Request for services in the context of the FC ENTR/2008/006, lot 3: A Study to support the Impact Assessment of relevant regulatory options for nanomaterials in the framework of REACH

Final Report prepared by

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Executive Summary

This Research Study has been undertaken to support the proposed forthcoming Impact Assessment on the REACH Regulation as it relates to Nanomaterials (NM), where the objective of the policy initiative is "to ensure further clarity on how NM are addressed and safety demonstrated in registration dossiers".

The Research Study includes an assessment of future options to address NM under REACH while taking into account, on the one hand, the competitiveness of the European chemicals and NM sector, innovation and employment, including SME-specific impacts, and on the other hand, human health and the environment and impacts from the use of NM.

Methodology

The Research Study was undertaken over a ten-month period starting from January 2013, with the following research methods being utilised:

- secondary evidence review;
- semi structured interview programme;
- testing cost capture and analysis;
- impact assessment; and
- options comparison informed by the assessment of multiple criteria.

In addition the Research Team worked closely with colleagues from the Commission on the development of the formal Public Consultation Exercise and have used the findings to inform the study. The Research Study additionally drew upon a number of prior studies, with the 'Bipro/JRC' 2012 Final Report, prepared for the European Commission, Joint Research Centre, Institute for Health and Consumer Protection providing comparative references and assumptions[1].

Problem Definition

The Problem Definition was developed primarily by reference to the Commission's Draft Road Map (Appendix One) alongside primary evidence from stakeholder interviews with industry, environmental, trades union and scientific bodies, the output from the Formal Public Consultation Exercise, as well as a secondary evidence review. Following Commission Impact Assessment Guidelines the Problem Definition has been outlined as follows:

> **The nature and scale of problem** – The principal problem is there is currently sub-optimal regulation of NM within REACH. This problem is considered by a broad range of stakeholders to be linked to the current perceived lack of clarity regarding informational requirements for NM within REACH. The consequence is that dossiers that are submitted for NM do not provide sufficient evidence to ensure protection of human health and the environment and the free movement of substances on the internal market while enhancing competitiveness and innovation, or alternatively/additionally that dossiers for NM are not being submitted to ECHA for assessment.

[1] BiPRO (2013) "Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials", Final Report, prepared for the European Commission, Joint Research Centre, Institute for Health and Consumer Protection.

Stakeholders most affected by it – Producers of NM are immediately impacted by current issues regarding clarity of requirements, which in turn will impact on a range of stakeholders across the supply chain from the production of NM into the product lifecycle for goods and products that contain NM, impacting as it does on consumers, workers and the wider environment. Stakeholders suggest that there may be disproportional impact for SME, micro enterprises and start-ups, which maybe more likely than larger enterprises to respond to current regulatory imprecision by withdrawing from the market or being dissuaded from entering the market.

Drivers or underlying causes of the problem – The immediate drivers of the problem relate to the absence of sufficient specific provisions for NM within the annexes of REACH. Results for the Commission's Formal Public Consultation Exercise found that in relation to the overall view of the current registration provisions and information requirements for the registration of NM, 68% considered it to be "unclear" and a further 18% "very unclear".

Problem Development and the impact of existing policies at Community or Member State level – A functional starting point for the problem can be identified from the establishment of REACH, the setting of the definition of NM by the Commission and then the issuing of ECHA Guidance. One of the main responses at Member State level has been the introduction of national registers of NM, although this has limited connection to the issue of the requirements for NM within REACH or the associated guidance provided by ECHA.

Assumptions, Risks and Uncertainties – Key assumptions relate to estimating the potential impact of any changes to the annexes of REACH on NM. There are risks relating to balancing potential regulatory benefits with increased costs for business and other stakeholders. Uncertainties pertain to the evolving evidence base on NM safety testing.

Justification for Community level action – The principle of chemical regulation being a Community-level responsibility is well established. Although there is scope for MS to support the guidance process, there remains an evident need for central coordination.

Options Development and Refinement
The European Commission provided options for change to the Research Team.

Baseline – The baseline option incorporates the European Commission's definition of NM and is supported by the most recent ECHA guidance on the interpretation of REACH requirements for NM.

Option 2 – Would introduce "changes to certain Annex provisions clarifying what companies are expected to do in accordance with the registration obligations of REACH and the specific guidance which takes into account CA/59/2008 and the RIPoN 2 and 3 reports from 2011". The measures would require more precise descriptions of the scope of the dossier, clarification of requirements for nanoform-specific information in endpoint sections, and clarification of how data is to be reported.

Option 3 – Is based on "soft law" and would include one or more of the following:

- Communication;
- Resolution; and
- Other Measures.

Option 4 – is built upon the requirements specified in Option 2 with further requirements focussed on additional testing, clarifications and elaborations to further describe the potential impact of the NM.

Option 5 – is based upon tailored information requirements in a dossier for NM placed on the market, a reduction in certain testing requirements, clarification of regulatory provisions and the ability to maximise the use of non-testing methods and exposure categorisation, and in doing so maintain openness to flexible solutions.[2]

Option 6 – includes the full implementation of Option 2 and 4 and the inclusion of a number of additional requirements. Option 6 gives additional emphasis to the generation of targeted information with the objective of further reducing uncertainty in an area where knowledge is still under development regarding the influence of particle and nanomaterial-specific properties on risk.

In terms of the overall integrity of individual options, it is difficult on an a priori basis to find the grounds to exclude individual measures within any of the options or to include further measures. What is certain is that, having established the costs and potential benefits of individual measures, there will need to be a level of scrutiny as to whether particular tests within each option are cost beneficial. This could lead to further restructuring of options or the partial or full merging of one or more options.

Cost Analysis

The data capture element of the Stakeholder Engagement Programme constituted a core element within the broader Research Programme and provides up-to-date estimates of the prospective cost of testing (where tests and such information are available from GLP-compliant laboratories currently offering NM testing to private clients as a service) as relevant to each of the Options considered within the study.

The methodology for the cost assessment included determining relevant tests, designing a Data Capture Tool, sourcing of laboratories and finally collating data returned from laboratories into a form for use in the Cost Data Assessment.

The presentation of the cost data divides into two broad elements. The first provides an overview of potential costs on a per form/dossier basis, providing a maximum and minimum scenario for additional characterisation costs that might arise.

The second element draws on these estimates to develop an updated set of aggregate estimates of cost developed utilising the assumptions that underpinned the last commissioned JRC/Bipro study on the regulation of NM under REACH[3]. In Table 0.2 the costs have been extrapolated to provide estimates of the respective costs under each of the substantive options under consideration (costs for each option being additional to the Baseline position).

[2] European Commission Impact Assessment of the possible amendment of REACH Annexes for nanomaterials Preliminary options and measures

[3] BiPRO (2013) "Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials", Final Report, prepared for the European Commission, Joint Research Centre, Institute for Health and Consumer Protection.

	Baseline	Option Two	Option Three	Option Four	Option Five	Option Six
Additional Testing Costs €M)	(183)*	30.75	n/a	104.4	-136.4	270.25
Additional Administrative Costs (€)	n/a	15,200	n/a	22,100	2,800	240,000

Table 0.2 Aggregate Cost Summaries based upon BIPRO assumptions
(*baseline costs i.e. 'additional testing costs' to be added to this baseline aggregate cost.)

It is important to stress that these costs could increase or decrease depending on the actual number of forms as well as the degree/level of read across that may be applicable.

Impact Analysis

Assessment of impact has been the least developed area of research into the regulation of NM and the Research Team were only able to make limited progress in assessing how each of the options under consideration may impact within the health and social, economic, and environmental domains. Assessment was principally qualitative, being based upon secondary review and expert input from toxicologists with health and environmental expertise.

- **Option 2** was viewed to have a potentially positive impact on human health and environmental safety, with a broadly neutral impact on economic or environmental issues.
- **Option 3** not being linked to any substantive clarification or extension of requirements had the same limitations in terms of impact as the Baseline (no change).
- **Option 4** extends the scope of REACH as well as providing additional requirements, with the potential to identify the highest consequence health and environmental impacts.
- **Option 5** could have positive impacts on employment, but increased risk of failing to identify and mitigate health and environmental risk.
- **Option 6** involved a potential doubling of costs over the baseline position with only a limited number of measures that could be viewed to have the highest potential impact on improved human health and environmental safety.

Impact on SMEs

Whilst improved clarity was considered to be advantageous to SMEs, micro enterprises and start ups, there was significant concern that an increase in the regulatory cost burden, and most particularly Option Six and to a lesser extent Option Four, could negatively impact on the ability of European small businesses to compete in the NM market.

Options Comparison

The final chapter of this study involves a comparison of each of the six options under consideration, bringing together assessments of effectiveness, efficiency and coherence, these being the assessment criteria set out in the European Commission's Impact Assessment Guidelines. Scoring for each aspect was ranked from minus 5 (least positive) to plus 5 (most positive), with a zero being a neutral (no impact) rating. Scores represent the total for a range of measures used to assess each summary measure.

The multi criteria assessment presents Options 2 to be significantly higher scoring than any other option. This stands in contrast to the summary response of stakeholders in the Public Consultation Exercise where Options 5 and 6 were the most popular, but is in line with stakeholder assessments of each Option when assessed on a measure-by-measure basis. The no change and soft law options received negative scores, which is likely to be in part a reflection of stakeholder evidence that was negatively impacted by perceptions as to the current application of REACH for NM as opposed to the ideal or complete application of all the measures that constitute each of these options.

Summary Impact Measure	Option One	Option Two	Option Three	Option Four	Option Five	Option Six
Effectiveness	**-1.4**	**1.6**	**-1.0**	**1.75**	**0.55**	**1.65**
Efficiency	**-0.8**	**0.4**	**-0.8**	**-1.0**	**1.4**	**-2.6**
Coherence	-2.4	3.0	-2.4	2.2	0.2	2.0
Total Assessment Score	**-4.6**	**5.0**	**-4.2**	**2.95**	**2.15**	**1.05**
Ranking	**6th**	**1st**	**5th**	**2nd**	**3rd**	**4th**

Table 0.3 Summary Option Assessment

Conclusions

This Research Study provides a range of new evidence and analysis to support the European Commission's Impact Assessment process. The core findings of the study are that:

- A significant majority of stakeholders believe REACH to be the appropriate means to regulate NM.
- Equally the majority of stakeholders believe that NM require particular provisions within REACH in order for the wider aims of REACH to be deliverable for NM.
- Stakeholders also agree that the current provisions within REACH require further development if the full benefits of REACH are to be obtained for NM.
- The multi criteria assessment presents Options 2 to be significantly higher scoring than any other option.
- There are a number of measures contained within each of the Options with high cost benefit, which suggests further review of the composition of existing options would be appropriate.

1.0 Introduction

This Draft Final Report is the fourth of the deliverables for the DG ENTR study to support the impact assessment of relevant regulatory options, in particular possible amendments of REACH Annexes, to ensure further clarity on how nanomaterials (NM) are addressed and safety demonstrated in registration dossiers in the framework of REACH. The study has been commissioned under Framework Contract ENTR/2008/006/Lot 3. The report provides all the tasks as substantively complete.

1.1 Policy Context

Market access to NM in Europe is regulated through REACH – the Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation.[4] The legal basis for adopting REACH is ex-Art.95 TEC (Current 114 TFEU) providing harmonising EU measures with the objective of establishing and supporting the functioning of the internal market. Therefore, the aims of REACH are twofold. The first provides a focus on the internal market and the second seeks to ensure the protection of human health and the environment. Consequently Art. 1 of REACH provides a balance between the aims of REACH: ensure protection of human health and the environment, including the promotion of alternative methods for the assessment of hazards of substances, and the free movement of substances on the internal market, while enhancing competitiveness and innovation.[5] REACH actively involves the industry as it places responsibility on the chemicals sector to manage risks and provide information on safety; manufacturers and importers are required to gather information on the properties of chemical substances, and to register the information in the European Chemicals Agency's central public database.[6]

REACH's remit covers that of NM, although NM are not explicitly identified within the scope of text of the regulation. This is because REACH was not designed to cater specifically for NM. The generalised treatment also stems from the fact that NM are a heterogeneous group of chemicals whose common denominator is *size*, not *matter*. To facilitate submission of registration dossiers that comply with REACH, the European Chemicals Agency has developed and published guidance that elaborates preparation of registration of dossiers for substances that entail, or could take, the form of NM. The European Commission has also been active in this area and has published a recommendation of a nanomaterial definition. The Recommendation concerning the definition of nanomaterials, adopted by the COM, assists various pieces of EU legislation, including REACH.[7]

Materials that have been commercialised for decades or longer dominate the current NM market. These include carbon black and synthetic amorphous silica. These materials are used in the production of tyres, toothpaste or as an anticoagulant in food powders. Newer kinds of NM and newer uses of these materials cover products such as electronics, solar panels, batteries and biomedical applications.[8]

Whilst the term "nanotechnology" was coined in the 1960s, the use of NM is not new. Nanoparticles were used over two millennia ago when clusters of gold nanoparticles were used to make vivid colours in Roman glass. The early 20th century saw the production of carbon black and in the 1940s fumed silica production followed. The further design and "more modern" use of NM took place only in parallel

[4] http://ec.europa.eu/enterprise/sectors/chemicals/reach/
[5] Ibid.
[6] Ibid.
[7] Commission Recommendation of 18 October 2011 on the definition of nanomaterial Text with EEA relevance
[8] http://europa.eu/rapid/press-release_AGENDA-12-33_en.htm

with the development of high-speed computing and modelling, advanced characterisation techniques, such as atomic force microscopy and scanning tunnelling microscopy, and synthesis routes, such as sol-gel processing,[9] which is needed to make technical progress on nanotechnology today.

The NM market is part of the overarching sectors of Key Enabling Technologies (KETs), which also includes micro- and nanoelectronics, advanced materials, industrial biotechnology, photonics, and advanced manufacturing systems. This market is forecast to grow to over one trillion Euros by 2015. This constitutes an increase of 154% from 2008, and over 8% of the EU GDP. Along with the rapid increase in industry turnover, economists also expect a rapid growth in jobs.[10] Many of these will be within SMEs (Small and Medium Enterprises) or spin-offs.[11] The former constitute around two-thirds of European industrial employment. SMEs are therefore central to industrial policy and to the development of the regulatory framework in Europe.[12]

Assessment of risks and potential impacts of NM on human health and the environment is subject to constant updating. Initial risk assessments suffered from a (historic) lack of reliable data, agreed indicators, and workable methodology. Juxtaposed to this is the potential of NM to contribute to economic, social and environmental wellbeing in Europe through improving products and product processes. Because of these complexities, well-functioning regulation is required, and the European Commission considers REACH to be the best possible framework to facilitate new and innovative products both effectively and safely.[13]

A number of reports have highlighted the need for a reappraisal of the current regulatory structure, hence the current review of the way NM are regulated under REACH.[14] Such a review should consider the extent to which current regulatory arrangements constitute a barrier to economic development and the single market or, alternatively, as not providing a platform for the effective management of risk with regard to human health and the environment.

The European Chemicals Agency (ECHA) is the coordinating European body vis-à-vis evaluation of potentially hazardous chemicals. Any hazardous chemicals should, according to the aims of REACH, be progressively substituted when suitable alternatives have been identified.[15] By law companies are obliged to ensure that the products they put on the EU market are safe. The obligation on the manufacturer and the importer to register a substance depends on the quantity manufactured and imported per year (more than 1 tonne per year per manufacturer/importer) as provided in Article 6 of REACH. In addition Article 2 of REACH provides certain exemptions that fall out of the scope of REACH. When risk assessments are required, these should be carried out in line with the REACH requirements and ECHA's guidance. If these assessments conclude that risks cannot be managed, the use of substances can be restricted.[16]

[9] Michael J. Pitkethly, Nanoparticles as building blocks? QinetiQ NM, Nano Today December 2003
[10] http://ec.europa.eu/enterprise/newsroom/cf/itemdetail.cfm?item_id=5968&lang=en&tpa_id=1022&title=Mission-Growth%3A-Europe-at-the-Lead-of-the-New-Industrial-Revolution
[11] The creation of an independent company through the sale or distribution of new shares of an existing business/division of a parent company.
[12] Study on REACH contribution to the development of emerging technologies, Final Report, GAIA, October 2012
[13] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of NM COM(2012) 572 final
[14] DG Environment (DG ENV) and the Joint Research Centre (JRC) Scientific technical support on assessment of NM in REACH registration dossiers and adequacy of available information Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1), March 2012
[15] http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
[16] http://echa.europa.eu/regulations/reach/understanding-reach

Since its implementation, REACH has been evaluated several times.[17] One of the more recent evaluation studies, published in 2012, concluded that REACH contributed to the competitiveness of the EU chemical industry and also supported the protection of the internal market. The study concluded that potential benefits still remain to be seen as the implementation of REACH progressed further.[18]

European Commission activities

The European Commission has, since 2004, underlined the need for "appropriate and timely regulation in the area of public health, consumer protection and the environment […] to ensure confidence from consumers, workers and investors". A significant proportion of nanomaterial regulation stems from Europe (through REACH and CLP – Regulation on classification, labelling and packaging[19]) and the European institutions are also central actors in funding and performing risk assessment and have been proactive in encouraging stakeholder engagement.[20] [21]

In 2004 the European Commission adopted the Communication "Towards a European Strategy for Nanotechnology"[22] and the "Nanosciences and nanotechnologies: An action plan for Europe 2005-2009"[23] which proposed a holistic NM strategy. The Action Plan specified that all applications and use of nanosciences and nanotechnologies must comply with the high level of European public health, safety, consumer and worker protection, and environmental protection. The Commission consequently announced a regulatory review of EU legislation in relevant sectors.[24] [25]

The Second Regulatory Aspects of Nanomaterials review[26] was published in October 2012. The review provides updates on the adequacy and implementation of EU legislation for NM, and follow-up actions. The review also responded to issues raised by the European Parliament, the Council and the European Economic and Social Committee.[27] The Second Review dovetailed with a Commission Staff Working

[17] http://ec.europa.eu/enterprise/dg/evaluation/reports_en.htm
[18] Final report Framework Service Contract for the Procurement of Studies and other Supporting Services on Commission Impact Assessments and Evaluations Interim, final and ex-post evaluations of policies, programmes and other activities Interim Evaluation: Functioning of the European chemical market after the introduction of REACH, Centre for Strategy & Evaluation Services, March 2012
[19] http://ec.europa.eu/enterprise/sectors/chemicals/documents/classification
[20] R Falkner, London School of Economics and N Jasper, Free University Berlin, Regulating Nanotechnologies: Risk, Uncertainty and the Global Governance Gap. Published in Global Environmental Politics, 12(1), February 2012, pp.30-55.
[21] European research and development projects funded through the 6th and/or 7th Framework Programmes are either encouraged, or duty-bound, to join the EU NanoSafety Cluster. This is an initiative begun to maximise the synergies addressing all aspects of nano safety including toxicology, ecotoxicology, exposure assessment, mechanisms of interaction, risk assessment and standardisation. See http://www.nanosafetycluster.eu
[22] Communication from the Commission Towards a European Strategy for Nanotechnology, 2004
[23] Communication from the Commission to the Council, the European Parliament, and the Economic and Social Committee Nanosciences and nanotechnologies: An action plan for Europe 2005-2009, 2005
[24] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Regulatory Aspects of Nanomaterials COM(2008) 366 final
[25] The attention to environmental requirements of products throughout their lifecycle is also explicitly mentioned in a number of EU policy documents, including the Sixth Community Environment Action Programme (to be succeeded by the 7EAP), the Green Paper and the Communication on Integrated Product Policy (IPP), the Thematic Strategies on Sustainable Use of Resources and Prevention and Recycling of Waste, and the Directive on Energy Using Products (EuP). See Nanotechnology and Lifecycle Assessment: A Systems Approach to Nanotechnology and the Environment, Synthesis of results obtained at a Workshop in Washington DC 2-3 October 2006 (organised with Pew Charitable Trusts and the European Commission, Woodrow Wilson International Center for Scholars, 2007
[26] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final
[27] These are Resolution European Parliament on Regulatory Aspects of Nanomaterials (2008/2208(INI), 24.4.2009, Conclusions on "improving environmental policy instruments" of 20 December 2010 and Opinion European Economic and Social Committee; INT/456 of 25.2.2009, Nanomaterials respectively

Paper.[28] This was published as a response to "the European Parliament's concern that the Commission's approach to NM was jeopardised by the lack of information on the use and on the safety of NM that are already on the market".[29]

Furthermore, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and the Scientific Committee on Consumer Safety (SCCS), the European Food Safety Authority (EFSA) and the European Medicines Agency (EMA) have been working on the risk assessment of NM since 2004 and have delivered a number of outputs. In 2009, SCENIHR concluded that "while risk assessment methodologies for the evaluation of potential risks of substances and conventional materials to man and the environment are widely used and are generally applicable to NM, specific aspects related to NM still require further development. This will remain so until there is sufficient scientific information available to characterise the harmful effects of NM on humans and the environment."[30]

The Commission and ECHA have taken two specific steps to facilitate the evaluation of REACH dossiers with nanoform, under REACH:

In April 2011, as a response to a European Parliament resolution, the EC published its definition of a nanomaterial, to be used "*as a reference for determining whether a material should be considered as a 'nanomaterial' for legislative and policy purposes in the Union*".[31] The EC definition recommendation has no regulatory impact in its own right. To have legislative impact it needs to be implemented in relevant regulations; for example it has been referenced in the EU Biocides and Ecolabel Directives.[32]

In December 2011, the European Chemicals Agency developed and published REACH guidance documents that specifically address the properties of NM and that elaborate preparation of registration of dossiers for substances that entail, or could take the form of NM.[33] These concern information requirements that have been developed to support registrants when preparing registration dossiers particularly for NM and the conclusions developed through the first of a series of studies (the RIP-oN reports[34]) commissioned by the EC. The recommendations encompass (inter alia) testing strategies, methods of testing, endpoint specific guidance, and dosage to ensure i) human health, and ii) the environment.

[28] Commission Staff Working Paper Types and uses of nanomaterials, including safety aspects, Accompanying the Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee on the Second Regulatory Review on Nanomaterials [COM(2012) 572 final], SWD(2012) 288 final

[29] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final

[30] Quoted from Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final

[31] Commission Recommendation of 18 October 2011 on the definition of nanomaterial Text with EEA relevance, Official Journal L 275, 20/10/2011 P. 0038 - 0040

[32] Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013

[33] These guidelines were based on three REACH Implementation Projects on Nanomaterials (RIP-oN) that evaluated the applicability of the existing REACH guidance to nanomaterials and how the guidance could be updated to better reflect nanomaterials

[34] http://ec.europa.eu/environment/chemicals/nanotech/#ripon

Despite actions taken to facilitate the current regulatory process, there are indications from ECHA- and JRC-commissioned studies[35] [36] that there is still extensive uncertainty around the submission of nanomaterial substances under REACH. Consequently many registration dossiers containing nanoforms/NM submitted during the first registration deadline may have shortcomings.[37] It is important to note, however, that the assessment in the NanoSupport Study report was on the first registration dossiers, and at the time the definition on NMs had not yet been adopted by the Commission.

1.2 Study Terms of Reference

This study's task is to support the proposed forthcoming Impact Assessment on the REACH Regulation as it relates to NM. Its purpose is to assess future options to address NM under REACH while taking into account, on the one hand, the competitiveness of the European chemicals and NM sector, innovation and employment, including SME-specific impacts, and on the other hand, human health and the environment and impacts from the use of NM.

The Study Terms of Reference state that the objective of the policy initiative is "to ensure further clarity on how NM are addressed and safety demonstrated in registration dossiers". The objective of the study, then, is "to provide technical assistance and support to the Commission with regard to certain elements of the impact assessment accompanying a potential policy proposal".

The Research Team has sought to produce a rigorous study that can usefully, and with robustness, feed into an Impact Assessment. In summary, the Research Team's overall strategy is built upon:

- Identifying, weighing and ranking risks related to NM based upon quantitative and qualitative evidence.
- Balancing health and environmental impacts with those on competitiveness and innovation.
- Working closely with stakeholders to establish a clear picture of registration costs (current and future based upon varying scenarios).

[35] DG Environment (DG ENV) and the Joint Research Centre (JRC) Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1), March 2012

[36] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012

[37] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012

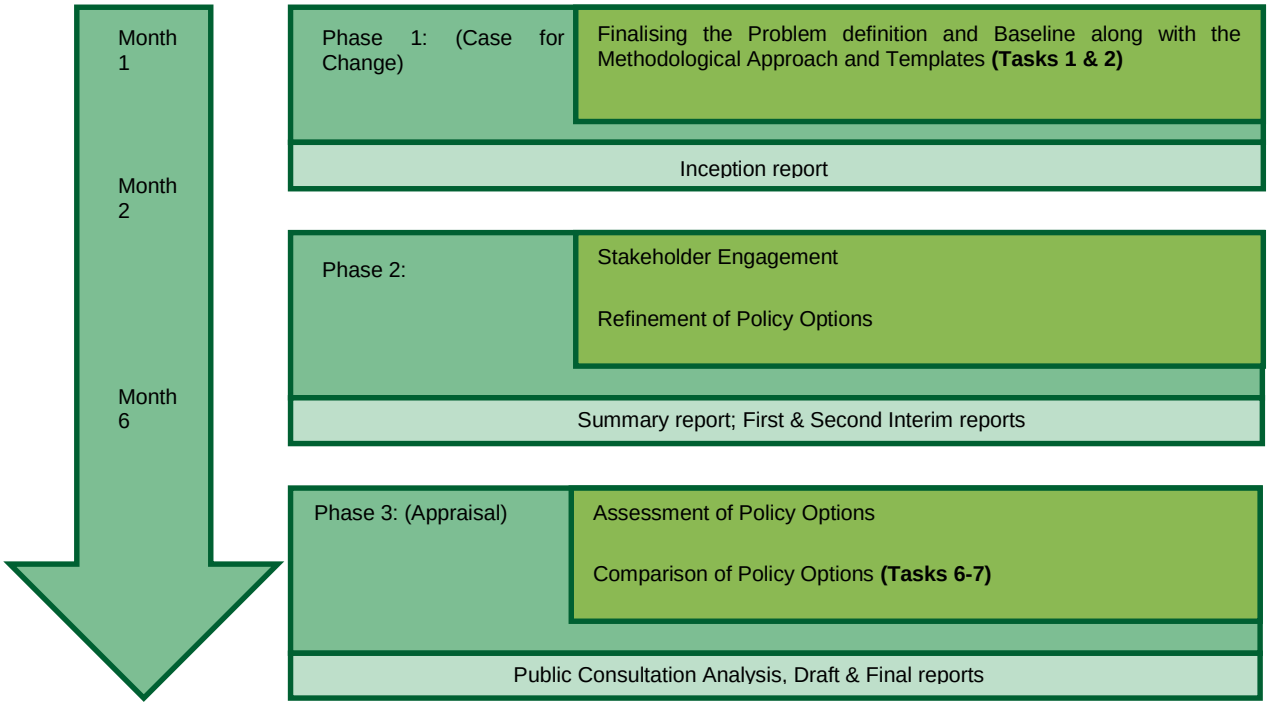


Figure 1.1 Study design

The Research Team has structured the study as illustrated above in Figure 1.

1.3 Research Programme

The study follows the key steps of an Impact Assessment as described in the Commission Guidelines.[38] These are:

- Developing the Analytical Framework
- Problem Definition
- Refining Policy Options
- Impact Assessment of Policy Options
- Comparison of Policy Options

The Research Team set out each of these steps in more detail in the remainder of this section, summarising the key research questions and methodological tools used to tackle them as well as providing an overview of the respective outputs.

The research programme for this study involved the collection and assessment of both primary and secondary evidence. In this chapter the focus is on primary data collection.

[38] SEC(2009), Impact Assessment Guidelines, Available at: http://ec.europa.eu/governance/impact/key_docs/key_docs_en.htm

There are a number of challenges related to the development of a primary research programme for this study. The first is that this is a rapidly evolving and dynamic environment, where scientific knowledge is subject to continuing review and update. Secondly, the nano industry is the subject of a significant level of research, assessment and review. This presents the dual challenges of avoiding duplication and ensuring that stakeholders are not subjected to potentially burdensome research requirements. Finally, it needs to be noted that whilst there is such a high level of research interest in nano, to date there has only been limited work focused on assessing and quantifying the potential costs and benefits associated with this sector of the economy.

To mitigate these issues the Research Team structured a research programme that uses as its anchor point the formal consultation process required of an Impact Assessment process undertaken by the European Commission. Built around this are a series of additional and complementary research inputs as outlined below:

- **Formal Public Consultation** – a questionnaire was designed to allow stakeholders to consider the problem definition alongside an assessment of the costs and benefits that might be associated with each of the six options currently under consideration. The Public Consultation involved a large number of potential respondents and as such has been the principal means to engage with relevant stakeholders.
- **Stakeholder Interviews** – Six semi-structured telephone interviews were undertaken to complement other elements of the research process. These interviews went into more detail about the current regulatory structure for NM as well as the options under consideration.
- **Data Capture** – An Excel Spread sheet was used to collect data on testing for Registration of NM via REACH with a particular, but not exclusive, focus on laboratory and associated administrative costs.
- **Materials Assessment** – To complement the Industry focus within the stakeholder interview programme, the Research Team undertook a small number of evidence reviews based upon a selected number of NM. The purpose of undertaking such studies was to focus more closely on understanding the potential impact of suggested measures in the regulatory system brought about by each of the options considered.

The decision as to how many and which materials to choose has been impacted by assessment of what will provide for the broadest and most representative sample of materials. On this basis the Research Team decided to build out from the heart of current research on NM and in particular on the two most recent studies by BiPRO for the European Commission and the RPA study for CEFIC. The materials subject to assessment are as follows:

- Titanium Dioxide
- Carbon Black
- Carbon Nanotubes
- Synthetic Amorphous Silica (SAS)

1.4 Estimating Regulatory Costs

As previously stated, the focus of the study has been to examine the additional marginal costs associated with the proposed measures for NM as nanoforms of a substance. These principally related to testing costs, but the Research Team have also sought to establish whether the preparation of dossiers for NM will involve additional administrative costs for consortium partners as well as costs

relating to the dissemination of any additional risk management guidelines. From secondary evidence and stakeholder interviews, the Research Team have established cost areas and estimates.

Beyond the case studies, the Research Team's challenge has been to provide a global estimate of costs that would be associated with proposed changes to the annexes of REACH. The challenge in doing this relates partly to the difficulty in assessing potential overall registration levels and also registration types, i.e. providing a breakdown of nanoforms as well as materials, and it remains possible that no robust estimate can be given.

Stakeholder Engagement

In addition to this exercise the Research Team have undertaken two associated pieces of primary data collection.

- General Stakeholder semi-structured Interviews.
- Formal Public Consultation support.

The segmentation of stakeholders has been as follows:

	Public Consultation	Semi-Structured Interviews	Costs Data
Industry	X		
ETPs	X		
SMEs	X		
Micro and Start Up	X		
Importers	X		
Downstream users	X		
Producers	X		
Industry Associations	X	X	
Public Bodies/Authorities	X		
Competent Authorities and Economic/Industry Ministries	X	X	
ECHA	X		
Testing Bodies			X
GLP Laboratories	X		X
Environmental Health & Safety	X	X	
NGOs	X	X	
Trade Unions	X	X	
Consumer Organisations	X		
European Associations	X		
National Associations	X	X	

Table 1.1 Overview of Stakeholder Engagement Programme

The interview process was designed to operate on a cascade basis anchored by engagement with representatives from Trade Associations, Environmental NGOs and Trade Union bodies.

Formal Public Consultation

The Commission launched its 12-week public consultation in June 2013. The Research Team was required to assist in preparing [3.1] and process and analyse the information provided in the public consultation [3.2]. The Formal Public Consultation Exercise was targeted at all the stakeholders that have an interest in matters relating to the regulation of NM. The report on the Formal Public Consultation is included in the Appendices to this report.

2.0 Problem Definition

In developing the problem definition for this study, the Research Team followed the EC Impact Assessment Guidelines. The Research Team had to ensure that the Problem Definition is kept within the parameters provided within the Study Terms of Reference. This requires that issues relating to the problem definition are focused on the issue of "clarity on how NM are addressed and safety demonstrated in registration dossiers". This has not always been a straightforward process as both secondary evidence and stakeholder feedback have highlighted issues beyond the immediate question. This includes issues such as the definition of NM or, more broadly, the applicability of REACH as a regulatory process for the assessment of NM. In summary, the Research Team has assessed the problem as follows:

Describe the nature of problem in clear terms and support the description with clear evidence to set out clearly the scale of the problem – The nature of the problem is that there is sub-optimal regulation based upon the current requirements for the regulation of NM through REACH, which are deemed to be unclear and/or lacking in appropriate detail. Additionally problems relating to the requirements have not been resolved by the issuing of guidance by ECHA. The overall situation is that insufficient numbers of dossiers may have been submitted and/or submitted dossiers may not contain sufficient evidence to enable the requirements of REACH to be met for NM. The scale of the problem relates principally to the impact of the current situation on the ability to ensure protection of human health and the environment. This includes the promotion of alternative methods for the assessment of hazards of substances, and the free movement of substances on the internal market while enhancing competitiveness and innovation. Whilst it is not possible to draw any direct conclusions by assessing the number of dossiers that have been submitted to date, there is evidence on the completeness of the dossiers for NM that have been submitted, that suggests the scale of the problem is significant.

Set out clearly who is most affected by it – Consideration of stakeholders affected by the problem can be divided into those immediately impacted, i.e. producers of NM, and then into secondary stakeholders; a process that tracks the supply chain for the production of NM into the product lifecycle for goods and products which contain NM. For producers the impacts will firstly relate to the regulatory process itself, including potential additional costs associated with the regulatory process that are a consequence of the available guidance being insufficient, incomplete or in some other manner sub-optimal. Beyond this there may be an additional broader impact in terms of regulatory uncertainty that may result in investment or production decisions being taken that could negatively impact on producers (and more broadly the market). Beyond these immediate stakeholders one must also consider the potential impact on innovation and competitiveness, particularly given the global nature of the NM industry. The consequent impact of regulatory problems is sub-optimal regulation of NM, which may result in a potential failure to identify risks associated with NM, including a failure to develop risk mitigation strategies. This could result in harms across the supply chain and product lifecycle, including workforce health issues and environmental harms. It could also cause economic harm to producers that are unable to realise an optimum market rate for their NM, where substances have not been successfully registered through the REACH process.

Identify clearly the drivers or underlying causes of the problem. – Firstly, the science around NM and the testing of NM is still evolving and this may impact on the ability to set requirements and provide guidance. This challenge is exacerbated by divergent stakeholder views on the interpretation of the scientific evidence that has been developed to date. A potential second driver is the limited timeframe within which stakeholders have had to digest and respond to current guidance.

Describe how the problem has developed over time and how existing policies at Community or Member State level affect it – There have been stages to the development of the problem as a European level. A functional starting point for the problem can be identified from the establishment of REACH, the setting of the definition of NM by the Commission and then the issuing of ECHA Guidance. There is also evidence of concerns relating to potential risks to human health and the environment being put forward by stakeholder groups alongside concerns that regulatory uncertainty was having a negative impact on industry, competitiveness and innovation. One of the main responses at Member State level has been the introduction of national registers of NM, although this has limited connection to the issue of the requirements for NM within REACH or the associated guidance provided by ECHA.

Identify a clear baseline, i.e. describe how the problem is likely to develop in the future without new EU action – The main challenge posed by the baseline position is that in the absence of further regulatory guidance dossiers relating to NM will not be of an appropriate level of completeness. There is a further risk that the absence of precise regulatory guidance may result in a reduced level of submitted dossiers. The impact in terms of human health and environmental protection is that any additional benefit that might accrue as a result of the specific regulation of NM will not be realised. There may also be challenges for the industry if the sector as a whole, and particularly SMEs and start-ups, consider that the regulatory environment for NM is not conducive and respond by disinvesting or moving investment and production outside the EU.

Identify clearly assumptions made, and risks and uncertainty involved – Risks include uncertainty regarding the scale and impact (financial) of the problem at all points. There are a number of assumptions that need to be made regarding the number of NM, as well as in establishing causality between requirements, guidance and the number and quality of dossiers, all of which have risk associated with them.

Describe why the problem needs action at Community level on the basis of principles set in the Treaty (Conferral and Subsidiarity) – The principle of chemical regulation being a Community-level responsibility is well established. Although there is scope for MS to support the guidance process, there remains an evident need for central coordination.

2.1 Nature of the Problem

The commercialisation and demand for NM and nanotechnologies appear to be increasing. As a result, augmented R&D and industry activities put pressure on national and international government structures to facilitate regulatory frameworks that are balanced between industry and economic needs, and health and environmental safety (HES). Technological progress in the use of NM equally has the potential to lead to increased benefits for humans and the environment. Regulatory uncertainty in dealing with emerging technologies not only hampers sufficient protection of human health and the environment, but also creates ambiguity for businesses[39] wanting to comply with regulation as a means of enhancing their competitiveness as a manufacturer or supplier.

[39] R Falkner, London School of Economics and N Jasper, Free University Berlin, Regulating Nanotechnologies: Risk, Uncertainty and the Global Governance Gap. Published in Global Environmental Politics, 12(1), February 2012, pp.30-55.

Despite actions taken to facilitate the current regulatory process, there are indications from ECHA- and JRC-commissioned studies,[40] [41] that there is still extensive uncertainty around the submission of dossiers for NM under REACH. Whilst the JRC study was not a compliance check for the regulatory requirements, it did indicate that many registration dossiers submitted during the first registration deadline containing nanoforms had shortcomings.[42] It should be noted, however, that 2010 registrations were undertaken in the absence of a NM definition and ECHA Guidance on NM.

Using the assessment of REACH dossiers submitted for the 2010 deadline, the Commission has highlighted the need for more specific requirements for nanoform dossiers submitted, in order to ensure further clarity on how NM are addressed and safety demonstrated.[43] These requirements are in addition to the Commission definition and the support provided by ECHA Guidance currently in place. The two main issues identified related to the following:

- The Recommendation on the definition of a nanomaterial[44] clarifies terminology, but in itself does not provide clarity to the registrants on how to address NM in REACH registrations.
- The updated guidance from ECHA has only partially addressed the problem.[45]

As the Commission's NM definition is due to be reviewed in 2014[46] there might be scope to allow the use of the definition and the ECHA Guidance to develop further before finally evaluating its impact. It should also be noted that there would be "further clarifications" in the REACH Annexes concerning NM in the framework of REACH that was agreed in the Second Regulatory review.

Currently, there is no prescription to undertake specific tests for each different form submitted in REACH dossiers, or to provide details about how different forms have been addressed in the registrations, although the dossier structure does allow for this to be included and ECHA encourages it through technical advice.[47]

In the document "Draft Roadmap Modifications in some REACH Annexes",[48] the Commission has identified the following contributory factors to the current lack of clarity and effectiveness:

- The description of the general provisions for assessing substances and preparing Chemical Safety Reports.
- Specific issues around physico-chemical properties for characterising NM.

[40] DG Environment (DG ENV) and the Joint Research Centre (JRC) Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1), March 2012
[41] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012
[42] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012
[43] NANO SUPPORT Project Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information between DG Environment (DG ENV) and the Joint Research Centre (JRC) Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1), March 2012
[44] Commission Recommendation of 18 October 2011 on the definition of nanomaterial (2011/696/EU)
[45] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012
[46] Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[47] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012
[48] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

- Uncertainty in application of test methods.
- Uncertainty about substance identification and the scope of the registration dossier.

This discussion in turn enabled the Research Team to pose two related questions to the problem definition. The first is to ask how guidance is able to support the Registration process and in doing so ensure appropriate regulation of NM under REACH. Feedback from environmental stakeholders suggests that current guidance has not been successful. Conversely, the industry view is that guidance is the correct approach and that clearer guidance will emerge as science develops; the fact that NM dossiers have already been submitted indicates that industry is responding. The overall conclusion is that current guidance alone has not been able to ensure the submission of sufficient numbers of sufficient quality and completeness for NMs.[49]

A second related question is whether current regulations are sufficient for industry to submit dossiers of an appropriate quality and completeness. The industry view on this question appears to be equivocal, with views varying in terms of whether more or revised regulations are required and, if so, whether these should be issued now or later when the scientific evidence base has been further developed. A number of the stakeholders interviewed talked about a need to move in line with the development of the scientific evidence base and not to pre-empt this through the premature introduction of new or additional regulatory requirements.[50]

This prompts the question of how the issues discussed above are linked to current problems related to requirements, guidance, registration levels and risk management. Certainly the view of environmental groups is that there is risk associated with the current manner in which NMs appear across the supply chain. Anecdotal evidence was given during the stakeholder interviews of engineered NM being produced in the EU with workers not being required to use protective equipment, although no direct connection was made to the impact of current REACH requirements or ECHA Guidance on this.[51] One stakeholder also cited the recent withdrawal from the engineered nano market of a large-scale chemicals manufacturer as evidence that Industry itself was increasingly aware of the risks associated with NM, although again no comment was made about whether the current position regarding REACH regulation or ECHA Guidance has impacted on this decision.

Few stakeholders commented directly on how the current regulatory requirements and guidance is impacting upon business and SMEs and on start-ups in particular.[52] Feedback from SMEs to the Formal Public Consultation Exercise did, however, align to the majority view that the current provisions are unclear.

2.2 Consequences of inaction

Inaction could have the following consequences:

Consequence [53]	Risk
Inadequate demonstration of safe use in the REACH registration dossiers:	

[49] Interview feedback
[50] Interview feedback
[51] Interview feedback
[52] Interview feedback
[53] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

• Industry may not get the right regulation at the right time or might not subject the material to the right tests, which could result in human health and environmental consequences across the supply and value chains.	Health and the environment, if inadequate demonstration of safe use in the REACH registration dossiers leads to harm.
Registration uncertainties for companies and impaired innovation: • Actors across the value chain may have less confidence about the materials concerned, which may impact on purchasing or handling. This is an issue of asymmetric information. Producers are usually more informed than consumers about the characteristics of their goods. While in many cases buyers can nevertheless grasp their main characteristics, sometimes asymmetric information can severely damage the proper functioning of a market. Regulations enhancing the safety of goods containing NM can limit the asymmetric information problem and enhance the confidence of buyers at any point of the supply chain (i.e. those who purchase intermediate goods and final consumers alike). A more subtle information issue involves the relationship between firms and employees. In principle workers can command higher salaries for jobs entailing a higher level of health hazard. However, some workers may ignore the dangers involved in their job, and in particular in the materials they may get in contact with. The features of REACH regulations in general, and those related to NM in particular, can therefore limit the amount of risk that workers may ignore. • NM producers may decide to move production out of the EU as a result of uncertainties in the regulatory system. In this way, NM could be imported into Europe already a component of a product, which would bypass REACH. • Any uncertainty with the regulatory system may impact on innovation and new product development, most particularly within the SME sector, which is more vulnerable and disproportionately affected through limited resources (human and financial). International consequences • Any potential producer / importer of materials into the EU may be impacted by an uncertain regulatory environment. • International competitors may initially benefit from a clearer and/or less involved regulatory regime. They would benefit by having less competition and potentially being more attractive to start-ups and other companies looking to develop NM.	Industry-affecting innovation, investment decisions and impaired competitiveness due to lack of clarity over what needs to be included in the REACH registration dossiers.

Table 2.1 Consequence of Inaction Table

2.3 Problem Scale

Research studies undertaken in the last two years have estimated that there are between 500 and 2,000 NM placed on the EU market[54] whilst the JRC found nine registered NM in its search of submitted dossiers in 2012.[55] The most recent figures for the Registration of materials between 100 and 1,000 tonnes suggests a total of four NM, equating to 50 dossiers.[56] Studies underpinning the EC "Draft Roadmap to Modifications in some REACH Annexes" suggest that in total there are between 200 and 400 European nanomaterial manufacturers,[57] although this number appears to exclude the supply chains of manufacturers. An RPA study from 2012[58] produced additional analysis in terms of materials, estimating ("best estimate") that

- 95% of newly engineered NM are conventional and equate between 475 and 1,900 NM
- 5% of newly engineered NM are "new" and add up to 25–100 NM.[59]

One of the most significant problems relating to current estimates is that none make a clear differentiation between distinct NM and nanoforms. That having been said, there still appears to be a gap between the total number of NM and nano forms and the current level of registered dossiers for NM. Whilst the causal link between current requirements and associated guidance and Registration levels cannot be definitively established, the comments of stakeholders would suggest it to be one of a number of impacting factors.

2.4 Affected stakeholders

There are a range of stakeholders who would be affected by problems with the current requirements and associated guidance on the Registration of NM within REACH.

Firstly, ECHA, along with competent authorities and enforcement authorities, will be affected as the agency with overall responsibility for the implementation of REACH via the competences that REACH gives to ECHA in the registration procedure or evaluation procedure, for example. ECHA would be responsible for implementing any changes to the regulation within REACH Annexes and would oversee dossiers submitted under new guidance or instruction.[60] Secondly, the chemicals industry and consortia submitting dossiers will need to adhere to REACH Annex amendments, which may entail changes in testing and administrative costs. These include not only European industries, but also any non-European, international industries, which equally have an obligation to register any substance imported

[54] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012

[55] NANO SUPPORT Project Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information AA N°07.0307/2010/581080/AA/D3 between DG Environment (DG ENV) and the Joint Research Centre (JRC) Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1)

[56] http://www.echa.europa.eu/view-article/-/journal_content/title/2-923-more-chemicals-registered-by-industry-under-reach via http://www.nanotechia.org/news/news-articles/early-results-indicate-total-4-nanomaterials-registered-2013-reach-deadline

[57] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

[58] Impact Assessment of the REACH Implementation Project on Substance ID for Nanomaterials Final Report prepared for Cefic, RPA March 2012

[59] Impact Assessment of the REACH Implementation Project on Substance ID for Nanomaterials Final Report prepared for Cefic, RPA March 2012

[60] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

on the European market. Also affected in the supply chain is the downstream user.[61] ECHA underlines that downstream users play a central role in the safe use of chemicals both in their own right and also as a communicator to suppliers and customers. Due to the many and varied uses of nanomaterials, NM-related supply chains are complex; thus impact will be felt not only within the European chemicals industry but also beyond it. This scenario is likely to impact on SMEs in particular.

If the current REACH requirements and associated guidance constitute a barrier to an optimised regulatory environment for NM under REACH, organisations across the value chain may lose confidence in the European NM industry. This could in turn impact on sales of NM and wide use, including handling. In the longer term, a troubled environment may persuade producers to relocate outside the European Union to avoid the regulatory system. From a reversed international perspective, regulatory uncertainty could dissuade producers who contemplate importing materials into the EU. International competitors may also develop an unfair advantage vis-à-vis the European chemicals industry.

Impact on SMEs

Ultimately, uncertainty in the regulatory system may impact on innovation and new product development, most particularly within the SME sector.[62] Other companies from the nanotechnology sector may be affected. There are also many newly founded SMEs and spin-off companies in this high-technology area. Nanomaterial-related employment in Europe is significant, with the European Chemical Industry Council calculating that by 2015 there will be around two million nanotechnology jobs worldwide, of which 300,000 to 400,000 will be in Europe.[63] These are predominantly high-skilled jobs. However, the exact number of jobs is undetermined. One projection forecasts 6 million new nanotechnology workers required by 2020 worldwide[64] although this is unverified.[65]

An industry association stakeholder[66] believes that for SMEs there is a problem of principle in relation to REACH in that it is proportionately more expensive to undertake the tests required for Registration at the lower tonnage levels that are typically more common for SMEs.

The stakeholder contended that registration is a burden for SMEs and that REACH is a barrier to small tonnage substances. The example was forwarded of the testing package for 1-10 tonne limits where costs may be between €30,000 and €50,000, and then over 1,000 tonnes it can be up to €1 million. The stakeholder argued that the cost per tonnage is much higher at lower tonnages and highlighted Option 6, which introduces a range of expensive tests and so makes it even more expensive. The stakeholder contended that this would all work against innovation.

The same stakeholder went on to give the example of one SME producing carbon nanotubes where a €5,000 increase in testing costs made a difference as they sought to increase production from 800kg

[61] Downstream users are companies or individuals who use a chemical substance, either on its own or in a mixture, in the course of their industrial or professional activities. ECHA definition available at http://echa.europa.eu/web/guest/regulations/reach/downstream-users
[62] See for example Final Report Study on REACH contribution to the development of emerging technologies, Gaia, 19 October 2012
[63] www.cefic.org/Policy-Centre/Environment--health/Nanomaterials
[64] Roco 2011. Via Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[65] Aída Maria Ponce Del Castillo Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[66] Semi structured interview with Industry Association stakeholder, July 2013

to 1000kg. The company went bankrupt in 2008 and whilst the stakeholder interviewed did not put this down to the impact of regulatory costs only, they did believe that it was at least a compounding factor.

Another Industry stakeholder contends that SMEs have bigger issues in terms of dealing with REACH in general than with NM. He argued that "For larger member companies … understand REACH but with SMEs they don't always know what data needs to be generated for nanomaterial dossiers." The respondent believed that SMEs find the general framework of REACH to be complex, irrespective of the nano elements concerned. He went on to argue that "The thinking behind REACH and the process itself is problematic for SMEs; it is a "draining task" even though most of them have a decent understanding of what is required of them. SMEs do not always know who to contact and when to contact them, although the overall preparedness is there."

More broadly, there could also be effects on workers' health protection and the health of the public at large.[67] A recent study by the ETUI underlines that occupational health is a specific impact of NM commercialisation and that the full impacts on workers' health are unknown as a result of lack of data.[68] Recent surveys[69] in the United States and France and quoted by ETUI suggest that companies dealing with NM are unsure about how best to protect health and safety or how to handle contaminations; there is also uncertainty around the exact number of workers potentially exposed to nanoparticles.[70] This may be a side effect of the heterogeneity characterising the NM industry and businesses operating within it.

2.5 Problem Drivers

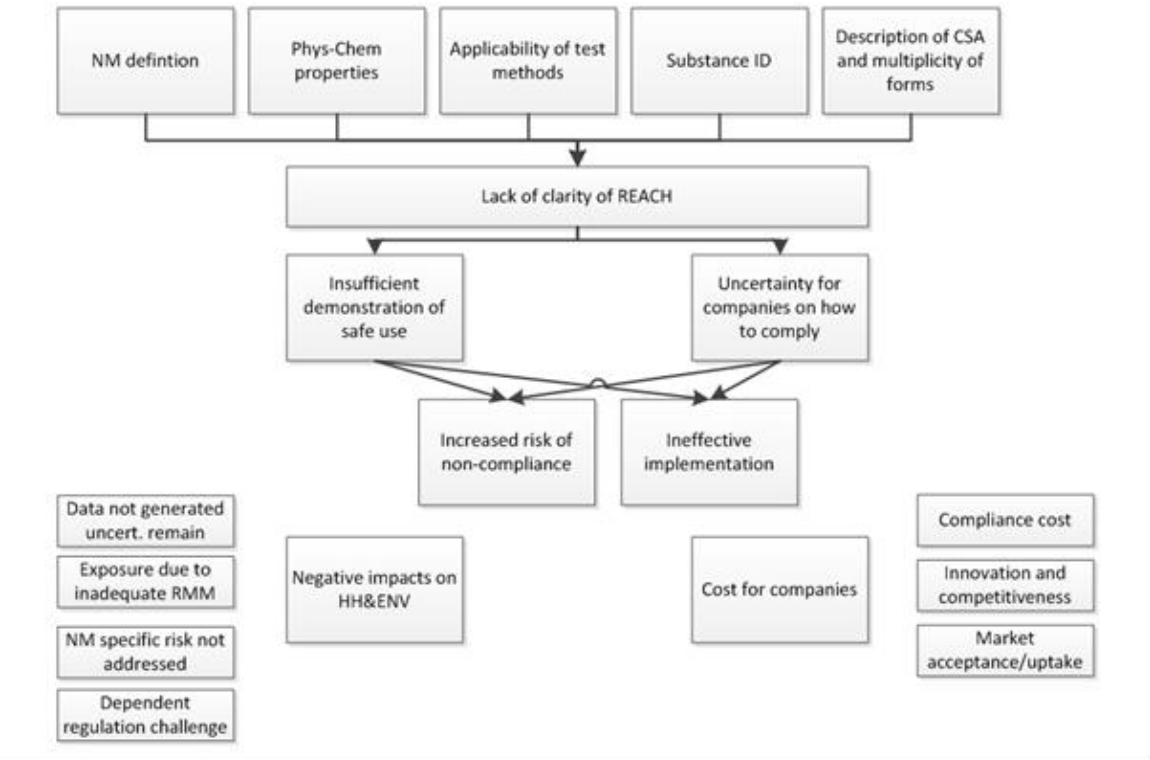
The European Commission's Second Regulatory Review considered issues relating to the regulation of NM under REACH.[71] As a result of the work carried out under this task the Commission has highlighted a need for more specific requirements for NM so as to ensure both clarity and safety.[72]

The Commission has identified[73] the following contributory factors to the current lack of clarity and effectiveness, which are elaborated below:

- The NM definition and the lack of a definition at the time of first Registration.
- The description of the general provisions for assessing substances and preparing Chemical Safety Reports.
- Specific issues around the physico-chemical properties for characterising NM.
- Uncertainty in application of test methods.
- Uncertainty about substance identification and the scope of the registration dossier.

[67] Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[68] Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[69] Conti 2008, INRS 2010b, Engeman 2012. Via Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[70] Aída Maria Ponce Del Castillo, Nanomaterials and workplace health & safety: What are the issues for workers? European Trade Union Institute, 2013
[71] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[72] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[73] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

Figure 2.1 Problem Drivers Overview



The responses to the formal Public Consultation point very strongly to current regulatory requirements for NM under REACH being the fundamental cause of the problem. In response to the question on respondents' overall view of the current registration provisions and information requirements for the registration of NM, 68% considered it to be "unclear" and a further 18% "very unclear".

When respondents to the Public Consultation were asked for further detail on particular problems with current guidance, a majority found problems with all aspects of current guidance i.e. scope of registration, requirements for substance identification, physical chemical properties, human health toxicity, ecotoxicity and environmental fate, chemical safety assessment, grouping of category approaches and the application of test methods. Of these, two were highlighted by respondents as being of proportionately highest level of concern: firstly guidance on current information requirements on use of grouping, and category approaches for nanoforms; and secondly other adaptations of the testing regime and current requirements on application of test methods and the relevance of results of tests performed on another form of material. These were the only two examples where more than half of all respondents felt current guidance to have had a "strong impact" on the overall problem.

EC NM definition

There appear to be a level of uncertainty relating to the Commission definition of NM.[74] In the Public Consultation Exercise, 77% of respondents believed the current definition had "some" or a "strong" impact on causing the problem.[75] Concerns focus on two main areas. Firstly there is the impact of the definition on the number of NM (caused by the choice to use number based particle size distribution). Secondly there are the difficulties with measurement (mostly caused by the identification of primary

[74] Stakeholder interviews CEFIC
[75] Strong Impact 51.7% and Some Impact 26.9%

particles in larger object such as agglomerates and aggregates). The threshold for particle size distribution is such that products (e.g. pigments) already on the market for a long time have been reclassified as NM. This issue is further compounded by the current situation regarding the definition of a primary particle. Another related uncertainty is the 50% threshold for nano material in terms of particles number.[76]

These issues are not considered further as they are not within the formal Terms of Reference for this study. However, it is sufficient to note the level of stakeholder interest in the issue of the definition of NM and the impact of the current definition of NM on dictating the number of NM and nanoforms that will be subject to regulation under the provisions of REACH.

Physico-chemical properties

REACH requires physico-chemical properties of substances to be described in dossiers submitted for registration. The relevance of some properties is limited, while other properties are not specifically listed. This can potentially lead to the inadequate characterisation of NM.[77] In the Public Consultation exercise, 85% of respondents felt the current guidance on physico-chemical properties of substances had “some” or a “strong” impact on the current problem.

Applicability of test methods

There have been ongoing disussions, among the EU's scientific committees and the OECD, on whether test methods applied on other substances can also be applied to NM. Consequently the EU and OECD have recommended that existing methods be applied, while care should be given in parallel to how the NM are prepared and dosed in the test systems. The lack of scientific certainty and continuing discussions have led to hesitancy amongst producers to perform or disclose existing tests that may prove later to be invalid.[78]

Substance identification and the scope of the registration dossier

Although the REACH Regulation clearly states that each substance must be registered in a dedicated registration dossier in accordance with the principle of “one substance one registration”, there are in practice many variables that influence naming and sameness of substances. The responsibility to distinguish between substances lies with the manufacturers. This SIEF process is completely separate from ECHA, although ECHA has also provided detailed guidance relating to the issue. This was, however, developed at a time when there was a lack of scientific understanding of NM and of physico-chemical properties to support substance identification.[79] Here the Public Consultation responses found that 72% of respondents believed this issue had “some” or a “strong” impact on causing the problem.

Description of Chemical Safety Assessment (CSA) and multiplicity of forms

The RIPoN studies (2 and 3) established that the basic paradigm of REACH chemical safety assessment as outlined in the Regulation’s Annexes is suitable also to most NM. But many stakeholders believe that the technical provisions as outlined in the Annexes lack clarity in relation to the required detail of the assessment and documentation of results when a registration dossier is covering a

[76] Stakeholder interviews CEFIC
[77] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[78] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[79] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials

multiplicity of forms of the same substance. Although not directly relevant to this study, another issue is that the assessment results for different forms may vary, which may prompt divergent approaches to risk management measures and information to users. This is an uncertainty which also affects ECHA and Member States in how they can determine when safe use has been demonstrated.[80]

2.6 Problem Development

As of June 2007, REACH is the European Union Regulation on chemicals[81] and is concerned with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. Although it has thus been in force for six years, it is – due to its scope, staged deadlines, and effect on the EU chemicals sector – a fairly new regulation. REACH has undergone a number of impact assessments and evaluations; the latter of which concludes, amongst other points, that it is still too soon to quantify the benefits of REACH.[82]

According to the REACH regulation Article 6 provides that first any manufacturer or importer that manufactures or imports a substance on its own or in mixtures, in a quantity of more than 1 tonne per year per legal entity has the obligation to register that substance to ECHA – one registration per one substance. Then Article 7 (1) provides the registration requirements for the substances in articles. Then REACH provides the requirements as regards what a registration dossier must contain. Under Article 7(5) ECHA also has the competence to request registration of a substance in case the conditions of that article are met.

