eu/transport/modes/inland/promotion/naiades2_en.htm

Option	Option 3A	Option 3B
Category	**IWV**	**IWV**
Reference period	2012 - 2050	2012 - 2050
INCREMENTAL COMPLIANCE COSTS		
Investment costs for IWT industry [1)]	361 m€	1.681 m€
Costs of ownership for IWT industry [2)]	851 m€	278 m€
INCREMENTAL BENEFITS		
Reduction of PM emissions, in 2040 vs. BAU	-4 130 t/y (-88%)	-4 224 t/y (-90%)
Reduction of NOx emissions, in 2040 vs. BAU	-63 615 t/y (-65%)	-84 824 t/y (-87%)
Monetised impact for PM	5.699 m€	5.926 m€
Monetised impact for NOx	9.478 m€	12.783 m€
Total benefits	**15.177 m€**	**18.709 m€**
BENEFIT-COST CALCULATIONS		
Net impact for society (NPV)	**14.326 m€**	**18.431 m€**
Benefit/Cost ratio	16,8	66,3
Benefit/Investment ratio	39,7	11,0

[1)] Marginal investment costs for the entire IWT sector

[2)] Marginal investment costs + operational costs for the IWT sector over 20 years

Source: PANTEIA, Reference period: 2012-2050

1.3.4.1. Socio-economic impacts

Option 3A assumes the continued use of diesel engines in the IWV sector which then would be expected to require SCR and DPF after-treatment for the bigger engines (above 600kW), DPF after-treatment only for engines from 130-600 kW. Given that Option 3A is aligned with after 2017-US standards as regards NOx and HC limits for the bigger engines, additional investment costs for research and redesign are fairly limited for this engine category which represents the bulk of engines in the IWV sector. Additional investment costs will predominantly incur for the DPF treatment system for engines in the 130-600 kW power range.

Operating costs will obviously increase due to urea (SCR) and higher fuel (DPF) consumption, as well as for the maintenance and replacement of the after-treatment system components. This results in significantly higher costs of ownership for the entire sector.

Relevant stakeholders such as engine and after-treatment manufacturers confirmed that the technical feasibility of Option 3A can be expected to be ensured by 2020.

Option 3B relies on the wide deployment of LNG engine technology in the IWV sector. Emission limits under this option are most stringent for the big engines >981 kW which were deliberately chosen to be identical with those of Euro VI for Heavy Duty road vehicles. These emission levels are expected to be achieved as of today only by vessels with LNG engines (mono-fuel or dual diesel/LNG fuel). Despite the fact that these have lower NOx and PM/PN “engine-out” pollutant emissions at than diesel engines, these need nevertheless to be further equipped with SCR and/or DPF filters in order to fulfil the ambitious emission standards under this option.

In the mid-size engine power range (304–981 kW), emission standards for this option also require the use of advanced after-treatment technology, either in combination with diesel engines (SCR and DPF), dual fuel LNG engines (SCR and DPF) or mono-fuel LNG engines (SCR and possibly a particle filter).

The technological shift towards LNG engines leads to very significant overall investment costs for the IWV sector under Option 3B. According to the study, however, the operational costs for this option are significantly lower in comparison to Option 3A which mainly results from the effect of lower LNG fuel costs (assumed to be 20% lower than diesel at the point of delivery, which corresponds to today's price levels) over the lifetime of a vessel. Overall, the total costs of ownership for the IWV sector therefore come down to a level which is significantly below the one under Option 3A.

Technical feasibility

Regarding the aspect of technical feasibility of Option 3B, it is worthwhile noting that the PANTEIA study states that the actual life performance of dual-fuel or mono-fuel LNG engines is not known as of today in inland waterway transport applications given the lack of real life data (currently, only one LNG-propelled vessel in operation in the EU). The study concludes that "the technology has not yet sufficiently matured to provide a solid basis to make final conclusions on the emission performance of dual-fuel LNG engines applied in inland water transport". As regards diesel engines fulfilling the standards of Option 3B, these would still need to be developed. It is, however, not certain whether the fairly low engine volumes in the upper power categories would still attract a sufficient number of engine manufacturers to engage in this work.

A technical challenge to overcome for LNG-fuelled vessels is the impact of methane (CH4) slip. Emission limits need to be properly defined for this technology in order to prevent an increase of climate change impact as a result of methane emissions which have a greenhouse gas warming potential far higher than carbon-dioxide (CO2). Finally, given a number of structural differences between engines and their operation profile in road and shipping applications, respectively, the assumption of using identical numerical limit values as in Euro VI Heavy Duty legislation would require further technical validation.

Other aspects

As regards social impacts, the introduction of more stringent emission standards could generally be expected to have a positive effect on employment due to a increased demand for products and services from engine manufacturers, equipment suppliers and wharves. Very ambitious emission limits, however, bear the risk of ship-owners deciding to leave the profession if faced with the need of significant new investments. According to the study, the freight would then need to be carried by other vessels, by truck or by rail. This may therefore affect the structure of the inland waterway transport sector, yet probably have a limited overall effect on employment.

Regarding the aspect of administrative burden, it may increase with the variety of technologies used for ship propulsion. In particular, technologies that may give rise to safety considerations (e.g. LNG) may entail separate certification and information requirements, resulting in additional administrative costs. Developing general standards could prevent these costs from becoming too high.

1.3.4.2. Environmental & health impacts

Engines used in IWT must currently comply with Stage IIIA emission standards according to Directive 97/68/EC. By comparison with the road haulage sector, these emission standards are significantly less stringent. As a consequence, inland waterway transport reached higher air pollutant emission levels than road transport per tonne kilometre for certain vessel types. Also, atmospheric pollution from inland shipping remains significant with 17% of the overall non-road emissions and with high concentration levels in certain harbours and cities. It should also be noted that around 9 out of 10 inland waterway vessels in the EU are registered in Belgium, the Netherlands, Germany and France, where the environmental impacts are more intense, due to a higher concentration of the population along waterways.

Against this background, the two options presented under this scenario appear of particular importance given that these tackle the issue of pollution from particles, an aspect of high environmental relevance in densely populated areas. In addition, it is worthwhile emphasising that average lifetimes of engines in inland vessels are very long in comparison with other applications, resulting in a slower reactivity as regards the effectiveness of new emission standards. It is therefore even more of the essence for this very sector to take necessary technological decisions in due time.

With a view to assessing the environmental and health benefits of the two sub-options Option 3A and Option 3B, the same approach was chosen as for CI engines in general NRMM applications (see chapter …) with regard the effect of a PN limit on $PM_{2.5}$ emissions. However, unlike in the calculations for general NRMM applications in the previous section or for rail applications, the underlying shadow prices for the PM and NOx damage costs in the PANTEIA study were consistently chosen to amount to 104 291 €/t for PM and 11 252 €/t for NOx, having their origin in different simulation algorithms of the programme developed in the PANTEIA study.

Option 3B reduces, in 2040 for instance, NOx emissions by 84 800 tonnes and PM by 4 200 tonnes as compared to the BAU scenario, whereas Option 3A reduces NOx by 63 600 tonnes and PM by 4 100 tonnes.

The PANTEIA study expects Option 3B to provide a significant stimulus to the switch to LNG engines on inland waterway vessels. This switch would also involve lower direct emissions of CO_2. The increased use of LNG may, however, also result in methane emissions through slip effects of methane which is a greenhouse gas with significantly higher warming potential than CO2. Though this impact could be mitigated by the use of methane catalysts where engine operating temperatures are sufficiently high (e.g. lean-burn engines), the environmental impact of CH4 slip would need to be further studied for engines technologies with lower operating temperatures which pose a technological challenge for the use of catalysts.

Overall, the emission reductions would lead to external cost savings, as compared with the BAU scenario, of € 18,709 billion for Option 3B and € 15,177 billion for Option 3A.

These benefits outweigh, for both options, the additional investment and operational costs in the longer term (until 2050).

Option 3B is expected to result in lower external costs for air pollutants per tonne/km than for heavy-duty road vehicles by 2030 whilst Option 3A would not reach that level.

1.3.5. CI engines in rail applications: Introducing more stringent emission limits, including PN limits

Railway diesel engines are niche markets, representing less than 2% of NRMM. Since 2012, rather ambitious Stage IIIB standards are in place under the current legislation which distinguishes between diesel engines for rail cars (commonly also referred to as Diesel Multiple-Units (DMUs)) and diesel engines for locomotives. Whereas engines for railcar application are most often derivatives of truck or industrial engines (typical power ~400kW), engines for locomotive application are derivates from generator sets, military or ship applications (typical power: shunter locomotives ~750 kW; hauling locomotives ~2000 kW).

Option 3A and Option 3B examined under this scenario represent two alternative possibilities for emission legislation of engines in rail applications. Option 3A is an sub-option which exclusively focuses on the issue of particle numbers (NOx and HC emission limits remain unaltered), whereas Option 3B can be considered as an environmentally very ambitious approach which would, besides PN, also strive for significantly more stringent limit values for NOx and HC emissions.

