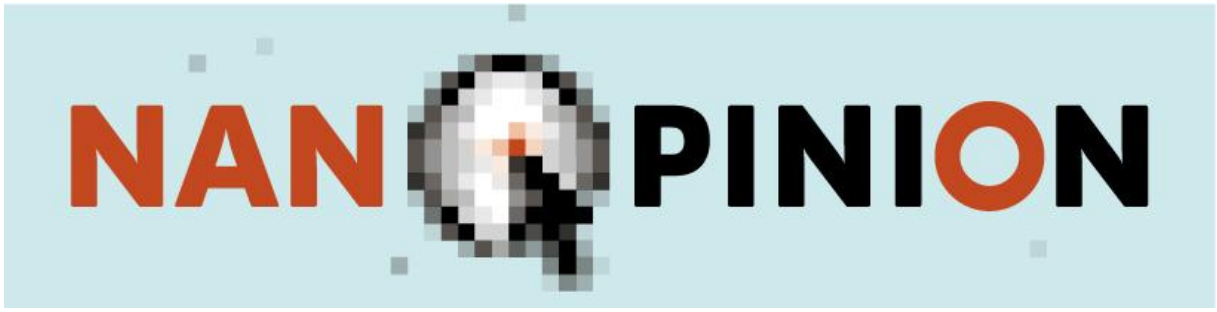

Monitoring public opinion on Nanotechnology in Europe

European Platform on Nano Outreach and Dialogue (NODE)
(Grant Agreement NMP.2011.3-4-290575)

D*1.4.* – Key Communication Requirements

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1. Executive Summary

The main purpose of this report is to analyse and identify current key requirements from a communication point of view. By analysing past outreach activities with respect to applications, topics and used terminologies around nanotechnology in which stakeholders are interested in or concerned about catalogues of issues, ordered by stakeholder, were compiled. These catalogued issues give an overview of current and future topics which could and should be talked about in the course enhanced communication and dialogue between science and society on nanotechnology.

The data basis for this analysis consists mainly on the reported experiences of the past FP 6 and FP 7 projects which included dialogue and outreach activities with various stakeholders concerning nanotechnology, these were the projects NanoYou, DEEPEN, NanoImpactNet, NanoCap, ObservatoryNANO, FramingNano and Nanochannels.

In order to identify the communication requirements a three step analysis was performed. The first step consisted in gathering applications, topics and issues which are of most interest to different stakeholders. This will be a rather general list which was analysed in the second step with focus on the terminology and the reasoning used in the discussion about nanotechnology. The third step consisted in deriving communication requirements based on the insights from the previous two steps. These insights were the result of looking at the identified difficulties and thinking about the consequences for a future conversation on nanotechnology between the stakeholders.

The three-step analysis outlined above subdivides stakeholders into the following groups: the public, scientists, policy makers and regulators, Civil Society Organisations (CSOs) and industry.

For the public the main communication requirements cluster around different providing information and discussing topics like risk literacy, the process of technology innovation and its impact on society, other stake holder's perspectives and participatory process.

Communication requirements for the stakeholder group of scientists emphasize issues like awareness raising of the societal role of science and scientists, the institutionalization of ethical, legal and social aspects (ELSA) in science and engineering and the how to deal with the publication bias in (nano)toxicology.

For policy makers and regulators the communication requirements include the explanation of the process of policy making and regulation and making it transparent with all the complex trade offs it includes. Furthermore the role of public participation in policy making should be explored more by policy makers. The issue of publication bias in (nano)toxicology and its consequences for policy making and regulation should be discussed with policy makers, regulators, scientists and industry.

Communication requirements concerning Civil Society Organisations are on topics like the societal needs and acceptable risks in relation to nanotechnology and the issue of whether nanotechnology is an evolution or revolution with consequences for questions like regulation.

Finally communication requirements for industry concern issues like the multiple facets of responsible development and industry`s contribution to the issue of publication bias in (nano)toxicology.

2. Aim and Scope

The main purpose of this report is to analyse and identify current key requirements from a communication point of view that will need to be addressed in the NAOPINION project throughout its different work packages. Therefore, topics and terminologies regarded as interesting, difficult to understand, or perturbing by the general public and relevant stakeholders, will be analysed.

The data basis for this analysis consists mainly on the reported experiences of the past FP 6 and FP 7 projects which included dialogue and outreach activities with various stakeholders concerning nanotechnology. By analysing past outreach activities with respect to applications, topics and used terminologies around nanotechnology in which stakeholders are interested in or concerned about catalogues of issues, ordered by stakeholder, were compiled. These catalogued issues give an overview of current and future topics which could and should be talked about in the enhanced communication and dialogue between science and society on nanotechnology. The catalogues include a broad range of different communication requirements. Some are linked to the expectations the general public has on nanotechnology, some are linked to the role of the scientists in society, some about the wicked problems of regulation, to name a few.

The report is structured as follows. Chapter 3 motivates public outreach and dialogue for nanotechnology, gives a short overview of the selected and analysed publications and FP 6 and FP 7 projects and describes the methodology of identifying the communication requirements. Chapter 4 will catalogue, issues, difficulties and communication requirements arranged according to the following stakeholder groups: the public, scientists, policy makers and regulators, civil society organisations (CSOs) and industry. Chapter 5 finally summarizes the results.

3. Rational and Methodology

3.1. Communicating Nanotechnology

To communicate with a larger audience about the development of science and technology, including an associated risk benefit analysis, is a rather new concept in science and technology policy, as described by Daniel Fiorino [9]:

> "Many observers argue that risk decisions are best left to administrative officials in concert with scientific experts, acting under instructions from elected representatives, and consulting as necessary with interest groups representing aggregated 'public'; interests. Given the sheer complexity of the issues, the 'transcientific'; nature of the factual premises, and the rapid changes in the definition of problems and their solutions, the lay public lacks the time, information, and inclination to take part in technically based problem solving. Elites, it is argued, will make more rational decisions."

This view changed gradually over the last 20 years with scholars arguing that one of the best and most effective forms of risk governance and risk communication should include participation and deliberation of a broad spectrum of stakeholders including citizens (i.e. people who are not technical experts in the field) focussing especially on dialogic communication formats between scientists, social groups and organized or unorganized citizens [10, 11]. Following this line of argument a whole host of initiatives started aiming at the creation of a

dialogue between experts and laymen about the potential benefits and risks of nanotechnology [2, 4, 12 – 16, 37, 38].

One example for the case of nanotechnology is the German Federal Government's Nano Action Plan which included the establishment of the NanoKommission in 2006 as a central national platform for dialogue. The NanoKommission's mandate was to foster exchange among stakeholders in society on the opportunities and risks presented by nanotechnologies and in doing so help to ensure responsible and sustainable use of nanomaterials. The NanoKommission carried out its work in two dialogue phases (2006–2008 and 2009–2011), each concluding with a Report and Recommendations to the Federal Government [37, 38].

Denmark has even institutionalized citizen participation in technology assessment with its Board of Technology which was established 1986 by the Danish Parliament as an independent institution with the goal to carry out comprehensive assessments of possibilities and consequences of technologies for society and citizens and to further public debate on technology. The board achieves this dual task by the use of participatory methods like scenario workshops and consensus conferences [17].