There are two types of substance according to the provisions within REACH[83]:

Phase in substance	**A substance which meets at least one of the following criteria:** **1. It is listed in the European Inventory of Existing Commercial Chemical Substances (EINECS).** **2. It was manufactured in the Community, or in the countries acceding to the European Union on 1 January 1995 or on 1 May 2004, but not placed on the market by the manufacturer or importer, at least once in the 15 years before the entry into force of this Regulation, provided the manufacturer or importer has documentary evidence of this.** **3. It was placed on the market in the Community, or in the countries acceding to the European Union on 1 January 1995 or on 1 May 2004, before entry into force of this Regulation by the manufacturer or importer and was considered as having been notified in accordance with the first indent of Article 8(1) of Directive 67/548/EEC but does not meet the definition of a polymer as set out in this Regulation, provided the manufacturer or importer has documentary evidence of this.**

[80] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[81] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/E
[82] See for example Evaluation of the Impact of the REACH Regulation on the Innovativeness of the EU Chemical Industry
[83] http://www.hse.gov.uk/reach/definitions.htm

	Non Phase-in substance	A new substance, one not covered by the definition of a phase in substance

Table 2.3 Phase-in and non-phase in substances

There are different deadlines depending on the amount of chemicals the registration concerns.

Date	Action
1 June 2008	• Pre-registration for existing ("phase-in") substances starts • Registration for new ("non phase-in") substances starts
30 November 2008	Pre-registration for "phase-in" substances ends
1 December 2008	Registration for existing substances (that have not been pre-registered) starts
1 January 2009	List of pre-registered substances published
1 December 2010 PHASE 1	By this date the following pre-registered "phase-in" substances should have been registered when supplied at: • > 1000 tonnes per annum (tpa) or; • > 100 tpa and classified under CHIP as very toxic to aquatic organisms or; • > 1 tpa and classified under CHIP as Cat 1 or 2 carcinogens, mutagens or reproductive toxicants
1 June 2013 PHASE 2	Deadline for registration of substances supplied at ≥ 100 tpa
1 June 2018 PHASE 3	Deadline for registration of substances supplied at ≥ 1 tpa

Table 2.4 REACH registration timetable[84]

The registration deadline for non-phase-in substances was on 1 June 2008 and for certain phase-in substances on 1 December 2010. Further deadlines are 1 June 2013 for phase-in substances manufactured or imported in volumes at or exceeding 100 tonnes annually per legal entity, and 1 June 2018 for substances at or exceeding 1 tonnes on similar conditions.[85]

Among the key requirements for dossiers with nanomatieral(s) the following are the most relevant in relation to this impact assessment supporting study:

[84] Adapted from www.hse.gov.uk/reach/timeline.htm
[85] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials

- "The registrant must ensure the safety of the forms placed on the market and provide adequate information to address the different forms in the registrations, including the chemical safety assessment and its conclusions (e.g. through different classifications where appropriate).
- The information requirements of REACH registration apply to the total tonnage of substance, including all forms. There is no prescription to undertake specific tests for each different form, or to spell out the way in which the different forms have been addressed in the registrations, although the REACH dossier structure allows this and the technical advice from ECHA encourages it.
- Guidance based on RIPoN on Information Requirements (RIPoN2) and the RIPoN on Chemical Safety Assessment (RIPoN3) has been in place since April 2012.
- The present provisions of REACH allows for using data for one form of a substance demonstrate the safety of another form, if scientific support for this can be made. Due to still developing understanding of e.g. drivers of toxicity for NM, this may limit the possibililties in practise at present. At any rate it is necessary that NM (or nanoforms) are assessed case-by-case."[86]

Case by case entails:[87]

- Clarity is required whether and which nanoforms of a substance are covered by a registration. These nanoforms should be adequately characterised, and the user should be able to identify which operational conditions and risk management measures apply to them.
- Information should be provided on which forms of a substance have been tested, with the test conditions adequately documented.
- Conclusions of a chemical safety assessment should cover all forms in a registration. Where data from one form of a substance are used in demonstration of the safe use of other forms, a scientific justification should be given on how, applying the rules for grouping and read-across, the data from a specific test or other information can be used for the other forms of the substance. Similar considerations apply to exposure scenarios and the risk management measures.

It should be noted that, to date, the assessed dossiers were registered before the ECHA specific guidance and the definition on NM. Nevertheless the Commission's ex-post assessment has clearly shown that the above requirements have generally not been adhered to by the registrants to date.[88] Moreover, Commission-initiated studies[89] have admitted that "many of the existing registration dossiers for NM do not specify clearly how specific risks of NM are addressed".[90] There are a number of factors making quantification difficult, for example the absence of an obligation under REACH to indicate whether a registration dossier concerns a nanoform (although this is possible on a voluntary basis

[86] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[87] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[88] COM(2012) 572 final Communication from the Commission to the European Parliament, The Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials
[89] RIP-oN 1-3
[90] http://europa.eu/rapid/press-release_MEMO-12-732_en.htm

through a tickbox in REACH-IT). In addition, it is often unclear whether and how the nanoform has been covered by the registration dossier; especially for substances with both nano and non-nanoforms.[91]

2.7 Problem Sustainability

As of February 2012 seven substance registrations and 18 CLP notifications have identified themselves to be "nanomaterial".[92] [93] There are approximately 20–30 NM substances on the European market which are produced in significant quantities[94] and according to the Commission, more than 99.9% of all NM on the market in terms of production volumes and sales are produced in quantities above one tonne per year.[95] Thus, the most ubiquitously produced and used NM have already been registered as they are produced in the high tonnage band. The nature of the issue going forward will depend on an assessment of the remaining number of NM and nanoforms that are currently subject to registration under the provisions of REACH or will become subject to registration by 2018, that being the deadline for the registration of materials produced in quantities from 1-10 tonnes. In addition there are likely to be new NM and/or nanoforms that, if produced in quantities above one tonne, will also need to be registered.

2.8 Public Intervention Added Value

The REACH regulation is the overarching chemicals regulation in the EU and has been in force since 2007. Although not yet quantified, the benefit of the regulatory system for chemicals through REACH is well established and it would be a major change of approach to see NM treated in a different way or through a different mechanism. Although acknowledging gaps and problems, the Commission stated in 2012 that it is "convinced that REACH sets the best possible framework for the risk management of NM when they occur as substances or mixtures"[96] but that there is also a need to develop more specific requirements under the current framework, through modifications in relevant REACH Annexes.

[91] http://europa.eu/rapid/press-release_MEMO-12-732_en.htm
[92] from Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final
[93] Full quote "At the end of February 2012, seven substances had selected 'nanomaterial' as the form of the substance in voluntary fields in their registration dossiers. Further assessment of registrations identified additional substances relating to nanomaterials. In some cases, substances occur only or mainly as nanomaterial. Therefore, there is little doubt that those registrations concern nanomaterials, even though the voluntary tickbox has not been ticked. In other cases, registration dossiers for substances with both nano and non-nanoforms contain information (such as particle size distribution) suggesting that the nanoform is covered by the registration dossier. As part of the REACH registration dossier, registrants must also indicate whether their substances meet criteria to be classified as hazardous substances. Most of the substances with known nanoforms have not been classified as hazardous. Where they have been classified as hazardous, both the nano- and bulk forms are normally hazardous. This information should however be taken with the caveat that this is self-classification by registrants and that often it is unclear from the registration dossier whether the classification or absence thereof concerns the non-nano and/or nanoform. Where this is not already covered by the REACH registration dossier, all hazardous substances, including nanomaterials must be notified to the European Chemicals Agency (ECHA), independently of their tonnage (thus also covering very small amounts). There is also the possibility for notifiers to indicate that the notification concerns nanomaterials. Among the dossiers received by ECHA, 18 CLP notifications had selected nanomaterial as the form of the substance". http://europa.eu/rapid/press-release_MEMO-12-732_en.htm
[94] http://europa.eu/rapid/press-release_MEMO-12-732_en.htm
[95] http://europa.eu/rapid/press-release_MEMO-12-732_en.htm
[96] From Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final

2.9 EU Added Value

The EU Chemicals market, including the European Union and the rest of Europe, posted sales of €642 billion in 2011, which is the equivalent of 23.4% of world chemicals sales in value terms.97 The same year (2011) the EU was the leading exporter and importer of chemicals internationally. It accounted for just under 40% of global trade. This includes intra-EU trade.[98] The EU Chemicals industry employs around 1.19 million staff and additionally generated twice as many jobs indirectly via the value chain. Yet direct employment has decreased by an average annual rate of 1.9% between 2002 and 2011.[99]

REACH's overriding goal is to respect sustainable development by ensuring both a high level of protection of human health and the environment and the competitiveness of the chemicals industry, within the framework of the Single Market.[100] This is equally valid for substances in the form of NM. At the time of the implementation of REACH, there was "a strong consensus among stakeholders including the institutions that comprehensive measures at EU level are required in order to achieve a high level of protection of human health and the environment while at the same time ensuring a level playing field for all economic actors in the Internal Market".[101] By logical extension, EU amendments to the Annexes of the regulation are justified in order to maintain the original objectives of REACH. European intervention and regulation of the chemicals sector through REACH is outlined in, inter alia, the Commission Staff Working Paper General Report on REACH.[102]

2.10 Conclusions

The evidence presented in the Problem Definition Section clearly indicates that the current situation regarding the requirements for NM under REACH is problematic. Although REACH as a European Regulation has been successfully implemented, the inclusion of NM has faced additional challenges including the issue of both the requirements and the ability of related guidance to support these. The science of NM appears unique in a number of respects and initial attempts to structure suitable requirements and associated guidance for industry has not resulted in optimum submission levels or submission quality.[103] The majority of stakeholders appear to support REACH as being the appropriate regulatory vehicle for NM and they also agree that the current situation is problematic. However, there are significantly different views as to the central causes of this problem and the ability to focus this on

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[97] The European chemical industry in worldwide perspective Facts and Figures 2012. Available at: http://www.cefic.org/Documents/FactsAndFigures/2012/Facts-and-Figures-2012-The-Brochure.pdf

[98] The European chemical industry in worldwide perspective Facts and Figures 2012. Available at: http://www.cefic.org/Documents/FactsAndFigures/2012/Facts-and-Figures-2012-The-Brochure.pdf

[99] The European chemical industry in worldwide perspective Facts and Figures 2012. Available at: http://www.cefic.org/Documents/FactsAndFigures/2012/Facts-and-Figures-2012-The-Brochure.pdf

[100] Commission Staff Working Paper Regulation of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restrictions of Chemicals (REACH), establishing a European Chemicals Agency and amending Directive 1999/45/EC and Regulation (EC) {on Persistent Organic Pollutants} "1 EXTENDED IMPACT ASSESSMENT {COM(2003)644 final} http://ec.europa.eu/environment/chemicals/reach/background/docs/eia-sec-2003_1171.pdf

[101] Commission Staff Working Paper Regulation of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restrictions of Chemicals (REACH), establishing a European Chemicals Agency and amending Directive 1999/45/EC and Regulation (EC) {on Persistent Organic Pollutants} "1 EXTENDED IMPACT ASSESSMENT {COM(2003)644 final} http://ec.europa.eu/environment/chemicals/reach/background/docs/eia-sec-2003_1171.pdf

[102] SWD(2013) 25 final Commission Staff Working Document General Report on REACH Accompanying the document Report from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions in accordance with Article 117(4) REACH and Article 46(2) CLP, and a review of certain elements of REACH in line with Articles 75(2), 138(3) and 138(6) of REACH

[103] NANO SUPPORT Project Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information between DG Environment (DG ENV) and the Joint Research Centre (JRC) Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1) March 2012

requirement related issues is hampered by ongoing concerns regarding tangential issues such as definition. However the fundamental difference in stakeholder views relates to differing views as to how any adjustment in the REACH Annexes could help to improve regulatory compliance levels, with a small number expressing doubt as to whether regulatory reform will help the aims of REACH to be achieved for NM.

Equally, whilst it can be concluded that a problem exists, it is more challenging to establish the size of the problem or to estimate the impact of the problem, particularly in quantified terms. This is partially a consequence of not being able to estimate precisely how current regulation and associated guidance impacts on levels and quality of current Registration and hence to estimate how such a Registration profile may impact at the production level for NM and then across the value chain, including estimates of downstream impact. These issues are addressed further in the next section on establishing a study Baseline.

3.0 Data Capture

The data capture element of the Stakeholder Engagement Programme constitutes a core element within the broader Research Programme as it provides up-to-date estimates of the prospective cost of testing (where tests and such information are available from GLP-compliant laboratories currently offering nanomaterials testing to private clients as a service) as relevant to each of the Options considered within the study.

In undertaking this task it has been necessary to determine which tests are relevant to this exercise. Secondly, it has been necessary to design a Data Capture Tool including the relevant tests for sending out to laboratories for cost information. Thirdly, appropriate laboratories have been sourced and selected for participation in the costing exercise. Finally, the data returned from laboratories has been collated into a form for use in the Cost Data Assessment.

3.1 Relevant Tests for Nanomaterials within REACH

Under REACH Article 13(3), new toxicological and ecotoxicological tests and analyses are conducted according to published Guidelines (e.g. OECD, US EPA) and under the auspices of Good Laboratory Practice (GLP). Technical Guidance Documents (TGDs) are available for the specific tests required to meet the information requirements under the REACH Annexes

In October 2012, in the Second Regulatory Review on Nanomaterials[104], the European Commission published a communication concluding:

In the light of current knowledge and opinions of the EU Scientific and Advisory Committees and independent risk assessors, nanomaterials are similar to normal chemicals/substances in that some may be toxic and some may not. Possible risks are related to specific nanomaterials and specific uses. Therefore, nanomaterials require a risk assessment, which should be performed on a case-by-case basis, using pertinent information. Current risk assessment methods are applicable, even if work on particular aspects of risk assessment is still required.

OECD launched a programme of work in 2006 to ensure that the approaches for hazard, exposure and risk assessment for manufactured nanomaterials are of a high quality, science-based and internationally harmonised. OECD have looked at whether current guidelines can be used or adapted for nanomaterials, rather than starting from the drawing board. In Q4 2012 OECD stated in their communication “Six Years of OECD Work on the Safety of Manufactured Nanomaterials: Achievements and Future Opportunities”:

The OECD and its member countries have come to the conclusion that the approaches for the testing and assessment of traditional chemicals are in general appropriate for assessing the safety of nanomaterials, but may have to be adapted to the specificities of nanomaterials. As with other chemicals, it is clear that each nanomaterial may pose specific challenges, but in most instances, they can be addressed with existing test methods and assessment approaches. In some cases, it might be necessary to adapt methods of sample preparation and dosimetry for safety testing. Similarly, adaptations may be needed for certain Test Guidelines. But it will not be necessary to develop

[104] Brussels, 3.10.2012 COM(2012) 572 final Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Review on Nanomaterials

completely new approaches for nanomaterials. OECD continues to review all existing methodologies to identify and implement the necessary changes needed for their application to nanomaterials.

At present it is not clear to testing laboratories what the exact nature of the "adaptations" to test guidelines would comprise per assay, and this represents a significant unknown for laboratories currently offering commercial services for nanomaterials testing, in defining the exact costs of testing a nanomaterial per assay; such adaptations to methods are still being discussed at OECD level in various working groups for different areas of testing; and some areas, like inhalation, are further along with their discussions than others. The most recent document from OECD in 2012, titled "Guidance on sample preparation and dosimetry for the safety testing of manufactured nanomaterials", and which is cited as being relevant to water insoluble manufactured nanomaterials (as soluble forms would not need special attention), provides further discussions, but the document does not offer definitive guidance to practitioners as to what should be done case by case. As the OECD notes, it is a living document, and is evolving as the science of NM characterisation for the purpose of safety assessment develops. The 2012 document states "due to the wide variety of nanomaterials, it is difficult to develop advice applicable to all nanomaterials; accordingly, the performer of a study will have to exert some judgment on a case-by-case basis on the applicability of the recommendations given in this guidance to their particular material".

For the purposes of this evaluation, the assumption has therefore been taken that all standard physico-chemical tests, mammalian toxicology and ecotoxicology guideline tests and risk assessment methods as used for "traditional chemicals", provide a relevant starting point in order to test and assess nanomaterials for REACH, as a minimum. These methods will need adapting case-by-case; in some instances significant costs over and above the standard protocols can be expected with respect to, for example, additional characterisation, additional and specific histopathology/tissue sampling, specific expertise in designing and interpreting study data, etc. Additional characterisation of nanoforms before and during (eco)toxicology testing (i.e. as manufactured, as dosed and as taken up by the human body/environment) may be required using analytical chemistry techniques that are not routinely used for "traditional" chemicals to assure shape, size and other properties of nanoforms, as can be related to toxicological effects (e.g. those listed in OECD WPMN and JRC NanoSupport project reports).[105] It is possible that there will also be variability in the tests required and a full battery of tests may not be needed for every nanoform.

3.2 Tests, Options and Measures

The list of tests presented down the left hand side of the "Endpoints and Measures" Table shown in the Appendices includes all of the standard guideline tests as may currently be performed for "traditional chemicals" for the purposes of REACH registration (e.g. standard physico-chemical measures, mammalian toxicology and ecotoxicology tests). There is no reason at present to suggest that all of the existing guideline tests as listed, and as required for Annexes VII to X, would not be relevant for nanomaterials. In the work undertaken in Task B1 of the RIPoN2 report, key physico-chemical parameters for NMs are considered to be water solubility, partition coefficient, granulometry and adsorption/desorption properties. It is noted here that current analytical methods may need to be modified and specialist measurements undertaken in specialist laboratories with specific equipment. Other more "standard" properties are also relevant for NM, e.g. melting point, boiling point etc., as relevant to the physical state of solid nanoparticulate forms. The question for this exercise is which tests relate back to the Options being considered here, and which would require *additional* nanoform-specific

[105] NANO SUPPORT Project Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information AA N°07.0307/2010/581080/AA/D3 between DG Environment (DG ENV) and the Joint Research Centre (JRC)

information over and above the Baseline set of tests. The JRC NanoSupport project and the EU nanomaterial definition provide the basis on which to consider this. The interpretations of the measures within each Option are key to the cost exercise and the JRC Nanosupport project provides some context on how the measures may be interpreted. Some of the wording of the measures does allow for more than one interpretation, however.

The Table also includes a list of nanoform-specific physico-chemical parameters that could additionally be required to characterise a range of physico-chemical properties specific to nanoforms using a range of specific analytical chemistry methods. This exercise in the "Endpoints and Measures" Table shows that all of the guideline tests are relevant to all Annex requirements and align (subject to interpretation) as marked to the different Options (2 to 6) under review in this project. The relationships between the tests and the 52 Measures within each Option can be seen in the analysis provided in the appendices.

The conclusion therefore is that the Data Capture Tool should include all of the standard guideline tests plus the specific types of chemical characterisation test methods that may be needed to characterise different forms of nanomaterial. The extent to which each test applies to a nanomaterial and to different nanoforms under each Option has cost implications and will vary from case to case. Grouping and read-across arguments are expected to be relevant and to limit the requirement for new tests, noting that this possibility is explicitly addressed by certain options within the scope of this study. With reference to the limited information regarding the nature and quantity of nanomaterials in the market and limited experience of registration of nanomaterials and nanoforms under REACH to date, there is no reliable basis for predicting the number of endpoints that may require further testing; the scope of additional testing will be determined in each case by expert judgement during the dossier preparation.

It is likely, however, that it will not always be necessary to perform a full battery of all possible tests (as per Annex requirements) for every nanoform. A sub-set of necessary information will be determined on a case-by-case basis, recognising that further specific investigations may be required for some endpoints. This noted, for the first data capture exercise, it is necessary to obtain costs for all of the possible tests, as all tests appear somewhere in a measure within the Options.

3.3 Data Capture Tool

The list of current standard guideline tests is included in a "Data Capture Tool" (Appendix 3, along with the additional physico-chemical parameter methods and measures (as outlined by OECD and JRC) that relate specifically to NM characterisation and the determination according to EU No 696(2011).

The laboratories were asked the cost of a test for a traditional chemical, the cost of a test for a nanomaterial and to provide comment on any technical issues or specific additional needs for the latter.

3.4 Process of Laboratory Selection

New testing for REACH requires studies to be performed to guidelines where possible and to Good Laboratory Practice (GLP). GLP studies are performed by GLP-accredited laboratories, and require adequate and authorised documentation of the experimental test to provide confidence in the study design, performance and results. The focus has been to send the Data Capture Tool to international and national GLP testing laboratories offering the different types of tests for nanomaterials.

A combination of sources were investigated to find appropriate GLP testing facilities to survey for the Data Capture exercise.

The National Coordinators for EU nanomaterials (organisations as listed in Appendix 4) were contacted by email to inform the project as to whether they knew of any GLP test facilities specifically for

nanomaterials testing in their respective countries. From those that responded, the general view was that GLP testing facilities offering commercial services were extremely limited, and if any were found during this project, they would be grateful to be provided with the information. They indicated that most testing was being done in “research mode” at present, and often within the industry, rather than using GLP Contract Research Organisations (CROs). While some nanomaterials testing has been performed under GLP, and certainly many bulk materials potentially containing nanomaterials have been tested using standard OECD guidelines to GLP, there is uncertainty regarding the relevance of the data from such studies specifically for nanoforms, for example when characterisation on the test samples is inadequate so it is not possible to evaluate if the material tested is relevant to real life exposures to particular nanoforms.

The list of participating commercial laboratories in European Projects and OECD working groups on the subject of nanosafety were reviewed and contact details obtained in order to find out whether they were GLP (or accredited for analytical chemistry testing) and offered commercial services for NM testing. The NanoCluster and NanoReg activities in Europe provide the widest source of information.

General web searches, test facility websites and the Research Team’s knowledge of individuals to contact involved in NM research and test method development was also incorporated into the overall search.

All of the 23 commercial laboratories found in the search were contacted by telephone in the first instance. If no response was received from three telephone attempts, email enquiries were sent highlighting the nature of the project and the cost data being sought. Those that responded favourably by agreeing to participate (14 GLP testing laboratories (toxicology testing) and two ISO/UKAS Chemical Characterisation services laboratories) were sent the Data Capture Tool by email to complete by return email with cost information. For the larger laboratories, this was circulated by the Business Development Manager around the company to the various technical personnel responsible for the different types of testing. The laboratories returned the completed Data Capture Tool, the last one being received mid-August 2013. Nine GLP CROs agreed to participate in the activity upon receiving the data capture tool, and their returned data are compiled in Appendix 3. Some laboratories declined to participate, and some did not respond at all to the communications.

Of the nine testing laboratories who responded to the exercise, they comprised: two large international GLP toxicology test facilities offering a broad range of tests, five GLP test facilities offering specific types of testing and two ISO & UKAS accredited analytical chemistry facilities. All toxicology testing laboratories were offering nanomaterials testing services to commercial private clients and in doing so responded to date with their “standard” costs of guideline toxicology tests as a baseline. All laboratories acknowledged that actual testing costs for nanomaterials could be significantly higher than for non-nano, as additional characterisation would likely be needed, but were not able to provide exact costs for such bespoke and case-by-case analysis per assay. NILU in Finland were the only laboratory to come back with nanomaterial-specific costings.

Three laboratories (large international GLP testing facilities) declined to participate in the Data Capture exercise, as the model they were operating was on a bespoke basis per nanomaterial, and per client need. These laboratories did not offer a standard package for testing nanomaterials, but a bespoke set of recommendations for testing based upon the nature of the nanoform to be risk assessed. The importance of up-front chemical characterisation and toxicokinetics understanding was emphasised in feedback from these laboratories. The testing required to provide this information could include a simple ADME study, with measurements in blood, urine and faeces, but could also include specific tissue analysis/histopathology. Radiotracer versions of the NM may also have to be made for such toxicokinetic analyses. The costs of this aspect of the work needed to aid interpretation of study results were determined on a bespoke basis and were therefore unavailable. The laboratories are happy to

discuss a bespoke case example with clients should there be a business need to support testing, but could give no advice on the nature of costings in a more generic sense, assay by assay as per the Data Capture Tool.

Four laboratories did not respond at all to the request for information.

3.5 Data Capture Responses

The completed Data Capture Tool, containing data from the nine laboratories that responded, is provided in Appendix 3. The aim was to obtain a minimum of two cost estimates for each assay type, to generate an average minimum cost per assay.

Commercial GLP laboratories offering specific types of tests from the complete list have been targeted according to the categories below:

- detailed chemical characterisation and information on dustiness (tests highlighted yellow in the Table in the Appendices);
- skin and eye (tests highlighted in pink in the Appendices);
- genetic toxicology studies (tests highlighted green, in the Appendices);
- mammalian toxicity studies: in particular acute toxicity testing for the most relevant route of exposure, repeat dose inhalation studies (all tests highlighted purple, in the Appendices) environmental fate and hazards: bioaccumulation, adsorption/ desorption behaviour, water solubility, algae testing, testing in soil and sediment organisms (tests highlighted blue in the Appendices); and
- Toxicokinetics.

3.6 Data Costs on Tests

Laboratories provided either a fixed cost per assay type or a min-max range of testing costs. The maximum cost is usually to account for any additional investigations/analysis that might be needed over and above the basic standard guideline protocol. This does not include additional characterisation work relating to nanomaterials or nanoforms, but is provided to cover the re-testing of certain samples or a satellite group, etc., or other factors that may vary when testing substances in general and that commonly influence basic study design.

Detailed Chemical Characterisation & Dustiness

Two accredited ISO and UKAS chemical characterisation laboratories offering commercial services for nanomaterials characterisation provided costs for assays in the Data Capture Tool. Very different information was provided by the two laboratories.

The first laboratory has been heavily involved in OECD working groups, and has significant experience in characterising nanomaterials in projects relating to the evaluation of safety testing. The advice from this laboratory was that it was difficult to provide generic costs per assay, as each nanoform they had experience with presented its own unique challenges when being characterised, and different methods were needed to obtain different parameters and measures to characterise size, shape, and a range of other properties that could be relevant to the toxicological properties of the material. The laboratory advised that, in its experience, costs had ranged from €40,000 to €500,000 for a “characterisation” package, the lower estimate being for a technically straightforward analysis of simple particulates and the higher estimate relating to more complex characterisation of nanoforms (e.g. nanoforms with unusual size and shape properties) that involve more complex analytical techniques, such as special

imaging techniques which require special expertise. It also covered dealing with different media such as cell culture buffers and other complex matrices used in (eco)toxicology studies. Analysis of nanomaterials from physiological fluids is challenging. For example, the simple technique of dynamic light scattering (DLS) is relatively cheap to perform (hundreds of pounds) but only when analysing a simple clear liquid; this technique cannot be used for complicated media such as cell extracts, urine or blood, for example. Nanoforms in aerosols can also be challenging. Simple granulometry tests can assess particle size, but more complex methods require more sophisticated techniques to be employed. It has not been possible in this generic exercise to determine a cost per assay for characterisation in as much detail as the more standard assays for toxicology. The nature of the characterisation testing required to support assay interpretation and verification of the form at various stages of testing, is influenced heavily by the nature of the nanoform to be analysed. The cost range given here reflects a low-end illustration of a more basic analytical package at €40,000, for a nanomaterial tested and as dosed. It does not account for any complicated extraction techniques that may be needed from physiological fluids, e.g. from toxicokinetics studies or radiolabel tracing from such studies. Similarly, the high-end €500,000 estimate represents analysis needed to support a testing package using more sophisticated techniques to define nano physico-chemical properties, etc., and in this case does include aspects of analysis of more complex matrices and radiotracing studies in biological fluids. This is the maximum that could be needed in terms of additional characterisation to support a package.

The second laboratory indicated the basic costs of running the simple assay types that it offered (as marked in the Table), as would be done for any particulate substance, not specifically for nanomaterials. Based on available evidence, it is considered unlikely that the analytical tests for NMs would be as inexpensive as indicated here; therefore this information has been downweighted.

It is considered from the interviews and discussions on the issues of chemical characterisation with all nine laboratories that, in general, this requirement for characterisation is an area where significant cost variations can occur. For the purposes of this exercise, in order to capture the possibilities for nanomaterials in general and to simplify the ensuing complexity, it has been assumed that the generic range of €40,000 to €500,000 is representative of a pragmatic minimum to outside maximum range. This has been adopted as a fit-for-purpose range that would cover the additional nature of characterisation according to the OECD WPMN parameters for nanomaterials and JRC list of characterisation methods that could be determined for nanomaterials according to EU No 696 (2011).

It is assumed that the process of obtaining the “standard” basic physico-chemical properties (as per a REACH dossier list for any chemical e.g. melting point, boiling point, basic granulometry etc) would be the same for nanomaterials as any other substance. Full, detailed characterisation of the nanomaterial would require specific additional analyses including some or all of the OECD WPMN parameters and JRC characterisation methods (€40,000 to €500,000), as necessary, to describe the nanoform as manufactured, as dosed and ideally as taken up by the organism in a test, and as exposed for the purposes of risk characterisation in the exposure scenario being assessed. In the course of performing toxicology tests, laboratories responded with a cost for the standard protocol of the assay, but recognised that there would be additional unknown characterisation/test sample analytical costs. Additional characterisation costs may be associated with each assay but laboratories could not provide costs for this on a per assay basis.

For the measure (M36) where only one characterisation method only may be used, a cost of 2000 Euro has been estimated here. This is based on the response where it was quoted that the cheapest ‘is in a situation where you have monodispersed nanomaterial and use of DLS equipment’ and ‘for 2-3 colloidal samples (without a report) this would be as a rough estimate, approximately 1000 euro’.

From experience on the characterisation of a silver colloid, it was the experience of one laboratory that to perform a characterisation package of testing to support the safety programme (i.e. to do CPS, DLS,

zeta-potential, SMPS, ROS, redox potential (using RO probe) and SEM particle sizing), principally as manufactured but also in test dosing solutions, was of the order of 40K Euro.

From experiences of analysing ZnO and CeO_2 particles, as supplied as powders and also in different types of test dosing solutions. Such analyses involved the generation of most of the list of OECD WPMN parameters, and particle sizing involved the use of several methods (e.g. CPS disc, TEM, etc.). The price for a comprehensive characterisation of these nanomaterials was of the order of 500K Euro. It can also be anticipated that for fibres and more complex nanoforms such as graphene or buckminsterfullerenes for example, costs could be of this magnitude.

In most cases, it can be expected that costs of characterisation for a test package (as supplied, as dosed and in some cases in analytes from the toxicology tests) can fall anywhere between these extremes, but there are no exact data available on which to base intermediary costs, as they can be highly variable.

For the purpose of this exercise and in the absence of better data, the cost range of €40,000 to €500,000 for characterisation provided is assumed to cover all additional characterisation costs for the testing dossier globally (i.e. for all tests and samples). This means that the cost of additional characterisation would be maximally €500,000. This range is a generic and broad indication of the costs associated with additional characterisation necessary per nanoform. It is suggested, one could err towards the lower end of the range (ie 40K) in a generic impact assessment, rather than the more sophisticated top end estimates of characterisation but this is included for maximal impact illustration.

It was not possible to obtain a costing relating to a measure of dustiness from a GLP/ISO/UKAS accredited (or indeed any) laboratory. Two companies involved in this area were asked about measurements of dustiness, but did not respond with cost information. It appears that methods are continually being developed in research mode for measuring ‘dustiness’ of nanomaterials but laboratories providing such measures as a contract research service to industry for regulatory dossiers are not readily available.

In Vitro Skin/Eye Irritation & Skin Sensitisation

It has been assumed that the costs of testing a nanomaterial in these tests would be the same as for a standard chemical. Two laboratories responded with cost data for these assays.

There is a lack of information about how nanomaterials would be handled in skin sensitisation assays, where application is via dermal application to mouse or guinea-pig as the test species of choice. Nor do any of the Options specifically address what would be done for skin sensitisation testing. Baseline testing has been assumed to include skin sensitisation testing as per Annex requirements and standard costings. It is possible that the validity of test results may be questioned in terms of hazard identification. Skin sensitisation assays are designed and have history regarding soluble materials in vehicles that help to carry the material into the body. For NMs, the substance may not pass the skin barrier, and in the context of the assay design currently one would not know whether that had happened or not, or whether the NM was intrinsically not immunogenic.

Gene Mutation testing

Four laboratories provided costs for standard gene mutation testing as required for REACH. One laboratory, NILU Finland, provided some indication of how testing of a nanomaterial would compare with standard testing.

Four laboratories provided costs for standard gene mutation testing as required for REACH. One laboratory, NILU Finland, provided some indication of how testing of a nanomaterial would compare

with standard testing. NILU responded that additional secondary characterisation and sample preparation may cost between 2000-8000 Euros additionally for each nanoform of a NM on top of the cost of the standard test

The COMET assay has also been included in the data capture, as guidelines are under development, and some GLP CROs are already offering the COMET assay (in vitro and in vivo) to evaluate nanomaterials. These data have been included in the analysis as, although this test is not a requirement of REACH at the current time, it is being more widely used to fill data gaps and helps with addressing the potential for gene mutations at the site of application.

NB: For the purposes of this exercise, the requirement for an Ames test in the REACH requirements of Annex VII and above, is maintained as an assay that would be performed. However, scientific discussions at OECD level would indicate that the Ames test may not be a valid assay to perform for nanomaterials. Costs could be amended if this were to be taken out of the analysis. Doak et al. (2012). Mutation research, 745 (2012) 104–111.

Mammalian Systemic Toxicology testing

Two sets of reliable costings from international large GLP test facilities were obtained for all systemic toxicology/repeat dose testing.

Ecotoxicology & Fate/Behaviour testing

Four laboratories provided costings for ecotoxicology testing, but not all laboratories performed the full list of tests. At least two data points were collected for the majority of assays.

Toxicokinetics evaluations

Toxicokinetics/ADME properties and the solubility/insolubility of nanomaterials may be viewed as key to their evaluation. This is covered in a specific measure in Option 6. JRC in the NanoSupport project did not suggest specific “Options” or measures in their conclusions around toxicokinetics. However, they did stress the importance of Toxicokinetics and having reliable ADME data, in Section 4.2.2.1 of the NanoSupport Project Report (reproduced below), and hence, these issues in relation to toxicokinetics and how they impact on the preparation of a dossier for nanomaterials should not be overlooked.

“4.2.2.1 Toxicokinetics (Annex VIII 8.8, IUCLID section 7.1)

At present, an ADME study is not a standard information requirement under REACH.

“Only” an assessment of the toxicokinetic behaviour of the substance to the extent that it can be derived from the relevant available information shall be provided by the registrant. Therefore, it appears relevant to discuss possible changes of the legal text on this endpoint in a broader context.

Thus, the Research Team will not present an option here, but like to point to a number of issues to consider for nanomaterials.

In line with the general options suggested in this report, the nanoform(s) addressed by a dossier should be specifically tackled in the endpoint sections. As part of a nanotoxicity testing strategy, it is of key relevance to compare available ADME data for a nanoform with ADME information for other nano and non-nanoforms (compare also with recent EFSA guidance [European Food Safety Authority (EFSA). Scientific opinion. Guidance on the risk assessment of the application of nanoscience and nanotechnologies in the food and feed chain. EFSA Journal 2011; 9(5): 2140]).

ADME data are also relevant to decide whether or not specific tests required at specific tonnage levels need to be performed or not (e.g. carcinogenicity study in Annex X).

As discussed in section 4.1.1.1 and 4.1.6, ADME data are also very relevant when considering read-across – not the least in relation to particle size.

Investigating particle translocation by using barrier transfer models (see RIP-oN2, 3.6) could deliver relevant information on the behaviour of nanomaterials, also in comparison to bulkforms, and could provide important information for *in vivo* testing design and interpretation.

Guidance on appropriate methods for detecting and characterising nanoparticles within the body needs to be provided.

Solubility studies may be used to investigate whether the substance is dissolved. If so, its subsequent behaviour would not depend on particle size for reading across of toxicokinetic data from the bulk form (especially for the oral and dermal routes).

The tendency of ion leaching from nanomaterials and differences compared to bulk materials should be taken into consideration. These issues could become part of a decision tree, but this would be rather a guidance issue.

In conclusion, the information requirement may differ from case to case. In some cases the available information or a dissolution study may be sufficient, in other cases the registrant may consider to make a separate ADME study.

As ADME data may trigger additional (or reduce) testing it seems not logic to make its requirement dependent on 'available' information. It may therefore be relevant to change the text in Annex VII 8.8 and delete 'available information' from column 1. It could become one of the options in column 2.

It seems more relevant that the registrant shall provide sufficient data to conclude on the toxicokinetics behaviour of the registered substance. He may also include a justification why this is the most appropriate way to do so.

However, as noted above, it is found relevant to discuss possible changes to the toxicokinetic information requirements in a wider context as the endpoint is also extremely relevant for other forms and chemicals in general."

The key issue in obtaining costs information for toxicokinetics evaluations is that few labs offer this as a standard service and expertise in this area is limited. It is difficult to estimate a cost for bespoke toxicokinetics studies and the bespoke analytical work and histopathology work included in such studies. A generic minimum value of €50,000 per study per route of exposure (€150,000 for all 3 routes) has been adopted in this work (see below), but costs could be significantly higher, particularly if radiotracer NMs are required to aid analysis and interpretation of data. The latter can run into the tens or hundreds of thousands of Euros, to be determined on a bespoke basis.

There are OECD test guidelines for performing in vivo ADME studies for all routes of exposure, and also OECD guidelines for in vitro skin absorption testing. But these tests do not specifically appear as requirements in the REACH testing list. Often, to perform ADME studies, traditional chemicals are radiolabelled to allow for more effective analysis of biological fluids. For nanomaterials bespoke analytical characterisations of their presence in biological fluids could be needed and this is challenging and technically complex. Laboratories indicate that such work on toxicokinetics is bespoke and it would cost at minimum €50,000 to perform per exposure route per nanoform. Costs could be significantly

higher than this, as the laboratories perform such analysis in “research mode”, albeit to the principles of GLP. There are in vitro methods using barrier methods for gut and lung absorption, but these do not have guidelines and have not been tested for use for nanomaterials.

The lack of test guidelines and test facilities offering toxicokinetics evaluations for nanomaterials could present a significant issue for safety testing of nanomaterials. Route-to-route extrapolation is considered as “challenging” for nanomaterials given the current lack of data and knowledge on toxicokinetic properties via the different routes.

An assumption has been made, based upon discussions with ADME scientists, that €50,000 is the minimum cost of assessing preliminary toxicokinetic properties of a nanomaterial/ nanoform per route of exposure. Costs could be significantly higher than this.

3.7 Testing Laboratories

It has been possible for the laboratories that have responded so far to provide the costs of the standard “analytical” or “toxicology” method part of testing a nanomaterial (i.e. that part covered by a Standard Operating Procedure and test guideline etc.), and the general view is that the cost of the guideline method part of the study would not change for testing of a nanomaterial, if the conduct of the experiment and result obtained proceeded as expected for the study type investigated. Further work may be needed to draw conclusions if tests did not proceed as expected.

If the commercial contract research organisation received the test nanomaterial and paperwork from a supplier and there was no further work for the CRO to do on characterisation (which is not routinely offered), then the material could in theory be dosed into an assay as a traditional chemical could be, and the results obtained taken without question. There may be technical and scientific interpretation limitations in taking this simple approach to testing, however, and this situation may change as more research and actual experience of running the assays develops. The risk of taking nanomaterials and treating them as if they were “traditional” chemicals in guideline assays is that erroneous and misleading test results could be obtained.

All laboratories indicated that whilst they were offering testing, a current lack of experience in actually doing any testing of nanomaterials meant the costs provided could be uncertain and further work may be needed to modify test design. Work would be conducted under the principles of GLP, but certain adaptations to methods may be required on a case-by-case basis to deliver test nanomaterials in the correct form into the assay. Different ways of analysing samples than are used for “traditional” chemicals may need to be adopted – in some cases using analytical chemistry techniques (as outlined in the JRC list of characterisation methods) that are not often present in toxicology testing facilities. Work may need to be done with sub-contracted CROs to perform accompanying characterisation work alongside a guideline test method, increasing time, administration and costs of performing a study. This is uncertain and unpredictable. This phenomenon is not covered in the current cost exercise at the per assay level. Only the standard cost of the toxicology test itself, which is all that the laboratories felt able to provide at the current time (even though the laboratories are knowledgeable about the additional work and technical challenges a NM would present), is included in the basic analysis. However, as a simple assumption in this complex exercise, a maximal “characterisation heavy” assumption of €500,000 is included in the costs analysis to cover the complexities involved in a full accompanying characterisation package and characterisation efforts in determining the nanoform as manufactured, as dosed and as taken up in the body/ environmental receptor.

The CRO laboratory contacts remarked during interviews that significant issues can be present in testing around the toxicokinetics of whether the nanomaterial is absorbed into the test system. If the material does not absorb, then a test may not lead to a scientifically valid result. It appears that the

CROs do not currently have experience in this regard. Additional characterisation and fate and behaviour work could be needed to ensure the form of nanomaterial being tested is identified as relevant to the risk assessment scenario. This is due to the toxicological effect being potentially as dependent upon the physical properties of the nanoform as well as the chemical nature of the material. Therefore the nature of the testing programme required may be dependent upon the findings of up-front characterisation and toxicokinetics work for which, at this current time, it is extremely difficult for laboratories to provide costs due to the bespoke nature of the work.

3.8 Cost Impact of Variations

Actual costs for a particular type of test can vary significantly for different substances or even different forms of the same substance, when prior chemical characterisation work is needed. For NM, it may be necessary to vary the study design, complete additional analytical work to adequately characterise the form of the substance and ensure exposure to the specific form of the substance is adequately maintained over the duration of the test. It may also be necessary to troubleshoot the assays, when a first run of the standard guideline test for a nanomaterial does not perform in the assay as expected or a scientifically equivocal result is obtained. For example, the latter may be the case if the nanomaterial does not absorb into the test system (in vitro cells or in vivo species) as required.

From initial discussion it seems that the toxicology testing laboratories are unable to provide costs estimates for the additional characterisation and toxicokinetics work that would be needed to support the scientific validity of the test performed. In some cases, the work could be done by the same company albeit in a test facility in a different location, or even a different country. Most often, the toxicology laboratory would receive the material from a third party who had characterised the material for testing. The importance of characterising NM more fully than a traditional chemical, is outlined below is some paragraphs from the OECD document “Guidance on sample preparation and dosimetry for the safety testing of manufactured NM”, Series on the Safety of Manufactured NM. No. 36. ENV/JM/MONO(2012)40. 18 December 2012.

Paragraph 33: ‘As for any other materials or chemicals, the inherent ability of a nanomaterial to cause an effect (being it desirable or adverse) relates to its chemical and physical properties, including its impurities. Physical-chemical characterisation of a nanomaterial is fundamental both for determining its identity and to properly execute and interpret the results of (eco) toxicological tests, including comparisons with other experiments with the same or similar materials. Indeed, characterization of the nanomaterial's physico-chemical properties before (eco) toxicity testing ensures that the results are related to the nanomaterial intended for the testing. Generally, characterisation of the nanomaterial should be conducted at least ‘as received’ (that is, as sampled directly from the received package) and ‘as administered’ (that is, after preparing the material for introduction into the test system) and ‘after administration or in situ’ (that is, once the material has been introduced into the (eco) toxicological test system, as appropriate).’

Paragraph 34: ‘In recognition of the unique properties of manufactured NM, several regional, national and international organisations formed Physical-Chemical expert panels for the purpose of issuing recommendations concerning the applicability of existing standardised test procedures (e.g. U.S. EPA Series 830 [U.S. EPA, 2007b] and the OECD Series 100 [OECD, 2007] test guidelines) to these materials. These workgroups identified a number of standardised test guidelines that are unlikely to be directly applicable to insoluble manufactured NM (for example, test guidelines for aqueous solubility and octanol/water partition coefficients); these same issues have ramifications for standardised test procedures in the areas of ecotoxicology, human health effects and in assessing the environmental fate (transport, degradation and accumulation) of these materials, The sample preparation step is crucial, so precise SOPs are required for every measurement technique.’

Paragraph 36: Dosing: (Eco) toxicological studies typically employ dosage procedures intended to be both reproducible and quantitative. However, aqueous nanomaterial dispersions may be very sensitive to the techniques employed in their preparation and they may not necessarily follow the principles of equilibrium partitioning. In particular, significantly more empirical data may be required in order to develop methods designed to ensure reproducible and quantitative dosimetry (especially with aqueous dispersions). Another aspect to be taken into account in dosing is the reduced (due e.g. to agglomeration or precipitation) or excessive delivery of NM into test systems, such as cells during the in vitro studies and to animals during in vivo studies. In fact high levels of exposure can give rise to overload effects that can be misinterpreted as evidence of cytotoxicity and vice versa. In all cases selected doses of administered NM should ensure adequate exposure, need to be scientifically justified and must reflect possible exposure scenarios in eco- or human toxicology. On the other hand, as NM may change form not only after sample preparation but also during and after release to the test system, dosing and exposure methodologies (including monitoring) may need to be adapted if material modifications are reasonably anticipated.

Analytical costs may be influenced by the specialist (non-standard) nature of chemistry technologies needed to measure specific nanoscale parameters that the toxicology testing facilities do not have established in-house and may need to sub-contract out. A focus for much of the costly laboratory activity may be determination of functional, physico-chemical and toxicokinetic properties, prior to toxicological testing aspects.

As many nanomaterial and nanotechnologies are in research and development stages, it appears to be the case that laboratories specialising in nanomaterial characterisation and testing are located in-house or funded by specific research projects.

OECD continues to review all existing methodologies to identify and implement the necessary changes needed for their application to NM. The OECD Sponsorship Programme for the Testing of Manufactured NM has run since 2007. Some of the outcomes are being publicised as “living documents” (e.g. Preliminary Guidance Notes on Sample Preparation and Dosimetry for the Safety Testing of Manufactured NM) and they are expected to be revised as new information becomes available. The CROs that have participated in the interviews and data capture process to date are currently finding it difficult to provide costs for the unknown additional requirements over and above what may be needed to the standard guideline part of the overall study, and predict what amendments to the existing guidelines could be recommended.

To gain more insight as to why there are uncertainties for testing laboratories, the Research Team has discussed the area of gene mutation testing with a key researcher highly involved in the relevant OECD working groups who stated:

“Prior to performing an in vitro genetic toxicology assay, physico-chemical characterisation analysis is in two areas;

1) primary particle size, usually measured by electron microscopy. Also, presence of impurities is checked. This part is currently done in advance (usually by the client for CRO testing).

2) agglomeration which could occur under experimental conditions is investigated? This measured by dynamic light scattering or similar. This should be done immediately prior to use.

For in vitro assays, there is a requirement for evidence of cellular uptake, particularly in case of a negative result – therefore an absence of genotoxicity in an assay can lead to further toxicokinetics work. Currently the situation is that Industry does the physchem analysis and then ships the substance to the CRO. How the substance is behaving when it gets into the test system is not known or taken into consideration.”

To date, the usefulness of the Ames test is coming under question, which uses bacterial cells, for which it is becoming increasingly clear that there may be technical issues with this test, in that the nanomaterial does not get inside the bacterial cell[106]."

As research evolves, it may become clearer, due to toxicokinetic limitations (i.e. a nanomaterial does not absorb into the test system to give a meaningful result), that other assays may similarly be determined as not relevant. But as of today, OECD working groups have not reached such a conclusion for other assays.

3.9 Cost Analysis

The process of performing the cost analysis per Option was as follows:

- **Derive an Average Cost per Assay** – obtain current costings of each test assay type (as provided in the data capture exercise by nine testing facilities where services were offered) and to generate an overall average cost per test. [Provided in the appendices Exercise and Average cost per assay].
- **Align the tests vs the measures and cost the measures** – account for the costs of any *additional* testing that may be needed as a result of each Measure. In doing so, it was necessary to take into account the tests that would or would not have already been performed as part of REACH Annex requirements. [Provided in the appendices Endpoints Annex requirements Costs per Assay and per measure]
- Estimate costs of admin/new data entry per measure – where there was no impact with respect to testing, but an amendment to a dossier, or some aspect of administration or data entry would need to be performed [Provided in Table 7 Additional Admin Costs per Measure]
- **Generate a Total baseline cost and total costs impact per Measure and per Option** – Adding together the costs of testing plus admin for all measures within an option [Provided in the appendices Overall Cost Impacts for Options, and below in summary]
- when there are more than one distinctly different nanoform then in using these cost data, a multiplier needs to be applied per NM assessed, if more than one Nanoform needs to be tested separately and grouping and read across cannot be applied. Whether read across can be done is hugely variable and we are not able to predict this at this time.

Derive an Average Cost per Assay

It was the general consensus from GLP laboratories surveyed that the cost of a regulatory guideline test for a nanomaterial would be the same as for a "traditional" substance, but there could be additional (sometimes unexpected) characterisation and toxicokinetics work needed to interpret the results from the standard tests. CROs found it straightforward to provide costs for their standard tests, but were not able to provide costs for any additional work that may need to be done, as a result of the test item being a nanomaterial. An average cost per test is taken forward into the analysis.

It was not possible to obtain reliable individual costs per assay for chemical characterisation; the work is considered bespoke to the nature of the material and can vary in scope and techniques required to describe a range of parameters. A global estimate of costs for a chemical characterisation package for a nanomaterial, ranging from €40,000 to €500,000, was obtained from a reputable laboratory involved in OECD work on nanomaterials and with significant experience. This range was used in the subsequent analysis. As a general principle, it is assumed that the higher "characterisation heavy" range (€500,000)

[106] Doak et al 2012

would cover all needs of characterisation within a nanomaterial dossier, including characterisation of dosing and in-test characterisations to assure stability of the nanoform during a test, etc. The lower range would be for a more basic nanomaterial characterisation package.

Align the tests vs the measures and cost of each Measure per nanoform

The Baseline test requirements for a REACH dossier per Annex, are marked in blue in the appendicies (Endpoints, Annex Requirements, Costs per Assay and Per Measure). All of the 52 Measures, within Options 2, 4, 5 and 6 are listed along the top of the table.

N.B. For the "soft law" Option 3, there are no specific alignments back to the testing requirements, therefore this Option is not analysed against the costs of testing and dossier preparation.

Options 2 and 4 align directly to the output from the JRC NanoSupport project Report. Options 5 and 6 contain additional options provided by the European Commission.

From the Data Capture exercise, an average minimum and maximum cost was determined for each test and this is provided in Table 3 Endpoints, Annex Requirements, Costs per Assay and Per Measure.

The matrix has been completed in this Table to show how each Measure relates back to a test type and whether it would need to be performed IN ADDITION over and above Baseline testing requirements per Annex. The (nanomaterial is tested for Baseline according to the Annex relating to the tonnage it is produced or distributed at in Europe. If a Measure would suggest further nanomaterial or nanoform specific testing is needed, then it is marked as a grey square in the table.

Taking into account all testing needs in a Measure, the costs are totalled to an overall cost (in Euro) per measure in Table 8.

Estimate costs of admin/new data entry per measure per nanoform

Where there is no new test required, but the Option requires additional administrative or data entry input in terms of preparing a dossier, then the Option has been marked as "ADMIN" in Table 7. An ADMIN cost per Measure is attempted as presented in a separate table on estimated Admin costs where they apply. A high level estimate of the additional time needed, and resulting costs (assuming €100/hour consultant cost) incurred to modify the dossier is calculated. These costs are highly uncertain and are dependent upon the interpretation of the measure. The costs of a full new dossier preparation (€18–30,000 for an Annex VII-VIII dossier, respectively) is a more confident figure from discussions with various professionals who prepare REACH dossiers.

Where the Option involves non-testing (categorisation or read-across) approaches to be used, then a cost of €10,000 for preparation of a scientific report (using available data) has been assumed (based upon experience of preparing read-across reports for traditional substances), as would be needed to justify the arguments supportive of non-testing. It is feasible that read-across between nanoforms may be simplified in some cases, but there is no guidance or precedent to confirm that this will be the case. Furthermore, new characterisation and/or toxicokinetics information may be required to support non-testing, as is currently the approach enforced by ECHA for traditional substances. In the case of some Measures, test cost savings may be made, e.g. as is most pronounced by pursuing a non-testing and/or waiving approach (in Measures M14, M24, M33).

iv) Generate a Total baseline cost and total costs per Option per nanoform

In the Overall Cost Impacts for Options Table in the Appendix, costs relating to Testing have been accrued into a Total Additional Testing Cost per Option (taking care not to double account when more than one Measure within an Option indicates the need to perform the same test – it need only be

performed once). Where there is a cost addition, this is marked in black; cost savings are marked in green.

All costs of the measures are combined together for a Final Total for each Option (2, 4, 5 or 6). These totals are shown below. The Total for option 2 plus 4 is also presented as these Options are complementary and Option 4 builds upon 2, assuming Option 2 has already been implemented.

The additional cost is also presented in the appendices as a % increase over and above the baseline cost, which varies for each Annex and each option.

As mentioned above, there is a potential large variation in costs for characterisation that is complex to model at a per assay level. A generic catch-all range from €40,000 to €500,000 illustrates a potential minimum–maximum range, accounting for additional characterisation in the description of the manufactured form, in test form and the form in the body, therefore this has been factored into parallel calculations in this Table as a min-max range for each Annex and each Option.

Option 6 results in a new testing programme and extensive characterisation, toxicokinetics and fate & behaviour analysis for each nanoform, and includes long-term tests via inhalation as the main routes, but all routes are covered, and this accounts for the high costs. It assumes that option 6 measures would be adopted after Option 2 and 4 measures have been implemented. However, in order not to double account in costing Option 6, costs have not been added to Option 2 and 4 combined cost, but stand-alone option 6 is a worst case estimate for a full set of testing.

Another dependency in terms of overall cost, is the nature of the testing programme required if the results of 28-day or 90 day repeat dose tests or in vivo genetic toxicology tests are positive (adverse). This may then require a 2 year bioassay to be performed (via relevant routes according to the exposure route being assessed), and this could ADD a further estimated €1 million to the overall costs for option 4 in Table 3 below. It is included in Option 6 and the annex requirements already include such a study however.

Totals Summary for Options 2, 4, 5 and 6 (Million Euro)#	**Baseline**	**OPTION 2 ADDITIONAL TOTAL**	**OPTION 4 ADDITIONAL TOTAL**	**OPTION 2 AND 4 both implemented (complementary measures)**	**OPTION 5 ADDITIONAL TOTAL**	**OPTION 6 ADDITIONAL TOTAL***
Realistic average cost						
(Annex X) characterisation 40K	3.16	0.06	0.02	0.08	-2.8	3.54
Annex IX) characterisation 40K	1.57	0.06	0.21	0.27	-1.18	1.93
(Annex VIII) characterisation 40K	0.49	0.14	0.49	0.63	-0.3	0.83
Annex VII) characterisation 40K	0.05	0.15	0.59	0.74	0.01	0.38
Maximal average costs						
(Annex X) characterisation 500K	3.16	0.65	0.02	0.67	-2.8	4.06
Annex IX) characterisation 500K	1.57	0.65	0.27	0.92	-1.18	2.45
(Annex VIII) characterisation 500K	0.49	0.74	0.66	1.39	-0.3	1.35
Annex VII) characterisation 500K	0.05	0.74	0.79	1.53	0.01	0.9

*Costs for an additional set of baseline tests, new dossier, plus additional NM-specific characterisation, TK and fate&behaviour work. Assumes 2 and 4 have been implemented, but costs for 2 and 4 have not been added to Option 6 total, as this would double account for some tests.

These costs are for testing and preparing/amending a dossier for one additional nanoform within one substance dos

Table 3.1 Summary of the Total Cost Per Option, per Annex and per nanoform

The costs in the above table are carried forward in the Impact Assessment, as additional costs over and above baseline per nanoform within a substance.

In order to estimate the overall cost to industry, further information regarding the number of nanomaterials and nanoforms to be registered under REACH is required.

The “Impact Assessment of the REACH Implementation Project on Substance ID for Nanomaterials” prepared by Risk & Policy Analysts Limited for CEFIC in March 2012 indicated that between 500 and 2.000 nanomaterials are expected to be placed on the EU market. This number was broadly confirmed during the stakeholder interviews conducted as part of this study, with weight of opinion indicating that the actual number was likely to be comfortably within this range. For the purpose of this review it is assumed that 500 to 2,000 nanomaterials will be manufactured or imported in quantities greater than 1 tonne per annum per legal entity and therefore subject to the REACH registration.

Several studies have aimed to assess the range and quantity of nanomaterials and nanoforms on the market. However, available information is limited. BiPRO, in its report “Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials” dated 12 December 2012 summarises the available information. It postulates that, based on provided information by experts of the steering group, a broader range of nanoforms is placed on the market for higher manufactured tonnage bands of nanomaterials. It also assumed that, for each nanosubstance, ten different nanoforms/classes are available. Of these ten nanoforms, BiPRO further hypothesises that nine “form groups” or classes could benefit from extensive read-across arguments due to similarity of surface-treating substance.