Option	Option 3A		Option 3A	
Category	**Railcars >130kW**		**Locomotives >130kW**	
Reference period	2015-2050		2015-2050	
	LOW	MEDIUM	LOW	MEDIUM
INCREMENTAL COMPLIANCE COSTS				
Fixed costs (engine & equipment manufacturer)	5,0 m€		100,5 m€	
Operational & maintenance costs (user)	0 m€		0 m€	
Total costs	**5,0 m€**		**100,5 m€**	
INCREMENTAL BENEFITS				
Reduction of PM emissions, in 2040 vs. BAU	-25 t/y		-44 t/y	
Reduction of NOx emissions, in 2040 vs. BAU	-		-	
Monetised impact for PM	7,9 m€	29,4 m€	13,8 m€	51,1 m€
Monetised impact for NOx	-		-	
Total benefits	**7,9 m€**	**29 m€**	**13,8 m€**	**51 m€**
BENEFIT-COST CALCULATIONS				
Net impact for society (NPV)	**2,9 m€**	**24 m€**	**-86,8 m€**	**-49 m€**
Benefit/Cost ratio	58%	488%	-86%	-49%

Option	Option 3B		Option 3B	
Category	**Railcars >130kW**		**Locomotives >130kW**	
Reference period	2015-2050		2015-2050	
	LOW	MEDIUM	LOW	MEDIUM
INCREMENTAL COMPLIANCE COSTS				
Fixed costs (engine & equipment manufacturer)	10,1 m€		201,0 m€	
Operational & maintenance costs (user)	196,6 m€		301,3 m€	
Total costs	**206,7 m€**		**502,3 m€**	
INCREMENTAL BENEFITS				
Reduction of PM emissions, in 2040 vs. BAU	-25 t/y		-44 t/y	
Reduction of NOx emissions, in 2040 vs. BAU	-2.688 t/y		-6.013 t/y	
Monetised impact for PM	7,9 m€	29,4 m€	13,8 m€	51,1 m€
Monetised impact for NOx	142,8 m€		319,5 m€	
Total benefits	**150,7 m€**	**172,2 m€**	**333,3 m€**	**370,6 m€**
BENEFIT-COST CALCULATIONS				
Net impact for society (NPV)	**-56,0 m€**	**-34 m€**	**-169,1 m€**	**-132 m€**
Benefit/Cost ratio	-27%	-17%	-34%	-26%

1.3.5.1. Socio-economic impacts

The overall trend in the EU is a strong decreasing diesel locomotive fleet which is expected to continue even beyond 2020 continue. This mainly results from the electrification of most railway infrastructures, a still on-going trend which makes that railway operators possess more diesel locomotives than actually required. Also, railcars will continue to replace locomotives for passenger traffic.

The diesel locomotive market is therefore mainly a replacement market in Europe. Optimistic estimates assume that the total market volume until 2020 is about 175 locomotives/year, but likely to be smaller in reality (UNIFE). Though reliable estimates for the period beyond 2020 are difficult to provide, it can be expected that the market is probably going to be reduced even further.

According to data put forward in the European CleanER-D project[27] and forecasts by UNIFE[28], the railcar fleet is expected to slightly increase until 2020 for the reasons outlined above, with an estimated sales volume in the range from 150 to 450 railcars/year. Beyond 2020, the diesel railcar fleet is expected to remain constant and hence also becoming essentially a replacement market.

Any additional costs for introducing new emission stages that require substantial technology changes must therefore be seen in the context of the aforementioned particular market characteristics, i.e. very small market volumes as of today and very limited perspectives in the future.

Both for railcars and locomotives, new emission standards according to Options 3A assume the use of DPF after-treatment, whereas the ones for Options 3B are expected to require SCR and DPF after-treatment.

[27] http://www.cleaner-d.eu/

[28] UNIFE - Association of the European Rail Industry

To meet today's Stage IIIB standards, rail engines need either SCR or DPF after-treatment. Therefore, costs taken into account for Options 3A refer mainly to additional redesign costs for locomotive and/or railcar manufacturers, whereas Options 3B consider, in addition, development costs for locomotive engine manufacturers (NB: railcar engine manufacturers are expected to benefit from available technology from Heavy Duty road engines), redesign costs (locomotive/railcar manufacturers) and additional operational costs.

From the point of view of social impacts, the introduction of more stringent emission standards could result in increased fares in public passenger transport (up to 2% for the most ambitious scenarios), hence negatively impact the mobility especially of socially disadvantaged groups. For freight, costs might also increase whereas a pass-through of costs is less likely given the high competition with road and inland waterways. SMEs are not directly involved in the production of railway engines and locomotives. Some of the clients of rail freight operators, however, can be expected to include SMEs who then could possibly switch to other transport means (road, inland waterways).

The use of SCRs in railway diesel engines such as for Options 3B would require, in addition, investments in the infrastructure such as for instance for the supply of urea. These do generally not exist as of today and would need to be separately taken into account.

Finally, in the light of the specificity of the diesel railway market, it should be mentioned that more stringent emission standards bear the risk that operators will maintain existing engines longer than what would be economically justified, leading ultimately to increased fuel consumption and higher emissions. Recent developments since entry into force of Stage IIIB standards in 2012 seem to confirm the existence of such adverse effects: for instance, less than 80 Stage IIIB locomotives are expected to be put into service in the first three years, whereas sales usually reach levels of around 175 locomotives per year.

1.3.5.2. Environmental & health impacts

From a global perspective, rail emissions from diesel locomotives and rail cars account as of today for around 10% of NRMM emissions. With the stringent emission standards according to Stage IIIB, in force since 2012, the share in NRMM emissions is expected to decrease by a factor of 4 or more in 2020. In absolute terms, diesel rail emissions could even decrease by a factor of 10 by 2020[29]. The phasing-out effect of diesel rail emissions is also confirmed by the analysis carried out in the EC's Air Policy review (see graphs, page 8).

With a view to assessing the environmental and health benefits of the two sub-options Option 3A and Option 3B, the same approach was chosen as for CI engines in general NRMM applications (see chapter 6.3) with regard the effect of a PN limit on $PM_{2.5}$ emissions.

[29] Arcadis 2009: Impact Assessment study, reviewing Directive 97/68/EC. Final report, page 182 ff.

Option 3B is expected to reduce, by 2040, NOx emissions by 2 700 tonnes/y (railcars) and 6 000 tonnes/y (locomotives), PM emissions by 25 tonnes/y (railcars) and 44 tonnes/y (locomotives) as compared with the BAU scenario.

Option 3A would only lead to a reduction of the PM emissions of the above magnitude, i.e. by 25 tonnes/y (railcars) and 44 tonnes/y (locomotives) by 2040 compared with the BAU scenario.

These figures illustrate, for both scenarios, the relatively low potential for emission savings in the railways sector. This is due on one hand to the effect of relatively stringent emission limits for the sector as of today (Stage IIIB in force since 2012), on the other hand to the trend of a strongly decreasing diesel fleet as a whole in the future.

Overall, the emission reductions would lead to net benefits[30], as compared with the BAU scenario over the time period 2020-2050, of

- For railcars: € -56 million/€ -40 million (low & medium PN damage cost estimate, respectively) for Option 3B, and € 2,9 billion/€ 19 billion for Option 3A

- For locomotives: € -169 billion/€ -142 billion (low & medium PN damage cost estimate, respectively) for Option 3B, and € -87 billion/€ -60 billion for Option 3A

More stringent emission legislation seems hence only justifiable for railcars, where the introduction of a PN limit and adaptation of the PM limit would lead to a positive net benefit. The particular situation of the diesel railway sector (i.e. very small market volumes and moderate sales perspectives up to 2020 and beyond) needs however to be carefully assessed with regard to the required investment needs for the sector, in order to still attract sufficient manufacturers and avoid monopolistic market structures.

As for locomotives, more stringent emission standards beyond the ones currently in force (Stage IIB) do not appear justified so that no change of the existing legislation seems most recommendable.

1.4. Option 4 - Extended level of ambition through enhanced monitoring provisions

This option aims at complementing the above regulatory options (i.e. Options 2 and 3) by providing additional assurance that the emission reduction effects expected from new limit values are actually achieved in practice. Furthermore, enhanced monitoring paves the way towards gaining quantitative knowledge on aspects which might potentially become subject to future regulatory measures, such as e.g. real-life emission behaviour or fuel-consumption performance. This can be expected to mainly result in higher administrative costs by comparison to Options 2 and 3. Finally, the negative effects on human health and the environment could be further minimised.

[30] NB: a negative amount indicates a net loss

1.4.1. Introducing In-Service Conformity (ISC) provisions

Current legislation on heavy-duty road vehicles includes provisions regarding the conformity of vehicles and engines with the emission limits during the useful life of the engine installed in a vehicle under normal conditions when properly maintained and used. To verify that, the vehicle manufacturer has to provide to the type approval authority data on the performance of a representative sample of vehicles or engines of which the manufacturer holds the type approval. This procedure is commonly referred to as “In-Service Conformity” (ISC) testing.

Considering that obtaining test data from the engine test bench, as required in the current legislation, is quite costly and time consuming (i.e. it requires the removal of the engine from the vehicle), the Commission is developing a new procedure, in cooperation with engine and measuring equipment manufacturers, type approval authorities and accredited technical services, to introduce in-service conformity provisions based on the use of portable emission measuring systems (PEMS).

The technical provisions included the applicable test conditions, the test protocol (i.e. the PEMS instrumentation performance requirements and the execution of on-vehicle emissions tests) and the data evaluation method.

This approach was studied for non-road engines as well: A pilot programme for non-road engines conformity testing based on PEMS was successfully carried out. These basically confirmed the possibility to apply the ISC method for NRMM engines in the power range 56 – 560 kW with minor modifications.

Benefits

The main benefit of ISC testing is that engine manufacturers are kept responsible for ensuring that their engines maintain their emission performance during the useful life of the engines as well as over the entire span of possible operation points. The experience in the road sector showed indeed that ISC provisions lead engine manufacturers to make necessary adaptations as early as during the very initial design phase of an engine.

As a result, ISC testing can be basically considered as a means to ensure that projected emission trends over time are actually kept on track. Currently, emission performance testing only occurs in the context of the type approval process, i.e. at the very beginning of the lifetime of an engine family. Any deviations of the actual emission performance of engines during their useful life are therefore not detected yet ultimately contribute to higher overall emission levels.