Public outreach, dialogue and participation in technology governance in general, as well as in the particular case of nanotechnology, can follow different rationales. The literature on public participation distinguishes three major rationales: the normative, the instrumental and the substantive [9, 18, 19]. The normative rationale says: one has to have public participation in a democracy; the instrumental rationale says: there is a specific goal we want to attain (e.g. public acceptance of a technology) and public participation is a suitable instrument to attain this goal; the substantive rationale says: public participation will lead to a substantially better outcome of the governance process (without predefining what the outcome should be). Project NanOpinion follows in its approach a substantive rationale of public engagement by a number of learning, information, outreach and dialogue activities in order to realise enhanced communication and dialogue between science and society for successful technology development and societal acceptance.

3.2. Selection of the analysed projects

All studies and project reports analysed here were published in the last three years. This timely limitation reflects the idea that the aim of this report is to identify *current* topics which should be addressed and not to follow the historic evolution of the field. For those interested in a sketch of the historic evolution of communicating nanotechnology, it can be found in for example in the NanOpinion *Report on the current state of debate on nanotechnology* [52]. Discussion about some topics in nanotechnology from the early 2000s has more or less stopped nowadays [43]. One example is the mainly dystopian futuristic visions and debates around an article in the magazine *Wired* authored by Bill Joy which featured, among others, nanotechnology leading to the destruction of the whole biosphere [44]. Therefore, in order to prevent going after outdated topics, the current analysis includes only projects, reports and studies concluded or published in the past three years (from 2010 to 2012). Some projects, which ended in this period, also feature older publications and reports which were included also in this analysis.

The NanOpinion DoW describes the one objective of the work package this deliverable belongs to and its basic procedure as follows:

> "The main objectives of WP1 are to: Create a comprehensive overview report of relevant past FP and OECD projects[…]"(DoW – Workplan Tables, p. 5).
>
> "Based on existing experiences of dialogue and outreach activities, this task will identify which are the applications, topics, terminology, that the general public, consumers in particular, and relevant stakeholders are interested in and mostly have difficulty with, or are concerned of." (DoW – Workplan Tables, p. 6).

Consequently the analysis in this report focuses on existing experiences of dialogue and outreach activities of past FP 6 and FP 7 projects: NanoYou, DEEPEN, NanoImpactNet, NanoCap, ObservatoryNANO, FramingNano and Nanochannels. Additionally two more studies were considered: the Eurobarometer 73.1 [7] since it provides important information about the situation in Europe as a whole and the study of Grobe et al. which provides insights about terminology and topics in the minds of the general public in particular as consumers by its open-question-methodology [8].

This report is complementary to the NanOpinion *Report on the current state of debate on nanotechnology* [52]. While latter looks at the current state of debate on nanotechnology at large and presents and characterizes the stakeholders, the former focuses more on details of the discussion, analysing the different interests, terminology and difficulties involved in the discussion about nanotechnology and what follows from all this for further communication and outreach.

The following paragraphs provide a short overview of the projects, reports and studies analysed.

The Eurobarometer 2010 (Special Eurobarometer 341 / Wave 73.1) [7] was a representative survey of the European general population, EU member states plus Coratia, Iceland, Norway, Swiss and Turkey. Main topic of the Eurobarometer was biotechnology and the authors regarded nanotechnology as a branch of biotechnology along with technologies like genetically modified foods, animal cloning or stem cell research.

In the study of Grobe et al. [8] the authors conducted in-depth interviews with 103 randomly selected consumers, 53 from Germany and 50 from Switzerland in winter 2010 and autumn 2011. The authors balanced the sample in terms of the demographic situation of both countries, taking into account age, gender and education. The main research questions and mode of operation were the following: "What do consumers know about nanotechnologies? How do they rate nanotechnologies? How do they obtain information? How would they like to be informed in the future? The interviews started with an open question, asking consumers what comes to their mind when they hear the word nanotechnologies. The topics mentioned by respondents were elaborated on; subsequently the respondents were asked about their general attitudes, information consumption as well as their expectations and wishes. All interviews were taped. The consumers' quotes were transcribed, encoded and evaluated. During the process the argumentation patterns were counted and the results of the German respondents compared with those from Switzerland"[8]. This was a follow-up to a similar study from 2008 and the authors compared the results of 2008 and 2011.

Project NanoYou [1] aimed primarily at improving the scientific understanding of nanotechnology on the part of the European youth (between 11 and 25) and teachers. Additionally the project engaged the young in a dialogue about ethical, legal and social aspects of this technology. Amongst other things NanoYou developed teaching materials for students and teacher training courses and a travelling expedition. During the project the NanoYou consortium conducted expert interviews, focus groups exercises and used online questionnaires to gain meaningful data about the target group.

Project DEEPEN [2] studied perspectives of lay people and experts from science and industry on ethical challenges posed by nanotechnology. The project looked at lay people from the UK and Portugal [26], as well as on scientist and industry representatives from multinational companies based in the Netherlands. DEEPEN used qualitative research designs: a three stage focus group procedure for the lay people in Portugal and the UK and semi-structured interviews with scientist and industry representatives in a focus group setting. The interviews with experts were combined with a content analysis of documents written by scientists and industrial representatives as well as observations of these two groups of experts during meetings [23].

Project NanoImpactNet [3] included very large international networking and coordination activities involving scientists from over 40 countries. This project brought together scientists from different disciplines as well as facilitated two-way communication to ensure efficient dissemination of information between stakeholders and the European Commission, while at the same time obtaining input from the stakeholders about their needs and concerns relating to the health and safety implications of nanomaterials. The network of NanoImpactNet included participants from over 40 countries. NanoImpactNet organized in total four international conferences, 19 workshops and 8 training schools. During its communication activities NanoImpactNet conducted several surveys utilising Delphi methods, questionnaires, debates, electronic polls and other methods. Stakeholders involved were academic researchers, industry, NGOs, regulatory bodies like EFSA, and the European Commission. This report will focus on NanoImpactNet WP 4: Communication. Here Communications relates to the dialog and networking between stakeholders. Of major interest were stakeholder views on or interest in the areas of nanomedicine, food contact material and how companies can make their data accessible. Broader and more general aspects were also discussed like transparency, labelling, regulation of nanotechnology. The reported views and interests were restricted to the expert level and does not involve explicit outreach to the public.

NanoCap [4] worked on the basis of working conferences, position discussions and workplace visits with the goal to organise a structured discussion between environmental NGOs, trade unions, academia and other stakeholders about nanotechnology. Furthermore NanoCap supported trade unions and NGOs in developing position statements about nanotechnology. NanoCap developed recommendations to enable public authorities to address health, safety and environmental risk issues related to the rapid introduction of nanotechnology into society. This report focuses in his analysis on the “final conference of the NanoCap project, organised with STOA/European Parliament, to present the positions and perspectives on nanotechnologies at the workplace and in the environment adopted by these civil society organisations. It reflects the dialogue that took place in two panel discussions between trade unions, environmental NGOs, consumer organisations, employers associations, industry, European parliamentarians, the European Commission and a broad audience.”[4]

Project ObservatoryNANO [5] aimed to support European policy makers through the provision of wide-ranging scientific and economic analysis of nanoscience and nanotechnology developments, which is further supported by assessment of ethical and societal aspects, impacts on environment, health and safety, as well as developments in regulation and standardisation.