Accordingly, BiPRO proposed that:

- Between 50 and 200 (untreated) nanomaterials must be registered that cannot rely on grouping / read-across arguments. BiPRO assumed the tonnage band distribution to be 10% in the 1 to 10 tpa range, 20% in the 10 to 100 tpa range, 50% in the 100 to 1,000 tpa range and 20% in the 1,000tpa + range. There is limited information to support this assumption, but no better information has been provided in the course of this study.
- Between 450 to 1800 (surface treated) nanomaterials must be registered that can rely on grouping / read-across arguments across 9 groups, so resulting in an additional 50 to 200 sets of information requirements. BiPRO assumed the tonnage band distribution to be 0% in the 1 to 10 tpa range, 20% in the 10 to 100 tpa range, 50% in the 100 to 1,000 tpa range and 30% in the 1000tpa + range. There is limited information to support this assumption, but no better information has been provided in the course of this study.

No new additional information to refine these estimates has been provided. The distinction between nanomaterials and nanoforms is not well made in literature. On the one hand, there is an open reference to thousands of nanoforms of carbon, yet there is no reliable source to support this.

For consistency with previous studies, notably BiPRO, and in the absence of more reliable information, it is assumed that additional testing requirements are required for 100 to 400 nanomaterials, and that this also cover registration of 400 to 1,600 nanoforms that can be adequately addressed through a grouping or read-across approach.

There is extensive uncertainty relating to the detailed strategy for registration and structure of a registration dossier for each of these substances. It is assumed that nanomaterials will be included within the registration dossier for the bulk substance. As noted already in this review, the extent to which

read-across and grouping can be applied in terms of relating to the nanomaterial to the bulk form of the substance or between nanoforms of the same material can only be determined on a case by case basis.

In addition, detailed characterisation and testing requirements are nanomaterial and nanoform specific. Study design, including the nature and scope of further characterisation required within the scope of new tests to support reliable interpretation of the results, can similarly only be determined on a bespoke basis, Laboratories have limited experience of conducting testing of nanomaterials for the purpose of regulatory compliance and it can be expected that best practice will continue to evolve.

Overview on number of nanomaterials / forms requiring registration (BiPRO, 2012)				
Tonnage band	1–10 t/y	10–100 t/y	100–1,000 t/y	> 1,000 t/y
% Distribution Untreated	10%	20%	50%	20%
Number nanomaterials / forms (Untreated)	5–20	10–40	25–100	10–40
% Distribution Treated†	0%	20%	50%	30%
Number nanomaterials / forms (Treated) †	0	10–40	25–100	15–60
Total number nanomaterials / forms to be registered	5–20	20–80	50–200	25–100
† Assuming grouping / read-across possible				

Table 3.2 Bipro Overview of Registration of NM requiring Registration

Taking this number of nanomaterials forward, the total range of expected costs by Option is set out in the table below.

Totals Summary for Options 2, 4, 5 and 6 (Million Euro)[#]	Baseline	OPTION 2 ADDITIONAL TOTAL	OPTION 4 ADDITIONAL TOTAL	OPTION 2 AND 4 both implemented (complementary measures)	OPTION 5 ADDITIONAL TOTAL	OPTION 6 ADDITIONAL TOTAL*
Realistic average cost						
(Annex X) characterisation 40K	15.8-63.2	0.3-1.2	0.1-0.4	0.4-1.6	(-14)-(-56)	17.7-70.8

Annex IX) characterisation 40K	31.4-125.6	1.2-4.8	4.2-16.8	5.4-21.6	(-23.6)-(-94.4)	38.6-154.4
(Annex VIII) characterisation 40K	24.5-98.0	7.0-28.0	24.5-98.0	31.5-126.0	(-15)-(-60)	41.5-166.0
Annex VII) characterisation 40K	1.25-5.0	3.75-15.0	14.75-59.0	18.5-74.0	(0.05)-(-0.2)	9.5-38.0
Maximal average costs						
(Annex X) characterisation 500K	15.8-63.2	3.25-13.0	0.1-0.4	3.35-13.4	(-14)-(-56.0)	20.3-81.2
Annex IX) characterisation 500K	31.4-125.6	13.0-52.0	5.4-21.6	18.4-73.6	(-23.6)-(-94.4)	49.0-196.0
(Annex VIII) characterisation 500K	24.5-98.0	37.0-148.0	33.0-132.0	69.5-278.0	(-15)-(-60.0)	67.5-270.0
Annex VII) characterisation 500K	1.25-5.0	18.5-74.0	19.75-79.0	38.25-153.0	(0.05)-(-0.2)	22.5-90.0

Table 4.3 Bipro Overview of Registration costs of NM requiring Registration

Considerations on number of nanoforms, impact of read across and data sharing

The costs that have been calculated in table 3.1, assume that one nanoform is addressed within a substance dossier. A baseline dossier would be generated for the substance, and the costs represent additional testing or administration costs that could be expected if the measures were implemented for a nanoform on top of baseline dossier requirements for the substance. These costs have then been used to scale up to total number of nanomaterials (using assumptions made in the BiPRO report) in Table 4.3 above.

It may be possible that more than one nanoform exists for a substance nanomaterial and in that case, if read across and categorisation approaches are not valid (ie data used from previously tested nanoforms), then multipliers of the costs for the number of nanoforms would need to be applied. This is unpredictable and highly variable. Some nanomaterials could be present as only a few distinctly different nanoforms (based upon different chemical and toxicological properties) and some nanomaterials could have hundreds of different nanoforms, some of which could be grouped into chemical categories. Obtaining evidence of this nature ie around the number of nanoforms associated with different substance nanomaterials, and evidence around how grouping can be used to read across when assessing large numbers of nanoforms, is outside of the scope of this cost analysis, as cost evidence on these aspects was not readily available at the current time.

Some measures in Option 5 relate to aspects of read across, and here it has been assumed that a second nanoform could be read across to a previously testing nanoform in a 1:1 read across. There would be cost savings associated with such an approach ie the second nanoform may not need to be tested, but again this is highly variable. There are currently no guidelines for read across for nanomaterials or nanoforms within a substance nanomaterial and it may not be successfully applied for all tests required.

Given the cost evidence available, costs above are calculated for one nanoform. Subsequently, multipliers can be applied to this data as more evidence from specific cases can be gathered to provide illustrations of the possibilities when there is more than one nanoform, or when guidelines become available such that it can be illustrated for categories of nanomaterials/nanoforms where testing costs can be saved as a result of successfully being able to apply read across.

There may also be cost savings to be had through processes of data sharing. Again this is highly uncertain, and aspects of data sharing have not been considered in the analysis. Other aspects of Annex VI information gathering would be covered off largely in baseline information for the substance and additional data entry relating to new testing and new descriptions of the nanoform in the dossier are already accounted for per measure where relevant.

3.10 Conclusions

In order to provide the most appropriate comparative assessment of costs the Research Team have drawn upon the estimates of NM set out in the BIPRO study and have remodelled costs based upon the updated estimates developed for this Research Study.

	Baseline	Option Two	Option Three	Option Four	Option Five	Option Six
Testing Costs (€M)	183	30.75	n/a	104.4	-136.4	270.25
Administrative Costs (€)	n/a[107]	15,200	n/a	22,100	2,800	240,000

Table 3.4 Summary Total Estimated Costs

The findings present baseline costs at €183m and then set out additional costs that maybe associated with the implementation of each of the substantive options under consideration. As can be seen from the table the additional costs of implementing Option 2 would amount to just over €30m or a 17% increase over baseline. Option 4 by comparison would represent a 57% increase over the Baseline position and Option 6 a 148% increase. By comparison Option 5 is the only substantive option under consideration that is estimated to be likely to produce a reduction in regulatory costs equating to approximately 74%, bringing such costs down from a Baseline figure of €183m to €46.6m.

[107] Baseline administrative costs were not estimated.

4.0 Baseline

In establishing a Baseline that is developed out of the Problem Definition, it needs to be stressed that the focus must remain on the impact of current and proposed future regulatory requirements and related guidance on the regulation of NM within REACH. Given that there is already an EU policy, the Impact Assessment Guidelines assert that the Baseline should represent a quantitative and qualitative assessment of the continuation of the current policy without any change, i.e. without any new or additional EU intervention.[108]

The Baseline section starts with a representation of the relevant provisions of REACH before providing a summary chronology of the manner in which guidance regarding the regulation of NM within REACH has been developed. The timescales for the Baseline have been set at 2028, being ten years subsequent to the final deadline for Registration of chemicals produced at over one tonne but under 100 tonnes. The section goes on to explore in brief how the provision of guidance has been supported at a national and pan-European level. The chapter then presents an overview of the assumptions that have been used to develop the baseline scenario.

4.1 Provisions of REACH

One of the main reasons for developing and adopting the REACH Regulation was to fill information gaps to ensure that the industry is able to assess hazards and risks of substances, and to identify and implement the risk management measures to protect humans and the environment. REACH was also designed to be a facilitating regulation, and to support innovation and competitiveness of the European chemicals industry. It actively involves the industry as it places responsibility on the chemicals sector to manage risks and provide information on safety – manufacturers and importers are required to gather information on the properties of chemical substances, and to register the information in the European Chemicals Agency's central public database.[109]

The main obligations under REACH can be summarised in the following steps:[110]

- **Pre-Registration of existing substances.** This indicates that a manufacturer or importer is intending to register a substance within the next 11 years. A Pre-Registration qualifies the manufacturer or importer for delayed registration deadlines. In contrast, a substance that has not been pre-registered must be registered immediately once production/import reaches 1 tonne (or more) per year.

- **Registration of substances that have been manufactured or imported, either on their own or in mixtures or intentionally released from other articles.** Registration requirement are dependent on the amount involved (in tonnage) and the properties of the substance. Details of the substance characteristics should be submitted in the technical dossier which is addressed to ECHA. Effects pertaining to occupational health and human health via the environment must be included.

ECHA and the relevant EU Member State Competent Authority can subsequently evaluate each technical dossier. Member States participate only in the substance evaluation (Article 45 of REACH).

[108] European Impact Assessment Guidelines January 2009 SEC(2009) 92
[109] http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
[110] http://www.hse.gov.uk/reach/otherreachprocesses.htm

In the compliance check MS representatives participate by means of their membership of the Member State Committee that is a sub-committee of ECHA.

Review may comprise

- **A dossier evaluation. This** is a compliance check and examination of testing proposals.[111] ECHA may examine any dossier in the compliance check on the basis of Article 41. REACH sets a percentage no lower than 5% of the total dossiers received by ECHA for each tonnage band and also sets a priority which is not exclusively to certain criteria (Article 41(5)). In compliance check, ECHA determines whether or not the information submitted in the selected subset of registration dossiers is in compliance with REACH. According to Article 41(3) of REACH ECHA is able to request any additional information that is needed in order to bring the registration dossier into compliance with the relevant information requirements. Such checks are able to address substance identity and information gaps, but also inappropriate use of adaptation possibilities such as waivers, weight of evidence or read-across that may represent challenges when applied to NM.[112]
- **A substance evaluation.**[113] This is undertaken by national Competent Authorities on substances that have been prioritised for potential regulatory action because of concerns about their hazardous properties.[114] There may be grounds for concern that a specific substance represents a risk for human health or the environment but the concern still needs to be clarified before action such as the authorisation or restriction procedure, if required, is considered. ECHA can then in cooperation with the Member States take the necessary steps for a substance to be placed in the Community Rolling Action Plan (CoRAP) and evaluated under substance evaluation, where the potential request to the registrants to generate the necessary information is not restricted to the standard information requirements of Annexes VII-X under REACH.[115]
- **An evaluation of intermediates.**[116] Intermediates are defined in Article 3(15) of REACH as “a substance that is manufactured for and consumed in or used for chemical processing in order to be transformed into another substance (hereinafter referred to as synthesis)”.[117]

4.2 REACH and Nanomaterials

The broad chronology for regulation of NM under REACH has been set out within Section 1.1 of the Introduction, with the 2011 Assessment (Nanosupport, part 1), the NM definition and ECHA Guidance and the CARACAL document of 2008/9 "NM in REACH" being the most notable milestones. The Commission has since 2004 underlined the need for “appropriate and timely regulation in the area of public health, consumer protection and the environment […] to ensure confidence from consumers, workers and investors”. In 2004 it adopted the Communication “Towards a European Strategy for Nanotechnology”[118] and the "Nanosciences and nanotechnologies: An action plan for Europe 2005-

[111] REACH Chapter 1: Articles 40 to 43
[112] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012
[113] Chapter 2: Articles 44 to 48
[114] http://www.hse.gov.uk/reach/otherreachprocesses.htm
[115] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012
[116] Chapter 3: Articles 49
[117] Concept of intermediates under REACH 9 July 2010. Available at http://www.ffw.com/PDF/Concept-of-intermediates-under-REACH.pdf
[118] Communication from the Commission Towards a European Strategy for Nanotechnology, 2004

2009,[119] which proposed a holistic NM strategy. **The Commission consequently announced a regulatory review of EU legislation in relevant sectors.**[120] [121]

Despite actions taken to facilitate the current regulatory process, there are indications from ECHA- and JRC-commissioned studies[122] [123] that there is still extensive uncertainty around the submission of nanomaterial substances under REACH, despite the Commission's actions to facilitate the process. Consequently many registration dossiers submitted during the first registration deadline containing nanoforms/NM may have shortcomings.[124]

The European Commission has confirmed that dossiers with NM have been selected for both dossier evaluation and substance evaluation. In total three cases have been selected for substance evaluation. In addition to these official evaluations, ECHA and the Commission have also undertaken a number of supporting activities to further facilitate the safe and efficient submission of dossiers with NM under REACH.[125]

A number of letters (the exact quantity is unknown to the Research Team) have been issued to firms to obtain more available information about physico-chemical properties of the substances registered, with an understanding that it is a pre-condition for any qualified assessment of the dossiers' compliance with REACH.[126.]

Established in January 2012, by DG Environment, the Group Assessing Already Registered NM (GAARN), chaired by ECHA, aims to build a consensus in an informal setting on best practices for assessing and managing the safety of NM under the REACH Regulation. The Group works to facilitate understanding among stakeholders towards the sustainable development of NM. GAARN reports to ECHA-NMWG and its conclusions are shared with stakeholders.

These additional support actions have been implemented, according to the Commission,[127] to facilitate improved quality in line with REACH compliance. The EC acknowledges this is a cumbersome and costly process, and it will take years before its true impact is known.

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[119] Communication from the Commission to the Council, the European Parliament, and the Economic and Social Committee Nanosciences and nanotechnologies: An action plan for Europe 2005-2009, 2005

[120] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Regulatory Aspects of Nanomaterials COM(2008) 366 final

[121] The attention to environmental requirements of products throughout their lifecycle is also explicitly mentioned in a number of EU policy documents, including the Sixth Community Environment Action Programme (to be succeeded by the 7EAP), the Green Paper and the Communication on Integrated Product Policy (IPP), the Thematic Strategies on Sustainable Use of Resources and Prevention and Recycling of Waste, and the Directive on Energy Using Products (EuP). See Nanotechnology and Lifecycle Assessment: A Systems Approach to Nanotechnology and the Environment, Synthesis of results obtained at a Workshop in Washington DC 2-3 October 2006 (organised with Pew Charitable Trusts and the European Commission, Woodrow Wilson International Center for Scholars, 2007

[122] DG Environment (DG ENV) and the Joint Research Centre (JRC) Scientific technical support on assessment of nanomaterials in REACH registration dossiers and adequacy of available information Final Report on analysis and assessment (Task I, step 3&4&5) and options for adapting REACH (Task II, step 1), March 2012

[123] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012

[124] European Commission, Joint Research Centre – Institute for Health and Consumer Protection – Ispra/Italy Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials REFERENCE: IHCP/2011/I/05/27/OC Final Report, Beratungsgesellschaft für integrierte Problemlösungen in cooperation with Institute for Applied Ecology, 12 December 2012

[125] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

[126] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

[127] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

There are an additional two caveats to the baseline:

1. It is likely that dossiers that are not directly implicated may not change, with the associated risks this may have on safety.

2. The dossiers reviewed so far tend to be from bigger companies that also often have more than one dossier. For these firms it may be easier to understand and appreciate the needs to fulfill legal obligations even if they are not expressly spelled out in the Annexes to REACH,[128] with improved clarity being the focus for this study.

With the above in mind, it is reasonable to conclude that the problem will ease and the situation improve in the near future. Yet, this assumption is rendered uncertain due to two main factors.

Firstly the lack of understanding of the precise number of dossiers with NM expected to be submitted in the next registration period and the estimated growth in the industry – i.e. number of new companies developing on the market. As has been demonstrated in this section already, the exact number of dossiers with NM is not clear – with estimates ranging from single figures to four figures.

Secondly, scientific research suggests that in some cases additional considerations are needed for NM specifically. This is because certain properties of NM or groups of NM generally share makes existing endpoints potentially more relevant for NM compared to other types of substance. Consequently, omission of data related to these may lead to a disproportionately lower level of protection for NM. Although REACH does not hinder the application of such additional considerations, as this kind of information is not requested when submitting dossiers, there is a risk that this type of data is not incorporated. Indeed, REACH's current general provisions on minimising testing may even discourage submitting parties to perform such relevant tests. This scenario will not change over time as there are no obligations in REACH enabling evaluation or enforcement of such considerations.[129]

4.3 Pan-European Activities

It is evident that there is a great deal of support activity surrounding the broader issue of NM and their regulation under the provisions of REACH. In addition to high-level meetings such as CASC Nano (European Commission Competent Authorities Subgroup on Nanomaterials) there are a number of specialist events relating to specific issues linked to guidance on NM within REACH. Feedback from stakeholder interviews and from the Public Consultation exercise suggests that stakeholders broadly value such groups and meetings, but for those critical of the nature of the current guidance, such activities are secondary to the need for structural change of the guidance itself.

4.4 Member State Activities

The relationship between the relevant Competent Authorities and Member States provides important additional support for the guidance process. There have been further developments at Member State level, the most notable of which has been the introduction by a limited number of Member States of registers for NM. France, Belgium and Denmark are three examples of Member States that have sought

[128] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012
[129] DG ENV (W. DG ENTR IN CO-LEAD) Draft Roadmap Modifications in some REACH Annexes (Nanomaterials), October 2012

to take national initiatives alongside those provided for under REACH.[130] [131] The relationship between such registers of NM and the provision of existing regulations and associated guidance is difficult to establish but it is evident that such registers are being associated with the introduction of systems to assess safety. As such they should be considered as having a material impact on how current regulations and associated guidance is being viewed by stakeholders. Feedback from industry representatives gathered for this study has spoken about how such national developments may be unhelpful to industry and to the process for the registration of NM through REACH.[132]

4.5 Baseline Assumptions

The baseline assumptions broadly divide into the following areas:

- Estimates of the number of NM
- Estimate the number of nanoforms per NM
- Estimates of current Registration levels
- Estimates of future Registration levels

For the purposes of developing the Baseline the following assumptions have been made:

Numbers of NM – There have been a range of estimates of the number of NM, with the band of 500-2,000 being cited in reports such as the BiPRO study and confirmed by a number of the stakeholder interviews undertaken for this study. What has proved more problematic is to assess how many of these 2,000 constitute distinct substances as opposed to forms. Attempts to sub-divide the 2,000 figure were undertaken for the BiPRO study and in the absence of any substantive new information, the Research Team has adopted the same approach for its own impact analysis. On this basis the Research Team has estimated the following with regard to the total number of substances and forms.

Current Registration Levels – Globally, raw nanoscale materials are estimated by industry to be produced at a rate of around 11.5 million tonnes per year.

- Carbon Black is estimated to account for 9.6 million tonnes (85%)
- Synthetic Amorphous Silica accounts for 1.5 million tonnes per year (12%)
- Aluminium oxide, barium titanate, titanium dioxide, cerium oxide, zinc oxide, carbon nanotubes, graphene, fullerenes and nanosilver constitute the remaining 0.4 million tonnes (3%) of which:
    - Carbon nanotubes, graphene, and fullerenes have annual production amounts in the 100s tonnes range[133]
    - Roughly 50,000 tonnes of Titanium dioxide nanoparticles were produced in 2010 and this amount is expected to grow to over 200,000 tonnes by 2015.[134]

[130] http://nanotech.lawbc.com/2013/07/articles/international/eu-member-state/belgium-notifies-ec-of-draft-decree-creating-nanomaterials-register/
[131] http://www.safenano.org/KnowledgeBase/CurrentAwareness/ArticleView/tabid/168/ArticleId/194/France-to-introduce-mandatory-reporting-of-nanomaterials-in-2013.aspx
[132] Interview with European Trade Association.
[133] Nanotechnologies Industries Association. Available at: http://www.nanotechia.org/sectors/chemicals-raw-materials
[134] Future Markets Inc, via Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php

Carbon black; paints, pigments, fillers; and metal oxides (e.g. zinc, titanium, aluminium and iron, semi-metal oxides including silicon and rare earth metals such as cerium) appear to be the groups of chemicals most regularly appearing on a nano scale.[135]

All of the above materials are likely to have been timetabled for Registration by November 2010 or May 2013. However, the total number of materials registered by 2013 is estimated to be four.[136] This equates to a total estimate of completed dossiers of 80. There are also likely to be a significant number of NM that have been registered under REACH in their bulk form, but no means has been established to estimate this number and by definition they would not have been assessed on the basis of being a nano substance or form. A recent JRC Report set out some of the challenges in identifying where dossiers include consideration of nanoforms.[137]

There is a requirement in REACH for dossiers to be of an appropriate structure, completeness and quality to provide assurance as to their safety or guidance for use that will improve their safety. Reviews to date have raised some concerns regarding aspects of the NM dossiers that have been submitted to date, which could impact on the degree to which the benefits of Registration may be accrued. However the Research Team was not able to assess or grade current submissions and as a consequence no assumption has been made regarding this issue.[138]

Future Registrations of NM – All NM produced in quantities in excess of one tonne will be required to have been registered under the provisions of REACH by 2018. It has been necessary to estimate the proportion of the 500–2,000 NM/Forms that will be subject to regulation by 2018.

In terms of the impact of guidance on dossiers one can assess there as being a broad divide between:

- Producers of NM who respond to the current guidance and support around that guidance to submit a registration dossier by 2018.
- Producers who despite current guidance remain unsure as to whether the materials they produce are fully or partially at nano scale and who respond by not pursuing the regulatory path for the substance as an NM.
- Producers who are aware that they are producing a NM but are uncertain of the regulatory requirements and who respond by not pursuing the regulatory path for the substance as a NM.

4.6 Conclusions

The Terms of Reference for the Research Study stipulate that the Research Team presents the impact of the regulations and associated guidance for NM under REACH. The challenge in doing this is to account for the Guidance and the related support groups, meetings and documentation, to assess qualitatively how stakeholders view such Guidance and then to link this to the Registration process itself. Given that the Guidance will only be one of a range of factors influencing Registration levels as well as the quality of the dossiers developed by industry, this process will depend on the veracity of the assumptions underpinning any estimate of impact.

[135] Safety Data Sheet: Guidelines for synthetic nanomaterials, Swiss Federal Department of Economic Affairs State Secretariat for Economic Affairs Chemicals and Occupational Health ABCH, April 2012
[136] http://www.nanotechia.org/news/news-articles/early-results-indicate-total-4-nanomaterials-registered-2013-reach-deadline
[137] http://ec.europa.eu/environment/chemicals/nanotech/pdf/jrc_report.pdf
[138] http://ec.europa.eu/environment/chemicals/nanotech/pdf/jrc_report.pdf

5.0 Refinement of Policy Options

The primary measure against which each of the options needs to be considered is Article 1 of the REACH regulation. According to Article 1, the purpose of REACH:

> "is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation."

REACH is therefore a key element of the EU commitment towards the implementation plan adopted at the 2002 World Summit on sustainable development, which aims to ensure that, by 2020, chemicals are produced and used in ways that lead to minimisation of significant adverse effects on human health and the environment".[139.]

The legal basis for REACH is Article 114 TFEU, this concerns the harmonisation or approximation of laws that have as their main object the establishment and functioning of the internal market. This Regulation is based on the principle that it is for manufacturers, importers and downstream users to ensure that they manufacture, place on the market or use such substances that do not adversely affect human health or the environment".[140] The provisions of REACH are underpinned by the precautionary principle as provided by Article 1(1) of REACH. The precautionary principle is provided by the Treaty of Lisbon in the framework of the EU policy on the environment in Article 191 TFEU. This means there is an inherent mechanism within the regulation which advocates taking precautionary action when chemicals pose possible threats to human health and the environment, rather than waiting for complete scientific proof of cause and effect.[141]

The 2003 REACH impact assessment evaluated potential health and environment benefits which would be the result of risk reduction measures by industry and by authorities through the systematic collection and generation of information on hazards and uses of chemicals:

"The positive effects of REACH on public health were assumed to start to occur 10 years after the start of REACH implementation, i.e. 2018, and would be fully observed after another 20 years, with total health benefits due to REACH in the order of magnitude of EUR 50 billion over the 30 years period (after discounting). The long-term benefits of REACH on the environment were estimated by another study to be up to EUR 50 billion over the 25 years period (after discounting). Notwithstanding the methodological difficulties the overall conclusion was that the benefits of REACH were expected to far outweigh the costs".[142]

Equally the situation with regard to the benefits from the regulation of NM is only likely to be seen over a ten to twenty year timescale after implementation.

In addition to these overarching assessment criteria, the Research Team have specifically considered how each option is likely to apply specifically to SMEs, Microenterprises and Start Ups. Policy options

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[139] REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 6/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

[140] http://echa.europa.eu/web/guest/regulations/reach/

[141] http://multinationalmonitor.org/mm2004/09012004/september04corp3.html

[142] General Report on REACH Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions in accordance with Article 117(4) of REACH and Article 46(2) of CLP, and a review of certain elements of REACH in line with Articles 75(2), 138(2), 138(3) and 138(6) of REACH

will be closely linked both to the causes of the problem and to the objectives, seeking to define an appropriate level of ambition for the options in the light of constraints such as compliance costs, workability and science base as well as considerations of proportionality. In the following section the Research Team describes and assesses each of the six options in more detail. For each of the options there is a table that sets out how each of the options relates to the objectives of REACH as well as more broadly to the issue of clarity.

5.1 Option One: Baseline

This section on the Baseline should be considered alongside Section 4 with the focus of this assessment being to set the Baseline alongside the other five options and in doing so to consider how each meets the general and specific aims of REACH.

REACH Objectives	Status	Baseline
Ensure a high level of protection of human health and the environment		The current guidance has resulted in the submission of registration dossiers for four NM. Aspects of the quality and completeness of the dossiers submitted to date has been questioned by the JRC[143].
Enhancing competitiveness and innovation		A significant majority of stakeholders responding to the Public Consultation believe current guidance to be unclear or very unclear.
Promote alternative methods for the assessment of hazards of substances		A majority of respondents to the Public Consultation stated that current guidance on methods for assessment of substances contributed to the current problem regarding the regulation of NM under REACH.
Promote the free circulation of substances on the internal market		Anecdotal evidence that current guidance has not limited free circulation of substances on the internal market.
Clarity Objective		Deemed in Public Consultation feedback, secondary evidence and stakeholder feedback to lack clarity.

Table 5.1 Assessment of Baseline against REACH Objectives

The Commission Recommendation of 18 October 2011 on the definition of nanomaterial was developed with help of the JRC (the Joint Research Council) and SCENIHR (the Scientific Committee on Emerging and Newly Identified Health Risks). This document is the basis for the application of the current EC definition of NM, which is based on size and should be applied for "legislative and policy purposes in the Union".[144] However the Recommendation simultaneously recognises the challenges in measuring particle size and particle size distribution and obtaining comparable results (specifically referring to

[143] NanoSupport was however not a compliance check but rather motivated by a scientific and technical requirements and not all are part to REACH Information requirements.
[144] Commission Recommendation of 18 October 2011 on the definition of nanomaterial (2011/696EU)

particle size distribution and surface area by volume). A primary need[145] is therefore the development and commercial availability of reliable testing and standardised measurement instruments, as well as guidance, while making the best use, as appropriate, of the methods for the measurement of NM available today. To ensure the definition and its descriptors reflect scientific progress; it will be reviewed in December 2014[146].

The associated ECHA Guidance describes REACH *information requirements* with regard to substance properties, exposure, use and risk management measures,[147] as well as registration and data entry to IUCLID, a required data format for registrations. Three sets of guidance cover general recommendations on what registrants should include for NM. These concern information requirements that have been developed to support registrants when preparing registration dossiers particularly for NM. The recommendations encompass (inter alia) testing strategies, methods of testing, endpoint specific guidance, and specifically appropriate dosing regimens in toxicology assays to ensure human health, and environment safety.

Dossiers on substances with nanoforms are assessed by ECHA on a case-by-case basis. The registration of substances with nanoforms under REACH follows the same procedures as that of all other chemicals. There are two voluntary tickboxes in IUCLID that indicate if the substance to be registered would also cover “any nanomaterial forms”; however, this function is not emphasised in guidance or usual manuals. Rather it is the technical guidance that clearly explains how to enter NMs into IUCLID format. ECHA can also make enquires and require registrants to provide further data as considered necessary under dossier evaluation. Any REACH registration dossier or substance may be subject to evaluation. In addition, the CLP Regulation compels businesses to notify ECHA of substances placed on the market – including NM – that meet the criteria for classification as hazardous regardless of the tonnage in question.[148] The challenge here is the absence of a requirement to identify nanoforms and provide safety data specific to the nanoform substance as well as the fact that CLP is based on available data while the nano discussion is about generating relevant data to enable a qualified classification instead of one based on no data. The Research Team assess that this may mean that materials could be being placed on the market with unknown toxicological effects and that the general population, worker health and the environment could be affected by inadequate testing using Baseline Annex requirements only.

NM REACH dossiers need to include data on constituent particle size distribution. Other information, including information on aggregation for exposure assessment, and information on dustiness is required by ECHA and by the registrants. Information on particle size may vary significantly depending on manufacturing method and/or between different registrants.

In terms of proportionality, the Baseline aims to ensure that nanoforms are assessed in the same manner as other forms of substances, and the definition of NM and nanomaterial-specific guidance were developed in order to provide a minimum and proportionate response to this requirement. In

[145] According to 2011/696/EU “Measuring size and size distributions in nanomaterials is challenging in many cases and different measurement methods may not provide comparable results. Harmonised measurement methods must be developed with a view to ensuring that the application of the definition leads to consistent results across materials and over time. Until harmonised measurement methods are available, best available alternative methods should be applied”

[146] The EC states in the Recommendation that the review should particularly focus on whether the number size distribution threshold of 50 % should be increased or decreased.

[147] http://echa.europa.eu/guidance-documents/guidance-on-information-requirements-and-chemical-safety-assessment

[148] From Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final

relation to the science base, ECHA Guidance has faced criticism from some stakeholders as not accounting for all aspects of current scientific best practice.

A number of stakeholders expressed concern with the voluntary underpinning to the Baseline regulatory process. Business and trade association representatives do not believe this to be a problem, arguing that a voluntary approach will lead to good levels of compliance over time. For trades union and environmental groups there is a problem with this fundamentally voluntary underpinning to the regulation of NM, which is argued to be out of line with the process for other substances.

In assessing which of the two sides of the argument has greater foundation, one is able to turn to the current levels of dossier submission as one potential indicator. For the first registration deadline in 2010 industry submitted 24,675 registration dossiers, which corresponded to 4,300 substances.[149] For dossiers submitted for this 2010 REACH registration deadline, three dossiers had selected "nanomaterial" in the registration form. For the 2013 deadline, four substances have been registered as NM according to ECHA's preliminary assessment.

The Commission's Second Regulatory Review on NM reveals that as of February 2012 seven substance registrations and 18 CLP notifications had selected "nanomaterial" as the form of the substance in voluntary fields and that a detailed assessment identified additional substances with nanoforms.[150] It should be noted that this was prior to the Commission's definition of NM.

A recent industry estimate suggests that there are between 500 and 2,000 NM placed on the EU market.[151] This suggests an under-representation of nanoforms. Whilst industry suggests that this low level represents an interim stage as companies come to a better understanding of the relevant guidance, there is further evidence to suggest that the Baseline option is problematic. In the press conference where the latest registration levels were released, Christel Mussel, Director of Registration, was quoted as saying the figures were similar to 2010 levels "despite lots of advice given to companies to help them indicate if they have a nanoform".[152]

Many dossiers assessed by JRC[153] in 2011 were, from the scientific and technical point of view, of a quality falling below appropriate scientific and technical requirements. This is believed to be the case for several reasons including fact that until recently there was no clear nanomaterial definition, along with specific nano guidance at the time of registration. In addition the existing REACH information requirements are rather general and thus not targeting NM, or even a multiplicity of nanoforms within one dossier. There may also be a lack of clarity in application of the test methods and about substance identification and the scope of the registration dossier.

The response of the Commission has been to consider a range of further measures that would extend testing requirements, provide further guidance and most importantly place these requirements within the Annexes of REACH and in doing so enhance their status.

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[149] General Report on REACH Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions in accordance with Article 117(4) of REACH and Article 46(2) of CLP, and a review of certain elements of REACH in line with Articles 75(2), 138(2), 138(3) and 138(6) of REACH Impact Assessment of the REACH Implementation Project on Substance ID for Nanomaterials. Final Report prepared for Cefic.

[150] from Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee Second Regulatory Aspects of Nanomaterials COM(2012) 572 final

[151] General Report on REACH Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions in accordance with Article 117(4) of REACH and Article 46(2) of CLP, and a review of certain elements of REACH in line with Articles 75(2), 138(2), 138(3) and 138(6) of REACH Impact Assessment of the REACH Implementation Project on Substance ID for Nanomaterials. Final Report prepared for Cefic.

[152] Chemical Watch Briefing, June 2013

[153] NanoSupport was however not a compliance check but rather motivated by a scientific and technical requirements and not all are part to REACH Information requirements.

Potential Amendments

To an extent the remaining options constitute means to amend or review the guidance provided at Baseline. Option 3 in particular gives consideration as to how non-legal measures could be used to improve the clarity and completeness of current guidance.

One European Industry Association stakeholder argued that as there are not that many engineered substances the focus should be on them and on making sure one gets as much as information that is relevant for further regulatory decisions out of them. If there was structured evaluation of the main four to six substance dossiers over the next few years it would be possible to assess common elements and themes and only then to change annexes if necessary required.

Conclusions

In relation to Article 1 the current Baseline represents sub-optimal regulation. This conclusion is based both on the relatively low overall levels of registration and on concerns regarding the quality and completeness of a number of the submitted dossiers. However, further comment on the impact of the Baseline on free circulation is hampered by a lack of evidence. The issue of competitiveness is an interesting one in that only a very limited number of producers of NM will be in a position to benefit from any marketing advantage that may accrue from having successfully registered through REACH. For innovation one can turn to stakeholder concerns regarding the clarity of the current arrangements and their impact on investment decisions, but no substantive evidence has been forwarded suggesting that decisions to invest in NM has been adversely affected by the current Baseline position. Finally, in relation to the potential impact on SMEs, stakeholder feedback suggests that clarity and transparency of regulatory requirements are important elements alongside cost and administrative burden. A stakeholder representing the interests of small business put one substantive example forward, where a company producing engineered nano went into bankruptcy with regulatory cost cited as one of the secondary causes.

Overall one must recognise that the Commission recommendation on the definition of NM and the circulation of ECHA Guidance have taken place only in the last 18 months. That said, concerns have been raised by a range of stakeholders concerning the basic underlying structure for the assessment of NM under REACH. These stakeholders question whether the voluntary and advice base will be sufficient to motivate industry to submit dossiers for nanoforms in sufficient numbers and of a requisite quality to enable the development of appropriate guidance.

5.2 Option Two: Changes to certain Annex provisions (clarification)

The Commission highlights that “the measures needing clarification in Option 2 are based on the advice the Commission requested from ECHA and the response given by ECHA in the context of the Nano-support project for this impact assessment”.[154]

Option 2 would introduce “changes to certain Annex provisions clarifying what companies are expected to do in accordance with the registration obligations of REACH and the specific guidance which takes into account CA/59/2008 and the RIPoN 2 and 3 reports from 2011”. The measures would require more precise descriptions of the scope of the dossier, clarification of requirements for nanoform-specific information in endpoint sections, and clarification of how data is to be reported.

[154] Impact Assessment of the possible amendment of REACH Annexes for nanomaterials Preliminary options and measures

The measures envisaged within Option 2 are:

- M1 - Explicitly require registrants to describe the scope of the registration dossier.

M2 - Explicitly require registrants to provide more detailed characterisation of NM/nanoforms.M3 - Require that nanoforms are explicitly addressed in the endpoint sections (to be introduced in the REACH Annexes for substance identification, physico-chemical properties, human health hazards, environmental fate and environmental hazards).

- M4 - Require detailed description of the test material / sample and sample preparation (to be introduced in the REACH Annexes for substance identification, physico-chemical properties, human health hazards, environmental fate and environmental hazards).
- M5 - Require scientific justifications for grouping / read-across / QSAR and other non-testing approaches for different forms (*to be introduced in the REACH Annexes for substance identification, physico-chemical properties, human health hazards, environmental fate and environmental hazards*).
- M6 - Require considerations of most appropriate / relevant metric with preferable presentation in several metrics (*refers to human health hazards, environmental fate and environmental hazards only*).
- M7 - Require that bioaccumulation is addressed specifically for the nanoform.
- M8 - Specify that absorption/desorption behaviour of NM should not be assessed based on Kd values derived from Koc and Kow.
- M9 - Require identification of uses and exposure assessment of the nanoform.

REACH Objectives	Status	Baseline
Ensure a high level of protection of human health and the environment		67% of respondents believe option 2 would increase or significantly increase the safe use of NM. Highest rank of five options considered in Public Consultation
Enhancing competitiveness and innovation		Ranked third in terms of an assessment of additional cost impact on industry with less than half of all respondents (44%) believing the option would cost “more” or “significantly more” than the baseline position.
Promote alternative methods for the assessment of hazards of substances		Although the option does represent a step change from the Baseline stakeholders did not consider it to address the issue of alternative methods of assessment.
Promote the free circulation of substances on the internal market		Option 2 was considered by respondents to be the most efficient of all the options with a small majority (51.7%) believing that it would more efficient or significantly more efficient that the baseline situation.
Clarity Objective		Assessing the rating for efficiency alongside additional feedback from stakeholders suggest that looking at the existing guidance that Option 2 does provide a improved clarity.

Table 5.2 Assessment of Option Two against REACH Objectives

Option 2 represents a change from the Baseline in that it requires additional description, scientific justifications and consideration of appropriate metrics. It also sets out specific requirements relating to materials being in nano form. Given that such requirements would involve amendments to the Annexes of REACH, Option 2 also signals a departure from an approach reliant entirely on guidance.

Initial stakeholder feedback appears to suggest that Option 2 is seen to be a logical iterative development from the Baseline and as such discussion is focused on whether it is a necessary and sufficient means to achieve the goals set out within REACH. One industry stakeholder stated that they felt that for industry the clarification issues in Option 2 could be helpful.[155] To an extent this would still be dependent not only on the success or otherwise of the initial tickbox self-categorisation of nanoforms, but also on the quality of the dossiers submitted, particularly as they relate to the requirement for additional information and justification.

From an environmental association point of view option 2 is viewed to be a good option in that "it provides further clarification and this is important and needed. However it doesn't propose any additional measures and lets not forget that the Commission feels that additional measures are needed. As such it is necessary but not sufficient."[156]

This raises an issue with regard to the potential level of variance of response resulting from the relative lack of specificity in Option 2. The question being: could this lead to lack of consistency in approach or is this necessary to allow applicants flexibility to efficiently and effectively determine how best to address specific requirements for individual nanoforms?

A number of the measures will be focused on increasing overall levels of protection; the question here being whether these are in themselves sufficient for an appropriate consideration of the safety of the full range of nanoforms. Impact in relation to the free circulation of materials, as well as broader issues of competitiveness and innovation, will be linked to the degree of success the additional measures have in increasing both the quality and quality of submitted dossiers.

Overall Option 2 measures generate more information (characterisation and better parameter measures) to better describe the substance under evaluation, but they do not provide specific information to better assure human health and environmental safety. However, when Option 2 and Option 4 are combined together as a package of measures, they provide a more powerful assessment of safety.

Potential Amendments

The following potential refinements for Options 2 have been identified by expects within the Research Team as being worthy of consideration.

- M1 - the Ames test is not necessary for a nanomaterial.
- (in Option 4) M13 Require non-bacterial in vitro gene mutation study.
- M2 - the assumption here is that appropriate characterisation generating data for the OECD WPMN parameter list would be done to sufficiently describe the nature of the nanomaterial and its nanoform(s).

[155] Industry Stakeholder Interview, July 2013.
[156] Environmental Association Interview, August 2013

- M3 - this measure may be considered as vague. The Research Team has assumed that this means the dossier is modified to include a description of the nanoform and whether the "test" has been appropriately conducted to be applicable, but the Research Team have not taken into account that if it had not been adequately covered a new test would need to be performed. It needs to be considered whether this is just a data entry measure.

Conclusions

Option 2, with respect to being able to provide increased clarity on the basis of the current guidance under REACH, appears to be a well structured option which enjoys a broad range of stakeholder support.

5.3 Option Three: Measures of non-legally binding nature

Option 3 is based on "soft law". In terms of initial presentation, Option 3 would include one or more of the following:

- Communication;
- Resolution; and
- Other Measures

REACH Objectives	Status	Baseline
Ensure a high level of protection of human health and the environment		Less than half (40%) of respondents believe option 3 would increase or significantly increase the safe use of NM. Second lowest rank of five options considered in Public Consultation.
Enhancing competitiveness and innovation		The second lowest assessment of additional cost impact on industry with less than half of all respondents (44%) believing the option would cost "more" or "significantly more" than at baseline. However there was limited evidence as to how a "soft law" option could significantly enhance competitiveness and innovation.
Promote alternative methods for the assessment of hazards of substances		The options is not structured to promote alternative methods.
Promote the free circulation of substances on the internal market		Assessed on the grounds of efficiency option 3 had the lowest ranking with less than a third of respondents (30.4%) believing it would result in "higher" or "significantly higher" regulatory efficiency.
Clarity Objective		There is a strong stakeholder belief in the value of additional engagement, but option 3 does not provide a substantive basis to provide clarity of guidance.

Table 5.3 Assessment of Option 3 against REACH Objectives

There are already a number of "soft law" groups and guidance in place. There is ECHA Guidance which is prescriptive in form and IUCLID advice on the existing requirements for NM under REACH, and there are already a number of bodies in place that would qualify as constituting "soft law" including the CARACAL subgroup on NM (commonly referred to as CASG Nano), and the Directors Contact Group (DCG).

Such "soft law" measures have been developed on an iterative basis over the last few years and have not as yet been subject to systematic evaluation and review. There are two broad challenges in relation to the current Impact Assessment. The first is to decide whether current "soft law" measures should be considered to be elements of the Baseline (no change) option or any of the other options or whether they should be considered to be elements of a distinct "soft law" Option. One possibility is to consider each of the current initiatives within a broader "soft law" framework. An initial assessment would suggest that for this to be the case the Commission would need to consider developing a set of benchmarks and success criteria that may be associated with the use of NM.

In doing this one must consider the extent to which improved communication, or means for resolution, could help improve the effectiveness of the existing tools within the Baseline Option. Considering these in turn, the first and potentially most impactful measure could be support in relation to the two nano-related tickboxes within the initial Registration Process. In this case a range of measures providing information and guidance to industry, and most particularly to SMEs, could result in an increase in the number of Registrations of nanoforms. For this to be the case there needs to be a clear indication that industry stakeholders are currently unaware that the materials they are producing contain nanoforms at a level that would require them to seek Registration as a nanomaterial or that they do not feel confident as to how to do this. Initial feedback from the stakeholder interviews has not established this to be the case.

A second challenge is the ability to assess the costs and benefits that might be associated with these "soft law" options. It will be possible to establish reliable cost estimates for enhanced guidance and the provision of groups and forums for discussion, but it may be more difficult to make an assessment of the impact of such measures on regulatory practice or more broadly on the objectives for REACH.

Stakeholder feedback regarding current ECHA Guidance does suggest that further communication and discussion could be of value and may impact on the quality of the dossiers that are developed. The degree to which such advice and communication could impact should be set alongside the fact that there is already a significant level of communication taking place. A recent statement from Christel Mussel, Director of Registrations, states that ECHA has "done a number of things" to encourage companies to register NM, such as carrying out webinars and setting up an expert group, but she goes on to comment that further review is required.[157] Another European Industry association representative stated that improvement from the Baseline could also involve authorities (ECHA, Commission and national competent bodies) improving the manner in which they interrogate and discuss dossiers, e.g. substance evaluation, GAARN, Nano-WG, CASG Nano and how they disseminate best practice, e.g. guidance.

In this light an assessment of costs will be discreet but benefit will be related to the impact that the particular "soft law" option may have in terms of compliance with the regulatory requirements for NM within REACH. This would require that "soft law" measures could be demonstrated to have increased compliance levels and/or improved the scientific basis and overall quality of dossiers.

[157] Chemical Watch Briefing, June 2013

Establishing the relationship between "soft law" measures and the achievement of the core objectives of REACH is a challenging process. If one is able to establish a rationale or logic model which can make a theoretical link between the introduction of a particular communication tool and improved understanding of the current ECHA Guidance, there is still the challenge of having a baseline from which to assess the level of improved understanding and any consequent impact on the quality of submitted dossiers within the wider Registration Process. As such the impact on overall levels of protection, the free circulation of materials as well as broader issues of competitiveness and innovation will be challenging to assess. Enhanced use of feedback tools and broader evaluations would help to establish how effective "soft law" options could be in relation to the Baseline, but also in terms of linking them to one or more of the other four options under consideration.

Potential Amendments

Although specific amendments could be proposed, none would make a meaningful impact in relation to meeting the objectives of REACH.

Conclusions

A range of "soft law" measures are already in operation around the Baseline, although it needs to be recognised that many of these have only been introduced very recently. Yet given the relatively low number of Registrations of NM to date one must question the potential effectiveness of such measures. That having been said, it may be the case that additional "soft law" measures could be used to successfully augment one or more of the other options under consideration.

5.4 Option Four: Additional measures to demonstrate safe use

The Commission highlights that the additional measures in this option are based on the advice the Commission requested from ECHA and the response given by ECHA in the context of the Nano-support project for this impact assessment.[158]

Option 4 is built upon the requirements specified in Option 2, i.e. this is best viewed as an addition enforcing the measures included under Option 2. Its further requirements are on additional testing, clarifications and elaborations to further describe the potential impact of the nanomaterial, specifically:

- M10 - Inclusion of information on dustiness.
- M11 - Requirement of acute toxicity data for the most relevant route of exposure.
- M12 - Change "particles" to "(nano) particles" for repeated dose toxicity studies (inhalation).
- M13 - Requirement of non-bacterial in vitro gene mutation study.
- M14 - Consideration of water solubility in relation to test waiving.
- M15 - Specification that long-term testing should not be waived based on lack of short term toxicity.
- M16 - Specification that algae testing should not be waived based on insolubility.
- M17 - Requirement that testing on soil and sediment organisms is prioritised.

[158] Impact Assessment of the possible amendment of REACH Annexes for nanomaterials Preliminary options and measures

REACH Objectives	Status	Baseline
Ensure a high level of protection of human health and the environment		Nearly two-thirds of respondents (62.8%%) believed Option 4 would increase or significantly increase the safe use of NM. Second highest rank of five options considered in Public Consultation.
Enhancing competitiveness and innovation		The second highest assessment of additional cost impact on industry with less than half of all respondents (79.3%) believing the option would cost "more" or "significantly more" than at baseline. Set against this one may consider that stakeholders do see the benefit of option 4 in terms of providing an improved regulatory platform for industry.
Promote alternative methods for the assessment of hazards of substances		Recognised by stakeholders to provide an augmented range of tests.
Promote the free circulation of substances on the internal market		Assessed on the grounds of efficiency option 4 again had the second highest ranking with close to half of all respondents (49%) believing it would result in "higher" or "significantly higher" regulatory efficiency.
Clarity Objective		Stakeholders broadly felt Option 4 would improve improved regulatory clarity.

Table 5.4 Assessment of Option 4 against REACH Objectives

Compared with the baseline and Option 2, these measures include additional tests and requirements, including information on dustiness, presentation of considerations of the test result metrics, and detailed descriptions of the test material / sample and sample preparation, more appropriate genotoxicity assays and longer-term systemic toxicology and ecotoxicology assays specific for the identified nanoforms. The additional requirements refer to cases where the existing information requirements in REACH are "not tailored for NM or where specific considerations are required for NM".[159] In this respect Option 4 encompasses a new and larger requirement sphere.

Measures under Option 4 would be implemented alongside the measures under Option 2. Option 4 measures also encompass an approach that existing endpoints for NM are addressed in lower tonnages than for other substances with non-nanoforms; inhalation exposure route for acute toxicity and repeated dose toxicity studies; and a non-bacterial gene mutation study (in vitro); in all annexes exclusion of waiving possibility on the basis of insolubility or lack of short-term toxicity, and a priority for test on soil and sediment organisms.[160] Option 4 total costs also include the possibility of in vitro genetic toxicology

[159] EC Nanomaterials REACH Roadmap
[160] European Commission Impact Assessment of the possible amendment of REACH Annexes for nanomaterials Preliminary options and measures

tests being adverse whereby an in vivo assay may be required following a standard genetic toxicology test.

Option 4 has a focus on requirements and as such would involve additions to one or more of the Annexes of REACH. Both the level of precision and the expansion of the remit of testing can be seen to represent a significant change to Option 2, but the additional information would protect health and the environment. The overall focus of the option on requirements suggests a regulatory tightening with reduced scope for individual interpretation. How this may impact on supporting the achievement of the regulatory goals of REACH will in no small part depend on how this more prescriptive approach impacts on the quality of the dossiers produced.

Impact in relation to the free circulation of materials as well as broader issues of competitiveness and innovation will be linked to the effectiveness of the measures contained in Option 4 in identifying potential areas of risk associated with NM. In all cases the potential benefits (e.g. in improved health and environmental impacts) will be highly dependent on the impact on prospective registrants of having higher levels of specification and requirement, which represent a meaningful and significant change from the guidance-based approach that underpins the Baseline position.

The costs associated with the implementation of Options 2 and 4 (even when test waiving is implemented in M14 for water solubility) are potentially significant for a company producing a nanomaterial at low tonnage, but the accompanying benefits to health protection that are afforded by Option 4, in regulating and managing identified human health risks better, would also be significant in preventing adverse outcomes. NB: Option 4 implementation is reliant on Option 2 implementation and in particular adequate characterisation of the nanoform being assessed in the additional Option 4 measures. To have an impact, the data from Option 4 must be shown to be relevant to the human and environmental exposure scenarios. Without adequate characterisation data there is the risk that testing performed could be irrelevant to the real life exposure scenario. Assuring this from a scientific point of view remains a potentially costly technical challenge.

Potential Amendments

Two amendments to Option 4 could be considered:

M11: Consider that route-to-route extrapolation is not valid and all mammalian toxicology tests (acute and long term) should be performed for the most relevant route.

Consideration could be given to the use of the COMET assay (in vivo and in vitro) to assess the potential genotoxic hazards at sites of local exposure to gut, lung and skin, when systemic absorption is not seen.

Conclusions

Option 4 also appears to be a clearly structured option which again enjoys a broad range of stakeholder support.

5.5 Options Five: Aiming to enhance competitiveness and innovation (greater specificity)

According to the EC's Draft Option, Option 5 aims to enhance competitiveness and innovation of companies by providing greater specificity to core implementation issues and reducing the burden for complying with REACH.

The measures incorporated in Option 5 indicate tailored information requirements in a dossier for NM placed on the market, a reduction in certain testing requirements, clarification of regulatory provisions and the ability to maximise the use of non-testing methods and exposure categorisation, and in doing so maintain openness to flexible solutions.[161]

The specific measures are:

- M18 - Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms.
- M19 - Specify that nanoform-specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous.
- M20 - Specify that a coated nanomaterial is considered as a special mixture, e.g. in classification and labelling as accepted e.g. alloys.
- M21 - Specify that the granulometry concept in 7.14 of Annex VII includes also shape and surface area of NM.
- M22 - Specify that the information on dustiness is required for nanoforms only where relevant for the worker safety assessment.
- M23 - Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints.
- M24 - Specify that the use of non-testing methods (e.g. read-across, grouping, categorisation etc.) is a priority for nanoforms.
- M25 - Specify and require explicitly that waiving of testing on the basis of exposure conditions and categories applies also for nanoforms, in particular when nanoforms are completely reacted (cured), incorporated or embedded into a completely cured matrix or permanent solid polymer form, or otherwise used in closed systems or controlled conditions.
- M26 - Specify that absorption/desorption behaviour of nanoforms can be based on biological surface adsorption index, affinity coefficient or other relevant parameters.
- M30 - Specify that information generated according to existing test guidelines and/or test methods is sufficient for the purposes of hazard assessment of NM under REACH.
- M31 - A nanoform consisting of aggregates is considered the same as bulk form and the same endpoint information for (eco)toxicological and environmental fate applies.
- M33 - Create presumption that non-testing methods are valid for NM in all endpoints.
- M34 - Amend the granulometry information requirements in Annex VII (1-10 tonnage band) for NM in line with Annex II, Section 9.1.a of REACH on Safety Data Sheet and respective ECHA Guidance on Compilation of Safety Data Sheets.
- M35 - Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys.
- M36 - Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS).
- M37 - For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696).
- M38 - Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative.

[161] European Commission Impact Assessment of the possible amendment of REACH Annexes for nanomaterials Preliminary options and measures

REACH Objectives	Status	Baseline
Ensure a high level of protection of human health and the environment		Option 6 was only the third ranked option in terms of protection with 58.6% of respondents stating that it would increase or significantly increase the safe use of NM.
Enhancing competitiveness and innovation		The highest assessment of additional cost impact on industry with more than our four-fifths of all respondents (82.1%) believing the option would cost “more” or “significantly more” than the current baseline.
Promote alternative methods for the assessment of hazards of substances		A Central feature of this option, stakeholders recognised that Option 5 would adopt a markedly different approach to the regulation of substances from that set out in Options 2, 4 and 6 in particular.
Promote the free circulation of substances on the internal market		Assessed on the grounds of efficiency option 5 had the second lowest ranking with 39.3% of respondents believing it would result in “higher” or “significantly higher” regulatory efficiency.
Clarity Objective		The approach within Option 5 has been to use an alternative approach which provides what it sets out to be a more focussed approach.

Table 5.5 Assessment of Option 5 against REACH Objectives

The overall purpose of Option 5 is to facilitate an overall reduction in regulatory burden by comparison with the Baseline position. This by definition would also mean that the option would constitute the lowest overall level of regulatory burden but it could come at the price of delivering the lowest level of health and environmental protection across the six options in terms of the categorisation of nanoforms subject to testing and the manner of negating such tests.

The focus on providing more specific information and guidance may or may not result in increasing overall levels of protection, this being dependent in part on the scientific basis for judgements such as increasing provision for read-across. It also relies in part on individual Registrants making judgements as to the most appropriate science to base dossier content on. Such an increased capacity of interpretation could result in a less comprehensive and reliable database of information with which to make decisions regarding protection of health or improved tools for understanding and predicting nano effects. Feedback from stakeholder interviews representing trades union and environmental interests suggests that Option 5 would be less successful in increasing overall levels of protection than the other options under consideration. One stakeholder commented that it would see nanoforms being subject to a lower level of regulatory scrutiny than non-nanoforms, whilst another felt it to be a step back from a Baseline position. Another industry association stakeholder commented that Option 5 is too extreme, not realistic and lacking in logic because it would involve a lower level of testing than is the case for other substances under REACH. Environmental stakeholders went even further, arguing that the option

does not fulfil the “no data no market” principle and that an option that is “only looking at economic benefit is not democratic”.[162]

Potential impact in relation to the free circulation of materials as well as broader issues of competitiveness and innovation will again be linked to the effectiveness of these measures in identifying potential areas of risk associated with NM. Beyond this there is the issue of how such measures may impact on overall confidence levels in the regulatory system and here there was only very limited stakeholder support for Option 5 increasing confidence levels. Finally, for nanomaterials themselves, there could be adverse implications for market acceptance, particularly in consumer applications or with environmental release.

Potential Amendments

One specific amendment is suggested with respect to Option 5.

M22 - Specify that the information on dustiness is required for nanoforms only where relevant for the worker and general population safety assessment. The suggestion would be for M22 to apply for the general population given that NM can be used in aerosols and powders for downstream use, and factory emissions.

Conclusions

Option 5 has been structured to provide improved clarity and to empower industry to respond to the regulatory needs of NM under REACH. It enjoyed significant support amongst the stakeholders within the Public Consultation but less so within the limited number of stakeholders engaged for this study.

5.6 Option Six: Emphasis on generation of targeted but more comprehensive information

This Option assumes moving forward from the Baseline to the full implementation of Option 2 and 4 and the inclusion of a number of additional requirements to those required for options 2 and 4. Option 6 should be considered the broadest of the six options in terms of the basis for assessing whether a nanomaterial should be subject to testing and the nature of the testing itself. Option 6 gives additional emphasis to the generation of targeted information with the objective of further reducing uncertainty in an area where knowledge is still under development regarding the influence of particle and nanomaterial-specific properties on risk. Information generated should also facilitate development of category approaches with all the associated impacts.

Option 6 implies a number of additional requirements to those outlined in Options 2 and 4:

- M39 - Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing.
- M40 - Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution.
- M41 - Information requirements for substances covered by Annex III (b) must also apply to nanoforms.