Costs

With regard to the most appropriate method to be used for ISC testing of an engine installed in NRMM, the following assumptions can be made:

- Engines <19kW: laboratory testing (without PEMS)
- Engines 56-560 kW: PEMS testing on full exhaust gas flow

- Engines >560 kW: PEMS testing on exhaust gas side-flow

The costs for engine manufacturers of conducting PEMS based tests as a legislative obligation are expected to include mainly the following elements:

- Purchase, maintenance and periodic renewal of PEMS equipment
- Running costs
  - Labour costs for preparation of PEMS tests
  - Labour costs for conducting the PEMS tests
  - Rental of working equipment and replacement machinery

The method of using PEMS on exhaust gas side-flows for NRMM with engines >560kW, being technically more complex, would still need to validated by means of a pilot testing programme similar to the one carried out for the 56-560 kW range. As such, it would be more cost intensive than ordinary PEMS testing.

On these grounds and on the basis of further assumptions as referred to in Annex III, Table IV.1, the calculations predict likely costs for the implementation of ISC testing on NRMM in the order of magnitude of about € 60 million for the period 2020-2030. These would mainly incur to engine manufacturers.

These costs must be seen in the perspective of potential benefits which could be expected by such as measure: Following the logic of 'avoided additional emissions' as outlined above, these costs would be offset by avoiding a deviation in the order of magnitude of 0,1% or higher of the total projected emissions of the NRMM sector during the period 2020-2030.

1.4.2. Introducing labelling for GHG emissions and fuel consumption

With the 2012 amendment[31] of the NRMM Directive, an obligation to also measure and report carbon dioxide (CO_2) emissions was introduced into the engine approval process. The CO_2 value provides an indication of the efficiency performance of an engine (i.e. its fuel consumption). This data is recorded in the test report, together with the measured values of the toxic pollutants (CO, HC, NOx, PM), which is then submitted to the type approval authority. However, it is currently not foreseen that information on the CO_2 value is made available to machinery manufacturers or end users. As a result, it does not have an effect on buying decisions.

On the basis of the reporting obligation in the 2012 amendment, the requirement to include this information in the technical specifications of an engine that engine manufacturers typically provide to customers (e.g. technical data sheets, sales prospectus) could be established. This measure is not expected to result in significant

[31] Directive 2012/46/EU of 6 December 2012

costs for engine manufacturers or type approval authorities, but could have a positive effect on the energy efficiency of the NRMM engines sold on the EU market.

1.4.3. Set-up of a public EU database on NRMM engine emissions

As already described in the previous section, CO, HC, NOx, PM and CO_2 emissions are measured during NRMM engine approval testing and recorded in a test report. At present, this data is only used by the type approval authorities who certify that a given engine complies with the applicable emission stage and can, therefore, be sold on the EU market. However, this information would potentially also be of value to importers, distributors and integrators of NRMM engines when making buying decisions. This information could be complemented with emission data from in-service conformity (ISC) testing, if such a provision is introduced in NRMM legislation. It can be expected that the buyers of NRMM engines would try to identify engines with a reliable emission performance that is also confirmed in ISC testing and avoid engines that do not perform well if they had direct and convenient access to this information. However, at present, it is difficult to obtain an overview of the emission performance of the various engines within a certain power band. This could be facilitated by setting-up a publicly accessible online database.

The cost associated to setting up an electronic database for the exchange of type approval information was already assessed in a feasibility study[32] commissioned by the UNECE in June 2006 and for cars, a European Type-Approval Exchange System (ETAES) already exists in the EU. While the feasibility study was not done on a publicly available database, it can still be assumed that the cost assessment provides a valid indication of the costs involved. The study predicted one off start-up costs in the € 50,000 to € 150,000 range and operating costs of € 5,000 to € 15,000 per month, depending on the length of the contract with the service provider. A similar monthly range is provided for operating a help desk service, if required.

The idea of an EU wide database was clearly supported by a number of stakeholders during the stakeholder consultation as a means to provide more transparency, both for manufacturers and end-users: indeed, a EU database is considered to be an important element on the way forward towards better market surveillance.

7. COMPARING THE OPTIONS

To compare the different options, first a table is presented (Table 7-1 below) that gives an overview on how they score on key criteria including their environmental benefits in terms of the expected pollutant reduction and their efficiency put as the ratio (environmental gains/compliance costs). For ease of reference, the quantitative data on costs and benefits presented in the individual chapters of the impact analysis has been translated into a simplified scale (++ / + / 0 / - / --) indicating relative merit. For criteria that cannot be assessed on the basis of quantitative data, the scoring is based on a reasoned qualitative judgement.

Assuming that all the criteria for comparison are given similar weight, Table 7-2 indicates that Option 2 (US alignment) is the preferred choice for all SI engines and the smallest and largest CI engines. Option 3 (closer alignment with road sector

[32] T-Systems 2006, Database for the Exchange of Type Approval Documentation (DETA) Feasibility Study.

ambition level) would apply to the CI engines in the middle of the power spectrum, where the bulk of CI engines is located. Option 3 would also be appropriate for railcars. Here the analysis points to sub-option 3A. Option 1 (no policy change) only leads to a satisfactory outcome for the engines of diesel locomotives, a segment of the NRMM engine market that will have all but disappeared by 2050.

For inland waterway vessels (IWV), the analysis reveals merits and drawbacks for Option 2 and Options 3A and 3B, which does not allow an easy straightforward selection. Considering, however, that Option 2 does not address an issue of high relevance for the EU (i.e. adverse health impact due to particle sizes), only Option 3A and Option 3B are being retained at this stage as preferred options.

Finally, the analysis indicates that the enhancement measures of Option 4 should be applied across the board.

Based on the scores presented in the table above, the checked boxes in the table below show the preferred combination of options by engine category that follows from the impact analysis.

Due to the considerable diversity of engines and applications in the NRMM sector, it was already expected that the preferred option would, in fact, be a combination of elements cutting across all four policy options. This result is also due to the fact that NRMM engine categories differ widely as to their expected future importance as a source of emissions, the technical feasibility of further emission reductions and the level or regulatory stringency that is already applied to them. The preferred combination would ensure that these circumstances are duly reflected in NRMM engine emission legislation in the future and, at the same time, would strengthen the effectiveness and coherence of the regulatory framework.

Table 7-1: Multicriteria analysis of options

	BAU	Option 2			Option 3							Option 4
	all engines	SI-engines (general)	CI-engines (general)	IWV	CI-engines (general)	IWV		Railcars		Locomotives		all
Multi-criteria scores						Option 3A	Option 3B	Option 3A	Option 3B	Option 3A	Option 3B	
NOx & HC reduction	--	+	+	-	+	+	++	0	+	0	+	++
PM reduction	--	0	+	+	++	++	++	+	+	+	+	++
Addressing PN issue	--	0	--	--	++	++	++	++	++	++	++	
Technical feasibility	++	++	++	++	+	+	--	+	-	-	--	+
Financing feasibility	++	+	+	++	-	+	--	-	--	-	--	-
Labour market effects	-	0	0	+	++	+	+	0	0	0	0	+
Competitiveness	-	++	++	++	0	+	-	-	--	-	--	0
Administrative burden	0	0	0	0	0	0	0	0	0	0	0	-
Benefit/cost ratio (efficiency)	(n.a.)	+	++	?	+	?	++	+	--	-	--	(n.a.)
Benefit/investment ratio	(n.a.)	+	++	?	+	?	--	-	--	-	--	(n.a.)

Table 7-2: Overview of the preferred combination of options by engine category

	Option 1	Option 2	Option 3	Option 4
	BAU (Baseline)	US alignment	road ambition	enhancing measures
SI engines				
SI engines 0 - 19 kW		√	(n.a.)	√
SI engines 19 - 56 kW		√	(n.a.)	√
SI engines for ATVs and SBS		√	(n.a.)	√
Si engines for snowmobiles		√	(n.a.)	√
CI engines - constant & variable speed				
CI engines 0 - 19 kW		√	(n.a.)	√
CI engines 19 - 37 kW			√	√
CI engines 37 - 56 kW			√	√
CI engines 56 – 560 kW			√	√
CI engines P > 560 kW		√	(n.a.)	√
CI engines - Inland Waterways Vessels			√ (Option 3B)	√
CI engines - Railways				
CI engines for railcars >130 kW		(n.a.)	√ (Option 3A)	√
CI engines for locomotives >130 kW	√	(n.a.)		√

8. MONITORING AND EVALUATION

The European Commission has several tools available to monitor if the objectives of the initiative under consideration are being achieved effectively. The most important one is market surveillance by the relevant authorities of the Member States. Non-compliance will also be spotted as a result of complaints addressed to the Commission. The emission data generated by the engine type approval procedure is also valuable for monitoring and evaluation purposes. In particular, if the database described in section 6.4.3 is set up.

A technical review of the NRMM legislation was carried out in 2008, which triggered the development of the current initiative. Such a review could be repeated a number of years after the entry into force of the revised NRMM legislation once sufficient evidence for the effects of the current initiative can be expected. This could be the case 5 years after the entry into force of new emission requirements.