This report focuses on the communication activity of the project which performed a case study consisting of the evaluation of the so called ObservatoryNano Ethics Toolkit. This Toolkit was developed to communicate nanoethics to scientist but could and should be adapted to be used with other stakeholders as well. Main goal of the Toolkit was to encourage scientists to develop a reflective approach on ethical and societal impacts of their research. The authors claim the toolkit has proven successful on this goal. The authors of ObservatoryNANO list remarks and recommendations that scientists gave as feedback after having worked with the Toolkit.

The aim of FramingNano [6] was to create proposals for a governance plan highlighting the needs, actions and recommendations necessary to develop safe nanotechnology at EU level and beyond. FramingNano analysed the current regulatory processes, the science-policy interfaces and the research on risk assessment through literature reviews and consultation with "all relevant stakeholders" [6]. Whereas "Relevant stakeholders were classified into four groups: Regulation & Control (government policy makers, regulator and standards agencies, lawyers); Research (academia, industry); Business (production, retail, insurance and finance, industrial/professional organisation); People (NGOs, consumer associations, social/ethical researchers, workers representatives)"[6]. The proposed governance platform was based on the results from a two-stage Delphi consultation with the above stakeholders and the outcomes of a multi-stakeholder workshop. Delphi first round: An electronic questionnaire was designed to identify the key themes considered most important and relevant for the future governance of nanoscience and nanotechnologies. The multi-stakeholder workshop: Members of the above mentioned stakeholders made direct input to the consultation process. A second-round Delphi questionnaire with 16 questions in text format was developed based on the responses, inputs and key themes identified from the first-round questionnaire and the multi-stakeholder workshop. This second-round questionnaire was designed to enable stakeholders to comment and elaborate further on identified key themes in nanotechnology governance.

Nanochannels [45] aimed at identifying the most appropriate communication channels and use them to engage a wide range of stakeholder groups in an open debate of ethical, legal an social issues raised by developments in nanotechnology. Nanochannels used traditional media, including press and radio as well as youth-oriented, web-based content combined with live events like debates and round tables to engage the lay public, scientists, NGOs, educators and other stakeholders. A series of debates took place in schools throughout the EU. During the Nanochannels project school students produced their own media content about issues around nanotechnology. Throughout the project, a series of surveys and focus group discussions took place, which is the part of the project most relevant for this deliverable, you are reading. A online survey in seven languages with 1334 respondents provided quantitative data, while focus group discussions in five countries and interviews with experts in the field of science communication provided qualitative information. Survey, discussions and interviews aimed at exploring people's attitudes, expectations and interests concerning nanotechnologies as well as to explore the potential of different communication channels to raise awareness within society for nanotechnology related issues.

3.3. Identifying communication requirements

This section outlines a three step analysis of the studies and publications listed in Section 2.2. Aim of this analysis is to identify requirements from a communication point of view that will need to be addressed in further outreach activities to the public during the NanOpinion project.

The first step of the analysis consists in gathering applications, topics and issues which are of most interest to different stakeholders. This will be a rather general list which, in the second step, will be analysed in more detail with a focus on terminology and reasoning used in the

discussion about applications and issues. The third step consists in deriving communication requirements based on the insights from the previous two steps. These insights were the result of looking at the identified difficulties and thinking about the consequences for a future conversation on nanotechnology between the stakeholders in terms of communication requirements. The communication requirements presented in chapter 4 are a combination of the recommendations of the authors of the analysed studies as well as requirements identified in the current analysis

The practical work during the three-step process described above was guided by a scheme for analysis. This scheme consists of a table with nine lines and two columns (cf. Annex 7.1). The nine lines of the first column include the nine categories according to which each project of study was analysed. These categories were:

- type of publication and source
- countries where participants came from
- type of study (e.g. online survey, focus groups, expert workshops etc.)
- stakeholders and target groups involved
- nanotech applications presented or discussed
- topics and applications in which stakeholders or target groups are interested
- terminology used (indicating interest or difficulties)
- communication requirements (arranged according to stakeholders)
- conclusion of the authors of the study concerning communication requirements

The three-step analysis outlined above subdivides stakeholders into the following groups:

- the public
- scientists
- policy makers and regulators
- Civil Society Organisations (CSOs)
- industry

This subdivision reflects the subdivision present in the reports analysed as well as the stakeholders grouping that is used in NanOpinion. For this report "the public" consists roughly of people who are not professionally working in the field of nanotechnology. Some of the analysed reports and publications invited people from this group (in general randomly selected citizens) to take part in activities like group discussions, in depth interviews or surveys.

The stakeholder group "the public" is certainly the most heterogeneous group. Even the concept of "the public" used in science communication has changed over the past 20 years [21]. The literature states that one can refer to the public in different ways for example as laity, as consumers or as stakeholder [5, 20]. In the particular case of nanotechnology the public is often referred to

- **as laity**, having a deficit in knowledge about the science, policy or regulation behind nanotechnology and therefore needs more information and education,
- **as consumers**, whose preferences are of interest or whose acceptance should be achieved concerning existing and future products of nanotechnology,
- **as stakeholder,** which, among other stakeholders, has interests and therefore is entitled to take part in the democratic deliberation about policies and regulations concerning nanotechnology.

The analysed studies and projects focused mainly on the latter two roles (consumer and stakeholder). This reflects the current trend to go beyond the so called (information) deficit model. This model identifies a deficit in information in the public as the primary concern of the communication of science and technology and the corresponding governance. Baruch Fischoff summarized the historic evolution of the basic assumptions underlying technology and risk governance from the information deficit model (in its various forms) to more participatory approaches[22]:

- All we have to do is get the numbers right
- All we have to do is tell them the numbers
- All we have to do is explain what we mean by the numbers
- All we have to do is show them that they've accepted similar risks in the past
- All we have to do is show them that it's a good deal for them
- All we have to do is treat them nice
- All we have to do is make them partners
- All of the above.

The last point of this list underlines that different paths can be chosen, depending on the specific objectives of the outreach activity. This is also stressed by the OECD *Planning Guide For Public Engagement And Outreach In Nanotechnology*[24] which lists points of consideration which should be reflected during the planning of public engagement activities. These points include the identification of social, cultural and economical context as well as the identification of interested groups or people (not yet interested or not even aware of the topic) one wants to engage with. The context of the issue itself, here different issues around nanotechnology, is also important and includes what is known or unknown to participants and what is the scope of the issue being discussed.

The current report in concert with the NanOpinion *Report on the current state of debate on nanotechnology* [45] deal with these issues by providing a comprehensive overview of the current state of debate about nanotechnology as well as the knowledge, interests and concerns of different stakeholders about this topic.

4. Issues, difficulties and communication requirements

This chapter contains the main results from the analysis of the considered studies and reports on outreach and dialogue activities around nanotechnology. The sections of this chapter are arranged according to the following stakeholders: the public, scientists, policy makers and regulators, civil society organisations (CSOs) and industry. Each section contains specific issues, terminology and difficulties concerning nanotechnology for the respective stakeholder group. For the stakeholder group "the public" there is an additional subsection concerned with applications. This difference between "the public" and the other stakeholders is mainly due to the fact, that "the public" is often regarded as consumers (cf. Section 3.3). If there is communication and dialogue about particular applications of nanotechnology this is mainly focused on applications in consumer products. Of course there are applications of nanotechnology used only in laboratories of scientists or industrial production facilities. But these applications are not addressed in public outreach and stakeholder dialogue projects. They are discussed in more technical projects and the scientific community (e.g. the EU projects NANO-DNA, NANOBIOMOFS or NANOPHOCAT).