[162] Interview with European Environmental Organisation, August 2013

- M42 - For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation to be considered.
- M43 - For nanoforms, require all available information on the use to be considered, even when the use would not be covered by the registration.
- M44 - For nanoforms, require additional physico-chemical characterisation along the particle's fate when particle properties impact on hazard.
- M45 - Phys-chem, (eco)tox and CSA documented separately for each nanoform.
- M46 - For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation.
- M47 - Require adapted DNEL setting based on different routes through the value chain / specific uses.
- M48 - Add to the SDS information relevant to Nano registries in Member States.
- M49 - Specify that list of substances in Annexes IV and V does not cover nanoforms of these substances.
- M50 - Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded.
- M51 - Perform toxicokinetic screening.
- M52 - For nanoforms, request 28-day repeated dose toxicity in Annex VII.

An assessment of the coherence of Option 6 should acknowledge the relationship of the provisions within it to those within the Baseline and then to Options 2 and 4. Equally whilst no explicit reference is made to Option 3, it can be supposed that a structured and potentially an augmented set of “soft law” options could be seen as a useful adjunct to an option that contains within it extended regulatory provisions and measures. This finding is applicable to all the options under consideration.

Option 6 could increase the overall documentation relating to nanoforms through specifications such as that relating to coating and shape, as well as requiring the provision of additional information for each nanoform. In addition the option also sets out a number of higher threshold tests such as inhalation for repeated dose toxicity and toxicokinetic screening. It is likely that Option 6 will result in a higher testing cost burden for industry than the other options, both by dossier and by the number of required dossiers, but the most comprehensive analysis of health and environmental safety. The extent to which this may increase overall levels of protection will again depend on scientific evidence relating to the relevance and effectiveness of particular tests as well as to the judgements relating to mandatory separation of particular nanoforms.

The consequent impact on the free circulation of materials as well as broader issues of competitiveness and innovation may be considered to be most challenged by Option 6 as it represents the most elaborated of the options, building as it does on Options 2 and 4. Stakeholder feedback from industry was clear that the option would be burdensome at a level that could impact on competitiveness and innovation.

From an environmental stakeholder perspective Option 6 is the only one that is acceptable as it is most closely based on current scientific opinion. One of the stakeholders interviewed for the study believes that Option 6 will help safety and environmental protection but it would also help innovation. Yet for this stakeholder, even this option is sub-optimal, as she believes that it still leaves hundreds of NM unregulated because of the tonnage thresholds.

Potential Refinements

a) The proposal asks for specific tests which in the Research Team's view will really help on ecotoxicity, which is one of the highest areas of potential risk. The fate of nanomaterial is an area with a limited knowledge base and as such this test would help.

b) Option 6 for the first time includes an element of toxicokinetic screening. Scientifically this is normally seen in the design of a testing strategy, as an upfront consideration in designing a test and evaluating the relevance of test conclusions to the route of exposure being assessed. An issue for the Research Team is: does the material get absorbed systemically, or is there a need for only local effects to be considered, etc. However, it is recognised that performing toxicokinetic screening is also an uncertain and potentially costly exercise. For this reason, further research into the value and impacts of toxicokinetic screening for nanomaterials – and whether this would be better considered in options 2 and 4, prior to testing to inform a more relevant testing strategy – could be beneficial to industry and potentially save costs of performing inappropriate long-term repeat dose testing.

Conclusions

Option 6 is evidently considered by all stakeholders to be the most financially burdensome option for Industry but it is also considered the most expansive in terms of regulatory coverage of issues relating to human health and the environment.

5.7 Conclusions

The focus of the current review is to consider whether the Baseline is fit for purpose and if not to assess whether amendments to the REACH Annexes and/or "soft law" measures could improve the functional regulation of NM under REACH. On this basis the answer to the question as to whether the options provide credible alternatives, is that it is apparent that each option has considered what to test, when to test and how to test and in doing so they have developed distinct alternatives as to how best to achieve this. Given that each of these aspects has been addressed it can be said that conceptually no one element is missing. Nor have any of the stakeholders interviewed made comment that there is any particular measure missing. Equally, in terms of the clarity of each of the options, whilst the wording of particular provisions could be subject to improvement they do appear cohesive. On this basis the Research Team consider the six options to be sufficient and as such have not proposed any additional option for consideration.

There are some common themes across options in terms of committing to testing methods and testing requirements or asking for justification of testing methods and requirements. This is linked to appropriateness and effectiveness as well as cost. Given that some of the tests and testing procedures are relatively more expensive than others and that some options have a more differentiated approach to the classification of nanoforms, it is likely to be the case that the cost–benefit assessment, when undertaken, will find significant variation between options.

Assessing the potential differential impact of the six options is more challenging. The reason for this is that each has the same goal of seeking to meet the goals of REACH by providing the most appropriate platform to support industry to provide high-quality dossiers based on the best available science. Whilst there are differences between the options in terms of content, the most striking difference is in how prescriptive each is, with Option 5 providing more latitude for industry to make judgements as to what constitutes best science and Option 6 providing the least leeway for variation by dossier. This issue will need to be accounted for within the cost–benefit analysis.

In terms of the overall integrity of individual options, it is difficult on an a priori basis to find the grounds to exclude elements of any of the options or to include further options. What is certain is that having

established the costs for individual tests there will need to be a level of scrutiny as to whether such tests are needed. Equally, where evidence on the potential harm that can be caused by nanoforms is identified, so then elements of options or complete options that may not be structured in a manner to allow for the full assessment of such risk will also be subject to challenge.

Considering each of the options in turn in relation to the four strategic objectives for REACH one can make a number of points regarding alignment. Each of the options from the Baseline through take as their starting point the assertion that the protection of human health and the environment will be enhanced by the suggested measures for the explicit regulation of NM, although Option 5 is considered by a majority of stakeholders consulted in this study to be at a level below that offered by the Baseline. The differences between the substantive options (all options with the exception of the "soft law" Option 3) rest in the varying scope and level of detail in measures regarding NM assessment and the manner of such assessment.

An assessment of alignment to the strategic objective of enhancing competitiveness and innovation requires consideration of each measure separately. Thus while it may appear to be the case that Option 5 would be more closely aligned to this objective, it could in fact be the case that additional clarification and comprehensive testing may – for a particular nanomaterial – enhance competitiveness by virtue of providing higher levels of market confidence across the value chain. If this were to be the case then it will be a matter of setting the benefits of enhanced competitiveness derived from the regulatory process against the costs in order to make an overall assessment of each measure and option. To some extent, the same can be said about innovation in that whilst reduced regulatory burden for nanoforms could provide an enhanced environment for innovation, so may a more extensive regulatory system if it were to provide improved transparency and confidence.

Alignment to the objective of the promotion of alternative methods for the assessment of hazards is apparent in each of the five substantive options under consideration and an assessment of the extent to which one option may be considered relatively better aligned will depend in part on how stakeholders view the relevance and value of individuals measures within options. This will be assessed from the findings to the Formal Public Consultation.

A number of the stakeholders interviewed for the study called for a staged approach that is aligned to the development of a better understanding of particular characteristics of nanoforms and consequently a fuller understanding of appropriate testing procedures. Options 2, 4 and 6 could represent such a staged approach, were measures to be introduced over time and once further review and evaluation had taken place.

A number of industry stakeholders believe that whilst the focus for the regulation of nano materials under REACH should be on guidance over specific changes to Annexes, there is little challenge to the principle of REACH being the appropriate vehicle for such regulation. For other stakeholders such as environmental groups, the challenge is more profound in that they question the ability of any of the options under consideration to deliver the objectives of REACH for NM. David Azoulay, attorney at the Center for International Environmental Law (Ciel) stated in June 2013 that "The numbers show that the approach adopted so far, simply does not work," and he went on to argue that "the latest information from this registration deadline shows clearly that the limited modification of the annexes of REACH, envisaged by the Commission, will be insufficient to address this serious issue."[163].

[163] Chemical Watch Briefing, June 2013

6.0 Impact Assessment

The Research Team present the assessment of the impacts following the European Commission Guidelines, therefore dividing them into economic, social and environmental impacts, while keeping in mind that some overlaps exist among those three dimensions. Before analysing them, the Research Team look at the aspects the Research Team have found in relation to specific NM.

6.1 NM Case Studies[164]

This section has been developed using material sourced through a secondary review. It describes four nanomaterials – Titanium Dioxide, Carbon Black, Carbon Nanotubes, and Synthetic Amorphous Silica – their characteristics, potential hazards, use, and the extent and potential of their commercialisation. All four chemicals are already registered with REACH.[165]

Introduction

Globally, raw nanoscale materials are estimated by industry to be produced at a rate of around 11.5 million tonnes per year.

- Carbon Black is estimated to account for 9.6 million tonnes (85%)
- Synthetic Amorphous Silica accounts for 1.5 million tonnes per year (12%)
- Aluminium oxide, barium titanate, titanium dioxide, cerium oxide, zinc oxide, carbon nanotubes, graphene, fullerenes and nanosilver constitute the remaining 0.4 million tonnes (3%) of which:
    - Carbon nanotubes, graphene, and fullerenes have annual production amounts in the 100s tonnes range[166]
    - Roughly 50,000 tonnes of titanium dioxide nanoparticles were produced in 2010 and this amount is expected to grow to over 200,000 tonnes by 2015.[167]

Carbon black; paints, pigments, fillers; and metal oxides (e.g. zinc, titanium, aluminium and iron, semi-metal oxides including silicon and rare earth metals such as cerium) appear to be the groups of chemicals most regularly appearing on a nano scale.[168]

Titanium Dioxide (TiO_2)

Titanium dioxide (TiO_2) is produced worldwide and has been in industrial use for decades.[169] Titanium dioxide occurs naturally in several kinds of rock and mineral sands. TiO_2 is currently not classified as

[164] This secondary review is using sources making use of either metric tonnes or of imperial tons.
[165] DG ENTR via Nano and Other Emerging Technologies Blog, NGOs Call for "Nano Patch" for REACH, and EC Responds, November 2012. Available http://nanotech.lawbc.com/2012/11/articles/international/ngos-call-for-nano-patch-for-reach-and-ec-responds/
[166] Nanotechnologies Industries Association. Available at: http://www.nanotechia.org/sectors/chemicals-raw-materials
[167] Future Markets Inc, via Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php
[168] Safety Data Sheet: Guidelines for synthetic nanomaterials, Swiss Federal Department of Economic Affairs State Secretariat for Economic Affairs Chemicals and Occupational Health ABCH, April 2012
[169] Cefic Titanium Dioxide Manufacturers Association (TDMA), About Titanium Dioxide, available at http://www.cefic.org/Documents/About-Us/Industry%20sectors/TDMA/About-TiO2-full-version-July-2013.pdf

hazardous under the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).[170] [171]

Titanium dioxide is used as a pigment to add whiteness and opacity to products, ranging from paints, plastics, papers, inks, catalyst systems, ceramics, floor coverings, roofing materials, cosmetics and pharmaceuticals, water treatment agents, food colorants to foods, toothpastes and personal care products, in particular sunblock, as it helps protect the skin from ultraviolet light.[172] [173]

The TiO_2 market

Titanium dioxide accounts for 70% of the total global production volume of pigments.[174] In monetary terms, the market was valued at approximately €6.6 billion in 2009, with the European industry worth around €2.1 billion (measuring sales). The TiO_2 industry in Europe directly employs 7,000 people.[175]

The European personal care products market is worth €72 billion (2012), and employs around 1.5 million staff, including more than 25,000 scientists.[176] The food industry sector is the second largest European manufacturing industry and accounts for 14.5% of total manufacturing turnover, which equals €917 billion for the EU-27. The absolute majority (99%) of businesses in the sectors are SMEs. The sector also represents 14% of total manufacturing employment.[177]

The European Council of the Paint, Printing Ink and Artists indicate that their industry is worth approximately €17 billion, and directly employing 120,000 staff, with indirect employment being far larger.[178]

The nanomaterial TiO_2 is engineered; that is, it has been purposefully manufactured with nanoscale dimensions.[179] Methods to manufacture nano-TiO_2 vary widely. As far as the Research Team understands, manufacturing is unique to each specific application of nano-TiO_2.[180]

Compared to the Titanium dioxide pigment, the nanomaterial is transparent and more effective at absorbing UV light. It also acts as a photocatalyst.[181] [182] Like the pigment form, the nanoform of TiO_2 is used inter alia in food and personal care products.[183] Due to the nanoform's increased performance (e.g. better absorption and transparency of sun screens) and new applications (e.g. as nanocrystals in

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[170] According to the United Nations' Globally Harmonized System of Classification and Labelling of Chemicals (GHS)
[171] Cefic Titanium Dioxide Manufacturers Association (TDMA), About Titanium Dioxide, available at http://www.cefic.org/Documents/About-Us/Industry%20sectors/TDMA/About-TiO2-full-version-July-2013.pdf
[172] Canadian Centre for Occupational Health and Safety http://www.ccohs.ca/headlines/text186.html
[173] Cefic Titanium Dioxide Manufacturers Association (TDMA), About Titanium Dioxide, available at http://www.cefic.org/Documents/About-Us/Industry%20sectors/TDMA/About-TiO2-full-version-July-2013.pdf
[174] Canadian Centre for Occupational Health and Safety http://www.ccohs.ca/headlines/text186.html
[175] Cefic Titanium Dioxide Manufacturers Association (TDMA) see http://www.cefic.org/About-us/How-Cefic-is-organised/Fine-Speciality-and-Consumer-Chemicals/Titanium-Dioxide-Manufacturers-Association-TDMA/
[176] Cosmetics Europe reports EU personal care market as the world leader. Available at: http://www.cosmeticsdesign-europe.com/Business-Financial/Cosmetics-Europe-reports-EU-personal-care-market-as-the-world-leader
[177] European Commission DG ENTR Food Market Overview. Available at: http://ec.europa.eu/enterprise/sectors/food/eu-market/index_en.htm
[178] http://www.cepe.org/ePub/easnet.dll/ExecReq/Page?eas:template_im=100087&eas:dat_im=1002FD
[179] For a discussion on this, please see http://goodnanoguide.org/What+are+nanomaterials
[180] US Environmental Protection Agency, Scientific, Technical, Research, Engineering and Modeling Support (STREAMS) Final Report State of the Science Literature Review: Nano Titanium Dioxide Environmental Matters, EPA/600/R-10/089 August 2010. Available at: http://www.epa.gov/nanoscience/files/NanoPaper2.pdf
[181] Cefic Titanium Dioxide Manufacturers Association (TDMA) About Titanium Dioxide, available at http://www.cefic.org/Documents/About-Us/Industry%20sectors/TDMA/About-TiO2-full-version-July-2013.pdf
[182] A photocatalyst is a substance that after illuminated by light, it enhances a chemical reaction although the substance itself will not undergo. Source: Photocoat / Jita Enterprise
[183] A Weir at al, Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environ Sci Technol. 2012 February 21; 46(4)

solar cells), the demand for TiO_2 nanomaterials is growing.[184] One estimate suggests that 50,000 tonnes of Titanium dioxide nanoparticles were produced in 2010 and this amount is expected to grow to over 200,000 tonnes by 2015.[185]

However, an estimation carried out by the US Environmental Protection Agency in 2010 appears less optimistic of volumes and indicates the following for US production:

Table 5 US Environmental Protection Agency TiO_2 estimates

Table 5-2. Estimated Annual Volumes of Nano-TiO_2 Globally and in the United States

Source	Total TiO_2 (Reported)			Nano-TiO_2[1] (Estimated)		
	Global Production (tonne/yr)	U.S. Production (tonne/yr)	U.S. Consumption (tonne/yr)	Global Production (tonne/yr)	U.S. Production (tonne/yr)	U.S. Consumption (tonne/yr)
USGS (2007 values)[4]	N/A	1,450,000	1,110,000	N/A	3,630	2,780
DuPont[3]	5,000,000	N/A	N/A	12,500	N/A	N/A

[1] This reference estimated that the global production of ultrafine TiO_2 is <0.25% of the global production of total TiO_2. The nano-TiO_2 estimates in this table assume both the global and U.S. production and consumption of nano-TiO_2 is 0.25% of the global and U.S. production and consumption of total TiO_2.[3]
N/A: Not Applicable – the value was not provided in the given source.

Source: US Environmental Protection Agency, Scientific, Technical, Research, Engineering and Modeling Support (STREAMS) Final Report State of the Science Literature Review: Nano Titanium Dioxide Environmental Matters, EPA/600/R-10/089 August 2010. Available at: http://www.epa.gov/nanoscience/files/NanoPaper2.pdf

TiO_2 nanoparticle is used in the field of producing chemical fibre, plastics, printing ink, coating, self-cleaning glass, self-cleaning ceramics, antibacterial material, air purification, sewage treatment, chemical industry, cosmetics, natural white moisture protection cream, beauty and whitening cream, morning and night cream, moistening refresher, vanishing cream, skin protecting cream, face washing milk, skin milk, powder make-up, foods packing material, coating for paper-making industry; it is also used for improving the impressionability and opacity of the paper and used for producing titanium, ferrotitanium alloy, carbide alloy, etc., in the metallurgical industry, astronautics industry, conducting material, gas sensor, and moisture sensor.[186]

Benefits of the TiO_2 nanoform use may be related to pollution-fighting capabilities and increased efficiency of solar energy conversion, although it is not stated how far progressed these developments are and the scope and monetary value of such applications, as the field is not well understood:[187]

- The multinational company Alcoa has already developed a titanium-based coating that enables buildings to convert airborne nitrogen oxide (a major contributor to smog and acid rain) into nitrates, thereby eliminating the smog.[188] Another Cleantech company has developed a similar

[184] Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php
[185] Future Markets Inc, via Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php
[186] TiO_2 Nanoparticles. Available at: http://www.nanoparticles-microspheres.com/Products/Nano-TiO2.html
[187] CleanTechnica (2012) Titanium Dioxide, Unchained! Available at: http://cleantechnica.com/2012/06/09/titanium-dioxide-could-lead-to-low-cost-solar-and-fuel-cells/
[188] CleanTechnica (2012) Titanium Dioxide, Unchained! Available at: http://cleantechnica.com/2012/06/09/titanium-dioxide-could-lead-to-low-cost-solar-and-fuel-cells/

TiO_2 concept for a surface treatment that could be applied to roads, to neutralise nitrogen oxide emissions from vehicles.[189]

- Titanium dioxide is also being explored as a means of increasing the efficiency of solar energy conversion. A solar cell enhanced with titanium dioxide would provide an emission-free way to produce hydrogen for use in fuel cells.[190]

Between 2010 and 2012, average prices for TiO_2 raw materials rose by almost 250%; however there is currently an increase in supply of titanium dioxide feedstock and analysts expect the market to calm in the foreseeable future.[191]

Health and environmental aspects of TiO_2

The European Commission's Scientific Committee on Consumer Safety (July 2013) opinion[192] on the Titanium dioxide nanoform is based on current knowledge, which is limited but, in comparison to other nanomaterials evaluated, still relatively rich. The committee conclusions are that the use of TiO_2 nanomaterials with certain characteristics, at a concentration up to 25% as a UV-filter in sunscreens, is not considered to pose any risk in humans after application on healthy, intact or sunburnt skin. This opinion, however, does not apply to products that might lead to inhalation exposure of TiO_2 particles such as powders or spray products. For the latter two categories "major hazard concerns" have arisen as TiO_2 particles have shown to lead to carcinogenic effects after inhalation.[193] Some TiO_2 nanoparticles have been shown to be able to damage DNA (genotoxic). However the evidence is inconclusive on this point.[194]

Research undertaken and tested on US food products by European and American academics and published in 2012[195] found that roughly 36% of food grade TiO_2 consists of particles which are less than 100nm in at least one dimension.[196] [197] Many of the products selected for the analysis did not carry a nano label, yet contained titanium dioxide nanoparticles ranging between 40 and 220nm. The analysis indicated that 36% of the particles were less than 100nm in at least one dimension.[198]

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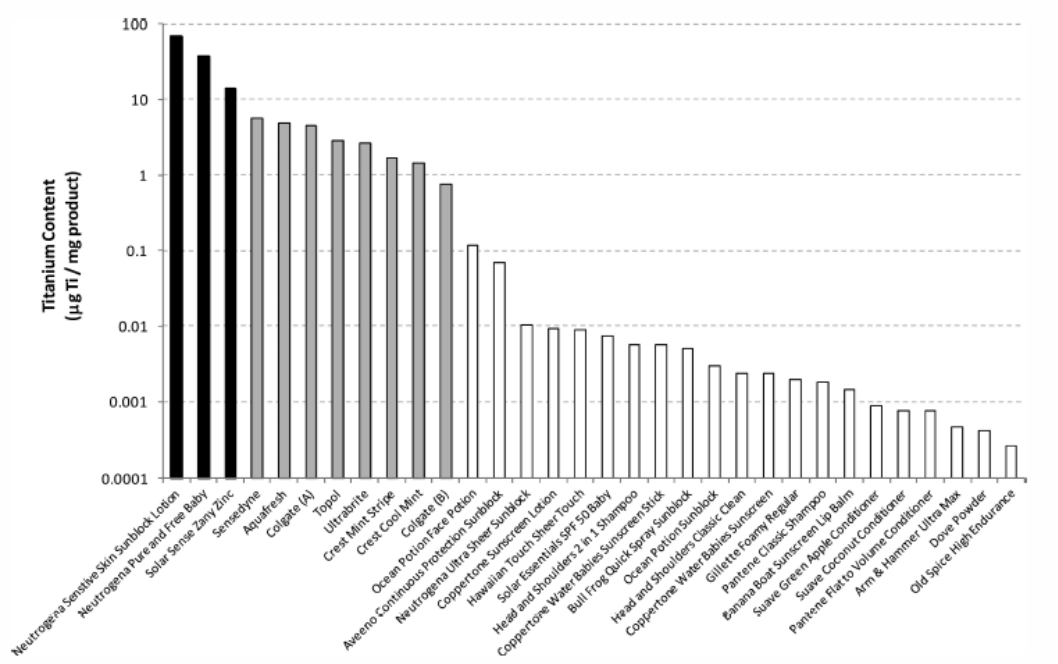
[189] CleanTechnica (2012) Titanium Dioxide, Unchained! Available at: http://cleantechnica.com/2012/06/09/titanium-dioxide-could-lead-to-low-cost-solar-and-fuel-cells/
[190] CleanTechnica (2012) Titanium Dioxide, Unchained! Available at: http://cleantechnica.com/2012/06/09/titanium-dioxide-could-lead-to-low-cost-solar-and-fuel-cells/
[191] Market Study: Titanium Dioxide, Ceresana, February 2013. Preview available at: http://www.ceresana.com/en/market-studies/chemicals/titanium-dioxide/ceresana-market-study-titanium-dioxide.html
[192] SCCS/1516/13 Scientific Committee on Consumer Safety (SCCS) OPINION ON Titanium Dioxide (nano form) COLIPA n° S75. The SCCS adopted this opinion by written procedure on 22 July 2013. Available at http://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_136.pdf
[193] SCCS/1516/13 Scientific Committee on Consumer Safety (SCCS) OPINION ON Titanium Dioxide (nano form) COLIPA n° S75. The SCCS adopted this opinion by written procedure on 22 July 2013. Available at http://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_136.pdf
[194] SCCS/1516/13 Scientific Committee on Consumer Safety (SCCS) OPINION ON Titanium Dioxide (nano form) COLIPA n° S75. The SCCS adopted this opinion by written procedure on 22 July 2013. Available at http://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_136.pdf
[195] A Weir at al, Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environ Sci Technol. 2012 February 21; 46(4)
[196] Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php
[197] For their experiments, the researchers selected a wide range of white foods from grocery stores in the U.S. Some of the foods were labelled as containing TiO_2, and others were not but the primary product or surface coatings (e.g., icings) had a white color. All 89 foods were digested using microwave methods (in a beaker with hydrogen peroxide and hydrofluoric acid), and their titanium concentration was determined.
[198] Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php

The same research also performed analysis on personal care products, which derived similar results (see the figure below, of which the white bars to the left are products that did not reference the use of TiO_2). The amounts of TiO_2 were in most cases low, but considering the widespread use of the products involved, a further focus was recommended on research on their environmental impact once disposed.[199]

Figure 2 Total titanium concentration for personal care products



"Black bars are sunscreens with TiO_2 listed on the label. Grey bars are toothpastes with TiO^2 listed on label. Open bars are for products whose labels did not reference TiO_2".

Source: Screenshot taken from A. Weir at al, Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environmental Science & Technology, 2012 February 21; 46(4)

Once discarded or used in products, TiO_2 nanomaterials eventually enter the sewage system leading to wastewater treatment plants.[200] These plants capture most of the TiO_2, however nanoparticles measuring between 4 and 30nm have been measured in the treated effluent. These nanomaterials are therefore released to surface waters, where they can interact with living organisms.[201] Quantitatively, the amounts released into the environment are unknown.[202]

Carbon Black

Carbon black is estimated to account for 9.6 million tonnes or about 85% of global production of nanomaterials. Carbon black, as placed on the market, is not strictly a nanomaterial. Carbon black is manufactured by heating a type of feedstock oil and mixing it with air in reactors. In the reactors, nanoscale carbon black particles form (called nodules – the primary particle). These nodules quickly

[199] A Weir at al, Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environ Sci Technol. 2012 February 21; 46(4)
[200] A Weir at al, Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environ Sci Technol. 2012 February 21; 46(4)
[201] Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php
[202] Nanowerk, New study shows that titanium dioxide nanoparticles are ubiquitous in food products, 15 February 2013. Available at http://www.nanowerk.com/spotlight/spotid=24290.php

come together in the reactors to form aggregates, and then the aggregates form agglomerates. Once formed, the agglomerates do not break down to the aggregate or nodule level. Carbon black pellets placed on the market are agglomerates in the 0.1 to 100 millimetre range.

Because the primary particle (the nodule) fits the definition of nanomaterial, Carbon black producers tend to refer to carbon black as a nanostructured material.

The Carbon black market

More than 90% of Carbon black is used in the rubber industry,[203] with the automotive industry being the largest consumer.[204] The primary use of Carbon black is as filler for reinforcing rubber.[205] (Amorphous) Carbon black was registered on REACH in 2009.[206]

Figures regarding the Carbon black market have not been updated recently. Tyres accounted for 69% of total volumes in 2007, while mechanical goods such as hoses, belts and rollers accounted for 23%. Special blacks (used in non-rubber outlets) make up the remaining 9%.[207]

The Carbon black market has undergone both change and growth in the last decade. Global demand grew by 7% in 2007 to 10 million tonnes, primarily driven by China.[208] The EU Member States accounted for 18% of world demand in 2007, which is also an increase on previous years. In particular growth stemmed from the Czech Republic, Hungary and Poland. Increased competition is also being experienced in the form of increased lower-cost imports from Egypt, Russia and Ukraine.[209] Thus there are indications of a shift in international supply and demand.

More recent estimates suggest that the global Carbon black market grew from an annual value of US$11 billion to more than US$14 billion in 2012.[210]

According to industry analysts, there are two main types of Carbon black manufacturers:

1. A few large-scale global manufacturers, which dominate the market
2. As a result of consistent growth rate over the past few years, numerous medium- to small-scale manufacturers have emerged in developing countries (China, Vietnam, Thailand, India, Brazil and South Korea). The Asia Pacific region is the world's largest automobile manufacturing hub – with a competitive edge by offering large quantities of low-priced carbon black based on manufacturing capacities close to raw materials, cheaper energy sources and lower tax regimes.[211] Asia Pacific consumed nearly 6 million tonne volume of Carbon black in 2012, in comparison to North America and Europe which together consumed more than 3 million tonne volume.[212]

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[203] http://www.nanopartikel.info/cms/lang/en/Wissensbasis/CarbonBlack
[204] http://www.pr.com/press-release/484009
[205] ICIS Chemical profile: Carbon black (2009). Available at: http://www.icis.com/Articles/2009/02/09/9190977/chemical+profile+carbon+black.html
[206] Pressrelease: http://chemicalwatch.com/2163/consortium-announced-for-carbon-black-substance-registration-already-submitted
[207] ICIS Chemical profile: Carbon black (2009). Available at: http://www.icis.com/Articles/2009/02/09/9190977/chemical+profile+carbon+black.html
[208] ICIS Chemical profile: Carbon black (2009). Available at: http://www.icis.com/Articles/2009/02/09/9190977/chemical+profile+carbon+black.html
[209] ICIS Chemical profile: Carbon black (2009). Available at: http://www.icis.com/Articles/2009/02/09/9190977/chemical+profile+carbon+black.html
[210] http://www.pr.com/press-release/484009
[211] http://www.pr.com/press-release/484009
[212] http://www.pr.com/press-release/484009

Industry analysts' assessment is that the Carbon black industry will grow continuously to 2018, reaching volumes close to 15 million tonnes annually. Asia Pacific will remain in a favourable position while North America and Europe are expected to begin to slow gradually over the 2013-18 period.[213]

Health and environmental aspects of Carbon black

As Carbon black in nano form has been in industrial use for many decades, the health effects from exposure have been studied for a long time.[214] Health impacts studies relate to cancer and to lung disorders.

The Carbon black industry asserts that the primary particles/aggregates do not exist outside of the reactors where the chemical is produced, although the industry has yet to fully characterise the size distribution of Carbon black to which workers are exposed. Carbon black size distribution studies are taking place, however.

Regarding the carcinogenicity of Carbon black, the evidence is inconclusive. Animal experiments on rats have shown the chemical to be cancer-causing but recent evidence indicates that this phenomenon is species-specific; that is, not applicable to humans.[215] Mortality studies on manufacturing workers and Carbon black have not found any association between exposure and elevated lung cancer rates.[216]

Similarly, morbidity studies involving workers, focused primarily on lung disorders as inhalation is the major route of exposure, have concluded that Carbon black workers do not appear to develop illnesses as a result of their work with this material.[217]

There is limited secondary material on Carbon black's environmental impact. With the exception of chemically treated and water dispersible Carbon black grades, Carbon black is most often disposed of in landfills. Carbon black is not biodegradable.[218]

Carbon Nanotubes

Industry estimates that Carbon nanotubes (CNT) have production rates of 100s of tonnes annually – not a very precise figure.[219] A CNT is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale.[220] CNTs typically have diameters ranging from <1nm up to 50nm.[221] There are high expectations on future developments for CNTs, as they have excellent mechanical, electrical and thermal, as well as conductivity, properties.[222] Although they are formed from essentially the same graphite sheet, CNTs have many structures and they vary in length, thickness, and in the type of helicity and number of layers. As a result their electrical characteristics also differ and they can act either as metals or as semiconductors.[223]

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[213] http://www.pr.com/press-release/484009
[214] Carbon Black User's Guide, Safety, Health, & Environmental Information
[215] Carbon Black User's Guide, Safety, Health, & Environmental Information
[216] Carbon Black User's Guide, Safety, Health, & Environmental Information
[217] Carbon Black User's Guide, Safety, Health, & Environmental Information
[218] Carbon Black User's Guide, Safety, Health, & Environmental Information
[219] Nanotechnologies Industries Association. Available at: http://www.nanotechia.org/sectors/chemicals-raw-materials
[220] Nanocyl. http://www.nanocyl.com/CNT-Expertise-Centre/Carbon-Nanotubes
[221] Nanocyl. http://www.nanocyl.com/CNT-Expertise-Centre/Carbon-Nanotubes
[222] Q. Zhang et al., The Road for Nanomaterials Industry: A Review of Carbon Nanotube Production, Post-Treatment, and Bulk Applications for Composites and Energy Storage, Special Issue: Low-Dimensional Carbon Materials Volume 9, Issue 8, pages 1237–1265, April 22, 2013. Abstract available at: http://www.ncbi.nlm.nih.gov/pubmed/23580370
[223] Nanocyl. http://www.nanocyl.com/CNT-Expertise-Centre/Carbon-Nanotubes

The usefulness of CNTs is that they can be functionalised; that is, different molecules or atoms can be bound to the carbon atoms of single-walled carbon nanotubes to provide the desired characteristics. There are over 50,000 functionalised CNTs; several have been identified as exhibiting similar toxicity but at different potencies.[224] The different types of CNTs are obtained through different raw materials and production processes.[225] CNTs can be characterised by their structures – Single-wall Nanotubes; Multi-wall Nanotubes; and Double-wall Nanotubes.[226]

Their potential usage is very broad and is outlined in the figure below.

Figure 3 CNT applications

	Large-volume applications	Limited-volume applications	Key attributes
Present	Sporting goods such as golf shafts, tennis rackets, baseball bats etc., battery electrode additives, plastics additives and masterbatches, fuel line systems	Battery electrodes, boat hulls & decks, wind turbine blades, prepregs, scanning probe tips, sensors, catheters, membrane filters, flat panel displays, textiles, printing & packaging	Excellent mechanical and electrical conductivity properties, compatibility, high surface area (~1000 m^2/g), excellent chemical stability in acidic environments, distinguished optoelectronic properties, insensitivity to electromigration, excellent thermal conductivities and semiconducting properties
Near term (less than five years)	Supercapacitor electrodes, transparent conducting films, field emission displays, LCDs and OLED-based displays, fuel cell electrodes, inks for printing, adhesives	Electromechanical memory device, hydrogen-storage electrodes, biosensors, multitip array X-ray sources, probe array test systems, brush contacts, thermal-management systems	
Long term (beyond five years)	Power transmission cables, structural composites applications for aerospace and automobile, photovoltaic devices	Field-Effect Transistors (FET), interconnects, flexible electronics, drug-delivery systems	

Source: M. Endo, M. S. Strano and P. M. Ajayan, "Potential Applications of Carbon nanotubes" Topics in Applied Physics, 111(2008) 13-61. Screenshot via Nanowerk, Global carbon nanotubes market – industry beckons, October 2011.

[224] C.J Green and S. Ndegwa Nanotechnology: A Review of Exposure, Health Risks and Recent Regulatory Developments. Available at http://www.ncceh.ca/sites/default/files/Nanotechnology_Review_Aug_2011.pdf
[225] T Coccini et al., Safety Evaluation of Engineered Nanomaterials for Health Risk Assessment: An Experimental Tiered Testing Approach Using Pristine and Functionalized Carbon Nanotubes, ISRN Toxicology Volume 2013 (2013). Available at: http://www.hindawi.com/isrn/toxicology/2013/825427
[226] Nanocyl. http://www.nanocyl.com/CNT-Expertise-Centre/Carbon-Nanotubes

The CNTs market

Examples of commercialisation of CNT-enabled products include racquets, golf clubs, surfboards, ice hockey sticks, mass transportation fuel system components, battery electrode additives, plastics additives, and masterbatches (a solid or liquid additive for plastic used for colouring plastics). Multi-wall CNTs-enabled engineering has also been used in cleanrooms for the production of computer chips and hard drives.[227]

In the past decade, Multi-wall CNTs have decreased in price from US$45,000 to US$100 per kg and the productivity has increased to several hundred tonnes per year for commercial applications such as lithium-ion batteries and nanocomposites. It is expected that when the prices of CNTs decrease to US$10 per kg their applications as composites and conductive fillers at a million tonne scale can be anticipated, replacing conventional Carbon black fillers.[228]

However, applications on a million tonne scale are not attainable as there currently remain too many challenges and the basic knowledge of growth mechanisms, efficient and controllable routes for CNT production, the environmental and safety issues, and the commercialisation models are still inadequate.[229]

In 2011, there were over 100 companies globally that manufacture CNTs, and by 2016 this number is expected to increase to more than 200. Simultaneously there are estimated to be more than 1,000 companies and institutions that are active in CNT research and development.[230] However, there are also examples of ceased investments in the CNT field. In May 2013 the multinational Bayer MaterialScience announced it was ending its CNTs projects and expressed concern about the mass commercialisation of CNT-enabled applications.[231]

The CNTs is dominated by a few large suppliers and producers that operate across several industries. Total industry turnover was estimated at US$668.3 million in 2010. Of this Multi-walled CNT stood for over 90% of this – US$631.5 million, with Single-walled carbon nanotubes reaching a production value of around US$36.8 million. By 2016, the industry is expected to increase to US$1.1 billion, which is equivalent to a compound annual growth rate of 10.5%.[232]

The US has the largest market share of CNTs (2010), followed by Japan, China and Germany. However, Japan is the leader in the production of CNTs, with China and South Korea catching up. In the EU, it is expected that France will take the lead in CNTs production. China and India are expected to become increasingly important as high-end plastics and composites and electronics production are shifting to these regions.[233]

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[227] Nanowerk, Global carbon nanotubes market – industry beckons, October 2011. Available at: http://www.nanowerk.com/spotlight/spotid=23118.php

[228] T Coccini et al., Safety Evaluation of Engineered Nanomaterials for Health Risk Assessment: An Experimental Tiered Testing Approach Using Pristine and Functionalized Carbon Nanotubes, ISRN Toxicology Volume 2013 (2013). Available at: http://www.hindawi.com/isrn/toxicology/2013/825427

[229] Q. Zhang et al., The Road for Nanomaterials Industry: A Review of Carbon Nanotube Production, Post-Treatment, and Bulk Applications for Composites and Energy Storage, Special Issue: Low-Dimensional Carbon Materials Volume 9, Issue 8, pages 1237–1265, April 22, 2013. Abstract available at: http://www.ncbi.nlm.nih.gov/pubmed/23580370

[230] Nanowerk, Global carbon nanotubes market – industry beckons, October 2011. Available at: http://www.nanowerk.com/spotlight/spotid=23118.php

[231] European Plastics News, Blow to carbon nanotubes, 3 September 2013. Available at: http://www.europeanplasticsnews.com/subscriber/newscat2.html?channel=410&id=3440

[232] Nanowerk, Global carbon nanotubes market – industry beckons, October 2011. Available at: http://www.nanowerk.com/spotlight/spotid=23118.php

[233] Nanowerk, Global carbon nanotubes market – industry beckons, October 2011. Available at: http://www.nanowerk.com/spotlight/spotid=23118.php

Sector-wise, the CNTs market is dominated by plastics and composites (69%) and this segment is believed to remain important. Other significant market shares are held by the electrical and electronics industries (10%) and by the energy sector (8%). It is expected that the energy sector will experience rapid growth in the next decade driven by batteries, wind turbine blades, and photovoltaic cells.[234]

Health and environmental aspects of CNTs

CNTs have been registered under REACH and are identified in at least two different Substance Information Exchange Forums (SIEFs).[235] [236] One SIEF has been set up with the purpose of registering CNTs as distinct chemicals with their own safety profile. Another, larger SIEF including the multinationals Bayer MaterialScience and Arkema, were reported as planning to register CNT as a form of bulk graphite which would not require a separate registration dossier.[237]

There are recognised knowledge gaps on environmental and health effects pertaining to CNTs, although there are a growing number of scientific articles available. The science published indicates that there are health hazards of note. Although not comprehensive or conclusive, these include:

a) Due to the needle-like shape and high durability of multi-walled CNTs, concerns have been raised that they may induce asbestos-like pathogenicity when inhaled and experiments with rodents have supported this hypothesis.[238]
b) Single-walled CNTs cause mitotic disturbances in cultured cells; however, a scientific paper from 2013 indicates that there are no current reports that single-walled CNTs are carcinogenic.[239]
c) Results of (multiple) rodent studies have showed that regardless of the process by which CNTs were synthesised and the types and amounts of metals they contained, CNTs were capable of producing inflammation, epithelioid granulomas (microscopic nodules), fibrosis, and biochemical/toxicological changes in the lungs.[240]
d) Comparative toxicity studies in which mice were given equal weights of test materials showed that single-walled CNTs were more toxic than quartz, which is considered a serious occupational health hazard if chronically inhaled.[241]

[234] Nanowerk, Global carbon nanotubes market – industry beckons, October 2011. Available at: http://www.nanowerk.com/spotlight/spotid=23118.php
[235] http://echa.europa.eu/regulations/reach/substance-registration/substance-information-exchange-fora
[236] Royal Society of Chemistry, Chemistry World, Nanomaterials cause classification headache for Reach, June 2009. Available at: http://www.rsc.org/chemistryworld/News/2009/June/16060901.asp
[237] Royal Society of Chemistry, Chemistry World, Nanomaterials cause classification headache for Reach, June 2009. Available at: http://www.rsc.org/chemistryworld/News/2009/June/16060901.asp
[238] S. Toyokuni, Genotoxicity and carcinogenicity risk of carbon nanotubes, Advanced Drug Delivery Reviews, 7 June 2013. Preview available at http://www.sciencedirect.com/science/article/pii/S0169409X1300149X
[239] S. Toyokuni, Genotoxicity and carcinogenicity risk of carbon nanotubes, Advanced Drug Delivery Reviews, 7 June 2013. Preview available at http://www.sciencedirect.com/science/article/pii/S0169409X1300149X
[240] C. Lam, A Review of Carbon Nanotube Toxicity and Assessment of Potential Occupational and Environmental Health Risks, Informa Healthcare, 2006, Vol.36, No3, Pp189-217. Available at http://informahealthcare.com/doi/abs/10.1080/10408440600570233
[241] C. Lam, A Review of Carbon Nanotube Toxicity and Assessment of Potential Occupational and Environmental Health Risks, Informa Healthcare, 2006, Vol.36, No3, Pp189-217. Available at http://informahealthcare.com/doi/abs/10.1080/10408440600570233

Synthetic Amorphous Silica (SAS)

Synthetic amorphous silica (SAS) is a form of silicon dioxide that is intentionally manufactured.[242] It has been used in industrial and consumer applications including food, cosmetics and pharmaceutical products for many decades[243] without significant changes in its physical-chemical properties.[244]

Pyrogenic, precipitated and gel SAS have internal structures in the nanoscale size range and are typical examples of recently defined nanostructured materials.[245]

The SAS market

Amorphous silica is produced to the quantity of 1.5 million tonnes per year, which is equivalent to 12% of total raw nanoscale materials production.[246] More precise commercial data is challenging to obtain. Outdated data reveals that annual European production of pyrogenic and precipitated silica in 2000 was 73,900 and 337,100 tonnes respectively, while the European consumption of these SAS was 368,000 metric tonnes;[247] thus there is an import surplus, a phenomenon that is unlikely to have changed.

Health and environmental aspects of SAS

SAS has already been registered under REACH. The first producer to do so was Evonik Industries, leading a consortium, in 2009.[248]

No environmental or health risks have been associated with SAS if produced and used under set standards.[249] This includes the nomenclature designating SAS a nanomaterial.[250]

6.2 Economic Impacts

A number of studies have sought to assess the costs and benefits of REACH.[251] These have been able to establish cost estimates in the range of €2.1 billion for the first registration period.[252] However in

[242] Association of Synthetic Amorphous Silica Producers (ASASP) Synthetic Amorphous Silica – ASASP's current interpretation as a nanomaterial. Available at http://www.sassiassociation.org/images/ASASP%20Nano%20Statement%20201210.pdf
[243] C Fruijtier-Pölloth, The toxicological mode of action and the safety of synthetic amorphous silica-a nanostructured material. Toxicology. 2012 Apr 11; 294(2-3):61-79. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22349641
[244] Association of Synthetic Amorphous Silica Producers (ASASP) Synthetic Amorphous Silica – ASASP's current interpretation as a nanomaterial. Available at http://www.sassiassociation.org/images/ASASP%20Nano%20Statement%20201210.pdf
[245] C Fruijtier-Pölloth, The toxicological mode of action and the safety of synthetic amorphous silica-a nanostructured material. Toxicology. 2012 Apr 11; 294(2-3):61-79. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22349641
[246] Nanotechnologies Industries Association. Available at: http://www.nanotechia.org/sectors/chemicals-raw-materials
[247] P-J. De Temmerman et al., Quantitative characterization of agglomerates and aggregates of pyrogenic and precipitated amorphous silica nanomaterials by transmission electron microscopy, Journal of Nanobiotechnology 2012, 10:24. Available at: http://www.jnanobiotechnology.com/content/10/1/24
[248] Evonik has succeeded in registering synthetic amorphous silica with the European Chemicals Agency – and is the first company in the market to do so. Press release available at: http://corporate.evonik.jp/region/japan/en/media/news/archive/pages/news-details.aspx?newsid=5335
[249] C Fruijtier-Pölloth, The toxicological mode of action and the safety of synthetic amorphous silica-a nanostructured material. Toxicology. 2012 Apr 11; 294(2-3):61-79. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22349641
[250] C Fruijtier-Pölloth, The toxicological mode of action and the safety of synthetic amorphous silica-a nanostructured material. Toxicology. 2012 Apr 11; 294(2-3):61-79. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22349641
[251] Centre for Strategy & Evaluation Services (CSES 2012): Interim Evaluation: Impact of the REACH Regulation on the innovativeness of the EU chemical industry. Final Report and Annexes, 14 June 2012. Available at: http://ec.europa.eu/enterprise/sectors/chemicals/documents/reach/review2012/innovation_en.htm.

[252] http://ec.europa.eu/enterprise/sectors/chemicals/documents/reach/review2012/chemical_market_en.htm

terms of impact the general focus has been on meeting objectives rather than estimating financial impact. In 2012 Bjørn Hansen, head of unit at the European Commission's environment directorate stated "It is too early to say REACH is achieving its objectives". However, he said there were "signals and signs here and there" showing that industry was now taking risk management decisions based on the legislation's health and environmental objectives.[253] Some early estimates looking at environmental benefit have focused on particular elements with very broad ranges.[254] For instance, this 2006 study cites a WWF study stating that over 30 years the reduced mortality could provide benefits in the region of €50 billion.

A particularly important aspect within the whole impact of REACH lies in the effects on SMEs.

The Commission's "Extended Impact Assessment"[255] released in 2003 provided suggestions that the costs associated to testing and registration procedures established under REACH could reinforce the trend, already present at the time, towards consolidation and concentration in the EU chemical industry.

Consolidation would consist in the reduction of company portfolio of chemical products, essentially through the withdrawal of those for which the same company is producing perfect or at least close substitutes. In other words, companies would limit their activities to chemicals leading to significant added value for their clients. The Commission argued that such consolidation could actually be welcomed by downstream users, who could reap the benefits arising from economies of scale and hence lower production costs.

Higher market concentration would arise from the market exit of firms whose viability is hampered by higher fixed costs, in particular "some specialised SMEs that produce substances in small quantities". This effect, however, "should not have a measurable impact on competition" in a highly fragmented sector.

At theoretical level, the increase in fixed costs can indeed lead to higher concentration in the market if some SMEs see their viability reduced. This effect would be stronger in a situation of lower availability of credit, as has been the case in most EU countries over the last few years, and in a sector where the information on future benefits of a small firm is not easy to access and process for potential lenders. Concentration could happen via market exit, but also through merger and acquisition processes, in particular for potentially profitable SMEs.

The shifting of costs onto downstream users and final consumers would be limited. Firstly, as a general rule, changes in fixed cost do not alter profit-maximising prices. Furthermore, when the starting condition is a highly fragmented market, the effect on prices of increases in concentration is relatively low.

Consolidation is also a sensible expectations. However, it remains unclear why benefits stemming out of economies of scale would not be realised also in absence of REACH, except for those improvement that can derive from an enhanced information base. This element constitute the pillar of future benefits of REACH, according to the Commission's document.

[253] http://www.euractiv.com/sustainability/reach-benefits-obvious-eu-admits-news-515082
[254] Giacomello et al., (2006) The Benefits Of Chemicals Regulation: DEFRA

[255] COM(2003)644 final

The information gathered would in fact benefit those in charge of risk management measures, as well as downstream users of chemical substances. It would also ease the speed of innovation across the EU.

Risk management is also one of the main area of benefits highlighted in following studies, as pointed out in the literature review presented by Okopol (2007).[256] However, those benefits are not quantified. Similarly, benefits in terms level playing fields, innovation increases and from reduction in the risk of paying health damages are only presented at qualitative level, as one could reasonably expect.

More recently, the survey by CSES (2012)[257] showed that there have been significant cost increases to firms in relation to the implementation of REACH, with total costs of registration processes estimated around €2.1 billion. This costs spurred the withdrawal of some substance, the reduction in the number of suppliers and price increases faced by downstream users. The dimensions of all three effects, however, have been found to be relatively small.

While costs have already been perceived to reduce the profitability of firms, benefits in terms of reduced uncertainties, increase in the information base and innovation activities are yet to be realised.

The recent note by the European Parliament[258] (EP) recaps the findings from CSES (2012) and other studies, and also present new evidence from interviews with a sample of firms. While there is a recognition of some growth in the general knowledge base, its positive impacts on competitiveness and innovation have been found to be very low, while some more positive views are expressed in terms of improvements of risk management.

On the other hand, despite some positive effects of support to SME, the cost of compliance with REACH regulation has been argued by respondents to the EP survey to be disproportionately higher for SMEs. This is leading to an increasing pessimism in relation to their future financial viability, up to the expectation that some SMEs will exit the market around 2018. The reduction on the number of SMEs and substances are therefore expected to become more significant over the next years, with some contrasting view over the extent of ensuing increases in prices for downstream users and final consumers.

The overall impact on the competitiveness of EU firms is found to be ambiguous, containing effects of opposite sign. The negative impact of higher costs could be compensated by the fact that EU importers may prefer to buy from EU firms, as they are compliant with REACH (otherwise the importer will face additional costs). With regards to non-EU buyers, they may be willing to pay more for safer products. This positive "confidence" effect is, however, yet to arise. Similarly, the boost to innovation from increased knowledge base has not yet materialised.

The EP note also points out that the impact of REACH is expected to be similar for innovative SMEs involved in the development of nanomaterials. Despite some differences in technical requirements, it is expected that cost increases "will be to the advantage of larger companies".

The worry expressed in the several surveys mentioned in the EP note is also shared across business associations. For instance, the UK "Federation of Small Businesses" (FSB) has recently issued a briefing note[259] expressing concern that the cost and complexity of complying with REACH "means that many small businesses could lose access to chemicals essential to their everyday business use." The

[256]Okopol (2007): "Analysis of studies discussing benefits of REACH" http://ec.europa.eu/environment/chemicals/reach/pdf/background/reach_benefit_studies.pdf
[257] CSES (2012): "Interim evaluation: functioning of the European chemical market after the introduction of REACH".
[258] European Parliament (2013): "The consequences of REACH for SMEs", DG for Internal Policies, Policy Department.
[259] FSB (2013): "Briefing Note – REACH", http://www.fsb.org.uk/policy/images/fsb%20briefing%20reach,%20may%202013.pdf

lack of in-house expertise among SMEs increases the increment in time and human resources, as well and the need to hire external consultants.

The challenges facing REACH are amplified for NM, with a consequent impact on the ability to structure a cost–benefit assessment. The additional challenges to be addressed include the relatively underdeveloped evidence base regarding NM and the fact that impact needs to be considered for materials in nano form. This is more straightforward for engineered nanoforms, but for non-engineered forms such as carbon black there is the challenge of considering a material that is only in part at a nano scale. Further issues to be considered include:

- Whilst there are estimates of the numbers of NM these are broad and there is no universally or generally accepted figure. The response to this will be to divide NM into engineered and non-engineered forms and to take the upper estimates that will include, for example, figures for pigments.
- There is a developing evidence base that nanoforms act differently in the environment, including interaction with humans and other organisms. The consequence of this difference is still a matter for debate, with associations with respiratory and other health impacts being postulated (with limited animal experiment research to draw upon). The response to this will be to generalise types of associated harm.
- It is also accepted that NM will have different types and levels of harm, with particular concern being raised in relation to engineered NM such as carbon nanotubes.
- It is difficult to estimate the downstream impact of NM – carbon black or pigments are used in thousands of products whereas carbon nanotubes are more limited. Equally, while some engineered NM will involve direct contact with consumers e.g. titanium dioxide in suncream, others will have a lower impact e.g. car paint.
- It is necessary to assess the number of workers who have contact with NM. A potential additional challenge in doing this may be that there are fewer equivalent workers working on NM than on the same non-NM forms.

The aim of the economic impact analysis is to provide global estimates of costs and benefits associated with the regulation of NM, with differentiated estimates of costs as they relate to each of the six options under consideration. This has required the use of available estimates on number of NM, number of European NM manufacturers, etc., the development of a number of assumptions and a consistent approach to extrapolation. The result has been the development of differentiated estimates of cost for each of the six options as well as an overall indicative estimate of benefits. However, the Research Team has not been able to quantitatively differentiate the options in terms of impact. This decision rested on the likelihood of the complexities involved in establishing overall impact making individual assessments for each option unreliable, but it also reflects the fact that each of the respective options could result in differing levels of compliance and differing levels of dossier quality. As an alternative the Research Team has provided a qualitative description of the potential of each option in terms of impact.

Among the economic impacts envisaged in the Commission's Impact Assessment Guidelines, the options under consideration are likely to entail effects especially (although not exclusively) in the following dimensions:

- Operating costs and conduct of business, affecting firms involved and most notably small and medium enterprises.
- Administrative burden on businesses.
- Functioning of the internal market and competition, affecting suppliers and buyers of goods across the whole supply chain, including buyers of intermediate goods and final consumers.

- Competitiveness, trade and investment flows, affecting firms, workers, consumers and overall EU economy and society.
- Innovation and research, affecting firms engaging in R&D, as well as research centres and other firms (through "spillover effects") and the overall social and economic systems in the EU.

The Research Team analyses the impacts of the options in comparison with option 1, the "baseline". As option 4 entails an incremental change with respect to the provision under option 2 (with a distinction that is mentioned below), and option 6 similarly builds upon what established in option 4, the three options are presented consecutively under the discussion of each impact.

Operating costs and conduct of business – Administrative burden on businesses – Small and Medium Enterprises

Estimates are provided for cost increments associated with requirements added or removed under each option. Possible savings are likely to arise from increments in clarity with regard to regulatory aspects.

As noted in the recent Commission's "General Report on REACH",[260] SMEs can be disproportionately affected by the cost of complying with more stringent regulations. It will be essential to ensure that rules on NM clarify the duties to firms producing, importing and/or using NM, so that estimations of likely costs can be derived with relatively ease when planning activities and in particular R&D investments.

Information on costs discussed earlier is re-produced below.

Figure 4: Summary of Total Cost per NM, distinguishing across Options and Annexes

Totals Summary for Options 2, 4, 5 and 6 (Million Euro)#	Baseline	OPTION 2 ADDITIONAL TOTAL	OPTION 4 ADDITIONAL TOTAL	OPTION 2 AND 4 both implemented (complementary measures)	OPTION 5 ADDITIONAL TOTAL	OPTION 6 ADDITIONAL TOTAL*
Realistic average cost						
(Annex X) characterisation 40K	3.16	0.06	0.02	0.08	-2.8	3.54
Annex IX) characterisation 40K	1.57	0.06	0.21	0.27	-1.18	1.93
(Annex VIII) characterisation 40K	0.49	0.14	0.49	0.63	-0.3	0.83
Annex VII) characterisation 40K	0.05	0.15	0.59	0.74	0.002	0.38
Maximal average costs						
(Annex X) characterisation 500K	3.16	0.65	0.02	0.67	-2.8	4.06
Annex IX) characterisation 500K	1.57	0.65	0.27	0.92	-1.18	2.45
(Annex VIII) characterisation 500K	0.49	0.74	0.66	1.39	-0.3	1.35
Annex VII) characterisation 500K	0.05	0.74	0.79	1.53	0.002	0.9

These costs are for testing and preparing/amending a dossier for one additional nanoform within one substance dossier.

*Costs for an additional set of baseline tests, new dossier, plus additional NM-specific characterisation, TK and fate&behaviour work. Assumes 2 and 4 have been implemented, but costs for 2 and 4 have not been added to Option 6 total, as this would double account for some tests.

[260] COM (2013) 49 final: "General report on REACH".

Significant cost increase can arise under option 4 and especially under option 6, especially in the short-run. As a result, the viability of small and medium firms could be hampered under these options. On the contrary, the cost reductions entailed by option 5 could ease market entry and permanence of SMEs.

Option 2

Two-thirds of respondents to the Public Consultation report that costs of compliance would increase under this option; "significantly" according to 34.5%.

According to ECHA, this option does not increase obligations but clarifies information requirements. However, the additional detailing of the scope of registration dossiers and of the characterisation, use, absorption behaviour of NM and so forth may entail both higher operating costs and administrative burden.

The cost increase in absolute terms is relatively modest, although it is significant in proportion to baseline costs in the "heavy characterisation" range, most notably in Annex VII.

It is important to note that, especially in the medium/long term, these costs may be compensated by savings, which could be higher or lower than cost increases. These savings arise from the increased clarity and hence reduced regulatory uncertainties, which permit firms to better plan business activities entailing the use of NM. Furthermore, the benefit that REACH brings about in terms of improvements in risk management measures (RMM) would be further enhanced by option 2, addressing the specificities of NM. Finally, the increment in the knowledge base regarding the property of NM is also likely to reduce costs in the long run, via higher production efficiency entailed by the appropriate use of NM.

Given the relatively small increase in costs, the Research Team does not expect significant impacts on the viability of the firms operating in the manufacture and trade of NM.

Likewise, downstream impacts on prices paid by firms buying products containing NM and on consumers are likely to be modest.

Option 4

The vast majority of respondents to the public consultation (79.30%) agree that costs of compliance with REACH regulations would increase under option 4, although the level of those who consider that the costs would "significantly increase" is not higher than with option 2. The recent BiPRO report for the Commission[261] provided estimates, in reference to nine of the requirements included in this option, ranging from €11 million to €73 million assuming grouping and read-across, and from €100 million to €600 million without those possibilities.

Our analysis points out that the increment in costs provoked by option 4 varies depending on characterisation and annex, as with all other options, and also on whether it includes M14 specification, considering water solubility in relation to test waiving.

In the future, the stronger testing requirements from option 4 and especially option 6 could also provoke some reductions in the uncertainties surrounding NM. The increased knowledge would therefore reduce the cost-increasing effect of these options in the long run.