List of abbreviations

ATV	All Terrain Vehicle
CECE	Committee for European Construction Equipment
CEMA	European Agricultural Machinery Industry Association
CI	Compression Ignition (commonly diesel fuelled)
CLIMA	Commission DG Climate Action
CO	Carbon Monoxide
DPF	Diesel Particulate Filter
EMPL	Commission DG Employment, Social Affairs & Inclusion
ENTR	Enterprise and Industry
ENV	Commission DG Environment
EPA	Environmental Protection Agency (United States)
EUROMOT	European Association of Internal Combustion Engine Manufacturers
GEME	Group of Experts for Machinery Emissions
GHG	Greenhouse Gas
HC	Hydrocarbons
IASG	Impact Assessment Steering Group
IWT	Inland Waterway Transport
IWV	Inland Waterway Vessel
JRC	Commission Joint Research Centre
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MOVE	Commission DG Mobility and Transport
NGO	Non-Governmental Organisation
NOx	Nitrogen Oxides (NO & NO_2)
NRMM	Non-Road Mobile Machinery

OEM	Original Equipment Manufacturer
PM	Particulate Matter
PN	Particulate Number
R&D	Research and Development
RTD	Commission DG Research and Innovation
SANCO	Commission DG Health and Consumer Protection
SbS	Side-by-Side
SCR	Selective Catalytic Reduction System
SG	Commission Secretariat-General
SME	Small and Medium sized Enterprises
SI or **PI**	Spark Ignition or Positive Ignition (commonly petrol fuelled)
TTIP	Transatlantic Trade and Investment Partnership
UNECE	United Nations Economic Commission for Europe
UNIFE	Association of the European Rail Industry

ANNEX I: SPECIFIC EMISSION LIMIT VALUES USED FOR THE ANALYSIS

SI Engines		Stage	Option 1 - BAU (Baseline)					Class	Phase	Option 2 - US alignment					
emissions in g/kWh			CO	NOx	HC	PM	PN			CO	NOx	HC	PM	PN	
SI engines 0-19 kW	SH:1 (<20cc)	II	805	50		-	-	III	2&3	805	50		-	-	
	SH:2 (20-50cc)	II	805	50		-	-	IV	2&3	805	50		-	-	
	SH:3 (>50cc)	II	603	72		-	-	V	2&3	603	72		-	-	
	SN:1 (<66cc)	II	610	50		-	-	I	3	610	10		-	-	
	SN:2 (66-100cc)	II	610	40		-	-	I	3	610	10		-	-	
	SN:3 (100-225cc)	II	610	16,1		-	-	I	3	610	10		-	-	
	SN:4 (>225cc)	II	610	12,1		-	-	II	3	610	8		-	-	
SI engines 19 – 56 kW		-	-	-	-	-	-	-		4,4 - 20,6	Σ 2,7 - Σ 0,8		-	-	1)
Engines for snowmobiles		-	-	-	-	-	-	-	2	275	-	75	-	-	
Engines for ATV & SBS*		-	-	-	-	-	-	-	1	35	1,5		-	-	

***: emissions in g/km**

(red) Limit values more stringent than current EU legislation

(green) US & EU limit values in line

1) limit values depending on (NOx+HC) / CO combinations

CI engines - variable speed		Stage	**Option 1** - BAU (Baseline)					**Option 2**					**Option 3**				
emissions in g/kWh			CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN
CI engines 0 - 8 kW		-	-	-	-	-	-	8	7,5		0,4/0,6	-	8	7,5		0,4/0,6	-
CI engines 8 - 19 kW		-	-	-	-	-	-	6,6	7,5		0,4	-	6,6	7,5		0,4	-
CI engines 19 - 37 kW		IIIA	5,5	7,5		0,6	-	5,0	4,7		0,035	-	5,0	4,7		0,015	$1x10^{12}$
CI engines 37 - 56 kW		IIIB	5,0	4,7		0,025	-	5,0	4,7		0,025	-	5,0	4,7		0,015	$1x10^{12}$
CI engines 56 – 130 kW		IV	5,0	0,4	0,19	0,025	-	5,0	0,4	0,19	0,025	-	5,0	0,4	0,19	0,015	$1x10^{12}$
CI engines 130 – 560 kW		IV	3,5	0,4	0,19	0,025	-	3,5	0,4	0,19	0,025	-	3,5	0,4	0,19	0,015	$1x10^{12}$
CI engines P > 560 kW		-	-	-	-	-	-	3,5	3,5	0,19	0,045	-	3,5	3,5	0,19	0,045	-

CI engines - constant speed		Stage	**Option 1** - BAU (Baseline)					**Option 2** - US alignment					**Option 3** - road ambition				
			CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN
CI engines 0-8 kW		-	-	-	-	-	-	8	7,5		0,4/0,6	-	8	7,5		0,4/0,6	-
CI engines 8-19 kW		-	-	-	-	-	-	6,6	7,5		0,4	-	6,6	7,5		0,4	-
CI engines 19-37 kW		IIIA	5,5	7,5		0,6	-	5,0	4,7		0,035	-	5,0	4,7		0,015	$1x10^{12}$
CI engines 37-56 kW		IIIA	5,0	4,7		0,4	-	5,0	4,7		0,035	-	5,0	4,7		0,015	$1x10^{12}$
CI engines 56-75 kW		IIIA	5,0	4,7		0,4	-	5,0	0,4	0,19	0,025	-	5,0	0,4	0,19	0,015	$1x10^{12}$
CI engines 75 – 130 kW		IIIA	5,0	4,0		0,3	-	5,0	0,4	0,19	0,025	-	5,0	0,4	0,19	0,015	
CI engines 130 – 560 kW		IIIA	3,5	4,0		0,2	-	3,5	0,4	0,19	0,025	-	3,5	0,4	0,19	0,015	$1x10^{12}$
CI engines P > 560 kW	other than Gen-Sets	-	-	-	-	-	-	3,5	3,5	0,19	0,045	-	3,5	3,5	0,19	0,045	-
	Gen-Sets	-	-	-	-	-	-	3,5	0,67	0,19	0,035	-	3,5	0,67	0,19	0,035	-

Limit values more stringent than current EU legislation

Limit values more stringent than US legislation

CI engines for Rail	Option 1 - BAU (Baseline)					Option 3A					Option 3B					
emissions in g/kWh	CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN	CO	NOx	HC	PM	PN	
Railcar CI engines > 130kW	3,5	2,0	0,19	0,025	-	3,5	2,0	0,19	0,015	$1x10^{12}$	3,5	0,4	0,19	0,015	$1x10^{12}$	2)
Locomotive CI engines >130 kW	3,5	4,0		0,025	-	3,5	4,0		0,015	$1x10^{12}$	2,0	1,74	0,19	0,015	$1x10^{12}$	3)

2) use of C1 test cycle

3) use of F test cycle

Auxiliary engines & engines for rail maintenance vehicles regulated as mobile equipment

Constant speed engines: use of D2 test cycle

Limit values more stringent than current EU legislation

CI engines for IWV		Stage	Option 1 - BAU (Baseline)					Cat	Tier	Option 2						Cat	Option 3A						Option 3B				
emissions in g/kWh			CO	NOx	HC	PM	PN			CO	NOx	HC	PM	PN			CO	NOx	HC	PM	PN		CO	NOx	HC	PM	PN
DP < 0,9	CI engines 0 - 8 kW	-		not regulated					3	8,0	7,5		0,4/0,6	-	1)	W0	8,0	7,5		0,4/0,6	-	1)	8,0	7,5		[illegible]	-
	CI engines 8 - 19 kW	-		not regulated					3	6,6	7,5		0,40	-			6,6	7,5		0,40	-		6,6	7,5		[illegible]	-
	CI engines 19 - 37 kW	IIIA	5,5	7,5		0,60	- 1		3	5,5	4,7		0,30	-	2)	W1	5,5	4,7		0,015	$1x10^{12}$	2)	5,5	4,7		0,025	-
	CI engines 37 - 75 kW	IIIA	5,0	7,5		0,40	-			5,0	4,7		0,30			W2	5,0	4,7		0,015	$1x10^{12}$		5,0	4,7		0,025	-
	CI engines 75 - 130 kW		5,0	7,5		0,40	-		3	5,0	5,4		0,14	-		W3	5,0	5,4		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,5		0,40	-			5,0	5,4		0,14			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	7,5		0,40	-			5,0	5,4		0,14			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,5		0,40	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,5		0,40	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	7,5		0,40	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 0,9 - 1,2	CI engines <130 kW		5,0	7,2		0,30	-		3	5,0	5,4		0,12	-		W4	3,5	5,4		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,2		0,30				5,0	5,4		0,12			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW	IIIA	5,0	7,2		0,30				5,0	5,4		0,14			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,2		0,30	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,2		0,30	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	7,2		0,30	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 1,2 - 2,5	CI engines <130 kW		5,0	7,2		0,20	-		3	5,0	5,6		0,10	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,2		0,20	-			5,0	5,6		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW	IIIA	5,0	7,2		0,20	-			5,0	5,6		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,2		0,20	-	1		5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 2,5 - 3,5	CI engines < 130 kW		5,0	7,2		0,20	-		3	5,0	5,6		0,10	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,2		0,20	-			5,0	5,6		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	7,2		0,20	-			5,0	5,6		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,2		0,20	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW	IIIA	5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 3,5 - 5,0	CI engines < 130 kW		5,0	7,2		0,20	-		3	5,0	5,8		0,10	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,2		0,20	-			5,0	5,8		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	7,2		0,20	-			5,0	5,8		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,2		0,20	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	7,2		0,20	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 5,0 - 7,0	CI engines < 130 kW		5,0	7,8		0,27	-		3	5,0	5,8		0,10	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,8		0,27	-			5,0	5,8		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	7,8		0,27	-			5,0	5,8		0,10			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,8		0,27	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,8		0,27	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW	IIIA	5,0	7,8		0,27	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 7,0 - 15	CI engines < 130 kW		5,0	7,8		0,27	-		3	5,0	6,2		0,14	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW		5,0	7,8		0,27	-			5,0	6,2		0,14			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	7,8		0,27	-			5,0	6,2		0,14			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	7,8		0,27	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	7,8		0,27	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	7,8		0,27	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 15 - 20	CI engines < 130 kW		5,0	8,7		0,50	-			5,0	7,0		0,34	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,14	-
	CI engines 130 - 304 kW	IIIA	5,0	8,7		0,50	-			5,0	7,0		0,34			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW		5,0	8,7		0,50	-			5,0	7,0		0,34			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	8,7		0,50	-			5,0	1,8	0,19	0,045				3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3300 kW		5,0	8,7		0,50	-			5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines 3300 - 3700 kW	IIIA	5,0	9,8		0,50	-			5,0	1,8	0,19	0,045				3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	9,8		0,50	-	2		5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 20 - 25	CI engines < 130 kW		5,0	9,8		0,50	-		3	5,0	9,8		0,27	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,140	-
	CI engines 130 - 304 kW		5,0	9,8		0,50	-			5,0	9,8		0,27			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW	IIIA	5,0	9,8		0,50	-			5,0	9,8		0,27			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	9,8		0,50	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	9,8		0,50	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	9,8		0,50	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP 25 - 30	CI engines < 130 kW		5,0	11,0		0,50	-		3	5,0	11,0		0,27	-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,140	-
	CI engines 130 - 304 kW		5,0	11,0		0,50	-			5,0	11,0		0,27			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	-
	CI engines 304 - 600 kW	IIIA	5,0	11,0		0,50	-			5,0	11,0		0,27			W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW		5,0	11,0		0,50	-		4	5,0	1,8	0,19	0,045	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW		5,0	11,0		0,50	-			5,0	1,8	0,19	0,045	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW		5,0	11,0		0,50	-		4	5,0	1,8	0,19	0,065	-		W9	5,0	1,8	0,19	0,065	-		3,5	0,4	0,19	0,010	$8x10^{11}$
DP > 30	CI engines < 130 kW								3	5,0	IMO3	2,00		-		W5	3,5	5,6		0,015	$1x10^{12}$		5,0	5,4		0,140	-
	CI engines 130 - 304 kW															W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	2,1	1,0	0,11	
	CI engines 304 - 600 kW															W6	3,5	2,1	1,0	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 600 - 981 kW	NA		Not Regulated				3	3	5,0	IMO3	2,00	M	-		W7/8	3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	1,2	0,19	0,020	$8x10^{11}$
	CI engines 981 - 3700 kW									5,0	IMO3	2,00	M	-			3,5	1,8	0,19	0,015	$1x10^{12}$		3,5	0,4	0,19	0,010	$8x10^{11}$
	CI engines > 3700 kW								3	5,0	IMO3	2,00	M	-			5,0	IMO	2,00	M	-		3,5	0,4	0,19	0,010	$8x10^{11}$