4.1. The public

Over the last years, most studies on lay public attitudes toward nanotechnology have focused on nanotechnology in general, e.g. [46, 47]. Only recently studies have started to investigate the perception and attitude of specific applications of nanotechnologies. This is in line with the approach of "decoupling nanotechnologies" [48] in order to better identify opportunities and risks of the different areas of applications (and of the different nanomaterials used) which is deemed essential for developing meaningful policies and risk assessment protocols. The following section analyses the applications lay public are more familiar with, and the risk perceptions associated to these.

An important data to highlight before doing this analysis is the familiarity of lay public with the term "nanotechnology" in the first place. Several studies have run surveys in Europe, Canada, US, and the result is consistent among these: most interviewed people are unfamiliar with this topic altogether; in the study conducted by Grobe et al [8] only 20% felt familiar with it and were able to provide the definition; a similar data was reported recently by Vandermoere and colleagues after a survey run in France (less than 20% "familiar" with nanotechnology). [49]

Five of the analysed studies dealt with the public: Eurobarometer 2010 [7], Grobe et al. [8], NanoYou [1], DEEPEN [2] and Nanochannels [45].

In a first approach only studies with open question design will be considered since they allow to get an idea of what topics and issues come up in people minds in contrast to ask them to give their opinion to a presented topic.

4.1.1. Applications

Project Nanochannels [45] looked, among others, at members of the general public as consumers of current or future nanotech products. The general trend showed that important issues with nanotechnological applications and products are the same as with other technologies. Consequently the price and quality of the products as well as an added value were seen as important by consumer driving their choice for potential nanotech products. There was little consideration for recycling issues as this was perceived as something too far away in time as to care much about, unless a potential environmental hazard would become considerable large. With regard to trust in industry and regulation participant showed considerable trust in familiar producers or known brands as well as local the local retailer. There was also general trust in the regulation of nanotechnological products available on the market "[...] a product is trustful once you can find it in the supermarket in your country" [45]. Lower trust was reported if nano products would come from an "untrusted country". Trust in medical applications was quite high as people perceived that such applications underwent a long and thorough testing phase.

The study of Grobe et al. [8] got in more details about the areas of applications consumers link to nanotechnology. Table 1 shows the six **most frequently mentioned** areas of applications as reported by Grobe et al. [8]. While the ranking has changed the areas of applications themselves stayed the same.

Top six areas 2011		Top six areas 2008	
1. Medicine	(71 %)	1. Medicine	(85%)
2. Automobile	(60 %)	2. Surface coating	(78%)
3. Surface coating	(50 %)	3. Food	(63%)
4. Food	(49 %)	4. Automobile	(62%)
5. Textiles	(45 %)	5. IT/Electronics	(61%)
6. IT/Electronics	(44 %)	6. Textiles	(55%)

Table 1: The six most frequently mentioned areas of applications for nanotechnology from German and Swiss citizens as reported by Grobe et al. [8]. The percentages indicate the fraction of respondents which mentioned an application from the respective area.

In all areas the number of applications mentioned dropped between 2008 and 2011 indicating that fewer people name applications. The trend seems to point to a reduced awareness of the existence of nanotechnology in consumer products. The largest changes in frequency of mentioning applications can be seen in the areas of environmental engineering (from 19% in 2008 down to 3% in 2011), surface coating (from 78% to 50%), building materials (from 41% to 23%) and military (from 20% to 9%).

Grobe et al. analysed the interview answers with respect to the expected benefits and feared risks which are connected to nanotechnology and its products and applications. The **most frequently mentioned expected benefit** was connected with increasing comfort, mainly through reduced cleaning of surfaces and textiles as swell as comfortable textiles that protect e.g. against wind and rain. Additional benefits were connected to health and beauty in terms of medical intervention and cosmetics. There was also the expectation that nanotechnology in general will boost innovation and be beneficial for the business location, improve the environment e.g. through enhancing energy efficiency and water cleaning and provide safety e.g. through bullet proof textiles and anti-theft devices.

On the other hand the list of the **most frequently mentioned risks and fears** include negative effects on health and environment, the misuse of technology, mainly in terms of military (mis)use. There is also the fear of ubiquity which is considered menacing perspective since it is impossible to choose to live without the omnipresent nanotechnology.

About 20% of participants neither mentioned benefits nor risks connected to nanotechnology during the interview. From 2008 to 2011 the number of participants that mentioned benefits consistently went down through all benefits while number of participants mentioning risks consistently went up through most risks as shown in table 2 and 3. It seems that while people are less aware of nanoproducts they began to see more risks and less benefits concerning nanotechnology over the last years.

Top five risks 2011		Top five risks in 2008	
1. negative health effects	(67%)	1. negative health effects	(55%)
2. negative environ. effects	(40%)	2. negative environ. effects	(29%)
3. Misuse	(12 %)	4. Ubiquity	(6 %)
4. Ubiquity	(5 %)	5. Cyborgs	(2 %)
5. Cyborgs	(1 %)	6. Misuse	(0 %)

Table 2: The five most frequently mentioned risks or fears concerning nanotechnology from German and Swiss citizens as reported by Grobe et al. [8]. The percentages indicate the fraction of respondents which mentioned a respective risk.

Top five benefits 2011		Top five benefits 2008	
1. Comfort	(40%)	1. Comfort	(58%)
2. Beauty/health	(31%)	2. Boost innovation	(61%)
3. Boost innovation	(31%)	3. Beauty/health	(52%)
4. Environment	(16 %)	4. Environment	(26 %)
5. Good for Business location	(6 %)	5. Good for Business location	(20 %)

Table 3: The five most frequently mentioned benefits of nanotechnology from German and Swiss citizens as reported by Grobe et al. [8]. The percentages indicate the fraction of respondents which mentioned a respective benefit.

During focus group exercises in project NanoYou European youngsters between 12 and 20 years mentioned the following nanoproducts known to them: nano sealing on panes, textiles and sunblockers. When asked which kind of product they would like to develop they chose products and devices in the field of medicine and information, communication technology (ICT) as well as clean and renewable energy.

Project DEEPEN used theatrical techniques to enable participants to act out, rather than simply talk about, ethical narratives they are concerned with. During these performances several imaginative applications of nanotechnology were presented. These applications were: cosmetic products for a younger look, self-diagnostic nano robots, crop yield increasing nanoparticles, cholesterol reducing nanomedicine, mood altering nanomedicine, targeted cancer chemotherapy based on nanoparticles , a nano bomb (20 times more powerful than a nuclear bomb), embryonic engineering to create customized babies in the petri dish and medical applications for a virtual indefinite life.

These imaginary products give an idea which products people regard as connected with important societal and ethical issues, since the DEEPEN project focused on lay ethics. Therefore these imaginary products are the most dramatic ones and represent extreme cases. The more mundane and more realistic applications of everyday life with not such great power to shake the whole ethical basis of society cannot be found in this list. The applications from Grobe et al. and NanoYou as well as the DEEPEN project are connected to topics that go beyond the simple usage of nanotechnology. In the DEEPEN project this is explicitly the case, since ethical considerations are the starting point for thinking and discussing about nanotechnology. The following section will focus more on issues around nanotechnology in general and its applications in particular. These issues involve what people know or do not know about the topic, what terminology they use and which difficulties become apparent.