[261] BiPRO (2013) "Examination and assessment of consequences for industry, consumers, human health and the environment of possible options for changing the REACH requirements for nanomaterials", Final Report, prepared for the European Commission, Joint Research Centre, Institute for Health and Consumer Protection.

The analysis on the effects on the prices paid by downstream users is complicated by the complexities involved not only in cost estimates but also in the multiplicity of NM, of their different uses and of the market structures of the sectors involved in the supply chains of products containing NM.

One aspect those different cases have in common is that the costs involved are “fixed”, meaning that if a firm has to engage in costly activities determined under this option, increasing its level of production using the same substances does not involve any additional cost. This implies that the profit-maximising sale price (facing a given, downward sloping “demand function”) does not change, unlike what happens when “variable” or “unit” costs increase, in which case decreasing production and increasing price is the profit-maximising response.

What could lead to downstream price impact is the possible exit from the market of some firms. In market structure with limited numbers of competitors, the reduction in the number of suppliers does lead to higher prices.

The Research Team lacks sufficient information to understand to which extent the viability of small and medium firms having to sustain the costs implied under option 4 could be affected. On one hand, the expenditure could, for some firms, be higher than the net present value of current and future profits. This would mean that option 4 would compromise the *economic viability* of some firms. On the other, some firms, despite being potentially profitable even taking into account those costs, may be unable to finance the immediate expenditure. This would mean that option 4 undermines the *financial viability* of those firms. This is likely to be a significant problem especially for firms operating in areas of the EU where financial systems have been severely affected by the crisis.

The cost-sharing possibilities provided in REACH in reference to Annex VII-X changes ameliorate these dangers.

Option 6

Option 6 adds more obligations than those established under option 4 and option 6. It would entail a higher number of dossiers and would add more requirements, e.g. in reference to presenting separate dossiers for NM that differ among themselves in terms of specific characteristics (coating, shape, form etc.).

Cost increases are substantial under this option. Increases vary from 110.9% (Annex X, basic characterisation) to 1,500% (Annex VII, “heavy” characterisation).

Respondents to public consultations express views that are in line with these estimates, as almost 90% indicate cost increases and half expect a “significant increase”.

The impacts on the viability of SMEs explained under option 4 move in the same directions, but their magnitude is stronger. SMEs involved in the manufacturing or importing of NM could see their viability severely affected.

Despite the fact that those incremental costs are “fixed”, impacts on prices paid by downstream users could be substantial if several firms were forced out of the market and a position of “market dominance” was created as a result of this option. More information is needed to establish whether this is likely to be the case in a relevant number of markets.

It is important to underline the possibility that, in the long run, the cost-increasing effect of this option could diminish while, on the other hand, firms could enjoy the benefits, including savings in safety procedure, stemming from an improved knowledge base from test results.

Option 3

Although more than 40% of respondents to the public consultation believe that a cost increase would arise from option 3, non-binding measures are unlikely to provoke increment of operational and administrative costs, except for those that firms may incur in order to achieve savings and/or benefits that would compensate them. At this stage the Research Team is unable to identify whether new practice established within the industries affected would hamper the operations of SMEs, that could, on the other hand, benefit from the generation of a common pool of information that they have relatively less capability to generate.

Option 5

Only 30.4% of respondents to the public consultation believe that option 5 would reduce costs of compliance; significantly so according to 9.7%.

Our evidence shows that substantial cost savings would only arise in case this option entailed read-across possibilities, under M24 or M33, which could however undermine the safety enhancing aspect of testing, as discussed below among social impacts.

As a symmetric counterpart to previous reasoning in reference to the other options, reductions in prices paid by downstream users are unlikely to arise, as this option would only entail lower fixed costs, unless new firms see this cost reduction as a removal of an entry barrier into an oligopolistic market, in which case prices would decrease.

Functioning of the internal market and competition

Previous studies (e.g. JCR-BiPRO and ETUI mentioned above) highlight the key role of SMEs in relation to production and processing of NM. Our case studies confirm a high level of market fragmentation, in particular for titanium dioxide. Big producers of carbon black are mostly located outside the EU, while importers into EU, which will be affected by new rules, tend to be relatively small firms operating in competitive markets.

Option 2

In principle the clarification involved in this option may foster an increment in the circulation of goods, due to a possible increase in confidence across borders with regard to product characteristics and safety. In that respect, approximately two-thirds of respondents to the public consultation believe that safety in the use of NM would increase. There are no concrete data at the moment validating this hypothesis.

Option 4

The effect on consumer confidence and hence on the circulation of goods described above in reference to option 2 would be potentially stronger under option 4, especially due to its greater focus on the prevention of diseases.

On the other hand, the possible effects on the viability of SMEs, in particular for NM subject to Annex VIII or VII, could also change the competitive landscape in several sectors, leading to greater market concentration in the manufacturing and importing of NM. Higher market concentration could also entail higher prices downstream in the supply chain.

Option 6

The further increment in requirement established under option 6 could enhance the magnitude of the effects mentioned under option 4 in terms of market concentration, and hence prices charged to

downstream users. The same holds with regard to confidence in safety of NM, although respondents to the public consultation do not indicate enhanced safety impacts with respect to option 4.

Option 3

The Research Teamdo not anticipate significant impacts on the viability of SMEs and hence on market structure under option 3. On the other hand, there could be positive effects in terms of easier circulation of goods in presence of greater clarity, if the latter results from “soft law” measures.

Option 5

Almost half of the respondents to the public consultation express the belief that safety in the use of NM could be undermined. Possible higher uncertainties with regard to safety could undermine the circulation of goods. Market concentration is unlikely to be affected; in fact, existing fragmentation in many EU sectors could even rise if lower costs boost market access.

Impacts on consumers

Following the logic described above, impacts on prices paid by buyers are likely to be limited, due to the “fixed” nature of the costs. While “variable” costs, i.e. costs per unit of product, do tend to be shifted in part downstream, with an effect that tends to be amplified in case of a long supply chain (such as the case here as NM are introduced into intermediate products), fixed costs do not entail impacts on profit-maximising prices. On the other hand, increases in market concentration, which may arise under option 4 and especially under option 6, could lead to price impacts.

As a general rule, if the price of NM increases, the impact on downstream users will increase with every passage along the supply chain, as each buyer of intermediate product will usually apply a profit margin on the prices of its output.

Limitations in data and high variability in the markets affected mean it is not possible to draw clear-cut conclusions.

Besides prices, other impacts on consumers relate to information and protection. At this stage the Research Team does not have enough information to establish ex ante, for each option, to which extent consumers are likely to receive and benefit from information specifically referring to NM. In principle consumers could enjoy the benefit from higher confidence in the characteristics, and in particular on the safety, of the products they are buying under each option. Stricter regulations may in fact ameliorate the “asymmetric information” problem, hence consumers can be more trustful on the characteristics of the products. Consumer confidence also entails effects in terms of competitiveness, which is analysed in more detail below. In any case, these effects are less relevant than potential effects in terms of real health benefits, in case a given option reduces actual chances to develop diseases.

Finally, availability of different substances to buyers of intermediate goods could also be affected. A previous KPMG impact assessment on REACH[262] reports that case study analysis provides no indication of future significant impacts in terms of availability of substances. While the Research Team cannot provide further evidence in that respect, increased information on NM arising from options establishing stronger test requirements could increase the knowledge base and future product development.

[262] KPMG (2005) “REACH – Further work on impact assessment. A case study approach”, Final report.

The effects of the options on health and safety are discussed in more detail in section 6.3 on social impacts.

Competitiveness, trade and investment flows, capacity to innovate

The current REACH framework is seen as comparatively advanced in terms of chemical regulatory system and there is evidence that Asian regulators are aiming to catch up with the gaps in their systems.[263] Specific regulations regarding NM are being developed in the US and in Asia. Also in that respect the Research Team understand that the EU is leading the way in terms of approaching potential hazards.

In the USA, a White House document[264] indicates that while "the mere existence of a hazard, regardless of the probability of it causing harm, may trigger some form of regulatory action", "In general, however, and to the extent consistent with law, regulation should be based on risk, not merely hazard, and in all cases the identification of hazard, risk or harm must be evidence-based". Nevertheless, the Environmental Protection Agency (EPA) is developing a Significant New Use Rule (SNUR) under section 5(a)(2) of the Toxic Substances Control Act (TSCA) that "require persons who intend to manufacture, import, or process certain nanoscale materials for an activity that is designated as a significant new use to submit a Significant New Use Notice (SNUN) to EPA at least 90 days before commencing that activity." This SNUN would "provide the Agency with a basic set of information on nanoscale materials, such as chemical identification, material characterisation, physical/chemical properties, commercial uses, production volume, exposure and fate data, and toxicity data." Furthermore, EPA is also "considering regulating pesticides containing nanoscale material under the Federal Insecticide, Fungicide & Rodenticide Act (FIFR)".[265]

In Asia there are no specific regulations and authorities are monitoring developments in EU and US regulations, used as benchmarks. However, Park remarks that in Japan the Ministry of Economy, Trade and Industry (METI) is developing toxicity test protocols and risk assessment methodologies for manufactured nanomaterials, while the National Institute of Occupational Safety and Health Japan (JNIOSH) is analysing exposure to manufactured nanomaterials at the workplace (Park, 2012).[266]

Overall, it appears that European REACH rules are already quite advanced in the global context. The implementation of option 2 would provide greater clarity in the EU regulatory environment, while options 4 and 6 would further reinforce the strong level of testing requirements in comparison to US and other counterparts. The effects on the competitiveness of EU firms operating with NM could be twofold. On one hand, increments in costs, possibly partially compensated by savings, would potentially harm the ability to compete in international markets. On the other hand, regulatory certainty, improvements in the knowledge and exchange of information could instead bolster competitiveness. In that respect, the interim evaluation on the effects in the chemical markets of REACH[267] reports that benefits are still to

263 Park, DaeYoung, REACHing Asia Continued (September 16, 2009). Available at SSRN: http://ssrn.com/abstract=1474504 or http://dx.doi.org/10.2139/ssrn.1474504

264 http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/nanotechnology-regulation-and-oversight-principles.pdf

265 http://www.fs.fed.us/research/nanotechnology/nanomaterials.php

266 Park, DaeYoung, Nanomaterials in Existing and Emerging Chemical Regulation of China, Japan, Korea, U.S., and the European Union (September 17, 2012). Available at SSRN: http://ssrn.com/abstract=2147746

267 Centre for Strategy & Evaluation Services: Interim Evaluation: Impact of the REACH Regulation on the innovativeness of the EU chemical industry. Final Report and Annexes, 14 June 2012. Available at: http://ec.europa.eu/enterprise/sectors/chemicals/documents/reach/review2012/innovation_en.htm

be realised. It can therefore also be expected that possible benefits in relation to provisions regarding NM would also materialise in the long term.

With regard to the capacity to innovate, it is difficult to foresee at this stage the effect of overall REACH regulations on innovation activities. In that respect, the KPMG impact assessment reports no substantial changes related to REACH with regard to R&D investments by firms in the chemical sector. Similarly, the more recent CSES[268] interim evaluation mentions that there has been no significant effect in terms of innovation activities. The JRC-BiPRO study also mentions that impacts on innovation from requirements related to NM could also arise in different directions, with increased knowledge being a possible driver of positive future impacts. Again, limitations in available data lead us to provide only qualitative analysis.

Options entailing significant enhancement of requirements, such as options 4 and 6, would entail both positive and negative impacts on innovation. On one hand, an increase in fixed costs could hamper innovation as compliance costs would take away resources that could otherwise be devoted to R&D activities. This negative effect would be even stronger if costs would reduce the financial viability of a number of SMEs working with nanotechnologies. On the other hand, testing requirements would in the medium and long term increase the knowledge base in the sector with regard to the characteristics of NM, possibly facilitating their employment in new avenues for innovation in nanotechnologies.

Option 2

The implementation of this option would aim to foster greater clarity and quality of dossier. In that case, and for suppliers of NM with limited cost impact, the competitiveness of EU producers using NM would increase, with positive effects in turn related to trade and investment flows. In the long run, possible cost increases would be likely to be offset by savings arising from higher efficiency in risk management processes and from the enhanced knowledge base in relation to NM.

Reductions in uncertainties could also foster R&D activities and innovation.

The impacts on competitiveness are summarised in the following table, which follows the European Commission's Operational Guidance for assessing impacts on sectoral competitiveness.[269] Please note that the impacts on innovation will be presented in the following section.

Cost and price competitiveness	Positive	Negative
Cost of compliance	Possible savings in the long term	Likely to increase slightly in the short term.
Cost of capital	May decrease in the long term due to reduced uncertainties	
Cost of production, distribution, after-sales services		Cost of production may

[268] Centre for Strategy & Evaluation Services (CSES 2012): Interim Evaluation: Impact of the REACH Regulation on the innovativeness of the EU chemical industry. Final Report and Annexes, 14 June 2012. Available at: http://ec.europa.eu/enterprise/sectors/chemicals/documents/reach/review2012/innovation_en.htm.

[269] SEC(2012)91 FINAL - European Commission (2012): "Operation Guidance for assessing impacts on sectoral competitiveness within the Commission Impact Assessment System", Commission Staff Working Document

		increase slightly in the short term.
Price of outputs (directly not through the cost, e.g. price controls)	Exit of some SMEs could lead to increase in prices. Unlikely to have a major impact.	
International competitiveness	Positive	Negative
Market shares (single market)	Possible increase due to higher confidence in EU products containing NM. Possible replacement of dangerous NM, to the advantage of producers of substitute products.	Possible exit from the market of producers or users of NM found to be dangerous.
Market shares (external markets)	Possible increase due to higher confidence in EU products containing NM	Possible exit from the market of EU producers or users of NM found to be dangerous.
Revealed comparative advantages	Possible increase due to higher confidence in EU products containing NM	
Capacity to innovate	Positive	Negative
Capacity to produce and bring R&D to the market	Stimulated by generation of information base on NM	Slight increase in cost of compliance could reduce resources devoted to R&D.
Capacity for product innovation	Same as above	Same as above
Capacity for process innovation (including distribution, marketing and after-sales services)	Unlikely to be affected	
Access to risk capital	In the long run fewer uncertainties may increase access to capital	

Option 4

Lack of specific data limits the scope of the analysis to the following reasoning, of qualitative nature.

The effects on costs, previously discussed, could hamper the competitiveness of EU firms. This effect is likely to be counterbalanced, as the specific incremental requirement could enhance buyers' confidence in the quality and safety of intermediate and final goods produced in the EU.

The existing REACH provisions regarding information sharing, like the "Data Sharing & Substance Information Exchange Forum (SIEF), reinforce the possible positive impacts on competitiveness of this option.

Similarly, the volume and value of trade and investment flows, as well as movement of goods across the EU and exports towards third countries, could increase due to higher confidence in product safety, or be reduced if cost increases drive firms out of business.

With regard to impacts on the capacity to innovate, enhancing requirements as established under option 4 can entail impacts of different signs. If costs increase, firms may be tempted to replace NM and hence give up related innovation possibilities. The opposite holds if savings arise. Hence, results in terms of costs will be used in order to shed light on impacts on innovation and research activities. The option could reduce or increase regulatory uncertainties, thereby stimulating or hampering innovations in the relation to NM. Greater clarity can also foster a level playing field, favouring those businesses that are more sensitive to safety issues, which may find themselves at a disadvantage under lighter requirements. Furthermore, the outcomes of testing activities can also enhance the knowledge base regarding the characteristics of nanomaterials.

Impacts could be reinforced by the "spillover" effect of innovation activities in case they are fostered (or hampered) by requirements under this option. Benefits from innovation activities related to NM manipulation could in fact spread across different firms, institutions and research centres, and ultimately contribute towards stronger competitiveness of the general EU socioeconomic system.

Cost and price competitiveness	Positive	Negative
Cost of compliance	Possible savings in the long term from improvement in risk management and enhanced knowledge of NM.	Likely to increase, especially in the short term.
Cost of capital	May decrease in the long term due to reduced uncertainties.	May increase if cost increases render the financial viability of SME uncertain.
Cost of production, distribution, after-sales services		Cost of production likely to increase, especially in the short term.

Price of outputs (directly not through the cost, e.g. price controls)		Exit of some SMEs could lead to increase in prices of NM (due to higher market concentration) that would be reflected in a price increase for downstream users.
International competitiveness	Positive	Negative
Market shares (single market)	Possible increase due to higher confidence in EU products containing NM. Possible replacement of dangerous NM, to the advantage of producers of substitute products.	Possible exit from the market due to higher costs. Possible exit if some NM are prohibited on safety grounds.
Market shares (external markets)	Possible increase due to higher confidence in EU products containing NM	Possible exit of firms unable to cope with increase in fixed costs. Possible exit from the market of EU firms if some NM are found to be dangerous in the short term – in the long term, prohibitions are likely to align in other markets.
Revealed comparative advantages	Possible increase due to higher confidence in EU products containing NM.	Possible disadvantage, especially in the short term, due to higher costs for EU firms.
Capacity to innovate	Positive	Negative
Capacity to produce and bring R&D to the market	Stimulated by generation of	Increase in cost of compliance could

	information base on NM	reduce resources devoted to R&D. Possible exit from the market of some SMEs operating in nanotechnologies.
Capacity for product innovation	Same as above	Same as above
Capacity for process innovation (including distribution, marketing and after-sales services)		Higher compliance costs could force SMEs to reduce investment in process innovation.
Access to risk capital	In the long run fewer uncertainties may actually increase access to capital	Uncertainty in financial viability could worsen the risk profile of SMEs.

Option 6

The summary table refleced a higher intensity of the effects presented above, in reference to option 4

Cost and price competitiveness	Positive	Negative
Cost of compliance	Possible savings in the long term from improvement in risk management and enhanced knowledge of NM.	Likely to increase .substantially, especially in the short term.
Cost of capital	May decrease in the long term due to reduced uncertainties.	May increase if cost increases render the financial viability of SME uncertain, thereby worsening the risk profile of those firms..
Cost of production, distribution, after-sales services		Cost of production involving NM as inputs likely to increase

		significantly, especially in the short term.
Price of outputs (directly not through the cost, e.g. price controls)		Exit of some SMEs as well as cost-shifting could lead to increase in prices of NM (due to higher market concentration) that would be reflected in a price increase for downstream users.
International competitiveness	Positive	Negative
Market shares (single market)	Possible increase due to higher confidence in EU products containing NM. Possible replacement of dangerous NM, to the advantage of producers of substitute products.	Higher possibility (with respect to option 4 and to all other options) of exit from the market due to higher costs. Possible exit if some NM are prohibited on safety grounds.
Market shares (external markets)	Possible increase due to higher confidence in EU products containing NM	Possible exit of firms unable to cope with increase in fixed costs. Possible exit from the market of EU firms if some NM are found to be dangerous in the short term – in the long term, prohibitions are likely to align in other markets.
Revealed comparative advantages	Possible increase due to higher confidence in EU	Likely disadvantage, especially in the short term, due to

	products containing NM.	higher costs for EU firms.
Capacity to innovate	Positive	Negative
Capacity to produce and bring R&D to the market	Stimulated by generation of information base on NM	Increase in cost of compliance could reduce resources devoted to R&D. Possible exit from the market of some SMEs operating in nanotechnologies.
Capacity for product innovation	Same as above	Same as above
Capacity for process innovation (including distribution, marketing and after-sales services)		Higher compliance costs could force SMEs to reduce investment in process innovation.
Access to risk capital	In the long run fewer uncertainties may actually increase access to capital	Uncertainty in financial viability could worsen the risk profile of SMEs.

Option 6 would in fact entail the same effects summarised in the table above in reference to option 4, but possibly with a greater intensity, both in terms of costs and in terms of beneficial spread of knowledge and buyers' confidence about relevant aspects of NM. A better understanding of the properties of NM, including toxicity and hazard in relation to coating and other aspects, can ameliorate the risks inherent in innovation and research activities. Cost increases, on the other hand, could affect the budget that firms devote to R&D. The Research Team do not have available data in order to determine which of those effects arise and prevail, and to which extent this option would boost or thwart innovation.

Option 3

Guidance under the "soft law" could have a small impact on competitiveness. The Research Team anticipate no substantial effects in relation to the aspects summarised in the tables presented for the previous options. Some limited effects may arise as recommendations could improve the landscape for innovation and research activities via reductions in uncertainties surrounding NM.

Option 5

The reduction of administrative burdens aims to enhance competitiveness mainly through cost reduction. The provisions under this option, on the other hand, may entail negative variations in safety and buyers' confidence. Changes reducing requirements can entail impacts of different signs on innovation and R&D activities. If, on one hand, savings can liberate resources, on the other hand lower testing activities can also diminish the collection of new information regarding NM.

Cost and price competitiveness	Positive	Negative
Cost of compliance	Cost decrease in relation to NM.	Possible long-term savings due to increased knowledge of NM are limited if informational requirements are reduced.
Cost of capital	Limited effect. May increase in the long term if reductions in informational requirements preserve uncertainties.	Enhanced viability may facilitate access to capital.
Cost of production, distribution, after-sales services	Likely to decrease, especially in the short term.	
Price of outputs (directly not through the cost, e.g. price controls)	Entry of new SMEs could result in stronger competition and decrease in output prices, in relation to NM and to products for which NM are used as input down the supply chain.	
International competitiveness	Positive	Negative
Market shares (single market)	Possible increase in the combined output of NM producers or importers, and in the output of firms using NM as production input.	Possible decrease (in comparison with the counterfactual option 1) due to lower confidence

		in EU products containing NM.
Market shares (external markets)	Possible increase due to lower cost of production for EU NM producers and importers.	Possible decrease (in comparison with the counterfactual option 1) due to lower confidence in EU products containing NM.
Revealed comparative advantages	Cost decrease.	Possible decrease (in comparison with the counterfactual option 1) due to lower confidence in EU products containing NM.
Capacity to innovate	Positive	Negative
Capacity to produce and bring R&D to the market	Reduction in cost of compliance could enhance resources devoted to R&D. Prevention of possible exit from the market of some SMEs operating in nanotechnologies.	Reduction in information requirements would entail less creation of new information regarding NM, that would otherwise be useful for innovation activities.
Capacity for product innovation	Same as above	Same as above
Capacity for process innovation (including distribution, marketing and after-sales services)	Lower compliance costs would allow firms, and SMEs in particular, to invest more in process innovation.	
Access to risk capital	Improvement in the risk profile of SMEs due to lower costs of compliance.	In the long run, uncertainties in safety could increase the risk associated with

		activities entailing the use of NM, and hence worsen the risk profile, in particular for SMEs.

Public authorities

The Research Team did not have data on the cost related to the activities of public authorities, so instead provide qualitative reasoning.

Option 2

This option requires additional efforts on the authorities' side in order to provide greater clarity. It is likely to entail some limited budgetary impact.

Option 4-6

These options would entail costs related to the verification of the incremental requirements.

Option 3

The additional guidance under the "soft law" approach would entail budgetary consequences that, naturally, depend on the concrete implementation of this approach.

Option 5

Savings would arise from limiting requirements and therefore verification duties.

Please refer to figure above for a scheme including the effects mentioned above, along with the social and environmental impacts discussed below.

6.3 Social Impacts

The potential social impacts stemming from the implementation of the options mainly involve the following areas:

- Employment and labour markets, affecting firms, workers and public authorities.
- Standards and rights related to job quality, affecting primarily workers but also their employers.
- Public health and safety, affecting workers, buyers of intermediate goods and final consumers, and the overall society.

Employment and labour markets

The development of nanotechnology is increasingly associated with job creation, as mentioned in section 2 on problem definition. Modification in regulatory requirements regarding NM may ease or hamper job creation, in firms specialised in nanotechnologies and in the other businesses operating with nanoforms. Data on the workforce involved in testing are very limited, and it is impossible to quantify

likely effects. The Research Team provide here a qualitative evaluation of the mechanisms behind effects in labour market.

Among previous studies, the CSES interim evaluation reports a downward trend in employment in the chemical sectors which is not, in principle, associated with REACH but rather to a long-term relocation trend of activities outside Europe, mainly into Asia, and increases in productivities leading to less need for workers. On the other hand, REACH also led to the creation of specialised units within firms devoted to regulatory requirements. Specific NM requirements are likely to have similar effects.

Option 2

Increases in the details regarding NM, defined under option 2, would create demand for professional services related to registration and testing. This would be the most direct, and possibly the strongest, effect. The extent of the positive impacts of this increase in demand on employment and salaries depend on several factors, including the landscape in specific sectors and in the overall economy.

The magnitude of salary growth depends on whether there is a “reserve” of unemployed people with required professional characteristics, in which case salary rates would remain largely unaffected, or if on the contrary there is scarcity of available workers, in which case firms will need to compete to attract them. Situations in EU labour markets widely vary across countries and regions, the presence of high unemployment effects will mainly involve an increase in employment rather than in salaries; the opposite will be true in contexts with low unemployment.

Labour demand would increase even more if increases in buyers’ confidence determine an expansion in the markets for goods produced using NM.

On the other hand, if some of SMEs involved in the supply of NM close down as a result of higher costs, this would shift downward the labour demand in the sectors affected, with negative impacts on employments and salary rates.

Option 4-6

As testing requirements increase in option 4 and even more so in option 6, the effects described above are likely to be stronger, having the same sign as in option 2.

Therefore increase in demand for professional figures involved in testing procedures would be expected to increase under option 4 and especially under option 6.

On the other hand, the materialisation of the danger of closedown for SMEs analysed above would negatively affect labour demand, and hence salaries and employment for workers operating in firms involved in the processing of NM.

Option 3

The “soft law” approach is likely to have a limited impact on labour market outcomes, unless authorities establish a remarkable increase in their operation and spur a significant market expansion effect.

Option 5

Limitations in the specificities of requirements regarding nanoforms could reduce demand for professional figures devoted to registration, testing and verification procedures. This effect could be counterbalanced by the possible effect of boosting economic activity via cost reductions.

Standards and rights related to job quality

The **job quality** dimension mainly involves safety in relation to the manipulation of substances containing NM.

The case studies above point towards potential issues in relation to lung cancer and other pathologies related to the respiratory tract. In particular a potential occupational safety issue may arise in relation to carbon black, although existing evidence is inconclusive, and in the manipulation of carbon nanotubes.

A document by the European Trade Union Institute[270] underlines that nanoparticles pose potential dangers additional to the ones already recognised in current REACH regulation with regard to chemical substances. Inhalation is the main route to exposure to nanoparticles, which can deposit in the respiratory tract and also be transported to other organs as they can easily enter the blood stream. Ingestion and absorption through skin are other potential entry routes, from which nanoparticles can enter the blood stream. Therefore NM could in principle exacerbate the occupational dangers inherent in the manipulation of chemical substances.

The 2003 Commission Staff Working Paper the "Extended Impact Assessment" of REACH[271] mentions that "it is impossible to identify the benefits that will arise from REACH" (p.25), and then provides an estimate of benefits equating to a 10% proportion of overall health damages related to chemicals that REACH might prevent.

It is even harder to establish and quantify health benefits for workers and consumers from modifications accounting for the specificities of NM. The recent BiPRO-JCR report, for instance, points out the lack of data that would allow a proper "bottom-up" approach to quantification of health benefits, namely, quantification which would take into account the number of health-damaging incidents avoided (or arising from) every different option and then quantify health impacts (e.g. number of lung cancer cases from inhalation exposure) and finally proceed to a monetary conversion of those impacts.

The lack of data on actual incidents affecting human health makes it impossible to provide reasonable estimates on the likely dimension of health damages that would arise in the counterfactual scenario, in the absence of specific intervention related to NM.

The Research Team therefore present potential impacts at qualitative levels. An economic evaluation of the potential benefits in relation to avoided health harm, in particular with regard to lung cancer is also provided. This is consistently found to be the principal dimension when it comes to estimating health damages in relation to chemicals, and in particular to nanomaterials.[272] For instance, the DHI study for DG Environment finds that when the willingness-to-pay approach is adopted and health benefits of REACH are expressed in terms of avoidance of cancer, then these health benefits represent between 93% and 95% of the overall benefits of REACH.[273] Similarly, the RPA study also for DG Environment indicates benefits of REACH over 30 years in relation to cancer prevention in the €17,591.6–€54,166.8 million interval and total benefits for occupational health (including impacts on skin, respiratory tract, eye and CNS) in the €17.6–54.4 million interval, representing a 99% of impact

[270] Ponce del Castillo, A.M. (2013): "Nanomaterials and workplace health & safety. What are the issues for the workers?" European Trade Union Institute.
[271] COM (2003) 644 Final, http://ec.europa.eu/enterprise/sectors/chemicals/files/reach/eia-sec-2003_1171_en.pdf
[272] Reihlen, A. and Luskow, H. (2007): "Analysis of studies discussing benefits of REACH", a Okopol report for the European Commission.
[273] DHI (2005): "The impact of REACH on the environment and human health", ENV.C.3/SER/2004/0042r, report to DG Environment.

attributable to cancer.[274] In absence of epidemiological data, the analysis of potentially harmful impacts of NM shows that effects on the lungs constitute the main danger, confirming findings from previous studies.[275]

A hurdle in estimation stems from the fact that there are no available data concerning the number of workers in contact with NM in the whole EU. The ETUI study[276] indicates that 3,340 workers are involved in NM production in France, but a recent update by the same authors upscales the figure to 8,500.[277] As previously mentioned, the European Chemical Industry Council estimated that by 2015 there will be around two million nanotechnology jobs worldwide, of which 300,000 to 400,000 will be in Europe.[278] Another projection forecasts 6 million new nanotechnology workers required by 2020 worldwide (Roco, 2011).[279] All studies concur that the use of NM is likely to increase significantly in the next future. There is at present no information regarding how many workers are involved in the production of NM, with the exception of the estimates mentioned above with regard to France,[280] and especially with regard to the extent of exposure for downstream users, while all studies mentioned underline the growth of nanotechnology applications and hence in the number of workers and consumers involved. As a first estimate, according to OECD estimates, there are 524 nanotechnology firms in France, and 2,014 overall in the EU.[281] This means that overall EU firms are 3.84 times French firms operating with nanotechnologies. In absence of specific data on workers involved in NM in all countries, take the assumption that the proportion "French-EU" for workers exposed to NM is the same as the proportion of nanotech firms. Multiplying the 8,500 number of workers exposed to NM to this 3.84 factor, it is estimated that there would be 32,640 workers exposed to NM in the EU. If the workforce exposed grows at the same rate indicated by Roco (2011) over the 2000–2008 period, 25% then over a period of 30 years, there will be **26,366,382 workers exposed to NM in 2042**.

The number of workers who would be saved from lung cancer as a result of a given regulatory intervention is much harder to estimate, given that there is no conclusive evidence of actual health impacts. As a first step, the Research Team has used the definition of a low risk level corresponding to a cancer incidence of 5 per 100,000 exposed workers, proposed in the REACH baseline study by Eurostat (2009).[282] Then the Research Team has made an assumption about the extent to which an option lowers that risk. For instance, a reduction equalling 20%[283] would entail avoiding cancer to 1 out of 100,000 workers. This approximation should be taken as a weighted average of the very variable risk levels entailed by the different NM and should be taken for illustrative purposes. The numbers can obvioulsy be modified,for instance modifying upwards ot downwards the level of risk in relation to NM to start with, besides the ameliorating effects of each option...

[274] RPA (2003): "Assessment of the Impact of the New Chemicals Policy on Occupational Health,", report for DG Environment.
[275] See, European Agency for Safety and Health at Work (EU-OSHA) (2009): "Workplace Exposure to Nanoparticles", https://osha.europa.eu/en/publications/literature_reviews/workplace_exposure_to_nanoparticles
[276] Aída Maria Ponce Del Castillo (2013): "Nanomaterials and workplace health & safety: What are the issues for workers?" European Trade Union Institute, 2013
[277] http://www.etuc.org/IMG/pdf/12-PONCE.pdf, quoting •INRS (2007) Production et utilisation industrielle des particules nanostructurées. Note documentaire 2277-209-07.
[278] www.cefic.org/Policy-Centre/Environment--health/Nanomaterials
[279] Roco, MC (2011): "The long view of nanotechnology development: the National Nanotechnology Initiative at 10 years" *Journal of Nanoparticle Research*, 13 (2), 427-445.
[280] A UK survey found that 385 workers at UK universities use nanomaterials. See http://www.hse.gov.uk/nanotechnology/nano-survey.pdf
[281] OECD, Key Nanotechnology Indicators, http://oe.cd/kni, June 2013.
[282] Eurostat (2009): "The REACH baseline study", European Commission, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-003/EN/KS-RA-09-003-EN.PDF
[283] This equates to the percentage increase in safety due to option 4 requirements, according to the expert consulted for the JCR-BiPRO study. However, please consider this percentage and the consequent avoidance of 1 cancer for each 100,000 as an example of what, based on the following estimation, the monetary value of intervention would be.

On the basis of the above calculations of workers exposed to NM, saving 1 out of 100,000 workers each year from lung cancer would avoid 1,317 cases over the 2013–2042 period.

The comparison of costs and benefits of policy option entails the need to quantify, and even monetise health impact. The basic question here would be: how much would society be willing to pay to avoid that one person getting lung cancer?

This question can be divided in the following elements:

- The loss to the person of years of life and of quality of life during a given period.
- The loss of productivity if the person is or was working at the time of developing cancer, if the disease prevented him or her to continue working.
- Healthcare expenditures, whether sustained by the person or the family or, as usually the case in the EU, by the society at large.

Healthcare expenditures are usually defined as "direct cost", while the former are "indirect costs" related to morbidity and mortality. Indirect costs are determined converting measure of quality and length of life such as DALY (disability-adjusted life years) or QALY (quality-adjusted life years) into money value. It is understood that the UK National Institute for Health and Care Excellence assign a value of £20,000–30,000 to one QALY when determining whether to reimburse a given health technology (e.g. a new drug),[284] and that the value assigned for life-threatening condition tends to be on the high range. Further estimations point to higher values, so the Research Team has adopted the £30,000 value in the estimation below, which converts into €36,000 using 1.2 exchange rates as per 7 November 2013.

The Research Team has estimated the monetary value of direct and indirect costs related to the risk of cancer. More specifically, the costs related to a person (averaging gender proportions) resident in the UK, who at 45 years of age will get lung cancer approximately 25 years later:

- €12.897.5 direct costs
- €133,383.6 indirect costs

The total, **€146.281**, is likely to be an underestimate due to the fact that occupational health risk related to hazardous substances may materialise before 25 from the onset, and in general before the person reaches 70 years of age (hence the loss of years of life may be much greater). Furthermore, the distance from the onset of cancer also results in heavy discounting (a 3.5% discount factor is used).

The indirect costs increase substantially, to **€519,412** if the disease starts 10 years after exposure, and to **€687,026** if it starts after 5 years, while direct costs sum up to **€21,607.80** in the former case and **€25,663.30** in the latter. Overall, the benefit of avoiding one lung cancer case that would arise 10 years from now sum up to **€541,020**, and to **€712,689** if the cancer avoided would start in five years.

Research specifically oriented to willingness-to-pay measures points towards similar values in relation to avoiding lung cancer. For instance, Cameron et al. (2009) find that a willingness-to-pay for 45-year-old people to reduce by 1 millionth the chance of getting lung cancer varies between $0.78 (death in

[284] Rawlins, M., Culyer, A. (2004): "A National Institute for Clinical Excellence and its value judgement", *British Medical Journal* 329: 224-7.

five years) and $0.97 (instant death). The DHI (2005)[285] study uses willingness-to-pay estimates derived from the literature review conducted in by Eftec (2004) for the UK government,[286] whereby fatal cancer cases caused by pollution were "valued" at **€1 million** (non-fatal at €400,000). Reporting to 2013 according to the UK government GDP deflator,[287] fatal cancers (the majority of lung cancers) would be valued at **€1,245,315**.

The following table summarises the estimates mentioned above, in relation to fatal lung cancer. The current value of those benefits form saving one out of 100,000 workers from cancer over the 2013–2042 period, is also provided using the 3.5% discount factor.

Benefits from avoiding one case of lung cancer				
	Matrix estimates			Eftec
Disease starts after	25 years	10 years	5 years	unspecified
Avoided costs	€146,281	€541,020	€687,026	€1,245,215
Saving 1 out of 100,000, 2013-2042	€82,400,192	€304,756,954	€387,002,238	€701,430,502

If the period was changed, two variations would ensue:, the amount of the current value would be reduced due to discounting. However, the number of workers "saved" would increase as the number of people in contact with NM is increasing. As the discount rate used is 3.5% and the growth rate of the workforce is assumed to be 25%, the second effect would clearly prevail.

Naturally, the most important assumption relates to the number of workers saved by the policy option. As there is no definitive proof of specific dangers related to NM, the number of avoided cases of lung cancer could in principle be null, hence there would be no benefits at all. On the other extreme, if NM turned out to entail dangers similar to those caused by asbestos, then the benefits of the interventions would be much higher, up to 100 times those estimated above.[288]

Those estimates above relate to how a given option would reduce the risk of lung cancer. Again, while this is by no means the only impact, it is the one that previous studies identified as the most relevant when proposing monetary values of the various social, economic and environmental impacts related to regulations on chemicals. As will be seen below, options 4 and 6 are those entailing reductions in the risk of lung cancer, while also causing higher costs in comparison both to the status quo and to the other options. Option 5 entails improvements in terms of cost reductions, but at a risk of losing some of the health benefits of REACH given the limitations in the scope of testing on the different specificities of NM.

[285] DHI (2005): "The impact of REACH on the environment and human health", ENV.C.3/SER/2004/0042r, report to DG Environment.

286 Eftec (2004): The Health benefits of Pollution Control: A Review of the Literature on Mortality and Morbidity Effects. London: DEFRA. Available at: http://www.defra.gov.uk/environment/airquality/valuation/workshop.htm

[287] See https://www.gov.uk/government/publications/gdp-deflators-at-market-prices-and-money-gdp-march-2013

[288] See e.g. the impact of exposure to asbestos on mortality in Yano E, Wang ZM, Wang XR, Wang MZ, Lan YJ.(2001): "Cancer mortality among workers exposed to amphibole-free chrysotile asbestos", *American Journal of Epidemiology,* 154(6): 538-43.

The illustrative figures relate to what have been found to be the impacts to which the higher costs are associated in terms of harms in reference to chemicals. Nevertheless, describing impacts solely on the basis of avoidance of lung cancer would result in an underestimation of the overall benefits of options reinforcing health and environmental safety.

Option 2

Two-thirds of respondents to the public consultation indicated the belief that option 2 would increase the safe use of NM. The percentage of those that expect a significant increase is limited to 28.3%.

Our analysis indicates that enhanced clarity can improve the effectiveness of current testing procedures, although potential health benefits do not reach the extent established under options 4 and 6.

This is the case, for instance, from the additional information about the nature of the NM being tested, established under M02, or the requirement that NM are specifically address (M03), but especially with regard to the M09 requirement of identification of uses and exposure assessment of the nanoform.

Overall, this option would entail potentially positive impacts on occupational health safety, albeit to a more limited extent in comparison with options 4 and 6, described below.

The impacts in relation to the specific requirements are presented in the table below.

Option 2 requirements	Impacts on health
M01 Explicitly require registrants to describe the scope of the registration dossier	No impact
M02 Explicitly require registrants to provide more detailed characterisation of nanomaterials/nanoforms	**Increased knowledge about the nature of the material being tested.** To have an impact on health, the material tested should be shown to be the same/similar as that to which humans are exposed in the various scenarios (e.g. ingested, inhaled by skin exposure). If the material identified is different from that to which humans are exposed, there would be no impact of knowing this information. Information on the physicochemical properties of the nanomaterial could raise questions around the validity of the toxicology data in the “standard” package, i.e. the confidence of a negative (favourable non-adverse) outcome may be reduced. It could also lead to more focused testing (e.g. inhalation cancer testing if shape and size was a health concern).

M03 Require that nanoforms are explicitly addressed in the endpoint sections	The Research Teaminterpret this to mean **increased knowledge about the characterisation and toxicokinetic properties of the material** such that data from standard assays can be interpreted in the context of the dosed material being introduced to the system as a nanomaterial; i.e. is the test outcome expected to be valid for the material tested? If the material has not changed its form (from that to which organisms are exposed), and has absorbed into the test system in a physical form similar to that which would be experienced in the organism, then the test result would be valid for the nanomaterial form. If the material has changed to something the body does not experience or is not absorbed then the endpoint result could be questioned. By not explicitly addressing the toxicokinetics, biotransformation and aggregation of the nanoforms in the endpoint sections, means some test result outcomes could be erroneous (both negative and positive).
M04 Require detailed description of the test material / sample and sample preparation	As for M03 - Would aid interpretation of whether the test data was valid
M05 Require scientific justifications for grouping / read-across / QSAR and other non-testing approaches for different forms	**Reduces test requirements but high uncertainty in outcome.** An area of high uncertainty and unlikely to be achievable for nanoparticles at the current time due to lack of data. If no testing were done, and read-across could be performed using other structurally related toxicants then nanoforms could be identified and classified as harmful toxicants by similarity but there may be a risk of false positives (e.g. classifying materials that need not be classified). Confidence in read-across from non-toxicants would be low, and there may be false negatives (i.e. not classifying when they should be).
M06 Require considerations of most appropriate / relevant metric with preferable presentation in several metrics	Aligns to the exposure assessment and relevant metrics used (e.g. for oral, dermal and inhalation exposures)
M07 Require that bioaccumulation is addressed specifically for the nanoform	Knowing whether there is bioaccumulation of nanomaterials in tissues and organs would raise a flag of concern for many potential health points and target organ toxicities and could lead to classification as PBT. Bioaccumulation may not always lead to toxicity however.

M08 Specify that absorption/desorption behaviour of nanomaterials should not be assessed based on Kd values derived from Koc and Kow	Not relevant
M09 Require identification of uses and exposure assessment of the nanoform	**Influences test needs.** Could drive the need for testing by particular routes e.g. oral, dermal or inhalation, to cover off potential cancer in gut, skin, lung, and target organ toxicities via route-specific systemic absorption

Option 4

This option entails a significant increase in requirements with respect to the baseline. Those requiring data on dustiness (M10), route of exposure (M11) and non-bacterial in vitro gene mutation study (M13) could potentially entail significant improvements on occupational safety, especially in terms of prevention of lung cancer, ameliorating the informational asymmetries suffered in this case by workers, who may ignore the extent of exposure to hazardous substances. Those health impacts would affect workers in the chemical sector but also those in downstream sectors using nanomaterials. Benefits would also indirectly affect employers, as they are legally responsible for workplace safety, as specified by the European Framework Directive 89/391/EC.

Under this option, potential risks related to lung cancer and other serious conditions, especially in relation to respiratory diseases, would be ameliorated. As is the case with previous evaluation exercises conducted for nanomaterials, and also with regard to the evaluation of REACH in general, it is difficult to establish to what extent occupational risk of a given condition is reduced under a specific regulatory option. Nevertheless, the Research Team will provide some estimations of monetary values of possible impacts.

The following table details the impacts of each requirement under option 4, in addition to the ones specified in reference to option 2.

Option 4 requirements	Impacts on health
M10 Include information on dustiness	**Prevention of Lung Cancer, Lung disease** (e.g. fibrosis). Small particles <10 micron (all nanoparticles) can enter the deep lung, larger particles cannot. Fibres can bioaccumulate in the lung. By virtue of their size nanoparticles are a physical hazard to the lung. Dustiness as a measure of particles/m^3 air could be relevant to risk assessment if a quantitative risk assessment framework exists for lung toxicity? A risk assessment can be performed if exposure (particles/m^3 air) is known and an effect can be quantitatively measured in an inhalation study. There may be a school of thought that even if only a small number of particles are airborne they present an unacceptable hazard/risk of adverse lung disease?

M11 Require acute toxicity data for the most relevant route of exposure (assumption - inhalation)	**Protects workers from death or serious harm** Can identify serious acute hazards if high (accidental) dose exposure is experienced and relevant to Classification & Labelling
M12 Change “particles” to “(nano)particles” for repeated dose toxicity studies (inhalation)	Null - the data would be the same in the study
M13 Require non-bacterial in vitro gene mutation study (annex dependent)	**Prevention of cancer, birth defects**, other effects of genetic damage – If the study were shown to be positive (adverse) then this would identify a potential genotoxin/mutagen and would trigger the need for an in vivo study to investigate further. NB. If the study were negative (favourable) the confidence in this result may be low unless kinetics data showed that the material had entered the cell.
M14 Consider water solubility in relation to test waiving (annex dependent)	**Information about the validity of performing tests.** If water solubility is low, some standard in vitro tests (e.g. testing using cells in aqueous solutions) may not be relevant to perform as the material does not enter the cell. Some in vivo tests may still need to be performed to cover the endpoint and the test be modified to ensure delivery of material. The test may need to be accompanied by toxicokinetics/distribution information or delivery into the test system in different ways e.g. via intraperitoneal routes or in special delivery vehicles etc. Sparingly water soluble materials can get into the body to cause toxic effects however.
M15 Specify that long-term testing should not be waived based on lack of short-term toxicity (for Annex VII and VIII additional testing); 0 additional testing for Annex IX and X (already done).	**Perform long-term testing to prevent cancer, and all forms of systemic toxicity related disease.** Confidence in the short-term tests is low. Short-term testing may not lead to confident “negative” (favourable) observations. These tests have not been validated as good predictors of chronic health effects (e.g. cancers, birth defects, chronic organ failures etc.) for nanomaterials which may work by different mechanisms (e.g. involving aspects of their physical form) than standard chemicals. Therefore perform long-term testing.
M16 Specify that algae testing should not be waived based on insolubility	No impact
M17 Require that testing on soil and sediment organisms is prioritised	No impact

Option 6

Option 6 further reinforces the prevention of disease established under option 2 and option 4. Additional requirements in terms of physico-chemical characterisation (M44) and separate documentation for each nanoform (M45) can enhance the informational benefits of testing, and establishing inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded (M50) can help protect from cancer and other respiratory diseases.

Impacts of all requirements that option 6 adds on top of those listed for options 2 and 4, are listed below.

Option 6 requirements	Impacts on health
M39 Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing	No impact
M40 Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution	No impact
M41 Information requirements for substances covered by Annex III (b) must also apply to nanoforms	No impact
M42 For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation is considered	No impact
M43 For nanoforms, require all available information on the use is considered, even when the use would not be covered by the registration	No impact
M44 For nanoforms, require additional physico-chemical characterisation along the particle's fate when particle properties impacts on hazard	**Assures relevance of test to real life exposure and helps protect people against the correct form tested.** For each test performed, concomitant characterisation is needed to show it is the same in the test as the nanomaterial to which humans are exposed
M45 Phys-chem, (eco)tox and CSA documented separately for each nanoform (retest and document dossier for each nanoform)	**Protect from all adverse health exposure to different nanoforms.** Each nanoform is different and the outcome of the tests could be different, so the Research Teamhave interpreted this as needing to have test data for each form
M46 For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation	To improve the knowledge of non-testing approaches and cross-validating the outcomes of non-testing vs testing approaches. No impact to health yet if not used in anger.

M47 Require adapted DNEL setting based on different routes through the value chain / specific uses	Assures relevance to exposure scenario. Specific uses of nanoforms needed
M48 Add to the SDS information relevant to Nano registries in Member States	No impact
M49 Specify that list of substances in Annexes IV and V does not cover nanoforms of these substances	No impact
M50 Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded	**Protects for lung cancer/lung disease** Perform all testing via inhalation, with particular attention to the delivery of nanomaterial in the correct nanoform into the inhalation dosing chamber. May require additional characterisation as part of the study
M51 Perform toxicokinetic screening (assume for all routes in vivo)	**Perform an ADME study for the route of exposure. Helps to direct most relevant testing programme for protecting people.** This might best be an upfront consideration (e.g in Option 2?) of any testing strategy for nanomaterials as it determines whether the body is likely to be exposed to the material and findings on toxicokinetics can dictate the type of testing needed – local gut, skin and lung or systemic target organ toxicity? See p113 of the JRC report Section 4.2.2.1 on Toxicokinetics. Quotes from JRC: "it is of key relevance to compare available ADME data for a nanoform with ADME information for other nano and non-nanoforms"; "ADME data are also relevant to decide whether or not specific tests required at specific tonnage levels need to be performed or not"; "ADME data are also very relevant when considering read-across"
M52 For nanoforms, request 28 day repeated dose toxicity in Annex VII	**Protect against all adverse systemic toxicity.** Test required. Assumes material is dosed in the correct nanoform, by the relevant route and absorbed into the test animal. Assume inhalation is often the most relevant route.
	No impact

NOTE: IF results of repeat dose testing leads to the need for a 2-year bioassay (inhalation most likely route)	Protect against cancer and all adverse systemic toxicity.

Option 3

The “soft law” approach could in principle entail some, limited health impact. A full-fledged analysis cannot be developed without knowing ex ante which types of measures would be developed.

Option 5

Here the analysis will focus on the extent to which the requirements removed under this option limit the risk of accident. This option could potentially entail a higher risk of disease for workers. The considerations developed for options 4 and 6 in terms of reduction of risk, in particular in relation to lung cancer, are reversed here. While there is no clarity with regard to actual risks in relation to nanomaterials, this option could allow potential dangers to materialise, and could therefore limit the health benefits, also in comparison with option 2 requirements. For instance, the omission of mutagenicity and acute toxicity tests in lower tonnages could result in missing the identification of adverse health impacts (e.g. cancer) and possibility of accidental death from acute exposure.

Option 5 requirements	**Impacts on health**
M18 Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms	Preparation of an accompanying report to justify read-across. See M05 above
M19 Specify that nanoform specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous/ dangerous	Unclear on what basis it would be classified as hazardous/dangerous
M20 Specify that a coated nanomaterial is considered as a special mixture e.g. in classification and labelling as accepted e.g. alloys	A coated nanomaterial would have distinct properties and is therefore thought of as distinct toxicologically.
M21 Specify that the granulometry concept in 7.14 of Annex VII includes also shape and surface area of nanomaterials	Would be useful to specify shape and surface area. Helps to characterise the material better to know what type of nanoform is being assessed
M22 Specify that the information on dustiness is required for nanoforms only where relevant for the worker safety assessment	Protects workers from lung disease/lung cancer. Exposure scenario dictates the risk assessment ie if no one is to be exposed then the information on dustiness does not add value. This position would not cover accidental exposure. If workers are exposed and information on dustiness is known, then a risk assessment could be done and risk management put in place.

M23 Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints	Two things are combined here: 1) Solubility Waiving here could miss identifying problems for lung toxicity. Insoluble nanomaterials are problematic to the lung if airborne. 2) Similar nanoforms - what would be the criteria to define similarity - chemical or physical form? No guidance. May just relate to oral and dermal routes?
M24 Specify that the use of non-testing methods (e.g. read across, grouping, categorisation etc. methods) is a priority for nanoforms	Too little information to relate chemistry to toxicological properties, to be confident on using read across for nanoforms at present time.
M25 Specify and require explicitly that waiving of testing on the basis of exposure conditions and categories applies also for nanoforms, in particular when nanoforms are completely reacted (cured), incorporated or embedded into a completely cured matrix or permanent solid polymer forms, or otherwise used in closed systems or controlled conditions	If the organism is not exposed, there would be no effects. If zero exposure can be shown, then no tox testing is impactful, except for accidental exposures.
M26 Specify that absorption/desorption behaviour of nanoforms can be based on biological surface adsorption index, affinity coefficient or other relevant parameters	Not relevant
M27 No specific obligations for nanoforms in 1-10 tonnage band	May miss identifying genotoxins/mutagens
M28 No specific obligations for nanoforms in 10-100 tonnage band	May miss screening for systemic health effects
M29 No nanomaterial specific obligations for 2nd exposure route at 10-100 tonnage band for acute toxicity	Could miss effects by the key route. The key route for the exposure scenario should be assessed, as route to route extrapolation for nanoforms is not valid scientifically
M30 Specify that information generated according to existing test guidelines and/or test methods is sufficient for the purposes of hazard assessment of nanomaterials under REACH	May miss screening for health effects, if tests are not valid. Key issues around delivery and toxicokinetics of nanomaterials in the test systems, that are specific to nanoforms, could be missed if this option were adopted. The basic 'toxicology' protocol to OECD guideline could be relevant but in practice may need to be modified case by case?
M31 A nanoform consisting of aggregates is considered same as bulk form and the same endpoint information for (eco)toxicological and environmental fate apply	No impact
M32 No specific obligations for nanoforms to provide ecotoxicological and environmental fate information	No impact
M33 Create presumption that non-testing methods are valid for nanomaterials in all endpoints	In principle yes, but in practice there is no data or guidelines to justify read across at present

M34 Amend the granulometry information requirements in Annex VII (1-10 tonnage band) for nanomaterials in line with Annex II, Section 9.1.a of REACH on Safety Data Sheet and respective ECHA Guidance on Compilation of Safety Data Sheets	No impact
M35 Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys	No impact
M36 Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS)	Would only lead to minimal information on one parameter, when many parameters contribute to the overall description of the nanoform
M37 For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696)	
M38 Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative	Miss adverse health impacts e.g cancer and possibility of accidentla death from acute exposure. It is possible that low exposures and low doses may cause toxicity for nanomaterials - dose-response relationships are currently unknown. Omitting mutagencitiy testing could lead to non identified genotoxins that could be relevant for adverse human health. Could miss identifying local skin effects. Costs to industry would be reduced from baseline

Public health and safety

The most direct health and safety impact is on the workers manipulating NM, which have been described above.

There is a priori a lower risk for potential danger for the final consumer, in comparison with workers, in relation to products during the elaboration of which NM have been employed. The additional safety provided to workers under options 4 and 6 could in principle benefit consumers, but in this case positive health impacts (and negative in relation to option 5) are likely to be smaller than in relation to occupational health. A potential exception pointed out in the case study analysis related to titanium dioxide, in particular in relation to powders or spray products. A monograph by the International Agency for Research on Cancer states that “Titanium dioxide is possible carcinogenic to humans (Group 2B) based on sufficient evidence on experimental animals and inadequate evidence from epidemiological studies”[289].

Other public health aspects relate to environmental issues, analysed below.

[289] http://monographs.iarc.fr/ENG/Publications/techrep42/TR42-4.pdf

6.4 Environmental Impacts

A previous report to DG Environment[290] identified several ways in which REACH regulations can ameliorate the discharge of chemicals into the environment. REACH can prevent harm in relation to several dimensions highlighted in the Commission's Impact Assessment Guidelines, such as **air quality, biodiversity, flora, fauna and landscape, soil quality, waste production, environmental risks, animal welfare**. Nanomaterials could in principle exacerbate environmental risks, as substances in nano form may more easily penetrate into the environment.

Data availability is very limited, so the analysis consists of a qualitative discussion of environmental impacts, keeping in mind that those impacts may in the long term turn into public health issues.

Option 2

Specification under this option improves the information derived from tests, without leading to clear-cut impacts in terms of environmental protection. This is the case, for instance, with regard to the M07 requirement that bioaccumulation is addressed specifically for the nanoform.

The summary of the impacts of option 2 is presented in the following table.

OPTION 2 REQUIREMENTS	ENVIRONMENTAL/TESTING IMPACTS
M01 Explicitly require registrants to describe the scope of the registration dossier	None
M02 Explicitly require registrants to provide more detailed characterisation of nanomaterials/nanoforms	One would know more about the nature of the material being tested. To have an impact on the environment, the material tested should be shown to be the same/similar as that to which the environment is exposed in various scenarios. If the material identified is different from that to which the environment is exposed, there would be no impact of knowing this information. Information on the physico-chemical properties of the nanomaterial could raise questions around the validity of the testing data in the "standard" package, i.e. the confidence of a negative (favourable non-adverse) outcome may be reduced.

[290] DHI (2005): "The impact of REACH on the environment and human health", ENV.C.3/SER/2004/0042r, report to DG Environment.

M03 Require that nanoforms are explicitly addressed in the endpoint sections	The Research Teaminterpret this to mean increased knowledge about the characterisation and toxicokinetic properties of the material such that data from standard assays can be interpreted in the context of the dosed material being introduced to the system as a nanomaterial; i.e., is the test outcome expected to be valid for the material tested? If the material has not changed its form (from that to which organisms are exposed), and has absorbed into the test system in a physical form similar to that which would be experienced in the organism, then the test result would be valid for the nanomaterial form. If the material has changed to something the body does not experience or is not absorbed then the endpoint result could be questioned. By not explicitly addressing the toxicokinetics, biotransformation and aggregation of the nanoforms in the endpoint sections, means some test result outcomes could be erroneous (both negative and positive).
M04 Require detailed description of the test material / sample and sample preparation	As for M03 – Would aid interpretation of whether the test data was valid
M05 Require scientific justifications for grouping / read-across / QSAR and other non-testing approaches for different forms	Reduces test requirements but high uncertainty in outcome. An area of high uncertainty and unlikely to be achievable for nanoparticles at the current time due to lack of data. If no testing were done, and read-across could be performed using other structurally related toxicants then nanoforms could be identified and classified as harmful toxicants by similarity but there may be a risk of false positives (e.g. classifying materials that need not be classified). Confidence in read-across from non-toxicants would be low, and there may be false negatives (i.e. not classifying when they should be).
M06 Require considerations of most appropriate / relevant metric with preferable presentation in several metrics	Aligns to the exposure assessment and relevant metrics used
M07 Require that bioaccumulation is addressed specifically for the nanoform	Ecotoxicology tests relating to bioaccumulation would be performed specifically for all different nanoforms of the same material. If persistence was seen, this would lead to P classification.
M08 Specify that absorption/desorption behaviour of nanomaterials should not be	Increases confidence in the testing results for this parameter. If something is highly adsorbed –

assessed based on Kd values derived from Koc and Kow	flag of concern for the environment. But not necessarily toxic.
M09 Require identification of uses and exposure assessment of the nanoform	Influences testing needs

Option 4

Similarly as with health impact, requirements under option 4 provide concrete measures to limit hazard to the environment. M15 specification that long-term testing should not be waived based on lack of short-term toxicity contributes to preserve wildlife; M17 requires that testing on soil and sediment organisms is prioritised and M16 helps prevent harm to algae, while M13, requiring non-bacterial in vitro gene mutation study, provides information regarding toxicity to mammalian wildlife and agricultural animals.