(red)	Limit values more stringent than current EU legislation	1)	regulated as mobile equipment
(light blue)	Limit values more stringent than US legislation	2)	other limit value data possible for other (NOx+HC) / CO combinations.
(hatched)	Unlikely (technical) configuration	M	Measured only, no limits
(bars)	Unlikely use in the EU	*	Auxiliary <560 kW regulated as non-road

ANNEX II: SUMMARY OF THE OPEN PUBLIC CONSULTATION

Public stakeholder consultation on the revision of Directive 97/68/EC on emissions from non-road mobile machinery engines

Summary of the contributions received

Author: P. Troppmann (ENTR B.4)

29 April 2013

Please note that this summary of the consultation does not express the position of the Commission.

1. INTRODUCTION

As part of the preparation of the impact assessment for the revision of the Directive 97/68/EC on emissions from non-road mobile machinery engines, hereafter referred to as "NRMM Directive", the Commission ran an internet public consultation for 12 weeks from 15 January until 8 April 2013.

This consultation sought opinions from stakeholders and experts in the field of non-road mobile machinery with a view to receiving additional information on a number of policy options identified as a result of an exhaustive preparatory work by the GEME expert group[33] as well as several studies. All European citizens, organised stakeholders, industries, institutions, NGOs and public authorities of EU countries were invited to contribute to this consultation.

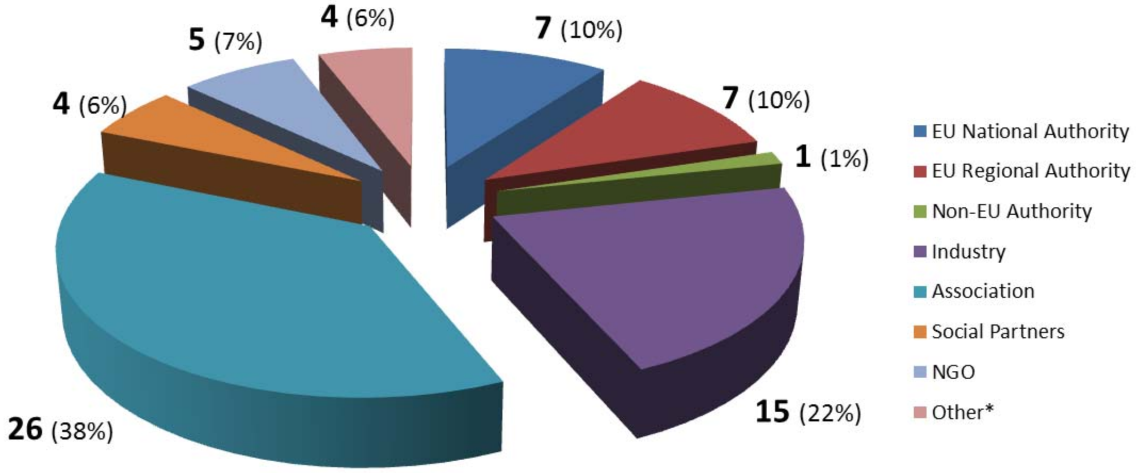
This consultation was supplemented by a stakeholder hearing on 14 February 2013 in Brussels which was attended by about 70 participants, mainly from industry, national or regional authorities, European associations and NGOs.

2. STRUCTURE OF THE QUESTIONNAIRE

The questionnaire used open questions on pre-identified policy options describing the possible content of the revision. Answers were not mandatory. It was explicitly highlighted that the pre-identified policy options are supposed to describe only major possible changes to the Directive which have been prepared solely for consultative purposes without prejudging the form and content of any future proposal by the European Commission.

3. CHARACTERISATION OF THE RESPONDENTS

In total, 69 contributions were received through the functional email box for NRMM activities (ENTR-NRMM-EXHAUST-EMISSIONS@ec.europa.eu). According to the figure below, the most represented contributors were professional associations (38%), followed by industrial companies (22%), EU national and regional authorities (10%, respectively), non-governmental organisations (7%) and social partners (6%); the remaining part of contributions (7%) was introduced by end-users, one citizen and Switzerland as non-EU authority.



Key contributors were (sorted by affiliation):

- Professional associations: Finnish Biogas, EBU (European Barge Union), Intl. Snowmobile Association, UK Railfreight Group, CEFIC (chemicals), AECC (emission control), CECE (construction equipment), VDMA, NGVA (Natural & bio gas vehicles), EUROPGEN (gensets), ESO-OIB (EU Skippers' Organisation), GIGREL (gensets), CEMA (agricultural machinery), EUROMOT (internal combustion engines), FEM (handling machinery), INE (Inland Navigation Europe), CER (railway & infrastructure companies), EURELECTRIC (electric industries), UEPG (aggregates), ATVEA (all-terrain vehicles), EGEA (garage equipment), Energy UK, VCD (Verkehrsclub Deutschland), UNIFE (rail industries), EGMF (garden machinery), TRANSFRIGOROUTE (temp-controlled road transport).

- Industries: WELL AUTOMOTIVE (Technology Service), NISSAN Forklift, RANSOMES JACOBSEN (turf care equipment), LIEBHERR (cranes), SDMO Energy Ltd, SDMO Industries (generator sets), VALTRA (tractors), VOLVO Penta, FIAT Industrial, EnBW Energie, EDF Energy, EMINOX (Emission reduction technologies), WESTPORT INNOVATION (Technology provider), THERMOKING – INGERSOLL RAND (transport refrigeration units) + 1 Anonymous.

- EU National Authorities: Belgium, Denmark, Italy, Netherlands, Portugal, Sweden, United Kingdom.

- EU Regional Authorities: Salzburg, Steiermark, Wien (AT); Flanders (BE); Nordrhine-Westfalia, Baden-Württemberg (DE); Greater London (UK).

- Non-EU Authorities: Switzerland

- NGOs: Deutsche Umwelthilfe (DUH) & Bund für Naturschutz (BUND), Naturschutzbund Deutschland (NABU), AirCLIM (air pollution & climate secretariat, Sweden), EEB (European Environmental Bureau), T&E - Transport & Environment.

- Social partners: IG Bau (Industriegewerkschaft Bauen-Agrar-Umwelt, Germany), Bundesarbeitskammer Österreich, EFBWW (European Federation of Building & Woodworkers), BAT-Kartellet (Danish Federation of Building & Woodworkers).

- Others: Endusers - Vienna Intl. Airport, SNCF, VTT (Vereiniging Verticaal Transport); Citizen (1)

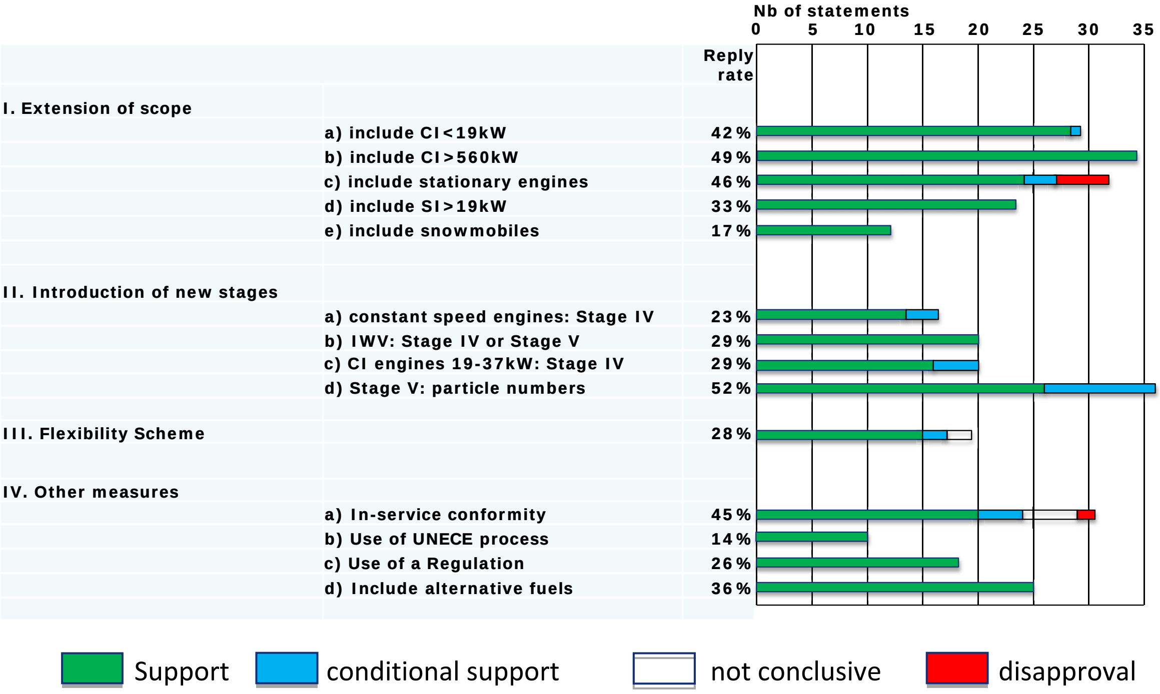
4. RESULTS OF THE ON-LINE CONSULTATION

The individual contributions received in response to the public stakeholder consultation are available at:

http://ec.europa.eu/enterprise/sectors/automotive/documents/consultations/2012-emissions-nrmm/index_en.htm