4.1.2. Issues, terminology and difficulties – The public

The previous section presented applications of interest as found in the works of Grobe et al., NanoYou and DEEPEN. All of them have in common that the applications were mentioned during a process of open discussion. These applications are often linked to a certain issue that is of some importance to the participants who discussed these applications. When a youngster for example says she would like to invent nanoproducts in the area of renewable energy this shows that the issue of environment is important to her. In this sense one can identify general issues to which people connect with nanotechnology. These issues correspond more of less with the areas which Grobe et al. connects to risks and benefits:

- Staying and getting healthy
- Staying and becoming beautiful
- Saving the environment
- Boosting innovation

All these points can be linked to benefits or risks. New medical treatments can ease ailments but also have unknown side effects. Cosmetics my help us look and consequently feel better but what about negative health effects or societal consequences of an arms race around superficial beauty ideals. Boosting innovation should lead ideally to increasing comfort and leisure (e.g. through textiles, information and communication technology (ICT)) however, innovations can also bring problems with them with major consequences on health, society and environment. Nanotechnology in food might be an innovation but consumers show very low acceptance compared to other areas of applications [25].

All of the above issues are of general importance to the public. Therefore it is not surprising that when the public is confronted with a new technology, like nanotechnology, people project onto it their hopes to find better solutions for issues of general importance in their life.

As mentioned before, the familiarity of lay public with “nanotechnologies” however is low in the first place. When asked the question “what nanotechnology is” by Grobe et al., only 20% of the participants were able to provide a definition. When asked for applications the terminology used was detailed only for one medical application: cancer treatments with hyperthermia therapy, in other medical areas there were only vague ideas using often “may be” or “perhaps”. These medical areas were mostly cancer therapy, implants and artificial organs. In the automobile sector applications were mostly about car finish, car polisher or car washing.

In the area of food the knowledge and corresponding terminology is diffuse. Nanotechnology was associated with chocolate coating, ketchup and food colorant but there was no clear idea how nanotechnology plays a role in these applications. Participants often remarked they have heard that nanotechnology is used in food but perceived the use of this technology in food as not transparent. Several recent studies have highlighted that the application of nanotechnology to the food sector, either inside food or through food packaging solutions, is a crucial topic that can influence public perception more than other applications [49, 50]. Whereas many studies report a tendency of perceiving that the benefits of nanotechnologies will outweigh their risks [46], the attitude towards the “nanotechnology in food” area is definitively more pessimistic [49].

In the area of textiles too, the “how nanotechnology works” is not clear nonetheless people were able to state clear the benefits they expect from nanotextiles: they should be water repellent, dirt repellent, breathable, non-iron, anti-bacterial and anti-odour. The use of nanotechnology in the area of textiles was generally seen as useful and people showed openness towards the use of these products.

As shown before in Table 1, mentioning topics of nanotechnology in environmental engineering dropped sharply between 2008 and 2011. In 2008 about 19% of the interviewees mentioned nanotechnology in the context of environmental applications, in 2011 it was only 3%.

In terms of content, several focus group reports [51] and studies have highlighted the need to limit the amount of technical information provided to the public on a given application, and focus on providing information on how the specific application can be beneficial to the consumer, what need it can fulfil, and how it compares with other current solutions, also in terms of cost.

Interestingly, many studies report how increasing lay people knowledge on nanotechnologies does not necessarily lead to its acceptance. Quite the contrary: people often take positions towards nanotechnology even when stating knowing very little about it and providing more information does not lead to a shift in their position. Precisely for this reason, when communicating nanotechnologies, there is the need to consider also ethical perceptions, values, and views on science and technology innovation [46].

For instance Project DEEPEN analysed the issues that concern the public with a focus on ethical narratives and identified here issues concerning the impact of nanotechnology like the consequences to human and natural order or issues of control, drivers, power behind the new developments in science and technology.

Project DEEPEN identified in its focus group activities five key cultural narrative used by the participants from the general public [2]:

a) 'Be careful what you wish for'
b) 'Opening Pandora's box'
c) 'Messing with nature'
d) 'Kept in the dark'
e) 'The rich get richer and the poor get poorer'.

These are all narratives emphasizing risk and warning. The authors of DEEPEN see these narratives as a form of resisting the enlightenment narrative which states that scientific and technological progress consequently leads to societal progress. Even though DEEPEN identified only narratives emphasizing risk the authors stress that in general participants saw pros and cons of nanotechnology not as separate but as intertwined. Visions of nanotechnology are far from black and white and recurrent themes in the discussions where the above mentioned consequences to human and natural order. Terminology used in this context describes a notion of awe:

- "a totally different world"
- "it's a mouth opener"
- "something completely new and that makes us think that we are entering the world of science fiction" [26]

and a "new" relation with nature

- "[…] we took […] the original creation and we played with it as if it were Lego […] [we] move forward with this technology with an amazing speed […] without the smallest idea of the consequences." [26]

This leads to a description of the disruption of natural life courses:

- "…these materials, ultra-resistant, ultra light, ultra-everything […] will they degrade or not, what can these fibres do when they degrade […]"?
- "messing with the natural orders of things"
- "…there`s a big difference being able to live longer but to be able to enjoy living is another question altogether…",
- "they talk about making more time available…for what? So that we may sit for 1,400 years in front of the TV? Or walk 3,000 years around the park?",
- "…either we stop the birth rate, or else Earth […] stops being large enough, but with nanotechnologies maybe we can reach other planets". [26]

And has possible consequences for our health:

- "if it is possible to have a device that can got to a cancerous cell an destroy the cancer, well, it's fantastic […] but why not change the project […] and start putting plaques on top of one another and cause a stroke."
- "…these are really small things that due to their dimensions can penetrate the skin, enter the circulatory system and get to the…the brain, for example or the liver." [26]

The participants also speak about control and power: Who controls nanotechnology and its development? Can the public/individual influence the development of nanotechnology? Is there consumer choice or are products foisted onto people? Are we creating high-tech solutions to problems that do not exist? Some of the terminology employed by participants (Sharon and David) here is:

- I: "And democracy hasn't much chance really? Sharon: "There are bigger forces." David: "Not at our level."
- "[…] it's just finding more new things to sell."
- "…there might be an end to mutual trust because if the kind of obsessive, police control made possible by […] these technologies."
- "I'm afraid of absolute control."
- "Now speaking of nanotechnology in robotics […] nowadays a computer grows and may turn against us."
- "I don't recognize in anyone the authority or capacity to say: this door is closed and this one is kept open." [26]
-

There is also a discussion about informing and information about nanotechnology:

- "If […] we have enough data (…) I personally will try out any medicine"
- "[…] I think that is a right we all have, the right to information […]"
- "[…] I prefer talk more of empowering citizens, rather than just informing them […]"
- "all responsible persons (…) let them pass through […] a course […] of awareness […] a kind of journey […] through different cultures, different philosophies […] so that they would reach a broad and comprehensive vision of humankind, because they are persons making decisions that will effect the whole humankind." [26]

Summing up there can be identified the following difficulties:

Public- issues, terminology and difficulties		
Topic	**Description**	**Comments**
Unfamiliarity with nanotechnology	Lay public is still unfamiliar with nanotechnology	Have heard of nanotechnologies: approx. 45% [7] Can provide a definition [8]: only 20% of respondents
Only few specific applications are known	Few applications, like the use of nanotechnologies in some innovative medical treatments, or the applications in care products, are known.	Some studies [8] highlight unfamiliarity with the application of nanotechnology in environment engineering
Unclear about how nanotechnology is applied in food	There is a lack of knowledge on how nanotechnologies are applied to the food sector	The application of nanotechnology to food is of concern to lay public [49] however there is a lack of knowledge on how nanotechnologies are used in this sector.
Ambivalent feelings towards emerging technologies	Ambivalent feelings towards the unknowns and the changes at personal, ecological and societal level which come with the advent of every major new technology	
Broad spectrum of attitudes	There exist a broad spectrum of attitudes toward the need for control and regulation of the development of nanotechnology	These attitudes range from distrust and feelings of powerlessness through the call for specially adapted regulation for nanotechnology to laissez faire approaches.
Demand for information on nanotechnology	People demand information, but, as quantitative surveys show [25], actively do not do much to look for information about nanotechnology.	In general, people are more interested in particular applications or products they are thinking about using or purchasing than information about nanotechnology as a whole.

Table 4. Summary of issues, terminology and difficulties for the lay public in relation to nanotechnologies.

The ambivalence between awe and fear from the participants of the DEEPEN project can also be found in the participants of NanoYou. The young participants used a terminology to express associations with and attitudes towards nanotechnology that was associated with the "world of small things" [1]:

- atoms
- chemistry
- bacteria
- "something very small"
- microchips
- 10^9
- small particles used in computer technology
- disease
- fungal infections
- Nano-motors
- CERN in Geneva
- "stuff that can solve cancer with the little robots"
- "…technology that might be able […] to control peoples' minds"

Except the last sentence the used terminology is mainly descriptive. The authors of NanoYou describe that the youngsters assume that nanotechnology has a great potential, especially in the medical branch but they also mention some fears like human cloning or doomsday scenarios like robots getting out of control [1]. On the other side of the spectrum some young people expect nanotechnology to fulfil their wishes for every kind of product, from 'beaming' a lá Star Trek to 'a drug that can heal every disease' [1]. In between these extremes there is the call for limits that should be set to guarantee that no harm is done with this technology. However, youngish idealistic exuberance is sometime expressed, e.g. by a 22 year old [1]:

- "…you just have to choose the positive things and do not get into the negative".

However, the young boys and men are very sceptical about the independence of control authorities and see a high possibility of corruption.

Taken together following difficulties for the youth can be identified:

- Young people may tend to adopt an uncritical attitude toward nanotechnology at first (new technology = better world) caused by lack of information about possible risks. The authors of NanoYou report that when the young are informed about possible risks they show a lot of concern. This may lead to a possible overshoot reaction leading to rejection.
- There seems to be a lack of a realistic/differentiated picture of risks and benefits of nanotechnology ("nanotechnology is a good thing, once all risks will be banned").
- On the one hand young people put emphasis on control through authorities, on the other hand there tend to be scepticism about independence and integrity of authorities (especially among boys and young men).

4.1.3. Communication requirements – The public

As described in Section 2.3 the communication requirements presented in this section consists of a collection of recommendations of the authors of the analysed studies and requirements identified by analysis described in this report.

Public- Communication Requirements		
Topic	**Description**	**Comments**
Terminology & information providing	Provide clear, straightforward, balanced information on nanotechnologies, focusing on practical applications, illustrated with explicit examples of high relevance to the consumer. Information needs to be shared in an interesting and entertaining way.	The information should be provided by a person who is perceived as "neutral" in the institution
Improve communication strategies	Improve communication strategies of several industrial sectors applying nanotechnology, but also of scientists and public authorities to communicate nanotechnology as an important topic in innovation.	Use of best-practice examples for communication strategies[1]
Benefits of nano-technology	Information about the functioning, characteristics, ingredients, benefits, added value (in comparison with current products), quality, durability, health benefits and environmental benefits should be provided. They should be illustrated with explicit examples of high relevance to the consumer.	Assessment of societal desirability: needs and advantages of existing and future nanotechnology applications
Risks of nano-technologies	The potential risks of nanotechnologies for humans and the environment should be described, putting these aspects in the context of risk associated to any new emerging technology, yet providing concrete examples in relation to nanotechnologies. Assessment for lay public "risk appetite": preferences about the level of tolerable risks. Focus on "Risk perception": values and criteria to balance risks against benefits.	Risk communication to the public must be encouraged (increase familiarity with concept of dose, exposure venues, risk assessment, etc.) highlighting the fact that every material, application, technology has an associated level of risk (risk cannot be "zero").

[1] For instance by referring to the NANOPINION Best Practice Report (D1.2)

Balancing benefits and risks	It should be communicated that with changing abilities (e.g. through nanotechnology) arise new possibilities, new unknowns and new risks. This is part of modern technological life and to be confronted with these possibilities as well as unknowns and risks is part of modern citizenship in open societies where topics of risk and benefits of technology are discussed openly. Discuss the challenge to find a realistic balance between accepted risks and unknowns and innovation. Whenever the elimination of all unknowns linked to new technologies comes on the table one would have to emphasize that this would grind technology development to a halt. On the other hand, whenever unbounded freedom of scientific and technological development is advocated one would have to emphasize a more responsible approach of risk management.	Risks and unknowns are part of modern society and scientific and technological development and inextricably linked to the benefits of latter. Encourage citizens to reflect under which circumstances would they see nanotechnology applications as being acceptable in terms of risks and unknowns. What level of governmental, regulative, activity so they expect. What do they expect from industry?
Attitudes towards the "unknown"	The ambivalent feeling toward the unknown should be addressed.	Encourage people to reflect and discuss how they react about the unknown and that this reaction might generate more fear and anxiety than its fair share, given the known data. One aim would be to make people aware that the price of living in an open society which evolves technologically is that open discussions about positive and negative aspects of technology take part and therefore everybody is going to be confronted on a regular basis with risks that may come with new technologies.
Topics of special interest	Communication should be application-specific with focus on topics of interest and concern to the public. Among these, the application of nanotechnology to the food sector (so called „Nanofood") demands special attention.	

Ethical concerns	Communication needs to consider wider ethical concerns related to use (and misuse) specific nanotechnology applications. Need to communicate the concept of "responsible innovation".	
Feelings concerning nano-technologies	Feelings ranging from distrust to powerlessness through the call for specially adapted regulation to laissez faire approaches. For each of these feelings different approaches in communication should be developed	The aim is to show that there is already much activity from science, policymakers, agencies or NGOs. For people with the feelings of distrust communicators could present the activities from governmental, regulatory, scientific and societal initiatives which deal with the various aspects of nanotechnology. For people who call for effective regulation one could discuss the practical problems and past and current efforts of regulation. For people calling for a laissez faire approach one can provide historical examples of too little regulation which lead to problematic development.
Process of technology innovation	Nanotechnologies in the context of material engineering innovation (nanotechnology as an „evolution" rather than an „revolution"). Making people conscious of a process of technology development which is constantly happening and that most people are not aware or not reflective about. Using nanotechnology communication as a way to bridge science and society (understanding of the process of innovation)	Nanotechnology should be presented as a continuous development from known technology to methods which work at smaller and smaller dimensions.