The summary of the impacts of the requirements that option 4 adds on top of those related to option 2 is presented in the following table..

OPTION 4 REQUIREMENTS	ENVIRONMENTAL/TESTING IMPACTS
M10 Include information on dustiness	Not relevant
M11 Require acute toxicity data for the most relevant route of exposure (assumption – inhalation)	Not relevant
M12 Change “particles” to “(nano)particles” for repeated dose toxicity studies (inhalation)	Null – the data would be the same in the study
M13 Require non-bacterial in vitro gene mutation study (annex dependent)	Consider impacts of genetic tox data re toxicity to mammalian wildlife and agricultural animals
M14 Consider water solubility in relation to test waiving (annex dependent)	Information about the validity of performing ecotoxicology tests.
M15 Specify that long-term testing should not be waived based on lack of short term toxicity (for Annex VII and VIII additional testing); 0 additional testing for Annex IX and X (already done).	**Prevent harm to environment/wildlife.** Long-term tests are performed to highlight potential hazards to ecology
M16 Specify that algae testing should not be waived based on insolubility	Do the algae test to predict harm to algae in the environment
M17 Require that testing on soil and sediment organisms is prioritised	Concern about nanomaterials entering soils and sediment and persisting in the environment. Could enter food chain and cause harm to environment, wildlife etc.

Option 6

This option provides limited additional protection to the environment, in comparison with option 4. M44 increases test relevance, while M45 helps protect against environmental harm through imposing separate documentation for each nanoform.

Option 6 involves all the impacts listed before in reference to options 2 and 4, plus the ones listed in the following table.

OPTION 6 REQUIREMENTS	ENVIRONMENTAL/TESTING IMPACTS
M39 Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing	No impact
M40 Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution	No impact
M41 Information requirements for substances covered by Annex III (b) must also apply to nanoforms	No impact
M42 For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation is considered	No impact
M43 For nanoforms, require all available information on the use is considered, even when the use would not be covered by the registration	No impact
M44 For nanoforms, require additional physic-chemical characterisation along the particle's fate when particle properties impacts on hazard	Assures relevance of test to real life exposure.
M45 Phys-chem, (eco)tox and CSA documented separately for each nanoform (retest and document dossier for each nanoform)	Protect environment from all damage
M46 For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation	To improve the knowledge of non-testing approaches and cross-validating the outcomes of non-testing vs testing approaches. No impact to environment yet if not used in anger.
M47 Require adapted DNEL setting based on different routes through the value chain / specific uses	Assures relevance to exposure scenario. Specific uses of nanoforms needed

M48 Add to the SDS information relevant to Nano registries in Member States	No impact
M49 Specify that list of substances in Annexes IV and V does not cover nanoforms of these substances	No impact
M50 Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded.	No impact
M51 Perform toxicokinetic screening (assume for all routes in vivo)	No impact
M52 For nanoforms, request 28 day repeated dose toxicity in Annex VII	No impact
	No impact
NOTE: IF results of repeat dose testing leads to the need for a 2-year bioassay (inhalation most likely route)	No impact

Option 3

The soft-law approach is likely to have a limited environmental impact.

Option 5

The main environmental danger under this option lies in the risk of missing the identification of ecotoxins, due to the removal of specific obligation for nanoforms in the 1-10 and 10-100 tonnage bands established under M27 and M28.

The summary of the impacts of option 5 is presented below.

OPTION 5 REQUIREMENTS	ENVIRONMENTAL/TESTING IMPACTS
M18 Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms	Preparation of an accompanying report to justify read-across. See M05 above
M19 Specify that nanoform specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous/ dangerous	No impact

M20 Specify that a coated nanomaterial is considered as a special mixture e.g. in classification and labelling as accepted e.g. alloys	No impact
M21 Specify that the granulometry concept in 7.14 of Annex VII includes also shape and surface area of nanomaterials	Would be useful to specify shape and surface area. Helps to characterise the material better to know what type of nanoform is being assessed
M22 Specify that the information on dustiness is required for nanoforms only where relevant for the worker safety assessment	No impact
M23 Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints	Clarify what they are here
M24 Specify that the use of non-testing methods (e.g. read-across, grouping, categorisation etc. methods) is a priority for nanoforms	Too little information to relate chemistry to toxicological properties, to be confident on using read-across for nanoforms at present time.
M25 Specify and require explicitly that waiving of testing on the basis of exposure conditions and categories applies also for nanoforms, in particular when nanoforms are completely reacted (cured), incorporated or embedded into a completely cured matrix or permanent solid polymer forms, or otherwise used in closed systems or controlled conditions	If the organism is not exposed, there would be no effects. If zero exposure can be shown, then no tox testing is impactful, except for accidental exposures.
M26 Specify that absorption/desorption behaviour of nanoforms can be based on biological surface adsorption index, affinity coefficient or other relevant parameters	i.e. recommending more relevant test methods for this parameter
M27 No specific obligations for nanoforms in 1-10 tonnage band	May miss identifying ecotoxins
M28 No specific obligations for nanoforms in 10-100 tonnage band	May miss identifying ecotoxins
M29 No nanomaterial specific obligations for 2nd exposure route at 10-100 tonnage band for acute toxicity	Not relevant
M30 Specify that information generated according to existing test guidelines and/or test methods is sufficient for the purposes of hazard assessment of nanomaterials under REACH	Key issues around fate and behaviour of nanomaterials in the test systems, that are specific to nanoforms, could be missed if this option were adopted. The basic “toxicology” protocol to OECD guideline could be relevant but

	in practice may need to be modified case by case?
M31 A nanoform consisting of aggregates is considered same as bulk form and the same endpoint information for (eco)toxicological and environmental fate apply	No impact
M32 No specific obligations for nanoforms to provide ecotoxicological and environmental fate information	No impact
M33 Create presumption that non-testing methods are valid for nanomaterials in all endpoints	No impact
M34 Amend the granulometry information requirements in Annex VII (1-10 tonnage band) for nanomaterials in line with Annex II, Section 9.1.a of REACH on Safety Data Sheet and respective ECHA Guidance on Compilation of Safety Data Sheets	No impact
M35 Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys	No impact
M36 Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS)	No impact
M37 For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696)	No impact
M38 Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative	No impact

The following figure illustrates the main economic impacts of the options modifying regulatory requirements. As an example, the analysis shows the chain of short-term effects that would arise if stronger requirements entail higher costs of compliance.


Stronger regulatory requirements
Costs (operating and admin burden)
Greater knowledge of nanomaterials (esp. long term), better RMM processes
Prices (+)
Buyers' confidence (+)
Market concentration of affected products (+)
Public expenditures (+)
Competitiveness and trade (+/-)
Innovation and research (+/-)
Occupational, public health and environmental safety (+)

7.0 Option Comparison

The Option Comparison process follows the requirements of the European Commission's Impact Assessment Guidelines by:

- Presenting a summary overview of economic, social and environmental impacts for each option under consideration:
- Setting out a comparison of the options against the baseline scenario; and
- Comparing the options on the basis of effectiveness, efficiency and coherence.

The Research Study has not developed general, specific and operational objectives, but has rather drawn upon the objectives set out in the Study Terms of Reference, which it has considered alongside the overall objectives for REACH.

The European Commission's Draft Roadmap states:

> The objective of the policy initiative is to ensure further clarity on how NM are addressed and safety demonstrated in registration dossiers. REACH must ensure a high level of health, safety and environmental protection. At the same time it should permit access to innovative products and promote innovation and competitiveness. The regulatory environment affects time to market, marginal cost structure and allocation of resources, especially for SMEs. It also creates new business opportunities and contributes to consumer and investor confidence in the technology.[291]

In addition the Commission has sought to further develop the objectives by setting out the following General and Specific Objectives[292].

> **General objective**
>
> The aim of REACH, as provided for in Article 1, is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation. In this framework the general objective of this initiative is to ensure that REACH is fit for the purpose of dealing with NM in line with the objectives of the legislation.
>
> **Specific objectives**
>
> In order to achieve the general objective and address the different problems identified, the following specific objectives have been established:
>
> - Clarify the legislative obligations acting on companies on how NM must be registered pursuant to REACH;
> - Ensure adequate demonstration of safe use of NM in registration dossiers;
> - Reduce uncertainties for companies on how to comply with their registration obligations.

These objectives have been drawn together and grouped in a manner that helps facilitate systematic

[291] Modifications in some REACH Annexes (Nanomaterials) DG ENV (W. DG ENTR IN CO-LEAD) 10 / 2012

[292] These objectives are currently subject to a process of on-going review and have not as yet been formally circulated externally.

assessment. The methodology for this assessment is set out in the following section.

7.1 Methodology

The overall aim of the Options Comparison section is to establish how efficiently, effectively and coherently each of the options under consideration are able to meet the General and Specific Objectives and demonstrate relevant social, economic and environmental impacts.

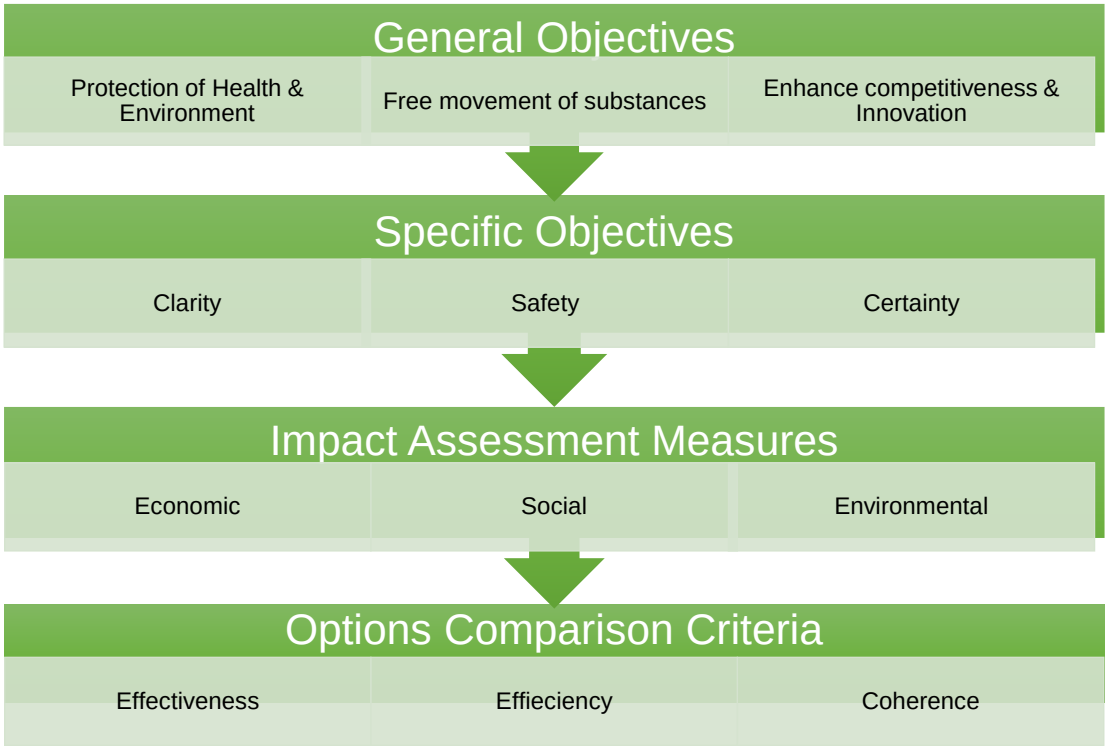

Figure 7.1 Options Comparison Approach

The overall assessment approach is set out in Figure 7.1. It sets out the three General Objectives and the Specific Objectives as set out above, followed by the Impact Assessment Measures. The manner in which the impact study is set out is to firstly assess each of the options in terms of how effectively they would be in meeting the Specific Initiative Objectives alongside the General Objectives. The second element assesses how efficiently each option would meet the same objectives. Finally in terms of coherence the Research Team consider how each option balances relevant social, environmental and economics impacts identified from the Commission's Impact Assessment Guidelines and in doing so seeks to achieve overarching policy objectives, most notable of which being Horizon 2020.

Assessment Criteria

The source material from the Research Study that is drawn upon to assess each of the options is as follows:

- Public Consultation Responses
- Testing Cost Assessment

- Impact Assessment
- Secondary Evidence Reviews
- Stakeholder Interviews

The scores relating to the Public Consultation are drawn from the Options Refinement and Impact Assessment chapters; those for the costs are drawn from the Cost Survey findings. These have been set alongside a qualitative consideration of the secondary evidence presented in the Problem Definition and Options Refinement sections.

Scoring System

Each of the measures have been scored from a minimum negative score of five to a maximum positive score of five, with zero representing a indication that the measure is not anticipated to have any meaningful impact of the achievement of the objective. Each of the Options has been assessed including the Baseline/No change. For the No Change option each measure has been scored in terms of how the presentation of the evidence would suggest the option would meet the designated policy objectives were all elements to be fully implemented and adhered to.

Each of the objectives have been subject to weighting to reflect their relative importance, with rationale set out within each of the respective sections. In terms of sensitivity testing, comment is made at appropriate junctures regarding the potential impact of particular factors; most notably where they have had a significant impact on particular options.

7.2 Effectiveness Assessment

The effectiveness assessment seeks to establish how effectively each of the options would meet the specific objectives relating to the regulation of NM within REACH alongside the General Objectives. In combination the three specific initiative objectives have been given 60% weighting equally divided between safety, clarity and certainty. In relation to the General Objectives the promotion of alternative methods being a related aspect of the promotion of health and environmental safety is given a 15% weighting as has the objective of supporting competitiveness and innovation. The final element of the General Objectives of REACH relating to free movement has been given a 10% weighting, reflecting the fact that this is not a primary focus of the initiative but remains a central element for REACH as a regulatory process. Further detail is provided in Table 7.1 below.

Objective	Weighting	Assessment
Clarity	20%	No specific question was asked in the public consultation regarding the likely impact of options and measures within options on improving the clarity of the regulatory provisions for NM under REACH. This aspect has consequently been scored on the basis of a qualitative assessment of the clarity of measures within each of the Options (as set out in Chapter 6). Additional reference is made relating to secondary and interview feedback as well as the overall rankings given to each of the options in the Public Consultation Exercise.
Certainty	20%	No specific question was asked in the public consultation regarding the likely impact of options and measures within options on improving the certainty of the regulatory process for NM under REACH. This aspect has consequently been scored on the basis of a qualitative assessment of the evidence for this Research Study. Additional reference is made relating to secondary and interview feedback as well as the overall rankings given to each of the options in the Public Consultation Exercise. Options that are more likely to increase overall stakeholder

		confidence in the regulatory system would be scored positively, those making no improvement to the baseline/no change would be scored 0 and those that are likely to reduce certainty by comparison to the baseline would be scored negatively.
Safety	20%	A specific question was asked in the public consultation regarding the likely impact of options and measures on managing risk. The overall scores and rankings for each option have been considered alongside the health and environmental impact assessment of each of the measures as well as on the overall options set out in sections 6.9 and 6.10 of the Report. Additional reference is made relating to secondary and interview feedback.
Innovation and Competitiveness	15%	No specific question was asked in the public consultation regarding the likely impact of options and measures within options on improving innovation and competitiveness. This aspect has consequently been scored on the basis of a qualitative assessment of the assessment of the evidence for this Research Study. Innovation and competiveness maybe deemed to be improved in the situation where the regulatory system is viewed by stakeholders to be supportive to industry and to SMEs, micro enterprises and start up's in particular.
Alternative Methods	15%	No specific question was asked in the public consultation regarding the likely impact of options and measures within options on improving the use of alternative testing methods. This aspect has consequently been scored on the basis of a qualitative assessment of the assessment of the methods underpinning measures within each of the Options (as set out in Chapter 6). This assessment has been additionally weighted on the basis of the qualitative data captured for this Research Study.
Free Movement	10%	No specific question was asked in the public consultation regarding the likely impact of options and measures within options on improving the free movement of NM within the EU. This aspect has consequently been scored on the basis of a qualitative assessment of the assessment of the evidence for this Research Study. Free movement maybe deemed to be improved in the situation where the regulatory system is made more efficient and effective i.e. it enables NM to demonstrate safety in an efficient and cost effective manner.

Table 7.1 Effectiveness Assessment Criteria

The overall scoring for 'effectiveness' is set out in Table 7.2. In relation to health and environmental measures it should be noted that levels of benefit could increase exponentially were it to be the case if certain NM were to present a significant risk to human health or the environment that only the measures contained within them were able to identify. In such cases the potential savings from averting a major health or environmental problem could be of a magnitude as to outweigh any increase in testing and administrative costs. In saying this what again must be made clear is that the Research Team have not identified research findings relating to any existing NM that would suggest such levels of risk.

Effectiveness	Option One	Option Two	Option Three	Option Four	Option Five	Option Six
Safety	-1	2	-1	3	-1	3
Clarity	**-2**	**2**	**-1**	**1**	**0**	**1**
Certainty	-2	2	-1	2	2	2
Competitiveness & Innovation	-2	2	-2	1	1	1

Alternative Methods	0	0	0	0	2	0
Free Movement	-1	1	-1	2	-1	1
Overall Weighted Average Score	**-1.4**	**1.6**	**-1.0**	**1.75**	**0.55**	**1.65**
Ranking	**6th**	**3rd**	**5th**	**1st**	**4th**	**2nd**

Table 7.2 Effectiveness Assessment

The assessment of effectiveness scored Options 4 and 6 and 2 to have the highest potential impact on achieving the Study Objectives. The significantly higher scores for these options reflect the measure-by-measure assessment, which in turn draws heavily from the responses to the Formal Public Consultation Exercise. However, the assessment was broader ranging including evidence from the secondary review and feedback from interviews with stakeholders. The negative scores for the Baseline and Option 3 reflect on-going concerns as to whether current provisions within REACH regarding NM are sufficiently broad and clear so as to enable Registration Dossiers to provide a basis for effective risk assessment. The marginally positive score for Option 5 broadly reflects a lack of stakeholder buy-in to the potential effectiveness of individual measures as well as to the overall design and structuring of the Option, providing as it does a higher level of latitude to Registrants to determine appropriate means of assessment.

7.3 Efficiency Assessment

This second element of the options comparison assessment focuses on how cost effectively each option can meet the general and specific objectives. Within Chapter 6 the Impact Chapter, the challenges regarding the ability to quantify and monetise impacts has been set out. In the absence of a full cost effectiveness assessment, this efficiency assessment has utilised an alternative approach. The approach brings together available evidence regarding testing costs; administrative costs as well ask stakeholder assessments regarding efficiency. Given that the efficiency assessment included assessment relating to cost effectiveness the overall weighting has been set by the Research Team at 40% for efficiency and cost, with administrative burden at 20%.

Measure	Weighting	Assessment
Efficiency	40%	A specific question was asked in the public consultation regarding the likely impact of options and measures on improving efficiency of the regulation of NM within REACH. In addition there is the evidence from the Research Study. These factors have been used to adjust the overall scores.
Testing Costs	40%	This is based upon the results of the testing cost survey that was undertaken as part of the Research Study. In addition a specific question was asked in the public consultation regarding the likely impact of options and measures within options on the overall cost of regulation within REACH. In addition there is the evidence from the Research Study, including the secondary review and stakeholder interviews. These factors have been used to adjust the overall scores where appropriate.
Administrative Burden	20%	This is based upon the results of the testing cost survey that was undertaken as part of the Research Study. In addition there is the evidence from the Research Study, including the secondary review and stakeholder interviews. These factors have been used to adjust the overall scores where appropriate.

Table 7.3 Overall Efficiency Assessment

Cost Assessment

The cost assessment is divided into two broad elements relating to the estimates of costs for undertaking tests for each of the measures contained within a particular option and then for the associated administrative costs that might be associated with undertaking such tests. The costs are an estimate for a single registration of a NM and are drawn from the cost estimates undertaken for the study. It must be recognised that the methodology for assessing costs has involved the development of a number of assumptions such as that characterization costs. There are also a wide range of additional variables such as read across that must be accounted for. The manner in which cost has been assessed for this final options comparison section has been to take an average of the costs for the lower (€40k) characterization cost assessment. Arguments can be made for other approaches but given the nature of the broader process, the Research Team believes this to be the most appropriate. From this each option was compared in terms of the percentage increase or decrease from the Baseline (no change) as was given between none and plus four or minus four marks

	Option One	Option Two	Option Three	Option Four	Option Five	Option Six
Testing Costs €M)	**183**	**30.75**	**n/a**	**104.4**	**-136.4**	**270.25**
Testing Costs Scoring	0	-1	0	-3	3	-5
Administrative Costs (€)	**n/a**	**15,200**	**n/a**	**22,100**	**2,800**	**240,000**
Administrative Costs Scoring	0	-2	0	-2	-1	-5

Table 7.4 Summary Cost Assessment

The summary assessment recognizes that only Option 5 is assessed to result in a reduction (-75%) in cost by comparison with the Baseline (no change). Option 2 would involve a cost increase in the region of 17% with further stepped increases for Option 4 (57%) and Option 6 (148%).

Efficiency Assessment

With respect to establishing which of the options would be most likely to achieve the highest level of efficiency, the balance of evidence has been drawn from the Formal Public Consultation where specific questions were asked in relation to the measures and options under consideration.

Whilst no specific question was asked in relation to the Baseline the summary question relating to the current regulatory provisions elicited a response of 86% believing them to be unclear or very unclear and only 11% stating that they believed them to be ‘clear’ or ‘very clear’.

For Option 2 of the overall ranking placed it as the highest scoring in terms of efficiency. When broken down in terms of the nine measures that made up the option the highest score (those respondents answering that the measure would ‘increase’ or ‘significantly increase’ efficiency) was 64% for i) require identification of uses and exposure assessment of the nanoform and the average score for all measures was 50%, making it the second highest ranking option.

Option 3 had the lowest overall ranking in terms of efficiency. Whilst 30% of respondents viewed the options in combination to be likely to result in 'higher' or 'significantly higher' efficiency, a further 27% believed the option in combination would result in 'lower' or 'significantly lower' levels of efficiency. 32% of respondents believed the option would make no difference to overall efficiency.

Option 4 was the second highest ranked option for efficiency overall, but the highest when considered in terms of the individual measures. Of the nine measures in that option the highest score was 74% for measure a) include information on dustiness. The average score was 53%.

Option 5 ranked third overall for efficiency, but fourth when assessed in terms of the average scores for the 21 measures contained within it. The highest score for any one measure was 62% for a) describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms. The lowest ranked measures were 14% for k) no specific obligations for nanoforms in 10-100 tonnage band' and 'l) no nanomaterial specific obligations for second exposure route at 10-100 tonnage band for acute toxicity'. The average score for the measures was 33%.

Finally Option 6, which ranked fourth for efficiency when looked at in terms of overall assessment moves up to third when considered in terms of the average for the 14 measures contained within it. Of these measures the highest rank was 49% for a) apply clear rules on when nanaoforms can be in one dossier or in separate ones based on possibility for data sharing. The average score was 41%.

The overall assessment set out in Table 7.5 demonstrates only a marginal difference between overall rankings and rankings based upon an assessment of individual measures. Only Option 4 achieved an average ranking for options in excess of 50% (respondents stating that the measure would result in an 'increase' or 'significant increase' in overall efficiency. Option One and Three have been given the same score on the basis that while Option Three was considered to be more efficient to Option One the difference was marginal and did not warrant a overall higher score. The same principle applied to Options Five and Six.

	Ranking by Option	Scoring
Option One	Sixth	-2
Option Two	First	3
Option Three	Fifth	-2
Option Four	Second	2
Option Five	Third	1
Option Six	Fourth	1

Table 7.5 Efficiency Assessment

The scores in Table 7.5 have been added to the Table 7.6 where aspects relating to testing and administrative costs have been added.

Efficiency	Option	Option	Option	Option	Option	Option

	One	Two	Three	Four	Five	Six
Cost	0	-1	0	-3	3	-5
Efficiency	-2	3	-2	2	1	1
Admin Burden	0	-2	0	-2	-1	-5
Overall Weighted Average Score	**-0.8**	**0.4**	**-0.8**	**-1.0**	**1.4**	**-2.6**
Ranking	**3rd**	**2nd**	**3rd**	**5th**	**1st**	**6th**

Table 7.6 Overall Efficiency Assessment

In terms of overall efficiency Option 5 is highest ranked with a weighted average score of 1.4 with Option 2 being placed second with an average score of 0.4. These scores reflect in particular both the lower overall costs incurred under both options alongside a broader consideration of cost effectiveness. Option 4 is given a negative overall score reflecting evidence that would suggest the Option would be effective in achieving a number of the general and specific objectives, but at a cost level that is significantly higher than Option 2 or the Baseline. This is also the reason for Option 6 being given a significant negative overall score.

7.4 Coherence Assessment

The European Commission's Impact Assessment Guidelines state that the assessment of coherence should focus on assessing the alignment of each option with overarching EU objectives, strategies and priorities. On this basis an option would score well where it is able to demonstrate a good balance of positive and negative (un)intended/(in)direct impacts in economic, social and environmental matters.

The approach to assessing coherence has been to draw upon the Impact Assessment Guidelines to identify relevant economic, social and environmental measures and in the following table consideration is given regarding the measures that are most applicable to the general and specific objectives under consideration. Such consideration also seeks to cover the issue of the ability of each of the options under consideration to support overarching EU objectives such as 2020.

Economic Impact Measures

In Table 7.7 seven of the eleven economic impact measures set out in the Impact Assessment Guidelines were assessed by the Research Team to be directly or indirectly linked to the objectives of REACH. Of these seven four were identified as having evidence from the Research Study that would enable them to be assessed more fully.

Economic Impact Measure	Link to Objectives?	Direct or Indirect?	Evidence Base?
Functioning of the internal market and competition	Yes	Indirectly	Of relevance but more related to market concentration rather than overall internal market functioning and as such not scored

Competitiveness, trade and investment flows	Yes	Indirectly	Literature Review, Stakeholder Interviews.
Operating costs and conduct of business/Small and Medium Enterprises	Yes	Directly	Testing Cost Data, Public Consultation responses.
Administrative burdens on businesses	Yes	Directly	Testing Cost Data, Public Consultation responses
Public authorities	Yes	Indirectly	The issue is partially picked up in the overall assessment of administrative burden.
Property rights	No	-	-
Innovation and research	Yes	Indirectly	Literature Review, Stakeholder Interviews.
Consumers and households	Yes	Indirectly	Qualitative account given in the main report but deemed too problematic to accurately assess in relation to individual options.
Specific regions or sectors	No	-	-
Third countries and international relations	No	-	-
Macroeconomic environment	No	-	-

Table 7.7 Economic Impact Measures

Social Impact Measures

Of the eleven measures set out in the Impact Assessment Guidelines, only three link to one or more of the REACH objectives or the associated General or Specific objectives set out for the Research Study and of these only two were assessed to be suitable for scoring on the basis of available evidence.

Social Impact Measure	Link to Objective?	Direct or Indirect?	Evidence Base?
Employment and labour markets	Yes	Indirect	Literature Review, Stakeholder Interviews.
Standards and rights related to job quality	Yes	Indirect	Not deemed to be feasible to assess differential impact relating to individual options.
Social inclusion and protection of particular groups	No	-	-
Gender equality, equality treatment and opportunities, non - discrimination	No	-	-
Individuals, private and family life, personal data	No	-	-
Governance, participation, good administration, access to justice, media and ethics	No	-	-
Public health and safety	Yes	Direct	Public Consultation, Literature Review,

			Stakeholder Interviews.
Crime, Terrorism and Security	No	-	-
Access to and effects on social protection, health and educational systems	No	-	-
Culture	No	-	-
Social impacts in third countries	No	-	-

Table 7.8 Social Impact Measures

Of the two options that have been scored that relating to Public health and safety has been based on an assessment of the potential for each option to positively impact on regulatory system to provide a high level of protection of human health and the environment. The scoring is common for each impact measure that is related to this objective. The measure related to employment represents a more subjective assessment by the Research Team as to the potential impact that each option may have on immediate employment within the NM industry.

Environmental Impact Measures

Eight of the twelve measures set out within the Impact Assessment Guidelines have been assessed by the Research Team to be linked to one of more of the REACH Objectives. Of these two have been selected as being measurable on the basis of the evidence collected for the Research Study.

Environmental Impact Measure	Link to Objectives?	Direct or Indirect?	Evidence Base?
The climate	No	-	-
Transport and the use of energy	No	-	-
Air quality	No	-	-
Biodiversity, flora, fauna and landscapes	Yes	Indirect	Options could have a meaningful differential impact, but assessment highly problematic.
Water quality and resources	Yes	Indirect	Options could have a meaningful differential impact, but assessment highly problematic.
Soil quality or resources	Yes	Indirect	Options could have a meaningful differential impact, but assessment highly problematic.
Land use **Renewable or non- renewable resources**	No	-	-
The environmental consequences for firms and consumers	Yes	Indirect	Public Consultation, Literature Review
Waste production / generation / recycling	Yes	Indirect	Options could have a meaningful differential impact, but assessment highly problematic.

The likelihood or scale of environmental risks	Yes	Direct	Public Consultation responses, Literature Review
Animal welfare	Yes	Direct	Although of relevance it was not considered to be of a scale to warrant individual scoring.
International environmental impacts	Yes	Indirect	Options could have a meaningful differential impact, but assessment highly problematic.

Table 7.9 Environmental Impact Measures

In assessing two environmental impact measures the first on environmental consequences for firms is again based on an assessment of how each option may impact on their ability to deliver a high level of protection of human health and the environment. The same approach applies to measure 3.

Coherence Assessment

The weighting for the coherence assessment has been divided into 40% for the overarching EU Objectives and 60% for the environmental, political and economic factors selected as being of relevance in the Impact Assessment Guidelines.

Measure	Weighting	Assessment
Overarching EU Objectives	40%	No specific question was asked in the Public Consultation regarding how each option may impact on the achievement of the overarching objectives for the EU. Equally a range of objectives could be considered. The Research Team have assessed that Horizon 2020 provides a relevant and wide-ranging overarching objective to assess. Scoring of each option has been based upon a qualitative assessment of secondary evidence and stakeholder interviews. Options have been given a positive score where they have been assessed to be likely to support this overarching aim, a neutral score where they would make no difference and a negative score where an option is assessed to be likely to be less likely to support achievement of the Horizon 2020 objectives that then 'no change'/baseline position.
Economic	20%	This category has been qualitatively assessed for each of the measures outlined in the economic indicators section on the basis of primary and secondary evidence collated for this Research Study.
Environmental	20%	This category has been qualitatively assessed for each of the measures outlined in the environmental indicators section on the basis of primary and secondary evidence collated for this Research Study.
Social	20%	This category has been qualitatively assessed for each of the measures outlined in the social indicators section on the basis of primary and secondary evidence collated for this Research Study.

Table 7.10 Coherence Criteria

In Table 7.11 each of the elements of this section are brought together. The option ranked highest is Option Two with Option Four assessed as being a close second. These options both scored strongly with regard to their ability to provide enhanced detail. Option 6 is third but with a lower score, attributable in the main to the lower potential economic benefits with this option alongside concerns as to the evidence base supporting the inclusion of a number of its additional measures. Although the stated objectives for Option 5 should see it as scoring well in relation to strategic policy objectives such as Horizon 2020, this was counterbalanced by concerns regarding the ability of this option to provide the base for a high level of health and environmental protection and to provide for sustainable development.

Coherence	Option One	Option Two	Option Three	Option Four	Option Five	Option Six
Overarching EU Objectives	-2	3	-2	2	0	2
Environmental	-2	2	-2	3	-1	3
Social	-3	2	-3	2	-1	2
Economic	-1	2	-1	2	3	0
Overall Coherence Score	**-2.4**	**3.0**	**-2.4**	**2.2**	**0.2**	**2.0**
Ranking	**5th**	**1st**	**5th**	**2nd**	**4th**	**3rd**

Table 7.11 Overall Coherence Assessment

The no change option and the soft law option received a negative overall score, on the basis that neither provided a basis for sustainable growth, nor did either of them offer means to provide significant social, environmental or economic benefits. Whilst it would be imagined that the soft law option would be higher scoring than the Baseline the difference was not of a magnitude to impact on the individual scores.

7.5 Option Comparison

The overall assessment of each of the options against the baseline is the most challenging of sections as there are a number of ways to bring together each of the respective cost and impact domains. The issue of whether and how to weight criteria was subject to considerable reflection. Not only could certain elements warrant weighting, as each domain or sub-category has warranted weighting. However, given that the overall assessment already includes a degree of subjective interpretation of the evidence the Research Team did not believe any further weighting of the three impact measures to be appropriate.

Summary Impact Measure	Option One	Option Two	Option Three	Option Four	Option Five	Option Six
Effectiveness	**-1.4**	**1.6**	**-1.0**	**1.75**	**0.55**	**1.65**
Efficiency	**-0.8**	**0.4**	**-0.8**	**-1.0**	**1.4**	**-2.6**
Coherence	-2.4	3.0	-2.4	2.2	0.2	2.0
Total Assessment Score	**-4.6**	**5.0**	**-4.2**	**2.95**	**2.15**	**1.05**
Ranking	**6th**	**1st**	**5th**	**2nd**	**3rd**	**4th**

Table 7.12 Summary Assessment

The **baseline or no change** option considers the currently regulatory arrangements for NM under REACH as they would be once fully implemented and fully adhered to. The overall assessment of the No change/Baseline makes it the lowest scoring and least desirable option with an overall negative rating of 4.6. It has to be remarked that evidence relating to the Baseline has been impacted by

stakeholder assessment as to how the regulatory system currently operates opposed to how they have been structured to operate.

Option Two scored highest of all the options having been assessed to have a score of 5.0. The reason for the score is that as an option it received positive score for its potential to improve clarity and with it improve the assessment of risk for NM, without having as high a negative impact on business or the economy as for options 4 and 6 which involved both enhanced regulatory requirements and increased regulatory costs. Option 2 did receive the highest score in terms of overall coherence was rated second in terms of the potential to improve efficiency and third in terms of effectiveness. It should be noted that Option Two appeared to be the most widely understood of the options under consideration, which may in part account for the level of positive stakeholder response to the option and to the measures contained within it.

Option Three as the 'soft law' option is for comparative purposes is best considered as an adjunct to the No Change Option in that it is make up of measures which could further support and/or clarify the regulatory arrangement currently in place under the Baseline. It scores a negative score of -4.2, reflecting evidence and stakeholder assessment that it could only marginally improve clarity as with it regulatory compliance, without any significant increase in costs or regulatory burden. Once again evidence for this option was impacted by stakeholder assessment of how the regulation of NM is currently operating, with many demonstrating uncertainty as to the precise measures that might be introduced for this option.

Option Four again gains a positive overall score, being the second highest of the six options under consideration. There are similarities to Option 2 in terms of scoring and weighting across each Impact Measure, with the most significant differences relating to the potential ability of the option to improve the safety of NM and the cost and administrative burden consequences of doing this.

Option Five received a positive overall score of 2.15 which ranked it third overall, although significantly lower than Option 2. A significant proportion of its positive score came from a combination of the lower overall testing costs that it would require by comparison with both the Baseline and the other options under consideration. In addition there was a significant level of stakeholder support for the option from business and business associations in particular. However, set against this is the responses to the Public Consultation Exercise which did not find either the Option or the measures within it to be potentially as efficient as other measures and options and a consistent message that the removal of some tests or elements of tests could have a negative impact on ensuring a high level of protection of human health and the environment.

Option Six derived a positive overall score of 1.05, making it the fourth ranked option. Scoring of the option was significantly impacted by the findings from the cost data survey which demonstrated that the option could involve a significant increase in regulatory costs by comparison with the Baseline but also in comparison with the second highest option in cost terms, that being Option 4. In addition to this whilst a number of the measures within Option 6 were considered likely to increase or significantly increase the level of protection of human health and the environment, the assessment of the potential benefit of individual measures within the option did not suggest an increase commensurate with the increase in costs. It also has to be borne in mind that Option 6 scored the second highest overall rating from stakeholders in the Public Consultation Exercise, an issue which is further reflected upon in the concluding section to this chapter.

7.6 Conclusions

The study has clearly established that a large majority of stakeholders believe there to be problems with the current regulatory system and the manner in which it is currently implemented. Whilst the value

of the guidance circulated by ECHA has been generally well received, few stakeholders believe that the current regulatory provisions within REACH provide the ideal basis for the regulation of NM. Yet an assessment of the challenges with the current regulatory arrangements initially focuses on the current definition of NM as well as the related issue of tonnages and classification of nano forms. For some stakeholders the current definition is appropriate, others believe it too be too broad. Equally whilst some stakeholders believe that the tonnage bands provided for within REACH to be wholly applicable to NM others believe the very nature of nano forms requires its own set of parameters including those regarding tonnages. These issues are not the focus for this study, but they do provide important context for consideration of the findings presented in this chapter.

With such variables taken as fixed, further comment on regulatory provisions have focussed on assessing potential domains of risk and alongside those the most appropriate and scientifically established means to assess such risk. Again there is significant variation with regard to both issues. For those that believe that nano forms constitute an a priori additional risk to chemicals in bulk form, the precautionary principle suggests that the current regulatory regime applied to bulk chemicals needs to be further developed and expanded for nano forms. By contrast those stakeholders that feel nano should not in of itself be considered as enhanced risk factor, the focus has been on providing greater clarity so as to enable to the same level of testing for NM as is currently the case for chemicals in bulk form.

Measures within Option 6 alongside Option 4 should be viewed to constitute a significant change to the current regulation of NM. The extent to which such an approach may be considered proportionate must be linked to an assessment as to the strength of the argument than nano forms are fundamentally different to bulk forms and that there scale presents a additional level of risk. The evidence drawn together in this report does not provide categorical support for such an assertion, but that evidence that has been presented in relation to the unique risk potential of particular nano forms and most notably a small number of those forms that have been engineered provides clear context as to the origins of such a view.

The six options under consideration in this study each address points related to the broad ‘level playing field’ approach and to the enhanced regulatory approach. Simple assessments relating to cost provide one means to compare the options. The issue here is that there are several variables that could have a considerable impact on costs. There is also the issue that whilst there are significant differences in relation to the overall costs for each option, there are also significant variations with regard to the cost of individual measures within each option. Of particular interest is the finding that in terms of the public consultation responses there is also only a limited correlation between the cost of particular tests and the potential for those tests to positively impact on human health and the environment.

On this basis it would be too simplistic to contend that more testing equates in any simplistic manner to increased protection against harm to human health or the environment. More appropriately one may say that there is a need to review each of the measures within the options provided in order to develop a better sense of how individual measures may impact, as well as deciding how measures drawn together may work in combination. As such it is a far from simple process to establish which combination of measures as set out within each of the five options may provide the highest level of protection whilst simultaneously supporting competitiveness and innovation. The evidence provided would suggest that were there to be a point of balance it would lay between Option 2 and Option 4, omitting perhaps some of the measures that take the REACH provisions beyond those for bulk chemicals. However even this provides too simplistic an account as it is equally apparent that there is a degree of support for aspects

of other options including the Soft Law option 3.

The case is not established that nano forms universally present a higher risk than chemicals in bulk form, yet it is evident from emerging research that NMs have unique properties as a consequence of their size and that research is only beginning to understand the full potential for such materials alongside the potential risks that will need to be managed. There is an evident need to review current regulatory provisions within REACH, but only evolving consensus amongst stakeholders as to how to weigh, measure or set objectives for regulatory reform. Cost will remain a crucial factor not least given the evidence that any significant increase in regulatory costs could have a significantly negative impact on SMEs and start ups and hence on innovation and development. Taking this into account any assessment as to how best to set regulatory burden and the introduction of new or revised regulatory provisions will need to clearly demonstrate an evidence base as to how they will materially contribute to improved human health and environmental safety within a individual or collective cost envelope that will not put NMs at a commercial disadvantage, particularly within a global context.

8.0 Appendices

Appendix 1 Draft Roadmap

[DRAFT] ROADMAP			
TITLE OF THE INITIATIVE	Modifications in some REACH Annexes (Nanomaterials)		
LEAD DG – RESPONSIBLE UNIT	DG ENV (W. DG ENTR IN CO-LEAD)	DATE OF ROADMAP	10 / 2012
This indicative roadmap is provided for information purposes only and is subject to change. It does not prejudge the final decision of the Commission on whether this initiative will be pursued or on its final content and structure.			
A. Context and problem definition			
(1) What is the political context of the initiative? (2) How does it relate to past and possible future initiatives, and to other EU policies? (3) What ex-post analysis of existing policy has been carried out? What results are relevant for this initiative?			
(1) The initiative has been announced by the Commission in its Communication on 'Second Regulatory Review on Nanomaterials' (COM/2012/572). The Communication reports on studies undertaken by the Commission with a view to determine the adequacy of existing legislation to ensure protection of the environment, health and safety from nanomaterials. The Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the registration, evaluation, authorisation and restriction of chemicals (hereinafter called "REACH") was identified as one of the key pieces of EU legislation for the management risks of nanomaterials when they occur as substances or mixtures. Many substances exist in different forms (solids, suspensions, powders, nanomaterials, etc.). Under REACH, different forms can be considered within a single registration of a substance. However, the registrant must ensure the safety of all included forms and provide adequate information to address the different forms in the registrations, including the chemical safety assessment and its conclusions (e.g. through different classifications where appropriate). Recently ECHA has updated guidance to take into account some of the identified issues and the Commission has adopted a definition on nanomaterials. The 'Second Regulatory Review on Nanomaterials' concludes that 'overall the Commission remains convinced that REACH sets the best possible framework for the risk management of nanomaterials when they occur as substances or mixtures but more specific requirements for nanomaterials within the framework have proven necessary. The Commission envisages modifications in some of the REACH Annexes and encourages ECHA to further develop guidance for registrations after 2013. (2) Since its Communication in 2005 on "Nanosciences and nanotechnologies: An Action Plan for Europe 2005-2009" the Commission has promoted a 'Safe, integrated and responsible approach' to nanotechnologies. As part of the Action plan, the Commission committed to review how EU legislation is able to deliver in accordance with the policy approach. The first Communication on Regulatory aspects of nanomaterials adopted in 2008. The Communication was extensively discussed in the European Parliament (EP) and lead to a resolution in 2009 in which a number of detailed questions were raised in regard to how EU legislation, including REACH would ensure safety in practice given the many uncertainties surrounding the risk assessment of nanomaterials and the volume based approach to registration. In tandem, nanotechnology (which is a significantly broader concept than 'nanomaterials') has been identified as a key enabling technology (KET) providing the basis for further innovation and new products. In its Communication "A European strategy for Key Enabling Technologies – A bridge to growth and jobs" the Commission has outlined a single strategy for KETs, including nanotechnology, built upon three pillars: technological research, product demonstration and competitive manufacturing activities. (3) The evidence base used by the Commission in its preparations for the 'Second Regulatory Review on Nanomaterials' was the RIPoN reports on the adequacy of the ECHA guidance (and the subsequent update of certain guidance provisions in April 2012) and a project report prepared by JRC in collaboration with ECHA, on the scientific and technical assessment of registrations by 2010 November deadline (the TASK I report).			

In conclusion, many registrations for substances known to have nanomaterial forms do not mention clearly which forms are covered or how information relates to the nanoform. Only little information is specifically addressing safe use of the specific nanomaterials supposed to be covered by the registration dossiers. These findings can partly be explained by the absence of detailed guidance to registrants on registration for nanomaterials and the general wording of the REACH annexes.

The Commission Recommendation on a definition of nanomaterial will clarify terminology, but will in itself not provide the necessary clarity to the registrants on how to address nanomaterials in REACH registrations.

What are the main problems which this initiative will address?

The information requirements of REACH registration apply to the total tonnage of substance, including all forms. There is no prescription to undertake specific tests for each different form, or to spell out the way in which the different forms have been addressed in the registrations, although the REACH dossier structure allows this and the technical advice from ECHA encourages it. In close collaboration with ECHA, the Commission has assessed how nanomaterials have been addressed in REACH registrations.

The Commission has identified a necessity for more specific requirements for nanomaterials to ensure further clarity on how nanomaterials are addressed and safety demonstrated in registration dossiers in order to attain the aims of REACH (Article 1). Separately, the Commission has indicated that *'the persisting innovation gap compared to US and Japan and increasing pressure from emerging economies indicate a need for more ambitious objectives in this area.'* Considering the innovation potential of nanomaterials, the efforts in the area shall be encouraged.

In case of inaction the potential results can be:

i) Inadequate demonstration of safe use in the REACH registration dossiers; and

ii) Registration uncertainties for companies and impaired innovation motivation.

Which increase the risks for:

1) health and the environment, if inadequate demonstration of safe use in the REACH registration dossiers leads to harmful use.

2) industry affecting innovation, investment decisions and impaired competitiveness due to lack of clarity over what needs to be included in the REACH registration dossiers.

The two negative impacts are anticipated to occur in function uncertainties regarding the precise requirements for nanomaterials in REACH. This uncertainty stems from several factors acting on the companies with an obligation to register nanomaterials, as well as on ECHA and Member States whose role it is to implement, evaluate and enforce REACH.

The following key underlying causes have contributed to the lack of clarity and may explain why the current system has not delivered for nanomaterials: lack of definition of nanomaterial at the time; lack of specific guidance at the time; the description of the general provisions for assessing substances and preparing Chemical Safety Reports; physico-chemical properties for characterizing nanomaterials; uncertainty in application of test methods; and uncertainty about substance identification and the scope of the registration dossier.

Who will be affected by it?

All stakeholders involved in the implementation of REACH and working with nanomaterials will be affected as well as the public at large.

Immediately affected is industry dealing with nanomaterials with an obligation to register these (both EU manufacturers and importers). The effects will be possible change, positive or negative, to administrative burden and a clearer legislative environment for fulfilling the obligations. Recent external studies performed for the European Commission in the context of the REACH Review estimated the total number of European nanomaterial manufacturers in the range of 200 to 400. Other companies from the nanotechnology sector may be affected. There are also many newly founded SMEs and spin-off companies in this high technology area. Currently, the direct employment in nanotechnology is estimated at around 300,000 to 400,000 jobs in the EU.

ECHA, competent authorities and enforcement authorities, will also be affected when performing their dedicated tasks in accordance with the REACH.

There will also be effects on works' health protection and the health of the public at large.

Is EU action justified on grounds of subsidiarity? Why can Member States not achieve the objectives of the proposed action sufficiently by themselves? Can the EU achieve the objectives better?

The purpose of REACH is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation.

Since the objectives of REACH, namely laying down rules for substances and establishing a European Chemicals Agency, cannot be sufficiently achieved by the Member States and can therefore be better achieved at Union level, the European Union may adopt measures, in accordance with the principle of subsidiarity, as provided by Article 5 of the Treaty on the European Union.

As chemicals are being traded across borders and as many of them can lead to cross-border contamination, Member States cannot by themselves achieve the objectives of the proposal sufficiently. Community wide legislation is therefore appropriate. In this context, it should be recalled that the opinions in the framework of the original REACH proposal of both the Council and the European Parliament call for a strong system of EU legislation in order to achieve a high level of protection of health and the environment while at the same time ensuring a level playing field for all economic actors in the Internal Market.

The modifications brought to certain REACH annexes do not change the overall aim of REACH, nor does it lead to any change in the assessment of the appropriateness of acting at EU level.

B. Objectives of the initiative

What are the main policy objectives?

The objective of the policy initiative is to ensure further clarity on how nanomaterials are addressed and safety demonstrated in registration dossiers. REACH must ensure a high level of health, safety and environmental protection. At the same time it should permit access to innovative products and promote innovation and competitiveness. The regulatory environment affects time to market, marginal cost structure and allocation of resources, especially for SMEs. It also creates new business opportunities and contributes to consumer and investor confidence in the technology.

Specifically, the policy initiative shall provide clearer REACH requirements for nanomaterials to ensure that industry demonstrates safe use in the registration dossiers in accordance with the aims of REACH Article 1(1) "..*to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substance, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation*.

Do the objectives imply developing EU policy in new areas?

No, the objectives are already established aquis in the EU.

C. Options

(1) What are the policy options (including exemptions/adapted regimes e.g. for SMEs) being considered?

(2) What legislative or 'soft law' instruments could be considered?

(3) How do the options respect the proportionality principle?

(1) Option 1

Assuming there is no new regulatory initiative(s), the baseline is the current requirements as implemented by ECHA that is responsible for the day-to-day administration of REACH (i.e. the obligations ECHA demands to consider a registration dossier in compliance with REACH). Specific guidance for nanomaterials has been made available following the current registration obligations in April 2012. The option assumes that the guidance is part of the baseline, but it will, if possible, indicate the potential impacts flowing from this element.

Option 2

This option envisages addressing the problem and reaching the objectives through soft law options without any legislative changes. The instruments considered could be the further development of guidance by ECHA, enhanced use of the Directors Contact Group and other information dissemination actions at EU and Member State level.

Option 3

Changes to the REACH annexes would be made based upon the potential additional requirements identified within the JRC report. Where it is possible and makes technical sense, the impacts of the proposed amendments will be described separately, allowing a distinction between different groups of requirements or even more sub-grades of these, if it is considered necessary.

Option 4

In light of the economic and innovation potential of nanomaterials, changes to the REACH Annexes would lighten the compliance burden through less stringent requirements and more flexible methodologies such as less stringent requirements for non-hazardous substances (including their forms), recognition of relevant safety assessment data for existing/old nonmaterial, and more flexible use of 'read across' and other alternative methods.

Option 5

Changes to REACH annexes would be made to introduce requirements to make a standalone chemicals safety assessment of nanomaterials and / or forms of each nanomaterial both in cases when registered as a nanomaterial and when registered together with a bulk substance form.

All options 2-5 considered are restricted in their scope with the general premise of the REACH review and the Nano-Communication that nanomaterials are covered within REACH, and the general conclusion of the REACH review as regards the revision of REACH in its enacting terms at this time. In other words, changes to REACH, if any, are to be introduced on the basis of the empowerment given to the Commission under REACH Article 131 (Amendments to the Annexes) in accordance with REACH Article 133 (Committee procedure).

REACH is already balanced between its requirements for new and existing substances, and between high production volume and other chemicals with its transitional provisions for existing substances based production volume, reduced requirements for low volume substances, exemptions for PPORD and a fee structure benefiting SMEs. As the options do not change any of these parameters, no particular extra measures will be needed, as the options only aim to implement what is already considered within the aim of the REACH Regulation.

(2) ECHA has already placed extensive guidance and guidance notes on its website that is giving detailed help to companies and authorities alike. Guidance on certain registration aspects related to nanomaterials was made available on 30 April 2012 and ECHA has been encouraged to work further on adapting its guidance material. The Commission has discussed at open meetings, conferences and workshops how REACH applies to nanomaterials. Policy documents, Communications and the Recommendation on the definition of nanomaterial have been broadly disseminated. All these important efforts will be continued to supplement the modifications made to the legally binding annexes to REACH.

(3) The proportionality of the specific options will be examined in detail in the impact assessment.

D. Initial assessment of impacts
What are the benefits and costs of each of the policy options?
No initial assessment of the benefits and costs of the presented options has been conducted.
Could any or all of the options have significant impacts on (i) simplification, (ii) administrative burden and (iii) on relations with other countries, (iv) implementation arrangements? And (v) could any be difficult to transpose for certain Member States?
(i) simplification The initiative will not have any simplification impact. (ii) administrative burden This will be examined in detail in the impact assessment (iii) relations with other countries None of the options are likely to have significant impacts on relations with third countries but firms in third countries will also need to comply so they will be affected. (iv) implementation arrangements The initiative aims to resolve issues that will smoothen the implementation of the Regulation. ECHA's helpdesk and competent authorities in Member States form an infrastructure that also will be able to provide prompt help with the implementation. (v) transposition

REACH is a Regulation and as such no transposition is required.
(1) Will an IA be carried out for this initiative and/or possible follow-up initiatives? (2) When will the IA work start? (3) When will you set up the IA Steering Group and how often will it meet? (4) What DGs will be invited?
(1) Yes, an IA is envisaged for this initiative given its policy sensitivity. (2) Data gathering and problem formulation has already started. (3) An IA Steering Group is envisaged to start in November. Overall, up to four meetings are planned. (4) Secretariat General, Legal Service, MARKT, TRADE, EMPL, TAXUD, CNECT, ENER, MOVE, CLIMA, SANCO, RTD and JRC
(1) Is any option likely to have impacts on the EU budget above € 5m? (2) If so, will this IA serve also as an ex-ante evaluation, as required by the Financial Regulation? If not, provide information about the timing of the ex-ante evaluation.
(1) No. (2) Not applicable

E. Evidence base, planning of further work and consultation
(1) What information and data are already available? Will existing IA and evaluation work be used? (2) What further information needs to be gathered, how will this be done (e.g. internally or by an external contractor), and by when? (3) What is the timing for the procurement process & the contract for any external contracts that you are planning (e.g. for analytical studies, information gathering, etc.)? (4) Is any particular communication or information activity foreseen? If so, what, and by when?
(1) A detailed overview of how nanomaterials have been addressed in 2010 registrations were extensively analysed and discussed with Member States competent authorities and stakeholders (with the limitation that the specifics cannot be disclosed due to confidentiality). The assessment is still in the process of being finished includes not only an assessment of what has been done, but also a set of options on what could be proposed to improve the situation. These options are being assessed for their impacts in accordance with the general guidelines for an impact assessment prepared by the Commission. (2) Additional information necessary to assess the policy options would be gathered through an external study that would be launched in November 2012. (3) A study that would be one of the sources for this impact assessment and that envisages data gathering and analytical work is expected to be launched in November 2012. The procurement process has already started. (4) The Communication on Second Regulatory Review on Nanomaterials and its Staff Working Paper will be presented and discussed at a stakeholder meeting and generally promoted by the Commission at external events on nanomaterials. As regards the specific process of modifying the annexes no specific activities have been envisaged beyond the useful awareness to be done by ECHA.
Which stakeholders & experts have been or will be consulted, how, and at what stage?
The Commission keeps Member States and stakeholders regularly informed of the progress of the work at meetings for the competent authorities under REACH. It is envisaged that some 3 – 5 meetings will be held during the preparatory work. In addition an official public consultation is planned to take place from January – April 2013 to gather further evidence and input.

Appendix 2 Interview Topic Guide

Regulation of Nanomaterials under REACH

Topic Guide

The Research Team assumes that there will be varying levels of awareness regarding the current requirements for nanomaterials under REACH.

The Topic Guide will not cover specific issues relating to each of the Options being considered for the study, but will rather seek to complement the focus of the Formal Public Consultation by focusing on three main issues regarding volumes, costs and impact of proposed changes to the REACH annexes for nanomaterials.

This will be explained at the start of the interview and each respondent will be encouraged to make a formal response to the Commission's Consultation Process.

Section 1: Background.

To establish how well understood the baseline position is.

Q: What relationship do you/your organization have with to the current regulation of nanomaterials under REACH?

Prompts:- direct, indirect etc?

Q: Can you describe your understanding of the current regulatory requirements for nanomaterials under REACH?

Prompts: - Awareness of ECHA guidelines, EC definition etc Functioning – what is your current practical involvement with the regulation of nanomaterials under REACH? Clarity – how clear and understandable do you find it?

Section 2: Problem definition

Assessing how stakeholders view the 'problem' associated with the regulation of nanomaterials under REACH. The following questions may be used as full questions or prompts within a broader discussion of the 'problem'.

Q: Do you feel that there are any problems associated with the regulation of nanomaterials under the provisions of REACH?

Q: What if any elements of the current system of regulation do you/your organisation consider to be problematic? How are they problematic and with what consequence?

Q: Are you able to assess the scale of the problem for you/your organization or more widely (if appropriate)?

Q: From your own perspective who do you feel is most affected by this problem?

Q: What do you believe to be the drivers or underlying causes of the problem?

Q: Can you describe how the problem has developed over time and how existing regulatory policies at Community or Member State level have impacted upon the problem?

Further prompts maybe appropriate as they relate to developing an understanding impact across the value chain and product lifecycle.

Section 4. Current and Future Registration Levels

The aim of this section is to help establish where the stakeholder believes future registrations will fall within the range of around a dozen to more than 2,500 potential registrations over the next decade and how many of this maybe innovative in form and/or pose particular testing challenges/result in particular hazards.

Q: Volumes – What would be your estimate of the numbers of nanomaterials which are currently subject to regulatory assessment as a nanomaterial? Are you able to provide projections or estimations for the next decade?

Q: Types – What is your assessment of the types of nanomaterials likely to be developed and therefore subject to regulatory assessment?

Prompts – use a categorization of nanomaterials, establish if they feel particularly innovative nano forms may be developed and link to the ability to assess the safety of such materials.

Section 5. Regulatory Costs and Burden

This section of the interview will be focused on understanding how stakeholder perceive potential costs and additional burden that may result from changes to the regulation of nanomaterials under REACH. The section relates only to validating the baseline position as asking detailed questions regarding potential future tests is better suited to the Formal Public Consultation process.

Q: Testing costs – What is your current awareness of costs associated with the testing of nanomaterials under REACH?

Q: Testing procedures – What is your current awareness of practical issues associated with the testing of nanomaterials under REACH?

Q: Testing other – What is your awareness of other administrative, managerial, business or related costs that might be associated with the regulation of nanomaterials under REACH?