The following chapters summarise the replies received from the respondents. Obviously, respondents did not always address all pre-identified policy options proposed in the consultation document. For this reason, the number of total replies received is indicated for each policy option, respectively.

The figure below provides a global overview on the number of replies received on the suggested policy options, each of which is being discussed in further detail in the sections hereafter.



4.1. Extension of the scope

4.1.1. Including compression-ignited (CI) engines <19kW

(29 replies – 28 supportive, 1 conditionally supportive) – The inclusion of smaller CI engines is clearly supported by the vast majority of responses received on this measure. Most respondents support the limit values contained in the consultation document which are aligned with those of the corresponding US Tier 4 power class. The creation of two power classes, namely <8KW and 8-19kW, is suggested by some of the respondents. The case of conditional support refers to engines in transportable refrigeration units (TRUs) for which longer lead times are requested due to the additional technical complexity resulting from dimensional constraints of such units.

4.1.2. Including CI engines >560kW

(34 replies – all supportive) - The inclusion of CI engines >560kW is clearly supported. The proposed limit values for variable speed engines which correspond to the US Tier 4 'non-genset' power class standard are largely supported, while others favour application of the limit for the 130-560kW power class. Also, the US approach of dividing these engines class according to 'genset' and 'non-genset' applications receives some support.

4.1.3. Including stationary engines

(32 replies – 24 supportive, 3 conditionally supportive, 5 disapproving) – The inclusion of stationary engines is supported by most of the responses received on the matter. However, there is also critical feedback on this measure, mainly with regard to the risk of potential double legislation with the 'Industrial Emission Directive' (IED) which regulates stationary engines > 50MWth and which requires the Commission

- to review the need to establish union wide emission limit values for diesel engines and report by 31 Dec 2013 (review currently in progress, by DG ENV)
- To carry out a review to determine whether there is a need to control emissions from installations <50 MWth and report by 31 Dec 2012 (review currently in progress)

As regards limit values, the approach of using identical values as for mobile engines in each power class, respectively, is mostly supported for engines operating for longer periods ("non-emergency engines"). For "emergency engines", less demanding limit values are favoured (typically Stage IIIA that does not require after treatment measures) whilst at the same time insisting on a clear and comprehensive definition of the term "emergency engine".

4.1.4. *Including spark-ignited (SI) engines >19kW*

(24 replies – 23 supportive, 1 non-conclusive) – The inclusion of larger spark-ignited engines appears to be an uncontroversial measure too. A restriction to a power range from 19 to 56kW is suggested by some respondents. As for the limit values, some respondents claim for alignment with US standards whilst disapproving the proposed (stricter) values put forward in the consultation document. One respondent requested further clarification as to whether or not LPG and CNG engines would also be included.

It's worthwhile mentioning that this measure is also supported for all-terrain and side-by-side vehicles by its European association (ATVEA), whilst pleading for a clear distinction between variable speed and constant speed engines with regard to limit values and test procedures.

4.1.5. *Including snowmobile engines*

(12 replies – all supportive) – The inclusion of snowmobiles is unanimously supported by respondents who provided feedback on this measure. One respondent suggests Stage IV limit values, whilst the others appear to support the proposed ones which are based on the US standards.

4.2. Introduction of new stages

4.2.1. *Constant speed engines*

(16 replies – 13 supportive, 3 conditionally supportive) – The approach of applying same limit values as for non-constant speed engines and hence introducing Stage IV standards to constant speed engines is generally supported. However, alignment with US standards in all power classes favoured by a majority of respondents which notably requires the proposed limits for the 19-37kW class to be adapted.

4.2.2. *Inland Waterways Vessels (IWV): Stage IV / Stage V*

(20 replies – all supportive) – Whilst the introduction of Stage IV emission limits for IWV (i.e. alignment with US standards) is broadly supported, a number of respondents favour stricter NOx limits in the 130-600kW class (as per IMO standards), the inclusion of standards for gaseous-fuelled (e.g. LNG) engines as well as the coverage of the full engine (i.e. including any after-treatment system) by the Directive. One respondent explicitly asks for a Stage V standard with a stringent NOx and particulate number (PN) standard.

4.2.3. *Engine class 19-37kW: Stage IV*

(20 replies – 16 supportive, 4 conditionally supportive) – Whilst this measure is broadly supported, most respondents express their preference for alignment with the US standard also on the PM limit rather than supporting the stricter one proposed by the Commission in the consultation document (some respondents make their support conditional on this).

4.2.4. *New emission limits: Stage V*

(36 replies – 26 supportive, 10 conditionally supportive) –The need for addressing particulate numbers (PN) in addition to particulate mass (PM) is largely acknowledged by the respondents. However, some request a comprehensive cost-benefit analysis before any further decision is taken. This includes also clarification of the question whether such standards should be limited to certain engines power categories (typically 56-560kW, possibly with a staggered introduction and sufficiently long lead times).

As for possible limit values on PN, the reference to EURO VI for standards & approach is generally preferred. Also, further aspects such as for instance availability of engines/technology, the use of NRMM-appropriate test cycles and the benefits of a joint approach with other important third markets (e.g. US, Japan) are highlighted.

4.2.5. *In-service conformity*

(31 replies – 20 supportive, 4 conditionally supportive, 4 non-conclusive, 3 disapproving) – Whilst the principle of in-service conformity (ISC) is supported by a significant number of stakeholders, there are also critical views on this measure: These mainly refer to concerns on possible implications in case of non-conformity and/or the lack of further information in this regard (conditionally supportive responses and non-conclusive responses). Opponents of ISC measures raised concerns as to the inaccuracy and replication difficulties of portable measurement systems for the wide variety of non-road applications; the rail sector, in addition, raised serious safety concerns in case of coupling ISCs with automatic engine stop features.

4.3. Specific transitional measures

4.3.1. *Flexibility scheme*

(19 replies – 15 supportive, 2 conditionally supportive, 2 non-conclusive) – Whilst the benefits of the flexibility scheme are generally acknowledged and its retention supported by the respondents, some mention the need to make this scheme more transparent and easier to enforce, monitor and control. In this context, the request to clearly designate the Legal Entity that is authorised to make the request under the flexibility scheme is put forward. Generally, there appears to be a preference for a more restrictive use of this instrument.

4.3.2. *Other transitional measures*

While the retention of the *Sell-off of stock provisions* (Art 9(4a)) is mostly supported in its current form – only one respondent explicitly claims the deletion of this provision due to significant additional administrative efforts and the incentivising effect for manufacturers to produce for stocks – the deletion of the *End of series provision* (Art 10(2)) is unanimously supported by the respondents, given that nearly no use is made of it.

As regards *Time limits for derogations*, a period of 2 years as suggested in the Commission consultation paper is widely supported for engines under the sell-off provision. As for the Flexibility Scheme, some stakeholders advocate a period of 5 years rather than the suggested 3 years, whilst others suggest alignment of the time limits for engines under the sell-off and flexibility provisions with limitation to 2 years. The rail sector argues to be a particular case in this regard, claiming that the NRMM Directive should not deal with any time limit given the conflict with the procedures established in the relevant TSIs (Technical Specifications for Interoperability).

4.4. Other measures

4.4.1. Alternative fuels

(25 replies – all supportive) - The extension of the NRMM to alternative fuel engines as outlined in the consultation document is unanimously supported by the respondents, along the principle of a fuel-neutral approach.

For LNG-fuelled engines, some respondents draw to attention to the need for avoiding methane leakage.

Some respondents raised concerns as to the fact that the inclusion of alternative fuels of any kind might represent a significant effort for this legislative act, so that it is suggested to include in the first instance only gaseous fuels.

4.4.2. Legislation

(18 replies – all supportive) - The choice of a Regulation as form of legal act is unanimously supported by the respondents, mainly for its facilitated and faster transpositions as well as its uniform application.

4.4.3. International harmonisation

(10 replies – all supportive) - The use of the UNECE process as a means of simplifying procedures and ensuring widest-possible harmonisation of standards is unanimously supported by the respondents.

4.4.4. Administration

The proposal of *Better labelling* of engines received broad support by a number of respondents: this mainly includes the marking on the engine of the actual production date (month & year), the Stage to which it complies and whether it is intended for use outside of the EU (export only).

A number of respondents also requested the introduction of more effective measures for *Market Surveillance* along the principles of the New Legislative Framework, as a means to avoiding the placing on the EU market of machinery that is not in conformity with EU legislation.