Other stakeholders perspectives	Share the perspective of other key stakeholders, in particular the perspective of scientists: scientists at large do not see it as one their professional responsibilities to dwell on societal aspects and consequences of the research they conduct.	People do not have to accept this perspective that scientists hold, but made aware of it. It is important to communicate that scientists consider societal aspects of their research not a part of their professional work, because nobody demanded it from them and they never saw it as an integral part of their work.
Participatory process	Preference should be given to participatory outreach events and venues (focus group, public debates, etc.). The focus of the debate about nanotechnology should move beyond technical questions of risk and scientific uncertainty (though these are important issues) towards more collective discussion about the direction for nanotechnology in terms of a science and its governance. Public participation and deliberation should move away from identifying concerns regarding speculative futures, toward public engagement exercises which focus on current emerging research directions and technological developments in order to critically assess their possible impacts and their normative implications	Use of best example practices and development of new methods and formats for deliberation to allow diverse forms of interaction and debate. Lay people reject the "technoscientific vision" that promotes the idea that technological progress leads automatically to improvement of society (DEEPEN Project). Hence this approach should be avoided

Education	Nanotechnology education should be a priority, starting from school education (students are multipliers for reaching other audiences, like their parents, and other sectors of the „lay public" group). Teaching and communication material should use examples that relate nanotechnology to daily life of the youth, with a focus on interdisciplinary education. ELSA topics should be included and special formats to discuss these aspects (e.g., role-play games, school debates, school competitions, etc) promoted to encourage young people reflection on these topics. Teacher training programs on nanotechnologies need to be organized in European countries. Professional education should apply at the stage of the education of professionals, in particular to strengthen the knowledge of professionals in the area of occupational safety and health.	Basic information about the science behind nanotechnology could be appropriately provided by schools (in chemistry and physics). Curricula mapping can be used to assess how nanotechnologies can be integrated in the science curricula of different countries[2].

Table 5. Summary of communication requirements for the lay public in relation to nanotechnologies.

It is probably not realistic to expect that an agreement between NGOs, trade unions, industry, policy and science can be reached. There seem to be too many irreconcilable interests involved. For outreach activities towards the public there is a challenge to confront lay audience with the dilemmas at hand: The trade-offs e.g. between going forward developing and marketing new products and the lack of knowledge about long-term effects. There is demand for new products on the one hand (not only consumer products but also material sciences which can make cars, trains and airplanes more fuel efficient, electronics less energy consuming, solar cells more effective and improve medical treatments or clean the environment, etc.) at the same time there is the wish to have knowledge about long term effects immediately. Should really any nanoproduct be strictly forbidden when there is no thorough risk assessment done? How thorough is thorough enough for new materials? What are nanoproducts? What are the properties of nanomaterials which determine how thorough they must be tested and by which protocols. Are really all non-nanotechnology products thoroughly tested and again: how thorough is thorough enough? If they are not thoroughly tested, is it feasible or not to go forward even though no thorough risk assessment is available for all nanomaterials or all nanoproducts at the time? Is it acceptable to postpone the development and marketing of nanotechnology products for say about 40 years to have proper long term (e.g. animal) studies on a large number of nanomaterials? After 40 years there would be some nanomaterials and applications that were considered safe and others not. Then further development would

[2] NANOPINION has produced a "School Mapping Report" (D4.1), which analyses the different science curricula in European countries, which already include nanotechnology; how nanotechnology could be integrated. Recommendations specific for each countries are provided.

continue but soon another moratorium on these new developments for another 40 years would be necessary. Who would pay for the 40 years of testing? If it would be industry it would probably quit nanotechnology or move to countries with less strict regulation. Are we willing or not to accept such a slow down of technological development under such rigid conditions? There is the challenge to present the public with the "wickedness" of the "problem" without discourage people of dealing with the situation since it may look so complicated and unsolvable.

4.2. Scientists

The projects which involved the group of scientist were mainly DEEPEN, NanoImpactNet, ObservatoryNano and FramingNano. Therefore this section will focus on these projects. In contrast to "the public", scientists are generally not asked about specific applications. Consequently this section will not discuss applications, as was done for the public. Instead the analysis will start with issues, terminology and difficulty of nanotechnology.

4.2.1. Issues, terminology and difficulties – Scientists

One can distinguish at least two broader classes of issues with which scientists are concerned in analysed studies [3, 4, 5, 6, 23, 27]. One class includes technical questions for example which tools (data, protocols, measurements, models etc.) are needed to come to a reliable risk assessment. The other class includes questions concerning the societal role and responsibility of scientists in the process of technology development and governance.

One project dealing with issues of the latter class is ObservatoryNano [5]. This project performed a case study which consisted of the evaluation of the so called ObservatoryNano Ethics Toolkit. Main goal of the Toolkit was to encourage scientists to develop a reflective approach on ethical and societal impacts of their research. The Toolkit was an over 70 pages long document with information about ethics in general and exemplified ethical questions in concrete nanotechnological applications in particular. The Toolkit was tested at several dozen meetings and workshops in scientific audiences of various types and sizes. Participants of the toolkit test workshops expressed general interest in learning more about ethical reflections with application to their own research. Some participants criticized the level of simplification and expressed interest to learn more than basic concepts. Connections being made in the toolkit between ethical concepts and particular technological cases were sometimes seen as artificial. Furthermore scientists pointed out that contemporary research being perceived by society through narratives, visions or fictions that circulate within its culture has considerable drawbacks. Since the connection between the narrative and the every-day work of a scientist is far from being self explanatory. "There is the risk of uncontrolled judgement on the basis of narratives that have little or nothing to do with the reality of contemporary science" [5]. Narratives have up- and downsides: Narratives are helpful getting people involved in the debate by appealing to affective reactions and personal concern is one major motivation for participating in any debate. However, the appeal to affection means that narratives are not purely rationalistic accounts of a topic. This can lead to a debate which is dominated more by affective reactions than rational thoughts or realistic accounts of the topic at hand. In other words: narratives help to get people involved in a debate, but this debate might be dominated more by affection than by rational accounts. Additionally, narratives are culture dependent and the current narratives in the toolkit are based on the European culture (this criticism came for example from Asian scientists in the workshops).

Another project which deals with nanoethics is DEEPEN and its findings indicate that scientists recognise ethical issues concerning the development of nanotechnology but do not see these issues as highly relevant to their professional role. Concerning ethical aspects in the development of nanotechnology scientists argue for a division of moral labour [23], i.e. scientist

see themselves mainly in the business of doing research while rejecting the responsibility to think about broader societal issues and consequences of their research. This, scientist tend to say, has to be done by others, e.g. consumers making purchase decisions, politicians providing policies and regulations, or industry providing products. Consequently, scientists reacted concerned when asked to consider the possibility that e.g. funding agencies would require them to anticipate ethical or social implication of their research in their grant application. This was seen as a requirement from the "outside" world which interferes with their daily business adding further bureaucratic burdens to their already heavy workload [23]:

- With respect to ethics in relation to animal experimentation one scientist said: "…you have a lot of regulations […] you have to write these 'Dear Experimental Commission' applications […] before you can do an animal experiment. It can take up to three months for every animal experiment you want to do […]"
- "People like me – leaders, coordinators – they are very pressured with administration…you wouldn't believe it […] if now suddenly I would see […] the EU having additional…where I have to fill in things that are not directly related to research, I would be annoyed, to be honest."