Section 6. Regulatory Impact, Benefits & Dis-benefits

The section will focus on the five options being considered by the Commission. The focus is not to go into a high level of detail but to establish the respondents overall assessment of the options and relative merits.

Q: What do you believe to be the strengths and weaknesses of each of the five options (to the Baseline) that are currently being considered by the European Commission?

Prompt: Which is your preferred option and why?

Prompt: Which is your least preferred option and why?

Section 7. Regulatory Impact, Benefits & Dis-benefits

The section will focus on establishing how stakeholders view the potential impacts of modifications to the regulation of nanomaterials. The aim will be to establish perceptions and domains more that detailed estimates of quantification.

This will not focus on options per se, the detail of which will be covered in the public consultation but will consider which objectives may best match up to proposed options

Q: What do you believe to be the primary purpose of the regulatory system for nanomaterials? Are there any other purposes that you believe it to have?

Q: What do you/your organization believe should be the objectives/success impact criteria for the regulation of nanomaterials under REACH?

Prompt on growth and sustainability

Q: What broad options would you consider could best match up to these objectives?

Q: If a nanomaterial is subject to change as a result of regulation e.g. additional guidance on safe handing is issued then how might this be experienced across the value chain?

Prompts: how effective would it be in positively impacting on health and environmental safety across the value chain i.e. from 'cradle to cradle'.

Q: How do you feel the regulation of nanomaterials under the provisions of REACH may impact on SMEs?

Q: How do you feel the impact of changes to the regulation of nanomaterials under REACH could be most effectively assessed?

Prompts: What level of impact might be felt from changes to regulatory provisions within REACH across the value chain? How could the impact on workplace health and safety be assessed? How could the impact on consumer safety be assessed? How could end of product lifecycle be assessed?

Section 8. Conclusions

Q: What is your overall assessment of the current regulatory arrangements for nanomaterials under REACH?

Prompt: Strengths, weaknesses etc.

Q: Do you have any further comments or points that you would like to raise in relation to potential changes to the REACH annexes for nanomaterials?

Section 9. Interview Close and Follow Up

Notes have been taken but there will not be a full transcript of the interview taken.

You will be provided with a copy of these notes and be given time to suggest any corrections or to provide additional comment.

Your responses will not name you personally but may name the organization you represent, unless separately agreed with the Research Team.

Many thanks for your cooperation.

Appendix 3 Data Capture Tool

DATA CAPTURE TOOL

REACH Information requirements as specified in Annex VI - X, OECD-WPMN (NM characterisation) and JRC (for NM definition)	Test guide-lines: OECD/EU/ ISO/Other	Average price of a standard test without nano (EUROS)	Price of a nano test (EUROS)	Comments e.g. Technical Challenges/Issues with nanomaterials testing. How would the standard test need to be modified? Etc.
CHEMICAL CHARACTERISATION				
v 011 - Spectral data				
v 012 - Analytical characterization	Bespoke			
v 014 - Development of analytical method	Bespoke			
v 5.02 - Melting point	102 / A.1			
v 5.04 - Relative density	109 / A.3			
v 5.05 - Vapour pressure	104 / A.4			
v 5.06 - Surface tension	115			
v 5.07 - Water solubility	105			
v 5.08 - Partition coefficient	117 & 107			
v 5.09 - Flash-point	A.9			
v 5.10 - Flammability	A.10			
v 5.11 - Explosive properties	A.14			
v 5.12 - Self-ignition temperature	A.15 or 16			
v 5.13 - Oxidising properties	A.17			
v 5.14 - Granulometry	EUR20268			
vii 5.18 - Stability in organic solvents	105			
vii 5.19 - Dissociation constant	112			
vii 5.20 - Viscosity	114			
SEE BELOW SECTION IN YELLOW FOR OTHER NANO SPECIFIC CHARACTERISATION				
vii 9. - Descript. of the analyt. methods of detect. and analysis				
- Vapour pressure calculation				
- Vapour pressure, static, others	Balance			
- Vapour pressure, gas saturation				
- Flammability (solids)				
- Flammability (contact with water)				
OECD-WPMN SP				
Agglomeration/aggregation				
Water Solubility/ Dispersibility				
Crystalline phase				
Dustiness				
Crystallite size				
Representative Electron Microscopy (TEM) picture(s)				
Particle size distribution – dry and in relevant media				
Specific surface area				
Zeta potential (surface charge)				
Surface chemistry, where appropriate				
Photocatalytic activity				
Pour density				
Porosity				
Octanol-water partition coefficient				
Redox potential				
Radical formation potential				
Other relevant PCs				
JRC listed methods				
DLS _Dynamic Light Scattering				
CLS - Centrifugal Liquid Sedimentation				
SAXS -Small Angle X Ray Scattering				
FFF - Field Flow Fractionation				
PTA - Particle Tracking Analysis				
AFM - Atomic Force Microscopy				
XRD - X Ray Diffraction				
TEM - Transition Scanning Microscopy				
MAMMALIAN TOXICOLOGY - SKIN AND EYE TESTING				
v 6.1 - In vitro skin irritation/corrosion	430 & 431			
vi 6.1.1 - In vitro skin irritation/corrosion	404			
v 6.2 - In vitro eye irritation/corrosion	437 & 438			
vi 6.2.1 - In vivo eye irritation/corrosion	405			
v 6.3 - Skin sensitisation (LLNA)	406			
MAMMALIAN TOXICOLOGY - Genetic Toxicology testing				
v 6.4.1 - In vitro gene mutation study (Ames test)	471			
vi 6.4.2 - In vitro cyrogenicity study in mammalian cells (CA)	473			
vi 6.4.2 - In vitro cyrogenicity study in mammalian cells (MNT)	473			
vi 6.4.3 - In vitro gene mut. study in mammal. cells (MLA)	476			
vi 6.4.3 - In vitro gene mut. study in mammal. cells (HPRT)	476			
vii 6.4 - Mouse micronucleus assay	474			
viii 6.4.4 - Furtherin vivo mutagen. study: micronucleus (487) or UDS test				
Comet Assay	under validation			
MAMMALIAN TOXICOLOGY TESTING - IN VIVO				
vi 6.5.1 - Acute toxicity, oral route (rats)	423			
vi 6.5.2 - Acute toxicity, inhalation route (rats)	403 / B.2			
vi 6.5.3 - Acute toxicity, dermal route (rats)	402			
vi 6.6.1a - Short-term repetead dose toxicity: 28 days, oral (rats)	407			
vi 6.6.1b - Short-term repetead dose tox.: 28 days, inhalation (rats)	412			
vii 6.6.1c - Further short-term repetead dose tox.: 28 days, dermal (rabbit)	410			
vii 6.6.1d - Further short-term repetead dose tox.: 28 days, inhalation				
vii 6.6.2 - Sub-chronic repetead dose tox. study: 90 days, oral (rats)	408			
Sub-chronic repetead dose tox. study: 90 days, inhalation (rats)	413			
viii 6.6.3 - Long-term repetead dose tox. study (longer than 12 month)				
vi 6.7.1 - Screening for reproduction/developmental tox. (rats)	421, 422			
vi 6.7.2 - Developmental toxicity study (rats), oral gavage	e.g. 414			
vi 6.7.2 - Developmental toxicity study (rabbits), oral gavage	e.g. 414			
vii 6.7.3 - Two-generation reproduction tox. study, oral gavage	416			
vi 6.8.1 - Assessment of toxicokinetic behaviour				
viii 6.8.2 - Further studies on toxicity of particular concern				
viii 6.9 - Carcinogenicity study (rats)	451			
- Subchronic inhalative, EU B.29				
- Fertility one generation, EU B.34				
- Metabolism study, OECD 417				
ECOTOXICOLOGY				
v 7.1.1 - Short-term acute toxicity study on daphnia	202 / C.2			
v 7.1.2 - Growth inhibition study on algae	201 / C.3			
v 7.1.3 - Short-term acute toxicity study on fish	203 / C.1			

Appendix 4 National Coordinators

List of National Co-ordinators contacted in Initial scoping exercise to find GLP test facilities in Europe

National Coordinator	UK	DEFRA
National Coordinator	Belgium	Nanotechnology Industries Association
National Coordinator	Sweden	Karolinska Institutet
National Coordinator	Sweden	NordMiljö AB (NOMI)
National Coordinator	Sweden	SwedNanoTech AB
National Coordinator	Portugal	ISQ - instituto de soldadura e qualidade PToNANO)
National Coordinator	Netherlands	Ministry of Infrastructure and the Environment
National Coordinator	Italy	Ministero della Salute
National Coordinator	Ireland	Trinity College Dublin
National Coordinator	France	INERIS
National Coordinator	Finland	Finnish Safety and Chemicals Agency (Tukes)
National Coordinator	Spain	Ministry of Economy and Competitiveness
National Coordinator	Denmark	National Research Centre for the Working Environment
National Coordinator	Germany	BMU Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
National Coordinator	Switzerland	Bundesamt für Gesundheit

National Coordinator	Switzerland	TEMAS AG
National Coordinator	Belgium	Federal Public Service Health, Food Chain Safety and Environment, DG 5 - REACH
National Coordinator	Austria	BMVIT Bundesministerium für Verkehr, Innovation und Technologie
National Coordinator	Austria	BioNanoNet Forschungsgesellschaft mbH

Appendix 5 Data Capture Exercise Average Cost per Assey

Data Capture Exercise and Average Cost per Assay

REACH information requirements as specified in Annex VI - X , OECD WPMN (NM characterisation) and JRC (for NM definition)	Test guide-lines OECD/EU GO/Other	Annex VII (>1tpa)	Annex VIII (>10tpa)	Annex IX (>100tpa)	Annex X (>1000tpa)	LABORATORY A: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY A: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY B: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY B: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY C: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY C: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY D: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY D: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY E: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY E: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY F: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY F: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY G: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY G: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY H: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY H: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	LABORATORY I: Average price of a standard test without nano (EURO) MINIMUM VALUE	LABORATORY I: Average price of a standard test without nano (EURO) MAXIMUM VALUE	Price of a nano test (EURO)	Averaged Minimum Cost	Averaged Maximum Cost	ADDITIONAL special cost +Nano	REACH information requirements as specified in Annex VI - X , OECD WPMN (NM characterisation) and JRC (for NM definition)	Comments
CHEMICAL CHARACTERISATION																																			**CHEMICAL CHARACTERISATION**	Standard chemical parameters can change in nanoform - therefore assume would need to retest for new nanoform
s.011 – Spectral data						€ 6,450									€ 100	€ 200																		€ 150	€ 6,450		**s.011 – Spectral data**	UV-vis-NIR, FTIR, Raman, XPS, EELS, EDX (min value is per assay data only, mas is for a package and report)
s.012 – Analytical characterisation	Bespoke																																	Bespoke	Bespoke		**s.012 – Analytical characterisation**	Bespoke
s.014 – Development of analytical method	Bespoke																																	Bespoke	Bespoke		**s.014 – Development of analytical method**	Bespoke
s.042 – Melting point	102 / A.1					€ 850									€ 100																			€ 100	€ 850		**s.042 – Melting point**	DSC method
s.044 – Relative density	109 / A.3					€ 750																												€ 750			**s.044 – Relative density**	
s.045 – Vapour pressure	104 / A.4					€ 3,780																												€ 3,780			**s.045 – Vapour pressure**	
s.046 – Surface tension	115					€ 1,900																												€ 1,900			**s.046 – Surface tension**	
s.047 – Water solubility	105					€ 4,930																												€ 4,930			**s.047 – Water solubility**	
s.048 – Partition coefficient	117 & 107					€ 3,800	€ 5,460																											€ 3,890	€ 5,460		**s.048 – Partition coefficient**	
s.049 – Flash-point	A.9					€ 950																												€ 950			**s.049 – Flash-point**	
s.050 – Flammability	A.10					€ 750																												€ 750			**s.050 – Flammability**	
s.051 – Explosives	A.14					€ 750	€ 3,800																											€ 750	€ 3,800		**s.051 – Explosives**	
s.052 – Self-ignition temperature	A.15 or 16					€ 1,620	€ 2,840																											€ 1,620	€ 2,840		**s.052 – Self-ignition temperature**	
s.053 – Oxidising properties	A.17					€ 750	€ 3,800																											€ 750	€ 3,800		**s.053 – Oxidising properties**	
s.054 – Granulometry	ISO/2009					€ 990	€ 3,480																											€ 990	€ 3,480		**s.054 – Granulometry**	
s5.5.18 – Stability in organic solvents	105					€ 4,930																												€ 4,930			**s5.5.18 – Stability in organic solvents**	
s5.5.19 – Dissociation constant	112					€ 1,260	€ 5,630																											€ 1,260	€ 5,630		**s5.5.19 – Dissociation constant**	
s5.5.20 – Viscosity	114					€ 1,630																												€ 1,630			**s5.5.20 – Viscosity**	
SEE BELOW SECTION IN YELLOW FOR OTHER NANO SPECIFIC CHARACTERISATION																																					**SEE BELOW SECTION IN YELLOW FOR OTHER NANO**	
s5.9. – Descript. of the analyt. methods of detect. and analysis																																					**s5.9. – Descript. of the analyt. methods of detect. and analysis**	
- Vapour pressure calculation						€ 750																															**- Vapour pressure calculation**	
- Vapour pressure, static, others	Balance					€ 3,780																															**- Vapour pressure, static, others**	
- Vapour pressure, gas saturation						€ 6,730																															**- Vapour pressure, gas saturation**	
- Flammability (contact with water)						€ 750																															**- Flammability (contact with water)**	
- Flammability (contact with water)						€ 1,070																															**- Flammability (contact with water)**	
OECD-WPMN SP																								40000	50000	NANO-SPECIFIC									€ 45,000	500,000	FULL CHARACTERISATION	OECD-WPMN SP	
Agglomeration/aggregation															€ 100		€ 100																		€ 100			**Agglomeration/aggregation**	
Water solubility/ Dispersibility						€ 4,930									€ 100		€ 100																		€ 4,930			**Water solubility/ Dispersibility**	
Crystalline phase															€ 100		€ 100																		€ 100			**Crystalline phase**	
Dustiness																																					**Dustiness**	
Crystallite size															€ 200		€ 200																		€ 200			**Crystallite size**	XRD or TEM
Representative Electron Microscopy (TEM) pictures															€ 200		€ 200																		€ 200			**Representative Electron Microscopy (TEM) pictures**	
Particle size distribution / Agglomeration state						€ 3,480									€ 100	€ 400	€ 100																		€ 100	€ 3,480		**Particle size distribution / Agglomeration state**	liquid-dry
Specific surface area															€ 100		€ 100							180												€ 100	€ 140		**Specific surface area**	BET
Zeta potential (surface charge)															€ 100		€ 100																		€ 100			**Zeta potential (surface charge)**	
Surface chemistry, where appropriate															€ 200		€ 200																		€ 200			**Surface chemistry, where appropriate**	XPS
Pour density																																					**Pour density**	
Porosity						€ 750									€ 100		€ 100																		€ 100	€ 750		**Porosity**	BET and Hg porosimetry
Pyrogenic and pyrolytic carbon															€ 100		€ 100																		€ 100			**Pyrogenic and pyrolytic carbon**	BET and Hg porosimetry
Photocatalytic properties						€ 5,490																													€ 5,490			**Photocatalytic properties**	
Radio-potential																																					**Radio-potential**	
Radical formation potential																																					**Radical formation potential**	
Other relevant info																																					**Other relevant info**	
JRC listed methods																																					**JRC listed methods**	
DLS - Dynamic Light Scattering															€ 100		€ 100				€ 1,000														£100.00	€ 1,000		**DLS - Dynamic Light Scattering**	
ELS - Electrophor. Light Scattering															€ 100		€ 100																		£100.00			**ELS - Electrophor. Light Scattering**	
SAXS - Small Angle X Ray Scattering																																					**SAXS - Small Angle X Ray Scattering**	
FFF - Field Flow Fractionation																																					**FFF - Field Flow Fractionation**	
PTA - Particle Tracking Analysis															€ 100		€ 200																		£100.00			**PTA - Particle Tracking Analysis**	
DMA - Differential Mobility Analysis															€ 200	€ 400	100 - 200																		£100.00	€ 200		**DMA - Differential Mobility Analysis**	Depending on media, field of view, etc
SAS - X Ray Diffraction															€ 200	€ 500	€ 200				€ BIOFER SAMPLE NO REPORT													£200.00	€ 800		**SAS - X Ray Diffraction**	
SEM - Scanning Electron Microscopy															€ 200	€ 500	200 - 500																		£200.00	€ 500		**SEM - Scanning Electron Microscopy**	Depending on sample preps' and also information required eg. Composition, morphology, crystallinity, PSD, etc.
MAMMALIAN TOXICOLOGY - SKIN AND EYE TESTING																																					**MAMMALIAN TOXICOLOGY - SKIN AND EYE TESTING**	
In vitro skin irritation/corrosion	430 & 431					€ 2,400		4,065																										€ 3,233			**In vitro skin irritation/corrosion**	
In vivo skin irritation/corrosion	404					€ 1,660		1,490																										€ 1,575			**In vivo skin irritation/corrosion**	
In vitro eye irritation/corrosion	437 & 438							2,320																										€ 2,320			**In vitro eye irritation/corrosion**	
In vivo eye irritation/corrosion	405					€ 1,000		1,485																										€ 1,573			**In vivo eye irritation/corrosion**	
Skin sensitisation (LLNA)	406					€ 5,520		3,120																										€ 4,320			**Skin sensitisation (LLNA)**	
MAMMALIAN TOXICOLOGY - Genetic Toxicology testing																																					**MAMMALIAN TOXICOLOGY - Genetic Toxicology testing**	
9.4.1 In vitro gene mutation study in bacteria	471					€ 1,950	€ 3,050	4,180																										€ 3,377	€ 4,775		**9.4.1 In vitro gene mutation study in bacteria**	**CAVEAT FOR NANO - NOT A RELEVANT STUDY**
9.4.2 In vitro cytogenicity study in mammalian cells (CA)	473					€ 12,200	€ 22,000	21,750																										4,000	6,500		€ 17,517	€ 21,550		**9.4.2 In vitro cytogenicity study in mammalian cells (CA)**	**CAVEAT FOR NANO - NOT A RELEVANT S TUDY**
9.4.2 In vitro cytogenicity study in mammalian cells (MN)	473					€ 12,200	€ 22,000	16,125																										15,900	18,450		€ 14,742	€ 20,200		**9.4.2 In vitro cytogenicity study in mammalian cells (MN)**	
9.4.3 In vitro gene mut. study in mammal. cells (MLA)	476					€ 12,200	€ 22,000	16,820																										20,300	22,800		€ 16,440	€ 22,400		**9.4.3 In vitro gene mut. study in mammal. cells (MLA)**	
9.4.3 In vitro gene mut. study in mammal. cells (HPRT)	476					€ 12,200	€ 22,000	17,920			27950			>8000 EUR extra[1]																				18,300	20800		€ 19,093	€ 21,400	8000	**9.4.3 In vitro gene mut. study in mammal. cells (HPRT)**	
9.4 Mouse micronuclear assay	474					€ 11,500	€ 16,000	15,080																										22,300	24,800		€ 16,293	€ 20,400		**9.4 Mouse micronuclear assay**	
9.4 In vitro gene mutation in mamm. study: micronucleus (MT) or UDS test						€ 21,200	€ 34,500				12500			>2000 EUR extra[1]																						€ 28,850	€ 34,500	2000	**9.4 In vitro gene mutation in mamm. study: micronucleus (MT) or UDS test**	
Comet Assay	under calculation	OR SPECIFIC FOR NANO?									6500	IN VITRO		>2000 EUR extra[1]																				31,700	34300	IN VIVO	€ 6,500	€ 34,300	2000	**Comet Assay**	
MAMMALIAN TOXICOLOGY TESTING - IN VIVO																																					**MAMMALIAN TOXICOLOGY TESTING - IN VIVO**	
9.5.1 Acute toxicity, oral route (rats)	423					€ 1,270		2,050																												€ 1,680			**9.5.1 Acute toxicity, oral route (rats)**	
9.5.2 Acute toxicity, inhalation route (rats)	403 / B.2					€ 6,000																														€ 6,000			**9.5.2 Acute toxicity, inhalation route (rats)**	
9.5.3 Acute toxicity, dermal route (rats)	402					€ 2,140		2,620																												€ 2,380			**9.5.3 Acute toxicity, dermal route (rats)**	
9.6.1a Short-term repeated dose toxicity: 28 days, oral	407					€ 60,000		67,000																												€ 66,000			**9.6.1a Short-term repeated dose toxicity: 28 days, oral**	
9.6.2b Short-term repeated dose tox.: 28 days, inhalation (rats)	412																																					**9.6.2b Short-term repeated dose tox.: 28 days, inhalation (rats)**	
9.6.1c Further short-term repeated dose tox.: 28 days, oral (rats)	410					€ 54,280		44,950																												€ 49,615			**9.6.1c Further short-term repeated dose tox.: 28 days, oral (rats)**	
Further short-term repeated dose tox.: 28 days, inhalation																																						**Further short-term repeated dose tox.: 28 days, inhalation**	
9.6.2 Sub-chronic repeated dose tox. study: 90 days, oral (rats)	408					€ 105,000		97,150																												€ 101,075			**9.6.2 Sub-chronic repeated dose tox. study: 90 days, oral (rats)**	
9.6.2 Sub-chronic repeated dose tox. study: 90 days, inhalation (rats)	413					€ 108,000																														€ 108,000			**9.6.2 Sub-chronic repeated dose tox. study: 90 days, inhalation (rats)**	
9.6.3 Long-term repeated dose tox. study (longer than 12 month)								331,180																												€ 331,180			**9.6.3 Long-term repeated dose tox. study (longer than 12 month)**	
9.7.1a Screening for reproduction/developmental tox. (rats)	421, 422					€ 67,530		71,650																												€ 69,590			**9.7.1a Screening for reproduction/developmental tox. (rats)**	
9.7.2 Developmental toxicity study (rats), oral gavage	e.g. 414					€ 86,410		87,060																												€ 86,735			**9.7.2 Developmental toxicity study (rats), oral gavage**	
9.7.2 Developmental toxicity study (rabbits), oral gavage	e.g. 414					€ 118,900		174,000																												€ 146,450			**9.7.2 Developmental toxicity study (rabbits), oral gavage**	
9.7.3 Two-generation reproduction tox. study, oral (rats)	416					€ 367,400		374,700																												€ 371,095			**9.7.3 Two-generation reproduction tox. study, oral (rats)**	
s7.6.5 – Assessment of toxicokinetic behaviour								50K per sample[2]																												€ 50,000	Uncertain estimate - could be more		**Assessment of toxicokinetic behaviour**	Additional charges in regard to bioanalytical method development/validation may be applicable.
9.8.2 Further studies on toxicity of particular concern	Bespoke																																	Bespoke	€ 815,890		**9.8.2 Further studies on toxicity of particular concern**	
- 9.8&9 Carcinogenicity study (rats)	451					€ 873,000		758,760																														**- 9.8&9 Carcinogenicity study (rats)**	
- Subchronic inhalation, EU B.29	see above 43.17																																					**- Subchronic inhalation, EU B.29**	
- Fertility one generation, EU B.34	Not requirement																																					**- Fertility one generation, EU B.34**	
- Metabolism study, OECD 417	Not requirement																																					**- Metabolism study, OECD 417**	
ECOTOXICOLOGY																																					**ECOTOXICOLOGY**	
Short-term acute toxicity study on daphnia	202 / C.2					€ 2,670									€ 6,540												€ 3,620			€ 4,561		5421		€ 4,348	€ 5,421		**Short-term acute toxicity study on daphnia**	
Growth inhibition study on algae	201 / C.3					€ 1,360									€ 7,750												€ 1,950			€ 5,146				€ 5,057			**Growth inhibition study on algae**	
Short-term acute toxicity study on fish	203 / C.1					€ 3,660									€ 7,448												€ 5,130			€ 5,116		6072		€ 5,339	€ 6,072		**Short-term acute toxicity study on fish**	
Activated sludge respiration inhibition testing	209 / L.13J					€ 2,450	€ 5,900								€ 3,028	€ 6,050											€ 3,920			€ 3,910				€ 3,327	€ 5,978		**Activated sludge respiration inhibition testing**	
9.1.5 Long-term toxicity study on daphnia, 21 days	211					€ 14,820									€ 23,253												18,400			€ 11,313				€ 22,595			**9.1.5 Long-term toxicity study on daphnia, 21 days**	
9.1.6 Long-term toxicity study on fish	e.g. 204																										7,000			€ 27,463				€ 17,231			**9.1.6 Long-term toxicity study on fish**	
9.1.6.1 Fish early-life stage (FELS) toxicity test	210					€ 32,480									€ 48,440												18,200			€ 27,463				€ 33,646			**9.1.6.1 Fish early-life stage (FELS) toxicity test**	
9.1.6.2 Fish short-term tox. test on embryo & sac-fry stages	212																										10,100			€ 15,806				€ 14,853			**9.1.6.2 Fish short-term tox. test on embryo & sac-fry stages**	
9.1.6.3 Fish, juvenile growth test	215					€ 15,290									€ 31,490												19,200			19,254		24299		€ 21,309	€ 24,299		**9.1.6.3 Fish, juvenile growth test**	
9.2.1.1 Ready biodegradability	301														€ 5,080												5,700			€ 6,639				€ 5,808			**9.2.1.1 Ready biodegradability**	
9.2.1.2 Simul. test. on ultimate degrad. in surface water	302					€ 5,470									€ 8,477																			€ 6,974	€ 53,731		**9.2.1.2 Simul. test. on ultimate degrad. in surface water**	
9.2.1.3 Soil simulation testing (for subst. adsorbing to soil, also for metabolites of pest.)	314-A,B,C,D,E														€ 50,862															€ 89,552				€ 70,207			**9.2.1.3 Soil simulation testing (for subst. adsorbing to soil, also for metabolites of pest.)**	
9.2.1.4 Sediment simulat. test. (for subst. adsrb. to water)																														€ 77,012				€ 77,012			**9.2.1.4 Sediment simulat. test. (for subst. adsrb. to water)**	
9.2.1.5 Further studies on confirmatory abiotic degradation	305A					P.O.A.									€ 72,180																			€ 72,180			**9.2.1.5 Further studies on confirmatory abiotic degradation**	
Abiotic degradation: Hydrolysis as a function of pH	0.7, OECD 111					€ 5,840	€ 17,260								€ 6,905	€ 36,921											6750	19950		€ 6,030				€ 6,381	€ 24,710		**Abiotic degradation: Hydrolysis as a function of pH**	
Identification of degradation products						P.O.A.									€ 1,453	COST PER ENTITY											4500	9500						€ 4,500	€ 9,500		**Identification of degradation products**	
Adsorption/desorption screening study (HPLC method)	121					€ 4,010									€ 4,239	€ 5,328														€ 6,197				€ 4,815	€ 5,328		**Adsorption/desorption screening study (HPLC method)**	
9.3.2 Bioconcentration in (one) aquatic species, preferably fish	305					€ 56,080									€ 51,466	€ 63,578											32080			59761		46012		€ 40,800	€ 76,565		**9.3.2 Bioconcentration in (one) aquatic species, preferably fish**	
9.3.3 Further studies on adsorption/desorption	106														€ 37,300															38388		42627		€ 37,844	€ 42,627		**9.3.3 Further studies on adsorption/desorption**	
9.3.4 Further environmental fate and behaviour studies : Aerobic transformation in soil	307														€ 42,385	€ 44,807											45000							€ 43,693	€ 44,807		**9.3.4 Further environmental fate and behaviour studies : Aerobic transformation in soil**	
Transformation in aquatic sediment	308														€ 8,730	€ 68,000											45000							€ 26,860	€ 68,000		**Transformation in aquatic sediment**	
Mineralisation in surface water	309														€ 4,360	€ 28,399											35000							€ 19,680	€ 28,399		**Mineralisation in surface water**	
Short-term toxicity testing on earthworms	207 / L.13J					€ 3,750									€ 5,752												9570			€ 5,672				€ 6,186			**Short-term toxicity testing on earthworms**	
Effects on soil micro-organisms	216														€ 7,932												16700	33400		€ 9,741				€ 11,458			**Effects on soil micro-organisms**	
Short-term toxicity testing on plants	208					€ 14,150									€ 12,887												12650			€ 16,119				€ 13,934			**Short-term toxicity testing on plants**	
Long-term toxicity testing on earthworms	ISO 11268-2														€ 13,927												13100			€ 9,791				€ 12,273			**Long-term toxicity testing on earthworms**	
Long-term toxicity testing on soil invertebrates	ISO 11 267 /																										12900			€ 8,955				€ 10,928			**Long-term toxicity testing on soil invertebrates**	
9.4.6 Long-term toxicity testing on plants															€ 18,922																			€ 18,922			**9.4.6 Long-term toxicity testing on plants**	
9.5 Long-term toxicity testing on sediment organisms	218														€ 29,064												15650			€ 21,493				€ 22,052			**9.5 Long-term toxicity testing on sediment organisms**	
9.6 Long-term or reproductive toxicity to birds:	206																													€ 120,880				€ 120,880			**9.6 Long-term or reproductive toxicity to birds:**	

Comments relating to specific areas:
(*Worker exposure by inhalation - is submitted dependent upon dosing method requirement for nanoparticles.
(1) Additional charges in regard to bioanalytical method development/validation may be applicable
(2) With individual repeat and detection of oxidative bases. Additional controls needed. Depends if we need to e.g. sonicate particles and send samples for secondary characterisation (in media/in situ). All work with nanomaterial requires additional characterisation (size, size distribution, z pot, surface charge etc). See price list for each analytical analysis

= n. This text is required under the respective Annex

Accreditation of laboratories who have supplied data below.

Laboratory A GLP compliant	Y	Y
Laboratory B GLP compliant		
Laboratory C GLP compliant		
Laboratory D (ISO & UKAS accredited)		
Laboratory E GLP compliant		
Laboratory F (ISO & UKAS accredited)		
Laboratory G GLP compliant		
Laboratory H GLP compliant		
Laboratory I GLP compliant		

NOTES TO ACCOMPANY COST TABLE

Appendix 6 Endpoints

Table X Endpoints, Annex Requirements, Costs per Assay and Per Measure

NB Blue and white Colors alternate according to measures

Data Capture Costs

REACH Information requirements as specified in Annex VI - X, OECD-WPMN (NM characterisation) and JRC (for NM definition)	Annex VII (>1tpa)	Annex VIII (>10tpa)	Annex IX (>100tpa)	Annex X (>1000tpa)	Minimum Cost	Maximum Cost
v 011 - Spectral data					150	6450
v 012 - Analytical characterization					Bespoke	
v 014 - Development of analytical method					Bespoke	
v 5.02 - Melting point					100	850
v 5.04 - Relative density					750	
v 5.05 - Vapour pressure					3780	
v 5.06 - Surface tension					1900	
v 5.07 - Water solubility					4930	
v 5.08 - Partition coefficient					3890	5490
v 5.09 - Flash-point					950	
v 5.10 - Flammability					1190	
v 5.11 - Explosive properties					750	3800
v 5.12 - Self-ignition temperature					1620	2840
v 5.13 - Oxidising properties					750	3800
v 5.14 - Granulometry					990	3480
vii 5.18 - Stability in organic solvents					4930	
vii 5.19 - Dissociation constant					1260	5630
vii 5.20 - Viscosity					1630	
In vitro skin irritation/corrosion					3233	
In vivo skin irritation/corrosion					1575	
In vitro eye irritation/corrosion					2320	
In vivo eye irritation/corrosion					1573	
Skin sensitisation (LLNA)					4320	
8.4.1 In vitro gene mutation study (Ames test)					3377	4775
8.4.2 In vitro cytogenicity study in mammalian cells (CA)					17517	21550
8.4.2 In vitro cytogenicity study in mammalian cells (MNT)					14742	20200
8.4.3 In vitro gene mut. study in mammal. cells (MLA)					16440	22400
8.4.3 In vitro gene mut. study in mammal. cells (HPRT)					19093	21400
8.4 Mouse micronucleus assay					16294	20400
8.4.4 Further in vivo mutagen. study: micronucleus or UDS test					16850	34500
COMET ASSAY - new test being offered	OR SPECIFIC FOR NANO?				6500	34200
8.5.1 Acute toxicity, oral route (rats)					1680	
8.5.2 Acute toxicity, inhalation route (rats)					8000	
8.5.3 Acute toxicity, dermal route (rats)					2380	
8.6.1a Short-term repeated dose toxicity: 28 days, oral (rats)					48000	
8.6.1b Short-term repetead dose tox.: 28 days, inhalation (rats)					50000	realistic Estimate
8.6.1c Further short-term repeated dose tox.: 28 days, dermal (rabbit)					49615	
Further short-term repeated dose tox.: 28 days, inhalation						
8.6.2 Sub-chronic repeated dose tox. study: 90 days, oral (rats)					101075	
8.6.2 Sub-chronic repeatad dose tox. study: 90 days, inhalation (rats)					108000	
8.6.3 Long-term repeated dose tox. study (longer than 12 month)					331180	
8.7.1b Screening for reproduction/developmental tox. (rats)					69590	
8.7.2 Developmental toxicity study (rats), oral gavage					86735	
8.7.2 Developmental toxicity study (rabbits), oral gavage					146450	
8.7.3 Two-generation reproduction tox. study, oral gavage					371095	
Assessment of toxicokinetic behaviour					50000	Low estimate
8.8.2 Further studies on toxicity of particular concern					Bespoke	
8.9a&b Carcinogenicity study (rats)					815890	
Short-term acute toxicity study on daphnia					4348	5421
Growth inhibition study on algae					5057	
Short-term acute toxicity study on fish					5339	6072
Activated sludge repiration inhibition testing					3327	5978
9.1.5 Long-term toxicity study on daphnia, 21 days					22595	
9.1.6 Long-term toxicity study on fish					17232	
9.1.6.1 Fish early-life stage (FELS) toxicity test					31646	
9.1.6.2 Fish short-term tox. test on embryo & sac-fry stages					14853	
9.1.6.3 Fish, juvenile growth test					21309	24299
9.2.1.1 Ready biodegradability					5809	
9.2.1.2 Simul. test. on ultimate degrad. in surface water					6974	53731
9.2.1.3 Soil simulation testing (for subst. adsorbing to soil)Simul. test. on ultimate degrad. in surface water					70207	
9.2.1.4 Sediment simulat. test. (for subst. asorb. to sedim.)					77612	
9.2.1.5 Further studies on confirmatory biodegradation rates					72180	
Abiotic degradation: Hydrolysis as a function of pH					6381	24711
Identification of degradation products					4500	9500
Adsorption/desorption screening study (HPLC method)					4816	5328
9.3.2 Bioconcentration in (one) aquatic species, preferably fish					49800	76565
9.3.3 Further studies on adsorption/desorption					37844	42627
9.3.4 Further environmental fate and behaviour studies - Aerobic transformation in soil					43693	44807
Transformation in aquatic sediment					26860	68010
Mineralisation in surface water					19680	28400
Short-term toxicity testing on earthworms					6186	
Effects on soil micro-organisms					11459	
Short-term toxicity testing on plants					13934	
Long-term toxicity testing on earthworms					12273	
Long-term toxicity testing on soil invertebrates					10928	
9.4.6 Long-term toxicity testing on plants					18922	
9.5 Long-term toxicity testing on sediment organisms					22052	
9.6 Long-term or reproductive toxicity to birds:					120880	
Descript. of the analyt. methods of detect. and analysis						
- Vapour pressure calculation					750	
- Vapour pressure, static, others					3780	
- Vapour pressure, gas saturation					6710	
- Flammability (solids)					1190	
- Flammability (contact with water)					1070	
- Subchronic inhalative, EU B.29						
- Fertility one generation, EU B.34						
- Metabolism study, OECD 417						
OECD-WPMN SP	ADDITIONAL CHARACTERISATION COSTS				40000	500000
Agglomeration/aggregation					100	
Water Solubility/ Dispersibility					4930	
Crystalline phase					100	
Dustiness					NO DATA	
Crystallite size					200	
Representative Electron Microscopy (TEM) picture(s)					200	
Particle size distribution – dry and in relevant media					100	3480
Specific surface area					100	140
Zeta potential (surface charge)					100	
Surface chemistry, where appropriate					200	
Photocatalytic activity						
Pour density					100	750
Porosity					100	
Octanol-water partition coefficient					5490	
Redox potential						
Radical formation potential						
Other relevant PCs						
JRC					100	1000
DLS _Dynamic Light Scattering					100	
CLS - Centrifugal Liquid Sedimentation						
SAXS -Small Angle X Ray Scattering						
FFF - Field Flow Fractionation					100	
PTA - Particle Tracking Analysis					100	200
AFM - Atomic Force Microscopy					200	800
XRD - X Ray Diffraction					200	500
TEM - Transition Electron Microscopy						
Option 1 - Baseline						
Option 2 - some expicit requirements						
Option 3 - Soft Law						
Option 4 - increasingly explicit requirements						
Option 5 - reduced measures for nano						
Option 6 - most explicit requirement						
Baseline Cost of Testing for Standard Annexes	51744	492312	1569482	3161640		

Amber = Highly uncertain cost data

COSTS ANALYSIS PER MEASURE in OPTIONS 2,4,5 & 6

MINIMUM COSTS

Characterisation light costs of 40K included generically to cover all aspects of characterisation within a measure

Annex X
Annex IX
Annex VIII
Annex VII

Characterisation heavy costs included at 500K generically to cover all aspects of characterisation within a measure

Annex X
Annex IX
Annex VIII
Annex VII

MAXIMUM COSTS (based on range data in cost exercise)

Characterisation light costs of 40K

Annex X	ADMIN	43480	ADMIN	ADMIN	20000	ADMIN	50000	50000	ADMIN	NO DATA	0	8000	0	0	0	0	0	
Annex IX	ADMIN	43480	ADMIN	ADMIN	20000	ADMIN	50000	50000	ADMIN	NO DATA	0	8000	34200	210448	0	0	64175	NB. OPTION
Annex VIII	ADMIN	43480	ADMIN	ADMIN	20000	ADMIN	99800	87844	ADMIN	NO DATA	0	8000	89100	511158	224,882	0	95754	There are no
Annex VII	ADMIN	43480	ADMIN	ADMIN	20000	ADMIN	99800	92660	ADMIN	NO DATA	8000	ADMIN	174650	547919	224,882	0	95754	

Characterisation heavy costs included at 500K

Annex X	ADMIN	503480	ADMIN	ADMIN	20000	ADMIN	50000	50000	ADMIN	NO DATA	0	8000	0	0	0	0	0
Annex IX	ADMIN	503480	ADMIN	ADMIN	20000	ADMIN	50000	50000	ADMIN	NO DATA	0	8000	34200	210448	0	0	64175
Annex VIII	ADMIN	503480	ADMIN	ADMIN	20000	ADMIN	99800	87844	ADMIN	NO DATA	0	8000	89100	511158	224,882	0	95754
Annex VII	ADMIN	503480	ADMIN	ADMIN	20000	ADMIN	99800	92660	ADMIN	NO DATA	8000	ADMIN	174650	547919	224,882	0	95754

Notes to aid interpretation of data

See Table X in Appendix Y for a description of the assumptions and interpretations of each measure

See Table X for the ADMIN costs proposed for those measures marked as 'ADMIN' above and in Table X in Appendix Y

Chem. - Costs of characterisation range from minimum estimate of 40K per nanoform to maximum estimate of 500K per nanoform dependent upon the nature of the nanoform and the analytical techniques required to fully characterise.

Categ - average 10K Euro annex independent minimum cost of preparing a scientific report to justify categorisation or read across approaches for a nanoform or group of nanoforms. Cost could be higher (estimate 20K Euro) dependent upon breadth of data and number of endpoints needed to be covered by read-across.

NO DATA - for the measure of 'dustiness' could be obtained from laboratories contacted - this would lead to an additional cost for this particular measure. Some information is provided in the BiPRO report on costs for dustiness, but it is not clear from where this comes?

M02 - granulometry min-max range applied
M07 - maximum costs includes an estimate of 50K for bespoke analytical work to support bioaccumulation study
M13 - assumes in vitro mammalian assays are needed for Annex VII nanoforms, already have data for Annex VIII and above; max range is for a full gene mutation package including in vivo data on occasions that in vitro are postiive.
M15 - in overall OPTION 4 only add 17232 for long term fish study to avoid double accounting.
M17 - in overall OPTION 4 only add 6186 for short term earthworm study to avoid double accounting
M24 - assumes read across can be done for all endpoints Annex VIII-X, based upon categorisation and grouping. Best case - only Annex VII tests needed. Worst case - all testing needed. Reality could be somewhere in-between these extremes
M44 - A full analysis of characterisation, toxicokinetics and fate and behaviour = assumes an estimate of 150000 Euros to cover all intake routes for TK data.
M45 - assumes worst case that a full new baseline dossier per Annex requirements is generated for the nanoform within the bulk substance dossier.

Appendix 7 Additional Admin Costs per Measure

Table X Additional Admin costs per Measure (*may depend upon number of studies in dossier)	BALL PARK ESTIMATE DATA ENTRY ADMIN Time (hrs)	100	Consultancy cost/hr					
M01 Explicitly require registrants to describe the scope of the registration dossier	4	400						
M02 Explicitly require registrants to provide more detailed characterisation of nanomaterials/nanoforms	16	1600						
M03 Require that nanoforms are explicitly addressed in the endpoint sections*	8	800						
M04 Require detailed description of the test material / sample and sample preparation*	4	400						
M05 Require scientific justifications for grouping / read across / QSAR and other non-testing approaches for different forms	100	10000						
M06 Require considerations of most appropriate / relevant metric with preferable presentation in several metrics	4	400						
M09 Require identification of uses and exposure assessment of the nanoform	16	1600						
OPTION 2 TOTAL	152	15200						
M12 Change 'particles' to '(nano)particles' for repeated dose toxicity studies (inhalation)	1	100						
Preparation of revised dossier and CSR (assume 50% of a full dossier (Annex dependent on scale of new data enrty see final column Table3)		9000-35000						
OPTION 4 TOTAL	1	9100-35100						
M18 Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms	4	400						
M19 Specify that nanoform specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous/ dangerous	4	400						
M20 Specify that a coated nanomaterial is considered as a special mixture e.g. in classification and labelling as accepted e.g. alloys	8	800						
M23 Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints	4	400						
M35 Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys	4	400						
M37 For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696)	4	400						
OPTION 5 TOTAL	28	2800						
	Hours				Cost			
	Annex VII	VIII	IX	X	VII`	VIII	IX	X
M39 Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing	8	8	8	8	800	800	800	800
M40 Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution	8	8	8	8	800	800	800	800
M41 Information requirements for substances covered by Annex III (b) must also apply to nanoforms	8	8	8	8	800	800	800	800
M42 For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation is considered	16	16	16	16	1600	1600	1600	1600
M43 For nanoforms, require all available information on the use is considered, even when the use would not be covered by the registration	16	16	16	16	1600	1600	1600	1600
M45 Phys-chem, (eco)tox and CSA documented separately for each nanoform (retest and document full dossier for each nanoform)	180	300	500	700	18000	30000	50000	70000
M46 For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation	100	100	100	100	10000	10000	10000	10000
M47 Require adapted DNEL setting based on different routes through the value chain / specific uses	16	16	16	16	1600	1600	1600	1600
M48 Add to the SDS information relevant to Nano registries in Member States	8	8	8	8	800	800	800	800
OPTION 6 TOTAL	360	480	680	880	36000	48000	68000	88000

Appendix 8 Overall Cost Impacts for Options

Baseline	OPTION 2 ADDITIONAL TEST COSTS	OPTION 2 ADDITIONAL ADMIN COSTS*, including preparation of read across report	OPTION 2 ADDITIONAL TOTAL	OPTION 4 ADDITIONAL TEST COSTS	OPTION 4 ADDITIONAL ADMIN COSTS* including dossier revision and preparation of revised CSR	OPTION 4 ADDITIONAL TOTAL	OPTION 2 AND 4 added on the assumption that Option 4 would be implemented after Option 2 is implemented	OPTION 5 ADDITIONAL TEST COSTS	OPTION 5 ADDITIONAL ADMIN COSTS* including preparation of read across report	OPTION 5 ADDITIONAL TOTAL (NB. Highly uncertain estimates)	OPTION 6 FULL TEST COSTS FOR NEW DOSSIER PER NEW NANOFORM PER ANNEX REQUIREMENTS PLUS ADDITIONAL CHARACTERISATION, TK and FATE & BEHAVIOUR WORK	OPTION 6 ADDITIONAL ADMIN COSTS (including costs of preparing new dossier and CSR)	OPTION 6 ADDITIONAL TOTAL
3161640	40990	15200	56190	8000	9100	17100	73290	-2810923	12800	-2798123	3451873	88000	3539873
1569482	40990	15200	56190	199241	15100	214341	270531	-1193845	12800	-1181045	1859715	68000	1927715
492312	128634	15200	143834	469054	25100	494154	637988	-301460	12800	-288660	782545	48000	830545
51744	133450	15200	148650	551893	35100	586993	735643	-1057	12800	11743	341977	36000	377977
3161640	623480	25200	648680	8000	9100	17100	665780	-2810923	12800	-2798123	3972857	88000	4060857
1569482	623480	25200	648680	258834	15100	273934	922614	-1193845	12800	-1181045	2380699	68000	2448699
492312	711124	25200	736324	631676	25100	656776	1393100	-311333	12800	-298533	1303529	48000	1351529
51744	715940	25200	741140	753987	35100	789087	1530227	-1057	12800	11743	862961	36000	898961
Baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline	% of baseline
3161640	1.29647904	0.48076315	1.77724219	0.25303324	0.28782531	0.54085854	2.31810073	-88.907118	0.40485318	-88.502265	109.1798244	2.7833656	111.96319
1569482	2.61168972	0.9684724	3.58016212	12.694698	0.96210087	13.6567989	17.236961	-76.06618	0.81555571	-75.250624	118.4922796	4.33263969	122.824919
492312	26.1285526	3.08747298	29.2160256	95.2757601	5.09839289	100.374153	129.590179	-61.233527	2.59997725	-58.633549	158.9530623	9.74991469	168.702977
51744	257.904298	29.3753865	287.279685	1066.58357	67.8339518	1134.41752	1421.6972	-2.0427489	24.7371676	22.6944187	660.9017471	69.5732839	730.475031
Baseline													
3161640	19.7201452	0.79705469	20.5171999	0.25303324	0.28782531	0.54085854	21.0580585	-88.907118	0.40485318	-88.502265	125.6581078	2.7833656	128.441473
1569482	39.7252087	1.6056253	41.330834	16.4916832	0.96210087	17.4537841	58.7846181	-76.06618	0.81555571	-75.250624	151.686926	4.33263969	156.019566
492312	144.445799	5.11870521	149.564504	128.308065	5.09839289	133.406458	282.970962	-63.238962	2.59997725	-60.638985	264.7770113	9.74991469	274.526926
51744	1383.61936	48.7012987	1432.32066	1457.14865	67.8339518	1524.98261	2957.30326	-2.0427489	24.7371676	22.6944187	1667.75085	69.5732839	1737.32413

Appendix 9 Impact Table

OPTIONS & MEASURES	COST ABOVE BASELINE	ACTION	Interpretation and Assumptions	HEALTH IMPACTS/BENEFITS	ENVIRONMENT IMPACTS/BENEFITS
Overarching assumption is that a 'Substance' has been registered and that the Measures below would be applied if one 'nanoform' of that substance existed. If more than one nanoform exists for the substance, then a multiplier would need to be applied to the costs. Additional costs calculated per measure are for one additional nanoform only. Some substances have multiple nanoforms.					
OPTION 2					
M01 Explicitly require registrants to describe the scope of the registration dossier	**ADMIN**	ADDITIONAL DATA ENTRY	Includes information on forms in VI by individual registrants plus agreement between regs on the common representation in the lead dossier	Null	Null - the data would be the same in the study
M02 Explicitly require registrants to provide more detailed characterisation of nanomaterials/nanoforms	**Characterisation cost (ball park min-max range, nanoform dependent) 40990-500990**	Additional nano-specific characterisation	It is assumed that 'standard' phys chem properties, including a granulometry measure, are included in the Annex requirements already for the substance. However, to cover a specific 'nanoform' an additional specific granulometry test and the non-standard characterisation parameters, as per OECD WPMN parameters, would be additionally generated as new data. [Although this information may already be known through R&D work, it may not be to a quality standard to meet regulatory requirements - assumption is this is new additional testing to provide 'more detailed characterisation']. The range of costs for this could be from 40-500K euro per nanoform, and include different sets of tests for different types of nanoform.	**Increased knowledge about the nature of the material being tested.** To have an impact on health, the material tested should be shown to be the same/similar as that to which humans are exposed in the various scenarios (e.g. ingested, inhaled by skin exposure). If the material identified is different to which humans are exposed, there would be no impact of knowing this information. Information on the physicochemical properties of the nanomaterial could raise questions around the validity of the toxicology data in the 'standard' package ie the confidence of a negative (favourable non-adverse) outcome may be reduced. It could also lead to more focused testing (e.g. inhalation cancer testing if shape and size was a health concern.	One would know more about the nature of the material being tested. To have an impact on the environment, the material tested should be shown to be the same/similar as that to which the environment is exposed in various scenarios. If the material identified is different to which the environment is exposed, there would be no impact of knowing this information. Information on the physicochemical properties of the nanomaterial could raise questions around the validity of the testing data in the 'standard' package ie the confidence of a negative (favourable non-adverse) outcome may be reduced.
M03 Require that nanoforms are explicitly addressed in the endpoint sections	**ADMIN**	Explicitly require registrants to describe the scope of the registration dossier	Addressed' does not mean generate data for each form. Think mainly about admin costs linked to documentation of consideration for each form. Directly linked to 'read-across' ability between forms, applicability of 'worst-case' and preparation of testing strategies. Note that a lot is linked to 'lead dossier", but some is also in individual dossiers - manufacturing, use, individual exp. scenarios. Note that in some cases this might imply costs not immediatly considered - e.g. evaluating environment details that impact on the behaviour of NM due to particle effects in exposure scenarios, consideration of state of aggregation/agglomeration (analog to degradation currently pursued for all chemicals)	Null	Null
M04 Require detailed description of the test material / sample and sample preparation	**ADMIN**	Explicitly require registrants to describe the scope of the registration dossier - specific nanoforms being covered etc.	Expected that consideration is given at every test, however not full battery would be required in all situations. Careful not to double-count with M01 and M02. The test material should be characterised at the same level by the same characteriser as the registered material in each endpoint study. In practice it can mean that it will be necessity to characterise test material more times in test media etc, so multiplicative factor should be available for this measure. This phenomena is included in the top end of the characterisation range (ie maximum of 500K Euro per nanoform) under M02 above. [N.B. It has not been possible to interrogate the 'per assay' additional characterisation cost in the scope of this project.]	Characterisation as performed under M02 - Data aids interpretation of whether the toxicology test data in the dossier are valid for the nanoform	Characterisation as performed under M02 - Data aids interpretation of whether the toxicology test data in the dossier are valid for the nanoform
M05 Require scientific justifications for grouping / read across / QSAR and other non-testing approaches for different forms	**10000**	Preparation of a scientific read-across report that accompanies the dossier	Assumption is nanoforms have been characterised in M02, and that there is some data on a similar nanoform to relate to. This report would be prepared by a consultant or other qualified person to describe the validity of read-across for each endpoint, per nanoform/category of nanoforms. Aspects of kinetics and mechanism of action would be considered, and categorisation of 'similar' nanoforms. For some endpoints it may not be possible to read-across due to lack of data or lack of scientific justification. This is a generic cost for the preparation of an accompanying report to explain the position for the nanoform being registered. It does not include any new testing that may be required to support read-across in this measure.	**Reduces test requirements but high uncertainty in outcome due to lack of guidance and approaches on how to categorise nanoforms.** An area of high uncertainty and unlikely to be achievable for nanoparticles at the current time due to lack of data. If no testing were done, and read across could be performed using other structurally related toxicants then nanoforms could be identified and classified as harmful toxicants by similarity but there may be a risk of false positives (eg classifying materials that need not be classified). Confidence in read-across from non-toxicants would be low, and there may be false negatives (ie not classifying when they should be).	Reduces test requirements but high uncertainty in outcome. An area of high uncertainty and unlikely to be achievable for nanoparticles at the current time due to lack of data. If no testing were done, and read across could be performed using other structurally related toxicants then nanoforms could be identified and classified as harmful toxicants by similarity but there may be a risk of false positives (eg classifying materials that need not be classified). Confidence in read-across from non-toxicants would be low, and there may be false negatives (ie not classifying when they should be).
M06 Require considerations of most appropriate / relevant metric with preferable presentation in several metrics	**ADMIN**	ADDITIONAL DATA ENTRY	Document transparently what is meant in your assessment. It will take effort to identify the best metrics. There is no simple conversion between different metrics. Considering the surface/volume as metrics can require additional characterisation measurements of for example, aggregation and agglomeration to estimate so called active surface of particles. This can require characterisation of test material in matrix (see M02). N.B. It is important that the same metrics for hazard characterisation and exposure assessment are dervied for risk characterisation.	Aligns to the exposure assessment and relevant metrics used (e.g. for oral, dermal and inhalation exposures) for improved risk characterisation	Aligns to the exposure assessment and relevant metrics used
M07 Require that bioaccumulation is addressed specifically for the nanoform	**49800**	ADDITIONAL ECOTOX DATA GENERATION (and BESPOKE NEW ANALYTICAL METHODS DEVELOPMENT)	Could require bioconcentration studies in lower tonnages that are not currently required? Aspects of characterisation already covered in M02 range. [n.b. it is possible that new analytical methods should be developed for this testing. Water solubility and partition coefficient can be important parameters and may need to be measured specifically for each nanoform. Characterisation of material can be needed, in particular aggreagtion/agglomeration, TEM picture, surface area, surface chemistry. Additional costs for bespokeanalytical work per nanoform are estimated at £10000 per form).	Although this measure is related to ecotoxicology mainly, knowing whether there is bioaccumulation of nanomaterials in tissues and organs would raise a flag of concern for many potential health points and target organ toxicities and could lead to classification as PBT. Bioaccumulation may not always lead to toxicity however.	Ecotoxicology tests relating to bioaccumulation would be performed specifically for all different nanoforms of the same material. If persistence was seen, this would lead to P classification.
M08 Specify that absorption/desorption behaviour of nanomaterials should not be assessed based on Kd values derived from Koc and Kow	**37844-42660**	ADDITIONAL ECOTOX DATA GENERATION	Perform additional HPLC-based or further specific studies on adsorption for nanoform, for lower tonnages where it is not already required by Annex requirements and as relevant for nanoform being registered.	Not relevant	Increases confidence in the testing results for this parameter. If something is highly adsorbed - flag of concern for the environment. But not necessarily toxic.
M09 Require identification of uses and exposure assessment of the nanoform	**ADMIN**	ADDITIONAL DATA ENTRY	Documentation of considerations for each nanoform	**Influences test needs.** Could drive the need for testing by particular routes e.g. oral, dermal or inhalation, to cover off potential cancer in gut, skin, lung, and target organ toxicities via route-specific systemic absorption	Influences testing needs, what receptors are exposed
OPTION 4					
M10 Include information on dustiness	**ADDITIONAL COST UNKNOWN [N.B. - NO COST DATA WAS OBTAINABLE FOR THIS MEASURE FROM LABORATORIES SURVEYED. TWO SPECIALISTS IN DUSTINESS WERE CONTACTED BUT NONE RESPONDED WITH COSTS]**	ADDITIONAL DATA GENERATION FOR INHALATION ROUTE	Dustiness is a nano-specific measure not required for other substances. A cost generate information on 'dustiness'	**Prevention of Lung Cancer, Lung disease** (eg fibrosis). Small particles <10 micron (all nanoparticles) can enter the deep lung, larger particles cannot. Fibres can bioaccumulate in the lung. By virtue of their size nanoparticles are a physical hazard to the lung. Dustiness as a measure of particles/m3 air could be relevant to risk assessment if a quantitative risk assessment framework exists for lung toxicity? A risk assessment can be performed if exposure (particles/m3 air) is known and an effect can be quantitatively measured in an inhalation study. There may be a school of thought that even if only a small number of particles are airborne they present an unacceptable hazard/risk of adverse lung disease?	Not relevant
M11 Require acute toxicity data for the most relevant route of exposure (assumption - inhalation)	**8000**	ADDITIONAL DATA GENERATION FOR INHALATION ROUTE	Acute inhalation toxicity study to be performed in rats accoridng to OECD guideline 403. Applies only to Annex VII, already done in Annexes VIII-X	**Protects workers from death or serious harm** Can identify serious acute hazards if high (accidental) dose exposure is experienced and relevant to Classification & Labelling	Not relevant