4.5. Further comments from stakeholders

The following aspects were mentioned as additional comments which some of the respondents made at their own initiative. These should therefore be interpreted as specific and singular remarks that cannot be statistically assessed with regard to their representativeness.

- **Specific test cycles for transport refrigeration units (TRUs)**- A specific test cycle aligned with the one in US legislation is suggested for TRUs which replicates their specific in-use operating modes.

- **EU database** – A EU-wide publicly accessible database is recommended that ensures transparency by mandatory publication of engine emissions performance

- **Separate shipment of after-treatment systems** – Against the background that anti-pollution devices are often produced in a different facility than the engine leading to separate shipping of these devices, the inclusion of clarification on separate shipment in the legal act is recommended, along the lines of a proposal by the GEME Working Group.

- **Field-testing equipment** – the inclusion of a derogation for regularising the practice of field-testing of engines during their development and prior to their type-approval is recommended.

- **ATEX** – A derogation clause is proposed for equipment used in potentially explosive atmospheres (ATEX), in the light of technical difficulties with engines operating under such circumstances. This would allow such engines to comply only with Stage IIIA standards.

- **Measuring of GHG emissions** – In analogy to Euro VI standards, it is suggested to measure greenhouse gases (mainly CO2 and CH4) under any new emission standard, with a view to giving industries and public authorities the possibility to make the best-informed decision possible.

5. GENERAL CONCLUSIONS

With a total of 69 responses received, the public stakeholder consultation had a very satisfactory and sufficiently representative reply rate. This holds also for the distribution of the respondent's affiliation which can be qualified as balanced with – expectedly – most significant participation from associations and industry stakeholders; but also (national and regional) public authorities and NGOs were well represented.

Overall, the consultation process went pretty smoothly, without any particular problems rising during the period of its publication. The stakeholder hearing event organised as an accompanying measure on 14 February 2013 in Brussels was well attended (about 70 participants) and very much welcomed by stakeholders as an opportunity for providing the Commission with first orientations and positions on the subject. In this context, it is worthwhile mentioning that four major industry associations (EUROMOT, CECE, CEMA & FEM) agreed on a common position and came up with a consolidated presentation at this event.

As regards the written contributions received on the public consultation, the revision of Directive 97/68/EC on NRMM along the proposed policy options appears by and large broadly accepted and well supported by all stakeholders. This holds for the proposed extension of scope, introduction and/or adaptation of new emission limits and a range of further operational and administrative measures.

An alignment with US standards – which intrinsically implies both an extension of scope and adaptation of (some) emission limit values – appears generally to be the preferred way forward for most industrial stakeholders. As opposed to these, public authorities and NGOs do generally tend to be supporting a more ambitious approach, with stricter and widest-possible coverage of harmonised emission limit values across categories. There is, however, a general consensus between nearly all respondents that the issue of particulate numbers, an aspect which is not addressed in current US legislation, needs to be addressed in forthcoming legislation. On this issue, a number of respondents, mostly representing industries, calls for a more cautious approach, notably building upon detailed cost-benefit analyses, the possibility of restricted application and further research into the issue, whilst other respondents advocate ambitious targets in direct reference to Euro VI road standards.

As for the transitional measures, and here more particularly the flexibility scheme, their general benefits in the past are mostly acknowledged. Unlike industrial representatives who claim the retention of this system in its current form, public authorities and NGOs however advocate a generally more restrictive and limited use of this instrument.

Finally, there appears to be unanimous support from all responding stakeholders to the use of the UNECE process as well as the use of a Regulation instead of a Directive as new legislative instrument.

The results of the public stakeholder consultation will be duly considered as input to the Commission's impact assessment work which currently is being carried out.

ANNEX III: SUMMARY OF COST ASSUMPTIONS FOR OPTION 3 (CHAPTER 6.3)

Table III.1: Particle Number (PN) data for NRMM engines (FOEN/BAFU).

Net Power	SWISS DATA	NRSC	NRTC
37 - 56 kW	30.5 - 36.4 kW	3.78E+11	5.28E+11
	33.7 kW	6.99E+09	3.06E+11
	47 - 55 kW	9.01E+11	3.01E+09
	47-75 kW	3.99E+10	2.89E+09
	54 - 55.4 kW	6.77E+10	7.96E+10
56-130 kW	54-110 kW	3.40E+10	6.20E+11
	55 - 86 kW	9.01E+11	4.15E+09
	75-110 kW	1.74E+11	2.29E+11
	80 - 115 kW	8.40E+11	6.89E+11
	80 - 115 kW	1.74E+11	2.29E+11
	89-129 kW	3.40E+10	6.20E+11
	94 - 129 kW	8.43E+10	6.72E+11
	94 - 104 kW	1.83E+10	5.43E+11
	98-129 kW	8.93E+09	1.18E+10
	100 - 129 kW	4.48E+11	4.59E+11
	105-129 kW	1.09E+11	5.01E+10
	120 kW	7.12E+11	3.33E+11
	129 kW	2.42E+10	7.02E+09
130-560 kW	140 kW	1.09E+10	1.68E+10
	140 kW	3.06E+11	4.06E+11
	140-175 kW	4.03E+11	8.66E+10
	140-175 kW	3.63E+10	3.69E+10
	152-201 kW	2.03E+10	4.42E+10
	160 kW	2.13E+11	5.18E+11
	160-250kW	1.74E+11	1.20E+11
	171 - 283 kW	1.78E+11	5.95E+10
	180 kW	9.51E+10	1.58E+11
	204 - 270 kW	2.50E+11	1.00E+10
	213-329kW	1.35E+09	1.87E+09
	220 - 380 kW	6.90E+11	8.12E+11
	235-255kW	1.29E+09	2.57E+11
	266 - 353 kW	2.90E+11	4.00E+09
	230-300 kW	3.40E+10	6.95E+10
	230-300 kW	7.26E+11	5.12E+11
	270 kW	7.32E+10	8.72E+10
	338kW	3.89E+09	1.52E+10

Table III.2: US-EPA DPF Costs per unit, adjusted for inflation and converted to €

EURO	**19-37 kW**	**37-56 kW**	**56-75 kW**	**75-130 kW**	**130-560 kW**	
Kilowatt	**24**	**56**	**110**	**184**	**370**	**485**
Material and Component Costs						
Filter volume (Litre)	**2.25**	**5.88**	**7.05**	**11.46**	**27**	**30.45**
Filter trap	244	640	766	1,246	2,938	3,311
Washcoating and canning	90	237	285	€ 463	1,089	1,229
Platinium	72	186	222	362	683	961
Filter can housing	12	12	12	19	26	26
Diferential Pressure Sensor	82	82	82	82	82	164
Direct Labour Costs						
Esitmated labour hours	2	2	2	2	2	4
Labour rate ($/hr)	48	48	48	48	48	48
Labour cost	96	96	96	96	96	191
Labour overhead @40%	38	38	38	38	38	76
Total Direct Costs to Mtfr (corrected 2012/Euro)	**634**	**1,291**	**1,501**	**2,305**	**4,951**	**5,958**

Source: USEPA (2003)

Table III.3a: SI engines: Market data[1] of small SI engine machinery (overall: 44 Million; 2005, EU15)

engine type	Engine numbers to EU 15 per year	Marketpopulation in EU 15	average power [kW]	engine class	EDP [h]	average running time per year [h]	2-stroke 2005	2-stroke trend 2010
chainsaws hobby	1.022.220	8.177.760	1.8	SH 2	50	6.25	100	100
chainsaws professional	227.160	454.320	3	SH 3	300	150	100	100
trimmers hobby	681.480	5.451.840	1	SH 2	50	6.25	80	50
trimmers professional	90.864	181.728	1.5	SH 3	300	150	90	70
others hobby	397.530	3.180.240	1	SH 2	50	6.25	70	50
others professional	68.148	136.296	1.5	SH 3	300	150	90	50
lawn mowers hobby	2.317.032	23.170.320	2.5	SN 3	125	12.5	< 20	0
lawn mowers professional	5.111	40.889	3.5	SN 3	500	62.5	< 20	0
riding mowers hobby	263.506	2.635.056	10	SN 4	250	25	~ 0	0
riding mowers professional	62.469	499.752	10	SN 4	1000	125	~ 0	0
TOTAL	**5.135.520**	**43.928.201**						

[1] SH1, SN1 and SN2 engine classes are not reported separately in the table due to low sales volume.