M12 Change 'particles' to '(nano)particles' for repeated dose toxicity studies (inhalation)	**ADMIN**	ADDITIONAL DATA ENTRY	Amend dossier accordingly. [NB. In repeat dose inhalation studies Bronchoalveolar lavage (BAL) and specific additional histology would be performed for NMs. The practical aspects of these are not accounted for here].	Null	Null
M13 Require non-bacterial in vitro gene mutation study (annex dependent)	**Minimum 0 Euros for Annex VIII and higher where in vitro genetox is negative. Maximum = 175K euro for in vivo and COMET assays to follow up on positive in vitro findings.**	ADDITIONAL DATA FOR ANNEX VII and VIII	In vitro mammalian cell gene mutation studies are already generated for substances under Annex VIII, IX and X. The costs assume that they would also be needed for Annex VI. However, there may be uncertainties around the interpretation of results and additional characterisation work needed. Therefore there is a range in costs, assuming that a minimum of 2 and maximum of 4 in vitro gene mutation tests would be needed with some supporting characterisation work. If a positive/unfavourable result is obtained, an in vivo micronucleus assay may be needed to satisfy conclusions from the gene mutation section. These costs also include the potential for an in vivo study to be needed in Annexes VI and VIII and are therefore high end estimates for this endpoint.	**Prevention of cancer, birth defects**, other effects of genetic damage - If the study were shown to be positive (adverse) then this would identify a potential genotoxin/mutagen and would trigger the need for an in vivo study to investigate further. NB. If the study were negative (favourable) the confidence in this result may be low unless kinetics data showed that the material had entered the cell.	**Consider impacts of genetic tox data re toxicity to mammalian wildlife and agricultural animals**
M14 Consider water solubility in relation to test waiving (annex dependent) i.e. shift away from the waiving possibility	**ADDITIONAL DATA GENERATION (when otherwise tests would be waived) 185,000-548,000**	ADDITIONAL TESTING COSTS	The assumption is that waiving, as currently done for substances,would not be possible for NMs. Full ecotoxicology testing would therefore be required as per Annex requirements.	**Can provide information about the validity of performing tests.** However, waiving on the basis of low solubility is usually relevant to ecotoxicology tests. If water solubility is low, some standard in vitro tests (e.g. testing using cells in aqueous solutions) may be questionable if the material does not enter the cell. Some in vivo tests may still need to be performed to cover the endpoint and the test be modified to monitor delivery of material. The test may need to be accompanied by toxicokinetics/distribution information or delivery into the test system in different ways e.g. via intraperitoneal routes or in special delivery vehicles etc. Sparingly water soluble materials can get into the body to cause toxic effects.	**Information about the validity of performing ecotoxicology tests and interpreting results.**
M15 Specify that long term testing should not be waived based on lack of short term toxicity (for Annex VII and VIII additional testing); 0 additional testing for Annex IX and X (already done).	**225,000**	ADDITIONAL TESTING COSTS	As applicable to ecotox testing only - as marked in Table 3	**Null**	**Prevent harm to enivronment/wildlife.** Long term tests are performed to highlight potential hazards to ecology
M16 Specify that algae testing should not be waived based on insolubility	**Null**	NO ADDITIONAL TESTING COSTS	Perform algae test. Already done for Annex VI	Null	Do the algae test to predict harm to algae in the environment
M17 Require that testing on soil and sediment organisms is prioritised	**64,000 to 96,000**	ADDITIONAL TESTING COSTS	Tests could be required as marked in Table 3	Null	Concern about nanomaterials entering soils and sediment and persisting in the environment. Could enter food chain and cause harm to environment, wildlife etc.
OPTION 5					
M18 Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms	**10000**	Preparation of a scientific read-across report that accompanies the dossier	Very dependent on how the measure is interpreted and implemented. Might have exactly the same impact as Opt 2 M1,2,3, 5. We assume here that the nature of the nanoforms are known and that an accompanying read-across justification needs to be prepared to use data on one form to support another.	Null in terms of improving safety evaluation but saves on testing costs.	Null in terms of improving safety evaluation but saves on testing costs.
M19 Specify that nanoform specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous/ dangerous	**ADMIN**	ADDITIONAL DATA ENTRY	Very dependent on how the measure is interpreted and implemented.Also different endpoints will be impacted in different ways. Assumption here: If a bulk substance is known to be 'hazardous' then a nanoform within the substance dossier would only be tested further, if it were insoluble and thought to be a specific hazard as a result of insolubility. N.B. For a new nanoform substance not yet registered at all, one would not know it was hazardous without testing.	N.B. Insolubility does not mean mammalian toxicology testing can be waived.	Insolubility indicates a potential problem for the environment, and therefore further testing could be warranted.
M20 Specify that a coated nanomaterial is considered as a special mixture e.g. in classification and labelling as accepted e.g. alloys	**ADMIN**	ADDITIONAL DATA ENTRY	Assume data for only one coated nanoform is added.	Null. A coated nanomaterial would have distinct properties and is therefore thought of as distinct toxicologically.	
M21 Specify that the granulometry concept in 7.14 of Annex VII includes also shape and surface area of nanomaterials	**2000**	ADDITIONAL LIMITED CHEMICAL CHARACTERISATION TESTING	Measures from the OECD WPMN list of parameters could be measured to define shape and surface area etc. Cost assumes the most basic of measures of size and shape to describe the nanoform.	Would be useful to specify shape and surface area. Helps to characterise the material better to know what type of nanoform is being assessed	Would be useful to specify shape and surface area. Helps to characterise the material better to know what type of nanoform is being assessed
M22 Specify that the information on dustiness is required for nanoforms only where relevant for the worker safety assessment	**ADDITIONAL COST UNKNOWN [N.B. - NO COST DATA WAS OBTAINABLE FOR THIS MEASURE FROM LABORATORIES SURVEYED. TWO SPECIALISTS IN DUSTINESS WERE CONTACTED BUT NONE RESPONDED WITH COSTS]**	ADDITIONAL DATA GENERATION (only if necessary)	Assuming: Worker safety assessment shows exposure to dusts.	**Protects workers from lung disease/lung cancer.** Exposure scenario dictates the risk assessment ie if no one is to be exposed then the information on dustiness does not add value. This position would not cover accidental exposure. If workers are exposed and information on dustiness is known, then a risk assessment could be done and risk management put in place.	Null
M23 Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints	**ADMIN**	ADDITIONAL DATA ENTRY	Very dependent on how the measure is interpreted and implemented. Waiving is as for any other substance. Needs further clarification on what 'significantly differ' means.	Two things are combined here: 1) Solubility Waiving here could miss identifying problems for lung toxicity. Insoluble nanomaterials are problematic to the lung if airborne. 2) Similar nanoforms - what would be the criteria to define similarity - chemical or physical form? No guidance. May just relate to oral and dermal routes?	Waiving of ecotoxicology assays is as for any other substance
M24 Specify that the use of non-testing methods (e.g. read across, grouping, categorisation etc. methods) is a priority for nanoforms	**0 to 2.8M saved for Annex X nanoform**	Preparation of a scientific read-across report that accompanies the dossier	Assume read-across can be done for all endpoints and testing costs are saved. In reality this may not be the case and may only be possible for some endpoints not the whole dossier. Therefore there is a highly variable impactof this measure on the costs. The assumption is that category approaches are successful for all endpoints, which is the best scenario. The worst scenario is that read-across cannot be done for any endpoint, so the baseline cost would apply. Highly variable cost depending on where read-across can be successfully applied per endpoint.	Too little information to relate chemistry to toxicological properties, to be confident on using read across for assuring safety of nanoforms at present time. No guidance for nanomaterials read across exists currently.	Too little information to relate chemistry to toxicological properties, to be confident on using read across for assuring safety of nanoforms at present time. No guidance for nanomaterials read across exists currently.
M25 Specify and require explicitly that waiving of testing on the basis of exposure conditions and categories applies also for nanoforms, in particular when nanoforms are completely reacted (cured), incorporated or embedded into a completely cured matrix or permanent solid polymer forms, or otherwise used in closed systems or controlled conditions	**ADMIN**	ADDITIONAL DATA ENTRY	To explain how the nanoforms ar coated, embedded or used in solid matrix etc.Perform exposure-based waiving	If the organism is not exposed, there would be no effects. If zero exposure can be shown, then no tox testing is impactful, except for accidental exposures.	If the organism is not exposed, there would be no effects. If zero exposure can be shown, then no tox testing is impactful, except for accidental exposures.
M26 Specify that absorption/desorption behaviour of nanoforms can be based on biological surface adsorption index, affinity coefficient or other relevant parameters	**-4800**	REMOVE ADSORPTION TESTING	Use phys-chem properties to cover this endpoint	Not relevant	May be less confidence in endpoint conclusion
M27 No specific obligations for nanoforms in 1-10 tonnage band	**NULL**	NO ADDITIONAL TESTING	Assume baseline for substance	**May miss identifying genotoxins/mutagens**	**May miss identifying ecotoxins**
M28 No specific obligations for nanoforms in 10-100 tonnage band	**NULL**	NO ADDITIONAL TESTING	Assume baseline for substance	**May miss screening for systemic health effects**	**May miss identifying ecotoxins**
M29 No nanomaterial specific obligations for 2nd exposure route at 10-100 tonnage band for acute toxicity	**NULL**	NO ADDITIONAL TESTING	Assume baseline for substance	Could miss effects by the key route. The key route for the exposure scenario should be assessed, as route to route extrapolation for nanoforms is not valid scientifically	Not relevant
M30 Specify that information generated according to existing test guidelines and/or test methods is sufficient for the purposes of hazard assessment of nanomaterials under REACH	**NULL**	NO NEW TESTING NEEDED	Assume what has been done historically and previously for a substance is sufficient.	**May miss screening for health effects, if tests are not valid.** Key issues around delivery and toxicokinetics of nanomaterials in the test systems, that are specific to nanoforms, could be missed if this option were adopted. The basic 'toxicology' protocol to OECD guideline could be relevant but in practice may need to be modified case by case?	Key issues around fate and behaviour of nanomaterials in the test systems, that are specific to nanoforms, could be missed if this option were adopted. The basic 'toxicology' protocol to OECD guideline could be relevant but in practice may need to be modified case by case?
M31 A nanoform consisting of aggregates is considered same as bulk form and the same endpoint information for (eco)toxicological and environmental fate apply	**NULL**	NO ADDITIONAL DATA	Assume no further testing is needed	**Might be true for some cases but cannot be generalized without consideration this this measure may have impact on safety.**	
M32 No specific obligations for nanoforms to provide ecotoxicological and environmental fate information	**NULL**	NO ADDITIONAL DATA	Assume no further testing is needed	Null	Key issues around fate and behaviour of nanomaterials in the test systems, that are specific to nanoforms, could be missed if this option were adopted.

M33 Create presumption that non-testing methods are valid for nanomaterials in all endpoints	**0 to 2.8M saved for Annex X nanoform**	Preparation of a scientific read-across report that accompanies the dossier.	Extensive use of read across	In principle yes, but in practice there is no data or guidelines to justify read across at present. Might be true for some cases but cannot be generalized without consideration this this measure may have impact on safety.	
M34 Amend the granulometry information requirements in Annex VII (1-10 tonnage band) for nanomaterials in line with Annex II, Section 9.1.a of REACH on Safety Data Sheet and respective ECHA Guidance on Compilation of Safety Data Sheets	**ADMIN**	ADDITIONAL DATA ENTRY	No new data	Null	Null
M35 Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys	**ADMIN**	ADDITIONAL DATA ENTRY	Describe the coatings and document separately	Null	Null
M36 Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS)	**2000**	LIMITED ADDITIONAL CHARACTERISATION	One method only, as relevant to describe the form best? However, different methods could be needed for different forms	Would only lead to minimal information on one parameter, when many parameters contribute to the overall description of the nanoform. May miss describing properties relevant to the safety evaluation	Would only lead to minimal information on one parameter, when many parameters contribute to the overall description of the nanoform. May miss describing properties relevant to the safety evaluation
M37 For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696)	**NULL**	NO ADDITIONAL DATA	Document accordingly	Null	Null
M38 Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative	**-96,000 to -15000**	REMOVE TESTING	**As marked in Table 3**	**Miss detecting adverse health impacts e.g cancer and possibility of accidental death from acute exposure.** It is possible that low exposures and low doses may cause toxicity for nanomaterials - dose-response relationships are currently unknown. Omitting mutagencitiy testing could lead to non identified genotoxins that could be relevant for adverse human health. Could miss identifying local skin effects. Costs to industry would be reduced from baseline	Null
OPTION 6					
M39 Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing	**ADMIN**	ADDITIONAL DATA ENTRY	Interpretation here can be variable as it is related directly to the content of how the 'rules' are defined. Sometimes the nanoform may be in one dossier, sometimes in a separate one. Document whatever is decided.	Null	Null
M40 Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution	**ADMIN**	ADDITIONAL DATA ENTRY	Interpreted to mean that no new additional testing is done, the data are just recorded more clearly in separate dossiers. Assumes one knows the forms from characterisation work in Option 2.	Null	Null
M41 Information requirements for substances covered by Annex III (b) must also apply to nanoforms	**ADMIN**	ADDITIONAL DATA ENTRY	Annex VII requirements apply to all nanoforms, not only those falling under Annex III categories	Null	Null
M42 For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation is considered	**ADMIN**	ADDITIONAL DATA ENTRY	Assess how the nanoform changes its properties and possible hazard profile over time as it changes physical form throughout its life cycle. It is known that this can happen, but is complex to evaluate experimentally. (links to M44)	Null	Null
M43 For nanoforms, require all available information on the use is considered, even when the use would not be covered by the registration	**ADMIN**	ADDITIONAL DATA ENTRY	Some use scenarios may require some specific testing to be carried out. Document need.	Null	Null
M44 For nanoforms, require additional physic-chemical characterisation along the particle's fate when particle properties impacts on hazard	**280,000 to 740,000**	ADDITIONAL BESPOKE CHARACTERISATION, TOXICOKINETICS AND FATE & BEHAVIOUR WORK	Interpreted this to mean specific information on how the material may change it's physical form as it passes through the body or through the environment - requires bespoke and novel testing. Additional toxicokinetics and fate & behaviour work. Very dependent upon the nanoform.	**Assures relevance of test to real life exposure and helps protect people against the correct form tested.** For each test performed, concomitant characterisation is needed to show it is the same in the test as the nanomaterial to which humans are exposed. Very challenging work but would ensure safety package is valid.	**Assures relevance of test to real life exposure. For each test performed, concomitant characterisation is needed to show it is the same in the test as the nanomaterial to which the environment is exposed. Very challenging work but would ensure safety package is valid**
M45 Phys-chem, (eco)tox and CSA documented separately for each nanoform (retest and document dossier for each nanoform)	**REPEAT AN ADDITIONAL Baseline dossier cost for each form per Annex**	ADDITIONAL DATA GENERATION	WORST CASE assumption - complete new dossier with full characterisation and toxicokinetic evaluations for all routes per each nanoform and with characterisation as manufactured, dosed and taken up.	**Protect adverse health from exposure to different nanoforms.** Each nanoform is different and the outcome of the tests could be different, so we have interpreted this as needing to have test data for each form	**Protect environment from harm**
M46 For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation	**Baseline cost for a new dossier (as per Annex) plus 10000**	ADDITIONAL TESTING AND Preparation of a scientific read-across report that accompanies the dossier	Assumed that testing would still need to be performed ie a full baseline dossier but alongside a read-across strategy run in parallel. The additional cost for this measure is therefore assumes as testing and read-across work. It is also assumed that the nanoform has been characterisaed as per M02 to support read-across.	To improve the knowledge of non-testing approaches and cross-validating the outcomes of non-testing vs testing approaches. Read-across/ non-testing offers no impact to health yet if not used in reality.	To improve the knowledge of non-testing approaches and cross-validating the outcomes of non-testing vs testing approaches. Read-across/ non-testing offers no impact to health yet if not used in reality.
M47 Require adapted DNEL setting based on different routes through the value chain / specific uses	**ADMIN**	ADDITIONAL RISK CHARACTERISATION WORK	N.B. Not sure if any new DNELs would need to be specifically derived for NMS, or whether existing DNELs would suffice?	Appropriate route specific DNEL setting assures relevance to exposure scenario. Specific uses of nanoforms needed	Appropriate route specific DNEL setting assures relevance to exposure scenario. Specific uses of nanoforms needed
M48 Add to the SDS information relevant to Nano registries in Member States	**ADMIN**	ADDITIONAL DATA ENTRY		Improves communication on risks	Improves communication on risks
M49 Specify that list of substances in Annexes IV and V does not cover nanoforms of these substances	**Baseline dossier cost**	ADDITIONAL DATA GENERATION	New dossier for each nanoform needed, as per Annex requirements	**Protect adverse health from exposure to different nanoforms.** Each nanoform is different and the outcome of the tests could be different, so we have interpreted this as needing to have test data for each form	**Protect environment from harm**
M50 Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded.	**108000 (plus 40-500K additional characterisation)**	ADDITIONAL DATA GENERATION	Specific information on bronchioalveolar lavage (BAL) fluid and histopathology would need to be included in this study. Additional characterisation costs during testing to account for test material exposures to the correct nanoform would be additional and in the range 40-500K depending upon nanoform and methods needed to be employed.	**Protects for lung cancer/lung disease** Perform all testing via inhalation, with particular attention to the delivery of nanomaterial in the correct nanoform into the inhalation dosing chamber. May require additional characterisation as part of the study	
M51 Perform toxicokinetic screening (assume for all routes in vivo)	**150,000**	ADDITIONAL DATA GENERATION	It is assumed that all 3 main routes of human exposure would need to be covered off separately, as route-to-route extrapolation is an uninvestigated area of research and it is likely that exposure via oral, dermal and lung is very different for NMs. 'Screening' here, is assumed to mean a basic bespoke non-standardised ADME study via the 3 different and relevant routes of exposure to assess whether the NM enters the body or not. Basic histopathology of major organs and blood, urine and faeces analysis would be included. N.B. However, bespoke analytical methods may need to be developed for biological fluids analysis of the nanoform and this is not included in this cost. Radiolabelled NMs may also need to be synthesised. This costs is unknown.	**Perform an ADME study for the route of exposure. Helps to direct most relevant testing programme for protecting people.** This might best be an upfront consideration (e.g in Option 2?) of any testing strategy for nanomaterials as it determines whether the body is likely to be exposed to the material and findings on toxicokinetics can dictate the type of testing needed - local gut, skin and lung or systemic target organ toxicity? See p113 of the JRC report Section 4.2.2.1 on Toxicokinetics. Quotes from JRC "it is of key relevance to compare available ADME data for a nanoform with ADME information for other nano and non-nanoforms"; "ADME data are also relevant to decide whether or not specific tests required at specific tonnage levels need to be performed or not"; "ADME data are also very relevant when considering read-across"	
M52 For nanoforms, request 28 day repeated dose toxicity in Annex VII	**148,000**	ADDITIONAL DATA GENERATION	Perform 28-day repeat dose study for all relevant routes	**Protect against all adverse systemic toxicity.** Test required. Assumes material is dosed in the correct nanoform, by the relevant route and absorbed into the test animal. Assume inhalation is often the most relevant route.	
NOTE: IF results of 90-day repeat dose testing leads to the need for a 2 year bioassay (inhalation most likely route)	**Add 1 million Euro to dossier**		Variable - study may or may not be needed depending on test results	**Protect against cancer and all adverse systemic toxicity.**	

Appendix 10 Public Consultation

Public Consultation Summary Report

Context

The Commission proposal of possible amendment of the REACH Annexes is foreseen to be made in 2013, and will be accompanied by an Impact Assessment. The objective of this consultation has been to provide the Commission with the best possible evidence base for its work with the above tasks.

Stakeholders were asked to give their qualitative assessment of the costs and benefits of baseline alongside each of the options under consideration as well as providing an overall summary assessment of their preferred option, with qualitative explanation if appropriate. Respondents were not asked to give monetised estimates.

Respondent Profile

A majority of respondents were representing an organization (82%) and reported having an excellent (60%) or good (30%) knowledge of REACH and an excellent (53%) or good (40%) knowledge of nanomaterials (NM). There were responses from 26 individuals (18%).

There were responses from half of all Member States. In terms of geographic spread a little over a quarter (26%) of the respondents were based in Belgium, although it must be recognised that this is partially due to the fact that a significant majority of the associations and NGOs that replied to the questionnaire are located in Brussels, and as such represent entities from across the whole EU. Germany provided the second highest number of responses (21%) the United Kingdom the third highest (9%), Italy fourth (6%) and France fifth (5%).

The organizational profile suggests that industrial/trade associations were the largest group (31%) followed by private companies (30%). NGOs made up one in ten respondents with seven respondents (6%) stating themselves to be an environmental NGO. Government authorities made up 15% of respondents, with the remainder made up of consumer associations, academic bodies and other. There were responses from 26 individuals.

Organisational Respondent Profile		
	Total	
Academic/research institution	4	3%
Consumer association	1	1%
Government authority	17	15%
Industrial or trade association	36	31%
Non-governmental organisation	10	9%

Other	14	12%
Private company	34	30%
Grand Total	**116**	100%[293]

Table 6 Respondent Profile

Of those responding over 80% of respondents reported their organization as having being directly involved in REACH and 76% directly involved in the regulation of NM.

A majority of respondents were senior representatives within their organization (55% were Board Director/Senior Manager/Manager) with the next largest group being researchers/scientist (15%).

Size of Business	Total	%
Large: >250	24	69%
Medium: <250	5	14%
Micro: <10	2	6%
Small: <50	4	11%
Grand Total	**35**	**100%**

Table 2 Respondent Profile by Size of Business

Of the companies that responded 69% were larger companies (over 250 employees). Only four respondents were SMEs (50 or less employees and two were micro enterprises (less than ten employees).

Report Structure

The aim of the report is to provide a summary of the main findings from the Public Consultation Exercise. Where possible each section considers both overall response and response by respondent group e.g. NGO, government authority, business and within groups by sub-category, most particularly focusing on SMEs and micro enterprises. Such reporting has been limited by the low number of SMEs (four respondents) and Micro Enterprises (two respondents) that responded to the questionnaire.

Summary Findings

In the final question of the survey respondents were asked to give their preferred option and to set out any rationale they may have or added comments they would like to make. Given that it was an open question not all the respondents gave a clear answer including a number who developed alternative options or declined to select a particular option. In Table 3 the extracted results from this question are

[293] All percentages have been rounded up from .5 onwards

set out. It needs to be made clear that these figures are indicative in that for a number of respondents it was not completely clear as to which if any option they had a preference. In addition a number of respondents linked their preference for one option to that for another (these have been categorised as 'mixed options').

Summary Option Assessment	Total	Percentage
Option One	3	2%
Option Two	8	6%
Option Three	4	3%
Option Four	6	4%
Option Five	41	29%
Option Six	44	31%
Mixed Options	20	14%
No Stated Option	16	11%
Total	**142**	**100%**

Table 7 Policy Option Preferences

The response to the Formal Public Consultation suggests that whilst the 'status quo' is only favoured by three respondents, the two clear preferred options are Five and Six. Option Two is the next favoured option followed by the 'soft law' option 3 and then Option 4. In terms of preferences by stakeholder group Table 4 below sets out response for Member State Authorities, setting out that a majority supported Option 6. There was no explicit support for Options 2, 4 or 5 although a number of respondents stated that they recognised Option 6 to be an extension of Options 2 and 4.

Member State Authorities Option Preferences	Number
No Option	3
Option Two	1
Option Six	10
Combined Options	3
Total	**17**

Table 8 Policy Option Preferences of Member State Authorities

All seven of the Environmental NGOs gave Option 6 to be their preferred option. Three out of six of the Research institutions that responded also gave Option 6 as their preferred option, with one giving option 5 and another option 2. The final respondent declined to give a preferred option. The one consumer organization which responded also gave option 6 as its chosen option. Industry had a strong preference for option 5, whilst competent authorities from Member States were more divided.

Industrial and Trade Associations Option Preferences	Number
No Option	3
Option One (No Change)	1
Option Two	2
Option Three	1
Option Four	1
Option Five	21
Option Six	1
Combined Option (Other)	4
Combined Option (with Option 5)	2
Total	**36**

Table 9 Policy Option Preferences of Industrial/trade Associations

A complementary means to assess each of the options is presented in Table 6. For the Policy Options respondents were asked a series of questions regarding the potential impact on overall cost (increase or reduce the cost of compliance), efficiency (higher or lower overall efficiency of the regulation of NM) and safety (increase or reduce the safe use of NM). Taking the combined answers for the top two categories i.e. 'higher' and 'significantly higher', 'increase' or 'significantly increase' the table below compares the overall summary results for each of the options. The overall ranking is a simple assessment based upon the rankings for each of the categories[294].

	Cost	Efficiency	Safety	Overall
Option Two	**Third**	**First**	**First**	**First**
Option Three	**Second**	**Fifth**	**Fourth**	**Fourth**
Option Four	**Fourth**	**Second**	**Second**	**Second**
Option Five	**First**	**Third**	**Fifth**	**Third**
Option Six	**Fifth**	**Fourth**	**Third**	**Fifth**

Table 10 . Ranking of Policy Options by Individual Measure

[294] For the category rankings first scored 1 and fifth 5 with the lowest total score getting the highest overall ranking.

It needs to be stressed that respondents were not explicitly asked to rank options, but the summary table provides interesting comparative insight. Notable points include Option Two receiving the highest overall ranking for both efficiency and safety, Option Five receiving both the highest rank for cost and the lowest for safety, but Option Six receiving the lowest ranking for cost but only the third highest for safety. Beyond this detail the most important finding of this assessment is that there appears to be a significant variation between the summary responses of respondents to when asked to choose an overall option and the detail of their responses when asked to comment in individual measures. However, such apparent variance can in part be explained by the fact that a significantly number of respondents choosing Option 6 stated that they recognised it to include within it implementation of Options 2 and 4.

Problem Definition

The Problem Definition section starts by asking respondents for their overall view of current provisions and information requirements for the registration of NM before going onto assess how respondents consider the impact of factors such as the current definition of NM. The section goes on to ask respondents to compare the costs and benefits for NM with those for other chemicals before going on to consider how a number of potential amendments to the Baseline may impact on the baseline position.

Respondents were asked to consider the current provisions and information requirements for the registration of NM. Ten per cent thought current provisions to be clear with the majority considering them unclear (68%) or very unclear (18%). All seven of the Environmental NGOs viewed the guidance to be 'unclear'. Assessing the problem definition section for variation by organizational type it was not possible to identify any additional trends. For example in response to the question as to overall view of the current registration provisions and information requirements for the registration of NM one of the two micro industry respondents felt these were clear and one that they were not clear. Of the four SME respondents there was the same split of half saying they were clear and half that they were not.

For those who considered current requirements to be unclear the questionnaire then posed eleven issues and asked respondents to make judgment as to whether each had had a strong or some impact, or had had no effect[295]. The strongest impact was viewed to be current requirements on the application of test methods with 59% viewing this to have had a strong impact and a further 23% some impact. The next most important issue highlighted related to current information on grouping and category approaches for nanoforms (55% and 30% respectively) followed by the determination of nanomaterial as prescribed within the current European Commission definition of nanomaterials (52% and 27% respectively).

The remaining eight issues were viewed by a majority of respondents who felt current provisions and information to be unclear as having had a strong or some impact on causing the problem. Only for three issues being current information on human health toxicity, requirements on ecotoxicity an environmental fate, current requirement on chemical safety did more than a quarter of respondents state the issue to have had no effect on the problem definition (28%, 27% and 27% respectively). More than half of all

[295] An absence of a definition of nanomaterial until October 2011; b. Determination of nanomaterial according to the current European Commission definition of nanomaterials; c. Current information requirements on how to describe the scope of registration; d. Current information requirements on Substance identification; e. Current information requirements on physical-chemical properties; f. Current information requirements on human health toxicity; g. Current information requirements on ecotoxicity and environmental fate; h. Current information requirements on Chemical Safety Assessment; i. Current information requirements on use of grouping and category approaches for nanoforms and other adaptations of the testing regime; j. Current requirements on application of test methods and the relevance of results of tests performed on another form of material; k. Lack of specific guidance

respondents added one or more additional issues that they felt had a strong or some impact on causing the problem. The qualitative responses for this section were wide ranging in nature but the large majority were focused on the current Commission definition of NM. One individual respondent argued that "No one knows which NM are produced and used in Europe, not even researchers or Member States. This creates a huge uncertainty and distrust in consumers, what negatively affects nano innovation."

Comments relating to the current definition include those that believe that the breadth to be problematic. For instance a respondent from an NGO representing the organic pigment producers stated that the "…very broad scope of the EU nanomaterial definition recommendation due to inclusion of aggregates and agglomerates leads to uncertainties in understanding the EU nanomaterial definition." The respondent goes onto conclude, "…that may end in missing the more important scope regarding the hazard assessment of free or deliberately unbound nanoparticles." Further comments relating to the impact of the phasing in of regulatory requirement included a researcher from an NGO stated that "As the legislation is today, many NM will not be registered until 2018 because of a long phase-in of REACH, which will not boost innovation. Instead, we run the risk that the general public is getting concerned about the uncertainty surrounding NM. This concern is furthermore strengthened by the lack of transparency in current legislation."

When asked to compare the likely overall costs of current requirements for NM within REACH with other materials there was a broader division with less than half believing costs were significantly higher (17%) or higher (29%) and somewhat fewer feeling that it made no difference (30%) or involved lower costs (11%). Interestingly when asked what the impact of current provisions on the safety of NM by comparison with other materials nearly a half (44%) felt there would be no difference with close to a quarter (23%) believing it to be significantly lower and 17% believing it to be either higher or significantly higher.

The next question posed three options for additional measures focused on improving clarity for registrants. Both the option of more specific ECHA guidance (84%) and the introduction of specific guidance (83%) were considered by respondents to be likely to increase or significantly increase clarity. For the third option of application of the Commission's definition of NM whilst 42% believed it would increase clarity, only 11% felt it would significantly increase clarity and more than a quarter of respondents (26%) felt it would in fact reduce clarity.

Again more than 50% of respondents offered further factors that they felt would impact on clarity with almost three quarters of whom felt such measures would significantly increase clarity. Additional measures again fell into similar broad grouping with modifications to the current European Commission definition being the most prominent. A common theme here related to the difference between nano forms with a trade association for NM manufacturers contending that the "Restriction of the definition to only cover intentionally engineered nanomaterials would clarify the requirements. Identification of nano size related characteristics that are already mature enough and measurable to use as regulatory requirement would add clarity. REACH should not be misused to gather data l'art pour l'art for future research."

A manufacturer/importer of NM stated that there was no need for further clarity as current systems were appropriate. The respondent stated "Current regulatory requirements do guarantee the safety of NM. We believe existing regulations are adequate to manage potential risks of NM, as they are for other chemical substances; these can and should be used to help facilitate the growth of nanotechnologies."

Questions relating to the impact of current regulatory change elicited a limited response but provided some interesting results. When asked of the potential impact of the Definition of nanomaterials by the

European Commission on the number of such materials in their company's portfolio 74% of the 34 respondents stated that it had either 'increased' or 'significantly increased'. Asked then whether the introduction of the definition had changed their safety assessment or dossier preparation/update, which close to two fifths said that it had 'changed' or 'significantly' changed it, the same percentage said that it had made no difference.

Option One

Option One representing the 'no change' option is considered within the Problem Definition section. The overall assessment is that there is little support for this option with only three respondents making it their preferred choice. That having been said one respondent supporting the 'no change' option did say the following:

> *Do as little regulation as possible - and as much as really necessary. Give a more precise definition of nanomaterials. Stop excessive regulation as one of the main reasons for Europe's torpor and for losing ground against ROW. Give way more innovation and ideas. Regulate really new nanomaterials (e.g. nanotubes, graphenes) used as powders or which may be released into the environment in free/non-bound/non-agglomerated form. No special nanoregisters - prevent separated national paths (e.g. in France).* (Industrial/trade association)

Of the three positive responses for Option 1, two came from industry and one from and industry trade association.

Option Two

Currently many dossiers are of a quality falling below the baseline obligations. This is believed to be the case for several reasons including the lack of definition on Nanomaterial and specific guidance at the time of registration as well as that the existing information requirements are rather general and thus not targeting NM or even just multiplicity of forms within one dossier. This option would therefore introduce changes to certain Annex provisions clarifying what companies are expected to do in accordance with the registration obligations of REACH and the specific guidance which takes into account CA/59/2008 and the RIPoN 2 and 3 reports from 2011. The measures target more precise description of the scope of the dossier, clarification of requirements for nanoform specific information in a number of specific end-point sections, and clarification of how data is to be reported.

The measures needing clarification in this option are based on the advice the Commission requested from ECHA and the response given by ECHA in the context of the Nano-support project for this impact assessment. This option would not change any existing obligations as they are understood to exist, but it would provide companies with a clearer understanding on what information they must provide in the registration dossier. This would be a help to companies and ECHA alike.

Six per cent of respondents (8) put Option Two as their first preference, with a broad spread across stakeholder groups. By comparison the Summary Table 1 puts the measures within Option 2 as the highest rated Option of the five, getting the highest overall score for safety and efficiency and the third highest rating in terms of cost.

The summary Table 7 suggests less variation that is the case for other options. The table establishes that with the exception of measure a) to 'Explicitly require registrants to describe the scope of the registration dossier' all the measures in Option Two were considered by a majority of respondents to 'increase' or 'significantly increase' the cost of compliance with three quarters of respondents believing this would be the case for the single measure i) to 'Require identification of uses and exposure assessment of the nanoform'.

In relation to efficiency there appeared to be a consistent response with approximately half of all respondents believing each of the measures would 'increase' or 'significantly increase' the efficiency of the regulatory process. All seven of the Environmental NGOs believed that Option 2 would lead to a 'significantly higher overall efficiency for the regulation of NM'.

Specific Measures	**Highest Cost Impact**	**Highest Efficiency Impact**	**Highest Safety Impact**
a) Explicitly require registrants to describe the scope of the registration dossier	35%	54%	49%
b) Explicitly require registrants to provide more detailed characterisation of nanomaterials/nanoforms	67%	55%	57%
c) Require that nanoforms are explicitly addressed in the endpoint sections	72%	50%	57%
d) Require detailed description of the test material / sample and sample preparation	60%	52%	54%
e) Require scientific justifications for grouping / read across / QSAR and other non-testing approaches for different forms	52%	48%	52%
f) Require considerations of most appropriate / relevant metric with preferable presentation in several metrics	57%	42%	49%
g) Require that bioaccumulation is addressed specifically for the nanoform	77%	45%	58%
h) Specify that absorption/desorption behaviour of nanomaterials should not be assessed based on K_d values derived from K_{oc} and K_{ow}	52%	40%	51%
i) Require identification of uses and exposure assessment of the nanoform	76%	64%	71%

Table 7. Summary Response for Option Two

Responses relating to safety were again broadly divided between the two categories of 'increase' or 'significantly increase' the safe use of NM. The one exception to this was again for the measure i) to 'Require the identification of uses and exposure assessment of the nanoform' where nearly half of all

respondents (48%) believed that it would significantly increase the safe use of NM. This appears to be the stand out measure within Option Two with the highest overall cost, impact and efficiency ratings. In terms of respondent comment the following was typical:

> *"Clarification would be enough. All the requirements are in practice already written in REACH. The registrant just has to understand how to interpret them".* (Academic/Research Institution)

When looking at the responses by stakeholder group there is an apparent trend relating to the level of response. For instance for the measure which had the highest overall cost rating (g) Require that bioaccumulation is addressed specifically for the nanoform divided into 33% of respondents who believed it would 'increase' costs by comparison with 44% who believed that it would 'significantly increase' costs. Yet of those who ticked 'significantly' all but one of the respondents who gave an organisational designation were made up of trade and business associations or private companies. By comparison when one examines the profile for the measure seen as having the highest potential impact on safety (i) Require identification of uses and exposure assessment of the nanoform) there appears to be a broader level of consensus across stakeholder groups. Close to half of all respondents believed this measure would 'significantly increase' the safe use of nanomaterials which divided into 15% private companies, 17% NGOs, 19% Competent Authorities and 6% Academic/Research institutions. Such a finding would suggest both that in relation to this measure there is a relatively high level of consensus regarding its potential efficacy.

Option Three

This option is focused on three distinct elements: further ECHA guidance, the role of the Director's Contact Group and provision for further informational support at Member State level. The Summary Table 3 shows this to be the second lowest in terms of cost impact, but least efficient and the second least effective in terms of safety. Its summary score places it as the fourth best out of the five options under consideration.

Option Three was chosen by four respondents (3% of the total) as their first choice, which placed it the fourth out of the six options. The four respondents divide into three from private companies and one trade association with a typical response from those supporting this option being the following:

> *At this time, there are great difficulty to distinguish if the substance is nano-material or not, because of lack of appropriate measurement guidance. To fill the gap, clear and operable common measurement procedure should be established and disseminated via guidance, or standard operation procedure manual. Such "soft-law" will improve these issues efficiently with less overall cost, and preferable to other options.* (Industrial/Trade Association)

Considered as a whole approximately a third of respondents felt that the three measures in combination would increase the safe use of NM nearly ten per cent felt that it would reduce or significantly reduce safety. One in four felt in combination that they would lead to a higher overall level of efficiency whilst one in three felt the measures would increase the cost of compliance whilst ten per cent felt they would significantly increase the cost of compliance. Table 8 sets out responses by business stakeholder and demonstrates that there is a mixed view as to whether in combination the three measures would positively impact on safety.

Impact of Soft Law Option on Safety

Business Respondents by Company Size	Total
Large: >250	23
Don't know	4
Have no impact on the safe use of nanomaterials	11
Increase the safe use of nanomaterials	8
Medium: <250	5
Don't know	1
Increase the safe use of nanomaterials	3
Significantly increase the safe use of nanomaterials	1
Micro: <10	2
Have no impact on the safe use of nanomaterials	1
Increase the safe use of nanomaterials	1
Small: <50	4
Have no impact on the safe use of nanomaterials	3
Significantly reduces the safe use of nanomatrials	1
(blank)	
Grand Total	**34**

Table 11 Impact of Soft Law Option on Safety (Industry Respondents)

Of the three measures the development of further ECHA guidance came out ahead of the other two on all three measures. Five out of ten respondents felt that this measure would have no impact on the cost of compliance, close to fifty percent of respondents felt it would increase the safe use of NM and close to one in four of respondents (22%) felt it would result in significantly higher overall efficiency for the regulation of NM.

Option Four

Option Four contains additional measures that from a scientific or technical perspective have been recommended to demonstrate safe use in cases where the existing information requirements in REACH are not tailored for NM or where specific considerations are required for NM. Stakeholders were informed that Option Four assumes the full implementation of Option 2.

Option Four was the second least supported of all the options under consideration with only six respondents (4% of total respondents) selecting it as their choice. By comparison in the summary table Option Four is the viewed by all respondents to be the second most efficient and effective option to improve the safety of NM, but it was also viewed to be the second highest in terms of its likely impact

on the overall cost of compliance. It had the second highest overall ranking of the five options under consideration. Again it was evident from the qualitative responses to the option choice that a majority of those choosing Option 6 recognised that it involved implementation of Options 2 and 4 and as such the low apparent rating for this option should be considered accordingly. Those that did explicitly support this option were made up of private individuals (4) and industry and trade associations (1) and other (1).

Typical of the respondents who supported Option Four is the following:

> At this time, we need to clarify through ECHA guidelines and impose to industry a better way to report nanomaterials under REACH, also adding specific endpoints, especially for phys-chem characterization and environmental fate and behaviour. In my experience, the information given in the publicly available documents on the safe use of nanomaterials is not sufficient, and not sufficiently explained (e.g. missing literature refences, no methods description). Industry probably already has a lot of the information and data assuring the safety of nanomaterials. They need to make them available to ECHA, in an efficient and organized way. (Individual Citizen)

In terms of individual measures there appears to be a clear delineation in terms of the potential cost and impact of each of the respective measures contained within the option. Table 9 below sets out how each of the measures is ranked.

Option 4 Impact & Cost Assessment by Measure	Impact on Cost[296]	Impact on Safety	Impact on Efficiency
a) Include information on dustiness	70%	91% (1st)	74% (1st)
b) Require acute toxicity data for the most relevant route of exposure	72%	68% (3rd)	50% (3rd)
c) Change 'particles' to '(nano) particles' for repeated dose toxicity studies (inhalation)	71%	54%	46%
d) Require non-bacterial in vitro gene mutation study	77% (3rd)	75% (2nd)	63% (2nd)
e) Consider water solubility in relation to test waiving	35%	52%	58%
f) Specify that long term testing should not be waived based on lack of short term toxicity	72%	59%	43%
g) Specify that algae testing should not be waived based on insolubility	81% (2nd)	56%	46%
h) Require that testing on soil and sediment organisms is prioritised	83% (1st)	53%	46%
i) Require consideration of most appropriate / relevant metric with preferable presentation in several metrics	65%	60%	47%

Table 12 Impact and Cost Assessment of Individual Measures for Option

Variation across the options was not significant with the percentage of respondents ticking either the 'increase' or 'significantly increase' box for six of the nine options being between 65-77%, with measures

[296] The higher the rating, the lower the perceived impact on the cost of compliance.

g) and h) being above 80% and option e) a significant outliner with only 35% of respondents believing this would increase or significantly increase costs. The measure to 'include information on dustiness' was ranked first overall with 55% of respondents feeling it would increase the safe use of NM and a further 36% feeling it would significantly increase safety. This compares to the lowest ranked measure where 27% ticked 'increase' and 26% ticked 'significantly increased'. The option considered to be likely to have the least impact on cost was measure e) to 'Consider water solubility in relation to test wavering' where 29% stating it would have 'little' and 6% stating it would have 'very little' impact on cost. This compares to measure h) where 50% of respondents considered it would increase and 33% significantly increase compliance costs.

Option Five

In light of the economic and innovation potential of NM, this option aims to enhance competitiveness and innovation of companies by providing greater specificity to core implementation issues and by reducing the economic burden for complying with REACH. The proposed measures foresee tailored information requirements for nanomaterials placed on the market, reduce certain information requirements, clarify regulatory provisions, maximize the use of non-testing methods and exposure categorisation, and maintain openness to flexible solutions.

Option Five was the option selected by the largest number of respondents. Close to a third of all respondents (41) chose this option. Option Five was also considered by respondents to be the best overall option in terms of cost, but also the lowest ranked in terms of safety. It ranked third on efficiency and also ranked third overall.

Option 5 Profile of Stakeholders	Number
Academic/research institution	1
Industrial or trade association	21
Non-governmental organisation	2
Private company	16
Private Individual	1
Total	**41**

Table 13 Profile of Stakeholders for Option 5

As can be seen in Table 10 Option five was the preferred option of Industrial and trade associations (21 out of 36) and Private Companies (16 out of 34). Two NGOs one academic institution and one individual also supported this option.

There was significant respondent consideration as to why Option Five was preferred. The following provides three representative examples of the comments provided in support of this option:

> *There has been generated a lot of information on NM already, and we should focus on what we already know rather than what we don't know. However, producers of NM must prove that*

the NM is safe to use. NM cannot be assessed and regulated by putting them all in one big bag. They require assessment on a case-by-case basis. (Manufacturer/Importer of NM)

Option 5 is preferred because it aims to enhance competitiveness, innovation and human safety while reducing animal testing. This option prioritizes the use of non-testing methods such as read-across, grouping and categorization methods. Option 5 will maximize human safety while remaining in line with using animal testing as a last resort. (NGO)

Option 5 is preferred to others as it provides the flexibility which allows to target information requirements which can influence the risk assessment in the end and make the use of nanomaterials safer, without resulting in too much generalisation of principles across nanomaterials which are all, in essence, different chemicals. (Industrial/Trade Association)

Overall 30% felt the options would reduce or significantly reduce the cost of compliance, with 40% feeling it would make no difference. Just fewer than 17% felt the measures in combination would result in an increase in the costs of compliance. When looking at the findings by stakeholder group in Table 11 there is a limited correlation between the belief that the Option will reduce regulatory burden and industry stakeholders. Just over one in ten respondents felt that the measures in combination would increase the safe use of NM with a further 4% feeling they would significantly increase the safe use of NM. A little over a third felt the measures would have no impact, whilst over 40% felt that they would reduce or significantly reduce the safe use of NM.

Stakeholder Group	No Impact	Increase costs	Significantly Increase Costs	Reduce Costs	Significantly Reduce Costs
Academic/research institution	3	0	0	0	0
Consumer association	0	1	0	0	0
Government authority	1	3	0	5	1
Industrial or trade association	21	0	0	10	3
Non-governmental organisation	3	6	0	0	1
Other	10	0	0	2	1
Private company	12	3	0	9	7
Private Individual	6	11	2	4	0

Total	**56**	**24**	**2**	**30**	**13**

Table 14 Profile of Stakeholders regarding Cost for Option 5

In relation to individual measures one would expect to see respondents commenting in particular on the impact on cost and efficiency of the measures as set out in Table 12.

Comparative assessment of the cost, efficiency and risk of Measures under Option Five						
	Cost - 'greatest reduction in cost burden'	Cost Ranking	Efficiency - 'greatest increase in efficiency'	Efficiency Ranking	Safety - 'highest increase in risk'	Risk Rating
a) Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms	11		62	1st	20	
b) Specify that nanoform specific information is required only when an insoluble or poorly soluble nanoform put on the market is classified hazardous/ dangerous	34	5th	53	2nd	36	
c) Specify that a coated nanomaterial is considered as a special mixture e.g. in classification and labelling as accepted e.g. alloys	23		30		38	
d) Specify that the granulometry concept in 7.14 of Annex VII includes also shape and surface area of nanomaterials	7		44		29	
e) Specify that the information on dustiness is required for nanoforms only where relevant for the worker safety assessment -	21		47	3rd	38	
f) Specify that waiving of endpoint specific information requirements for classified insoluble or poorly soluble nanoforms applies as for any other forms and also when nanoforms do not significantly differ from each other in specific endpoints	32		30		40	
g) Specify that the use of non-testing methods (e.g. read across, grouping, categorisation etc. methods) is a priority for nanoforms -	31		44		41	
h) Specify and require explicitly that waiving of testing on the basis of exposure conditions and categories applies also for nanoforms, in particular when nanoforms are completely reacted (cured), incorporated or embedded into a completely cured matrix or permanent solid polymer forms, or otherwise used in closed systems or controlled conditions	34	5th	39		32	

i) Specify that absorption/desorption behaviour of nanoforms can be based on biological surface adsorption index, affinity coefficient or other relevant parameters	17		17		32	
j) No specific obligations for nanoforms in 1-10 tonnage band -single choice reply- (compulsory)	24		19		50	3rd
k) No specific obligations for nanoforms in 10-100 tonnage band	25		14		51	2nd
l) No nanomaterial specific obligations for 2nd exposure route at 10-100 tonnage band for acute toxicity	24		14		39	
m) Specify that information generated according to existing test guidelines and/or test methods is sufficient for the purposes of hazard assessment of nanomaterials under REACH	30		32		39	
n) A nanoform consisting of aggregates is considered same as bulk form and the same endpoint information for (eco)toxicological and environmental fate apply	45	4th	44		42	
o) No specific obligations for nanoforms to provide ecotoxicological and environmental fate information	27		21		48	4th
p) Create presumption that non-testing methods are valid for nanomaterials in all endpoints	34	5th	20		64	1st
q) Amend the granulometry information requirements in Annex VII (1-10 tonnage band) for nanomaterials in line with Annex II, Section 9.1.a of REACH on Safety Data Sheet and respective ECHA Guidance on Compilation of Safety Data Sheets	11		33		31	
r) Specify explicitly that coating agents of nanoforms are registered separately in line with practices already accepted for e.g. alloys	17		25		33	
s) Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS) -	53	2nd	22		47	
t) For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696)	47	3rd	45	5th	40	
u) Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative	69	1st	46	4th	44	5th

Table 15 Comparative assessment of the cost, efficiency and risk of Measures under Option Five

Of all the measures within Option 5 measure u) had the largest number of respondents believing that it would ‘significantly reduce’ (35%) or ‘reduce’ (33%) the costs of compliance. The next most impactful option in terms of reducing the costs of compliance was measure s) with the number of respondents

reporting that it would significantly reduce (13%) or reduce (40%) the costs of compliance. Measure u) also ranked as the fifth highest in terms of the impact it would have in 'reducing' or 'significantly reducing' the safe use of NM.

Somewhat surprisingly one in four of respondents felt that each of the measures would significantly lower the overall efficiency of the regulation of NM. Option a) followed by Option b) was considered by respondents to provide for the highest increase in efficiency.

Once again taking one of the measures to assess the breadth of stakeholder views one can see the level of consensus regarding the likelihood that this option would reduce the overall cost of compliance, although in terms of stakeholders that believe that it would 'significantly reduce' costs is more concentrated within company and industrial/trade associations respondents.

Stakeholder Group	Reduce Cost	Significantly Reduce Cost
Government authority	4	4
Industrial or **trade association**	**11**	22
Non-governmental organisation	7	1
Other	2	3
Private company	10	16
Private Individual	12	4
Consumer association	1	0
Government authority	4	0
Industrial or trade association	11	0

Table 16 Measure u) Omit mutagenicity by Stakeholder Group

Equally one would expect Option 5 to rank highly in terms of efficiency. Table 14 does support this to a limited extent, however it also shows how such a view is largely supported by industry related stakeholders.

Stakeholder Group	Don't Know	Higher Efficiency	Lower Efficiency	No Difference	Significantly Higher Efficiency	Significantly Lower Efficiency	Total
Academic/research institution	0	1	0	1	0	2	**4**
Consumer association	0	0	0	0	0	1	**1**
Government authority	2	1	6	1	0	7	**17**
Industrial or trade association	0	22	1	9	3	1	**36**
Non-governmental organisation	0	0	1	1	1	7	**10**
Other	1	2	4	0	0	7	**14**
Private company	2	17	2	10	3	0	**34**
Private Individual	2	3	1	3	4	13	**26**
Grand Total	**7**	**46**	**15**	**25**	**11**	**38**	**142**

Table 17 Efficiency Assessment for Option 5 by Stakeholder Group

Option Six

With this option additional emphasis is put on generation of targeted information with the objective of reduction of uncertainty considering that knowledge is still under development regarding the influence of particle and nanomaterial specific properties on risk. Information generated should also facilitate development of category approaches with all the associated impacts.

Option Six has similar high level of support to Option 5 being supported by close to a third of all respondents. However, when looked at in relation to a summary assessment of the measures within the Option it rated as the lowest ranked of the options. Taking each of the measures contained within it in combination suggests that it is likely to result in the highest increase in the cost of compliance and to be only the fourth most efficient of the five options. Notably it was also only the third highest ranking option in terms of the perceived impact on increasing the safe use of NM. That having been said Option Six needs to be considered alongside Options Two and Four, both of which ranked highly in terms of the aggregate assessments of the measures contained within them.

Of the 41 respondents supporting this option there was again a good deal of detail provided as to why the option was considered to be the most appropriate. Again three representative respondent comments are set out below:

> *Option 6 is the best option for protecting health and environment, it will also significantly increase innovation as information will ensure enforcement and risk management and as a consequence consumer trust and boost of safe NM in the European market.* (Individual Citizen)

Option 6 is the preferred option as this is the most clear and consistent approach to regulate nanomaterials enhancing legal security as well as safety for human health and environment. (Organisation/Other)

I by far prefer option 6, not least because it includes option 2 and 4. Option 6 will ensure a thorough risk assessment of nanomaterials and clear distinction between the bulk and nano form. With a thorough assessment of the safety of each nano form also innovation would be enhanced since it would be more safe and beneficial to invest in a specific substance. Without proper characterization of nano materials and a clear description of the uses, the safe use of the substances cannot be ensured, causing health risk to humans and the environment. (Individual Citizen)

Examining the respondents by stakeholder type reveals a broad divide, with a particular issue of note being that ten of the 17 responses from Member State Competent Authorities supported this option as did seven out of ten NGOs.

Option 6 Profile of Stakeholders	**Number**
Academic/Research Institution	2
Consumer association	1
Government authority	10
Industrial or trade association	1
Non-governmental organisation	7
Other	7
Private company	1
Private Individual	15
Total	**44**

Table 18 Profile of Stakeholders (Option 6)

Looking then within Table 16 at the individual measures all but one of the 14 measures were considered by more than 50% of respondents to be likely to increase or significantly increase the cost of compliance, with five of the options scoring at 80% or more of all respondents. For eight of these options more than 40% of respondents believed that there would be a ‘significant’ impact on the cost of regulation

Comparative assessment of the cost, efficiency and risk of Measures under Option Six	Cost - 'greatest increase in cost burden'	Cost Ranking	Efficiency - 'greatest increase in efficiency'	Efficiency Ranking	Safety - 'highest increase in safety'	Risk Rating
a) Apply clear rules on when nanoforms can be in one dossier or in separate ones based on possibility for data sharing	49		49	1st	49	
b.) Introduce rules to ensure mandatory separation between nanoforms identified and addressed in the dossier whenever they differ in coating, shape, crystalline form or prescribed classes of particle size distribution	64		42	3rd	55	
c) Information requirements for substances covered by Annex III (b) must also apply to nanoforms	69		39	5th	61	
d) For nanoforms, require all information on potential alterations of hazard due to operational conditions upstream the exposure situation is considered	69		40	4th	62	5th
e) For nanoforms, require all available information on the use is considered, even when the use would not be covered by the registration	85	2nd	39	5th	48	
f) For nanoforms, require additional physic-chemical characterisation along the particle's fate when particle properties impacts on hazard	53		42	3rd	76	1st
g) Phys-chem, (eco)tox and CSA documented separately for each nanoform	80	4th	42	3rd	51	
h) For nanoforms, explicitly limit the potential for use of non-testing approaches for hazard and exposure where science is not consolidated, but encourage its parallel application and documentation	75	5th	38		49	
i) Require adapted DNEL setting based on different routes through the value chain / specific uses -	62		38		56	
j) Add to the SDS information relevant to Nano registries in Member States	63		40	4th	46	
k) Specify that list of substances in Annexes IV and V does not cover nanoforms of these substances	73		42	3rd	44	
l) Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless such exposure can be excluded.	61		42	3rd	67	2nd
m) Perform toxicokinetic screening	82	3rd	47	2nd	63	4th
n) For nanoforms, request 28 day repeated dose toxicity in Annex VII	87	1st	40	4th	65	3rd

Table 19 Comparative assessment of the cost, efficiency and risk of Measures under Option Six

In terms of potential impact on safety one measure stands out. Measure f) 'For nanoforms, require additional physic-chemical characterisation along the particle's fate when particle properties impacts on hazard' was thought by more than three quarters of respondents to be likely to 'increase' or 'significantly increase' the safe use of NM.

Additional Responses

A number of additional letters and comments were submitted alongside responses to the Formal Consultation. These were as follows:

- AmCham additional document
- Cabot Corporation additional document
- CEFIC additional document
- Dow Europe additional document
- Bavarian State Ministry of Environment and Health questionnaire
- ETRMA additional document
- French authorities questionnaire
- Lo questionnaire
- Swedish Chemical agency questionnaire

Conclusions

The Public Consultation Exercise was a targeted process that sought to gather stakeholder views relating to the Problem Definition, the Baseline scenario and the five additional substantive options under consideration. It appears to be the case that respondents were able to give nuanced and considered responses and that as a result the survey presents a detailed assessment of each option and the specific measures within them.

The overall ranking provide two clear preferences (Options Five and Six) which stand at each end of the spectrum in terms of the potential impact on regulatory cost and safety of NM. These rankings also stand in contrast to the assessment of respondents' consideration of individual measures. Here Option 2 and Option 4 were given the highest overall approval by respondents. As previously discussed this is not necessarily a contradictory finding in that a significant number of respondents selecting Option 6 make explicit note of the fact that this option already incorporated Options 2 and 4 within it.

It was also apparent that within each option there was a significant level of variation. For instance in Option 4 whilst it was apparent that certain options such as a) 'Include information on dustiness' were regarded as being significantly more beneficial than other such as h) 'Require that testing on soil and sediment organisms is prioritised'. For Option Two there were certain measures which were viewed to be potentially much higher in terms of impact on cost such as with options g) Require that bioaccumulation is addressed specifically for the nanoform and i) Require identification of uses and exposure assessment of the nanoform.

Equally whilst Options 5 and 6 had lower overall levels there were certain stand out measures in relation to Option 6 for impact on safety f) For nanoforms, require additional physic-chemical characterisation along the particle's fate when particle properties impacts on hazard -single choice reply- (compulsory) and l) Choose inhalation as the appropriate route of exposure in repeated dose toxicity study unless

such exposure can be excluded. Equally for Option 5 certain measures were viewed to be likely to increase safety such as a) Describe whether and which different nanoforms are covered in the chemical safety assessment, including a statement when and how information on one form is used to demonstrate safety of other forms' and others could significantly reduce the costs of compliance such as u) Omit mutagenicity and acute toxicity tests in lower tonnages. No skin irritation, skin corrosion or in vivo eye irritation information required for 10-100 t/y if the assessments in 1-10 t/y has been negative -single choice reply, s) Reduce the set of combined methods for nanomaterial determination (Nanomaterial definition, EU/2011/696) to only one (e.g. DLS) and t) For the purposes of REACH, consider aggregates as constituent particle (primary particle) in the nanomaterial definition (EU/2011/696).

Looking at each of the issues of cost, efficiency and impact on human health and the environment it is apparent that stakeholders did not view any of the options as being likely to result in an overall reduction in costs. Option 5 registered the highest score for cost efficiency but even here only a third of respondents believed that it would 'reduce' or 'significantly reduce' costs. So too with efficiency there was only limited belief that any of the options would improve overall efficiency.

In terms of variance by stakeholder group there are a number of important findings. Of the two highest ranked options (5 and 6) it is apparent that support was most forthcoming from private companies and business and trade associations. There was limited support for the option from Member State authorities, other NGOs including environmental and trades union, or from members of the Public. Option 6 by comparison enjoyed a broader level of support from a wider range of stakeholders, but found very limited support from private companies and trade and business associations. Broader assessments regarding stakeholder group were not possible due to the limited number of responses from SMEs in particular.

The variation in response by measure if also notable. Not only was it evident that stakeholders had given very precise responses to each of the measures under consideration, but that there was a high level of congruence with regard to views as to the relative merits of each. This in summary would suggest that each option would be worthy of further review, as each contained measures which elicited significantly less than 50 per cent support from stakeholders with respect to their potential impact on cost, efficiency and health and environmental impact.