Table III.3b: Market structure of small SI engine machinery

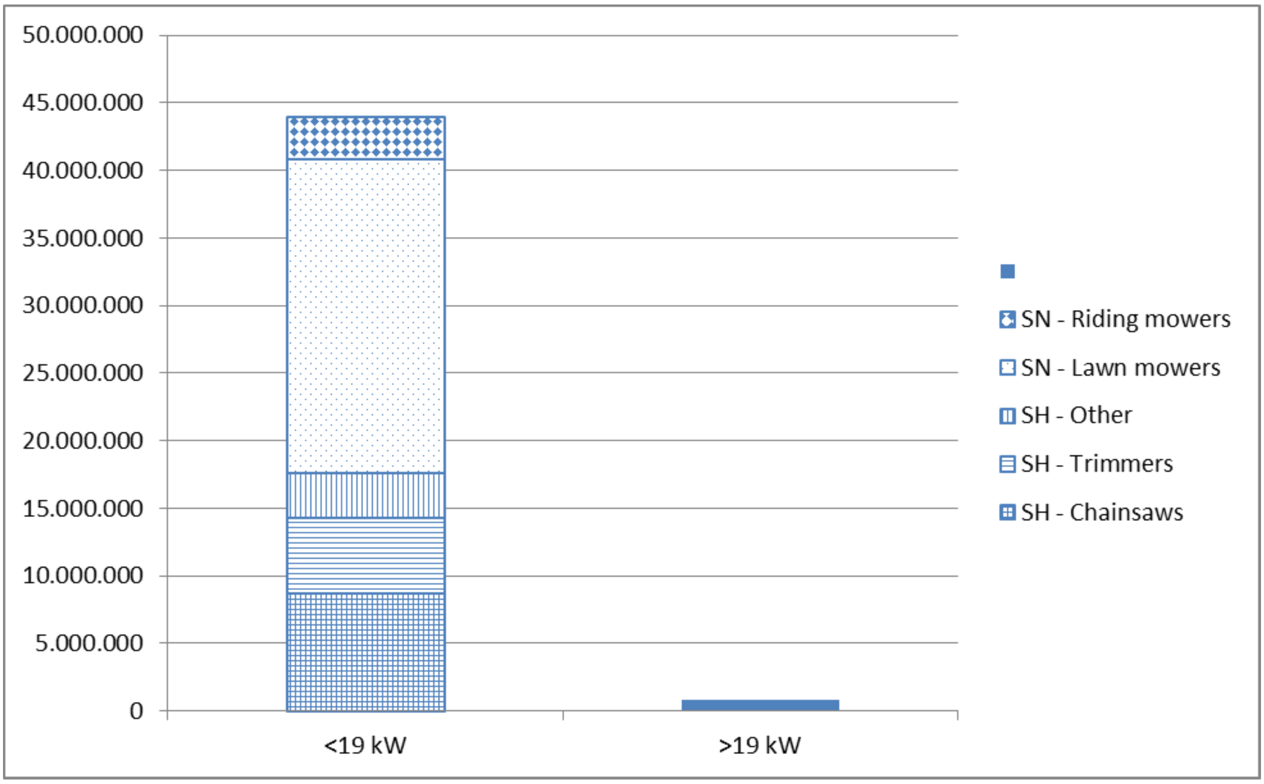


Table III.4a: CI engines (except rail and IWV): Total number of machinery on the market per equipment category and power class (overall: 6.7 Million; 2005, EU15)

Total engines on market	< 19 kW	19-37 kW	37-56 kW	56-75 kW	75-130 kW	130-560	> 560	Total num	Total(%)
	9.5	28	46.5	65.5	102.5	345	800		
Small Equipment (Agri)	190000	0	0	0	0	0	0	190000	3
Small Equipment (Constr)	350000	150000	0	0	0	0	0	500000	7
Generator Sets	142500	232500	204000	144000	120000	84000	47999	974999	14
Agricultural Tractors	146700	32600	521600	782400	782400	234720	0	2500420	37
Agricultural Harvesters	0	0	0	0	12287	138240	3071	153598	2
Light Construct. Equip.	300000	300000	408000	1032000	0	0	0	2040000	30
Heavy Construct. Equip.	0	0	0	0	217800	141900	6600	366300	5
Total number	1129200	715100	1133600	1958400	1132487	598860	57670	6725317	
Total (%)	17	11	17	29	17	9	1		

Table III.4b: CI engines (except rail and IWV): Market structure of CI engine land-based machinery

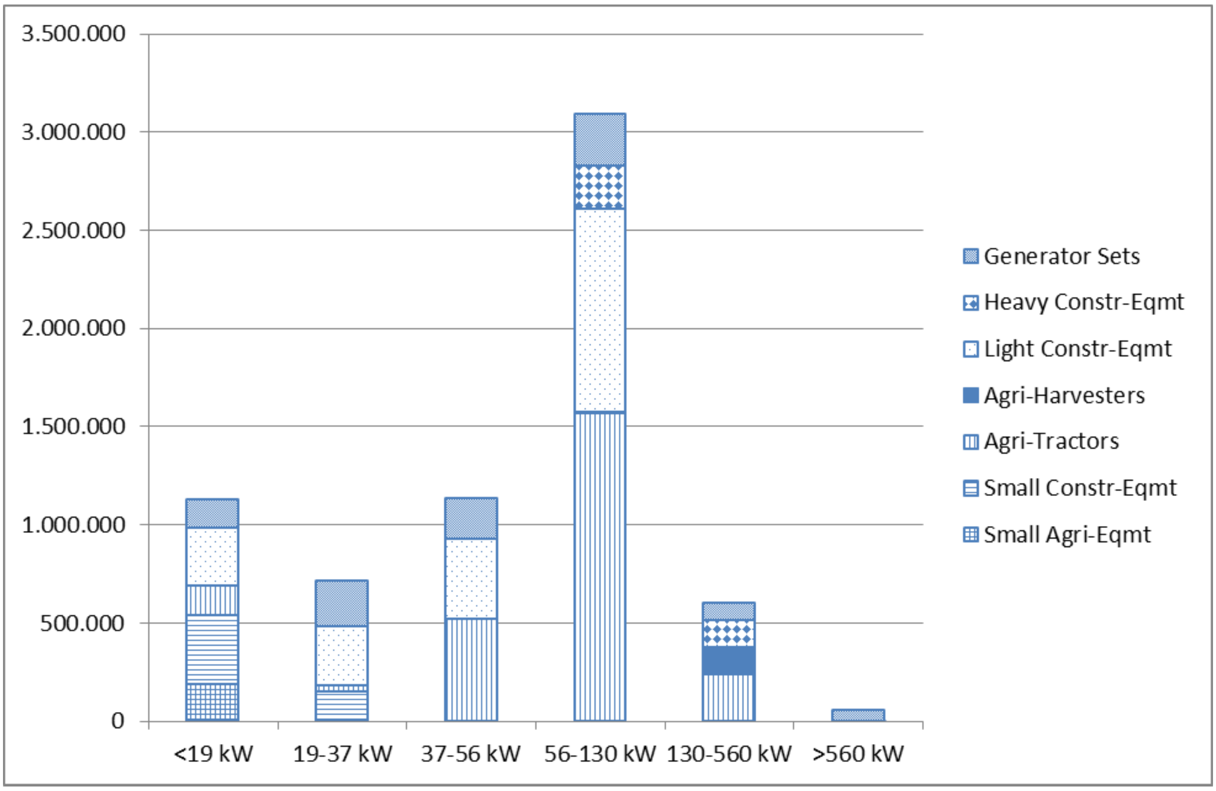
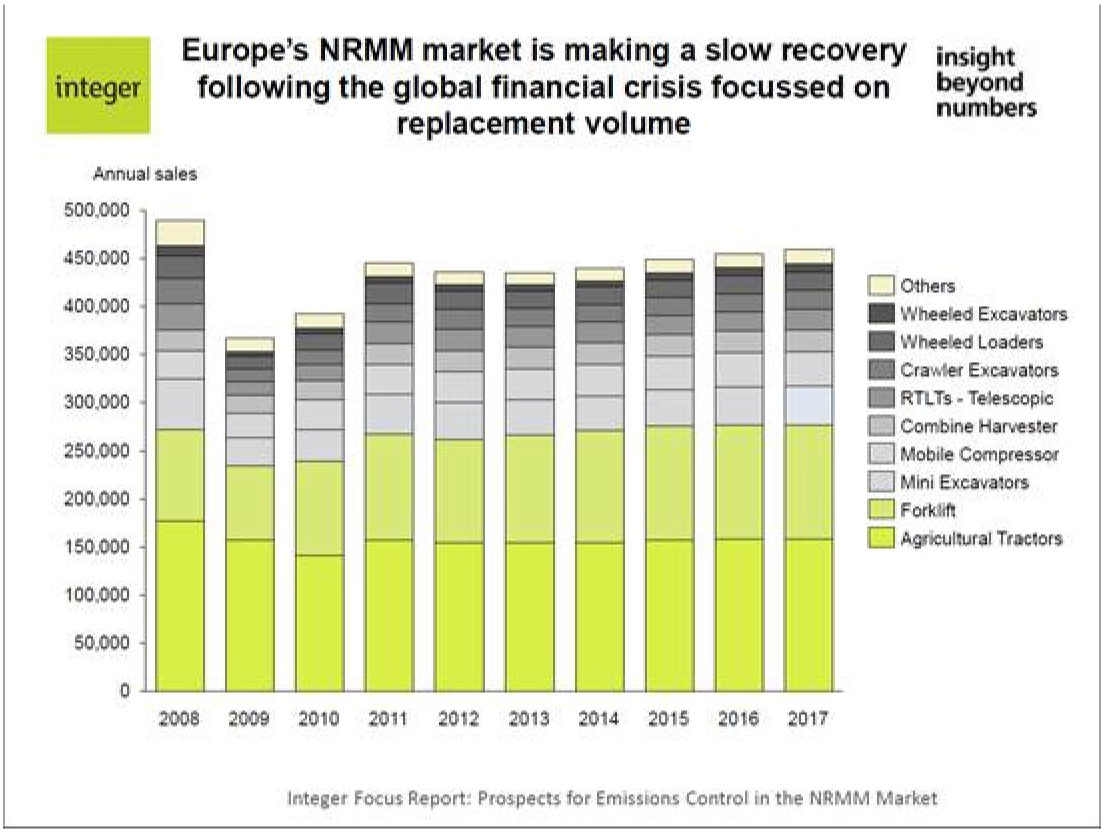


Table III.5: EU's NRMM annual sales from 2008 (Integer Focus Report).



ANNEX IV: SUMMARY OF COST ASSUMPTIONS FOR OPTION 4 (CHAPTER 6.4)

Table IV.1: Underlying assumptions for the NPV calculation of costs for ISC implementation

		ISC method	Engine mfcts	Families/mfct	Eng fam tests	Operational costs		Invest costs	
			(total)			k€/test	total/year	k€/PEMS	total
SI engines	<19 kW	Lab testing	27	6	81	15	1215	0	0
	>19 kW	PEMS	20	3	30	30	900	200	4000
CI engines	<19 kW	Lab testing	10	3	15	15	225	0	0
	19 - 560 kW	PEMS	26	8	104	30	3120	200	5200
	>560 kW	PEMS side-stream	13	4	26	45	1170	400	5200
					256		6630		14400