In order to open up scientific practice for considering ethical reflections as part of basic research scientists recommended financial incentives and institutional support, e.g. by deans and universities [23].

There is another, more technical, class of issues with which scientist were dealing in the course of the analysed projects. There were two broader issues go beyond specific technical questions. These two issues can be summarized in two questions: are the issues "Is nanotechnology something new?" and "Which data do we have?".

The first question has contact points to policy making and regulation. If nanotechnology is something completely new, then there is a need to a completely new policy and regulation of this technology. But if nanotechnology is a somewhat more sophisticated version of physics, (bio)chemistry and engineering then the policies and regulations in place are in principle suitable to deal with it.

Project FramingNano identified four major positions that stakeholder hold concerning the need for the regulation of nanotechnology [6]:

1. Existing regulation is adequate
2. Existing regulation is generally adequate but development of specific standards when dealing with nanotechnology is needed
3. Existing regulation should be amended on a case by case basis for specific nanotechnologies and nanomaterials
4. Existing regulation is not adequate at all. Nanotechnologies and nanomaterials should be subject to mandatory, nano-specific regulations.

The authors of FramingNano came to the conclusion that scientist most strongly support position 2 and 3. Scientists tend to say that nanotechnology is neither something completely new nor something to which one can simply apply the current regulation. This corresponds to a perspective that nanotechnology is a continuous technological development. Therefore it has parts that are just like "traditional" physics, (bio)chemistry and engineering and can be treated like them. But it has also parts which are new and which have to be regulated in a different way.

The dichotomy between "nano is something new" and "nano is nothing new" is also described by the authors of Project NanoImpactNet. There, the Delphi exercise with 92 experts showed

that “few respondents think there is no special or peculiar complexity in the toxicological basis of nanoscale particle behaviour” [27], however, “the majority think there is” [27].

Conversely, there are scientists saying that there is considerable data available already which can help to show the way forward: during a panel discussion in project NanoCap[4] a university based environmental scientist pointed out that there is considerable data and knowledge about some nanoparticles especially titanium dioxide and silicon dioxide. It would therefore be possible to regulate for titanium and siliceous nanoparticles. In a next step one could regulate by analogy (e.g. if one knows that bacteria develop resistance to antibiotics when regularly exposed to them by analogy development of bacterial resistance is to be expected for regular use of nano-silver and should be regulated accordingly).

Beyond the above mentioned dichotomy the Delphi exercise of NanoImpactNet with experts from academia, industry and government identified ten priorities in the development of nano-safety [3]:

- the need for realistic exposure scenarios
- better established dose–response relationships
- improved extrapolation from in vitro to in vivo
- identification of the most relevant assessment parameters
- understanding the dynamic biological interfaces
- long term studies
- information about stability and reactivity
- understanding the behaviour of the protein corona
- having test guidelines adapted to manufactured nanomaterials
- development of more advanced statistical and computational methods

In general scientists think that there are “enormous gaps in the experimental and observational data needed for the purpose of risk assessment and management, although the data are slowly accumulating.” [27]

The second question, “which data do we have?”, touches on the difference between industrial and academic research. Academic research goes public and discusses its results in the scientific community while industrial research is much less open due to issues of intellectual property and the competitive R&D relationships between companies. As reported by project NanoImpactNet academics say that information e.g. about the safety of nanomaterials should be bi-directional. They “do not just want to hand over or publish their analysis, they also want to be informed of work by companies, which they believe exists, but is not forthcoming.”[34]. Several academics believe “that the large chemical companies sit on mountains of valuable toxicological and ecotoxicological data, and this includes growing amounts on nanomaterials and nanoparticles. They believe that, when approached, the companies say that no such studies have been carried out, but when another scientist finds or suggests a potential hazard, a study ‘miraculously‘ appears and must have existed all along. This scepticism—that industry is being economical with the information it provides – is shared by NGOs.[…] Academics want to see more articles from industrial researchers in peer reviewed journals.” [34]. Furthermore academics point out that “the vast majority of articles are about successes, but surely many molecules fail to meet expectations or safety criteria. These unpublished data are science which should be communicated too.” [34] If a line of research showed toxicity during R&D pursuing a new product idea, this idea would probably be abandoned. However, the results of the research, which showed toxicity is valid and important scientific data but probably never published (cf. [34]). However, the problem of publication bias does not concern industry science only. Academics and editors of scientific journals are also involved. Both groups might regard for

negative results, for example studies containing no statistically significant results as uninteresting leading to a reluctance of scientists to submit or and editor to accept a paper for publication. Consequently over reporting of positive findings can occur in the literature potentially favouring also the publication of false positives [41].

Industry is not ready for full disclosure due to issues of commercial confidentiality and economic competition. "[…] companies see no reason why they should disclose information about the direction of their research and the potential toxicity of new formulations, just because they are at a nano scale. Why give clues to competitors by publishing positive or negative results? This is especially true of potentially toxic dead ends. These firms see potential pharmaceutical or chemical products and risks […] rather than nano products and risks."[33]. Therefore industry does not consider nanotechnology to be something special but simply a new set of technological tools which are used and which risks can be handled perfectly well with current safety approaches and regulations. Here, the discussions runs again into the first question mentioned above, is nanotechnology something new?

The following table summarizes the identified issues and difficulties.

Scientists - issues, terminology and difficulties		
Topic	**Description**	**Comments**
Division of moral labour	Scientists tend exclude societal issues of their work as important part of their professional role. They refer to industry, policy or society as the responsible agents for consequences that arise when scientific knowledge is turned into real world applications.	Statements of two scientists participating in the DEEPEN project: "…there is also ethics[in science], but it's not at all instrumentalised […]" [23] "I think it's mainly industry and people who are selling products […] who should be asked 'OK, is this safe or not', and they can ask us to help them to answer this question." [23]

Different perspectives in different positions	A group leader has more interactions with the outside world and will more likely be confronted with and address broader issues concerning their research. In contrast junior staff tends to focus more on technicalities of their work and their careers, rather than broader issues [23].	In the DEEPEN project one senior scientist comments with respect to invitation to talks and colloquia: "[…] more than 25% of people who invite me are just on nanotechnology but more about what does this mean for us […] and what is the impact for society..." [23] While senior feel the demand one DEEPEN author points out that it is "the overwhelming view that there have not been changes in research practices" [23] with respect to integrate broader, e.g. societal, issues.
Lack of institutionalized ELSA in science and engineering	The predominant culture in the natural sciences implicitly states that ethical and societal issues are not of primary concern for, or does not necessarily belongs to, the job of a researcher. Most institutions like universities or funding agencies do not demand to deal with societal or ethical questions within most of their natural science projects (except in biomedical research which include test with animals or humans). However, there are some initiatives to institutionalize such questions, for example the PhD+ programme, which was part of the Dutch nanotechnology R&D initiative NanoNed. PhD+ gave graduate students in nanosciences "an opportunity to spend some time exploring the broader issues of their research." [23]	One scientist during DEEPEN focus groups commented: "…I think raising ethical questions in the normal work situation is not very usual to say the least."

Open Data	Academics ask for access to industrial research data. Industry is not ready for full disclosure due to issues of commercial confidentiality and economic competition. Unpublished data can potentially be useful to study toxicological effects of therefore potentially hinders toxicological researchers and regulators to access risks as complete as existing data would allow.	Unpublished data and the resulting publications bias is not only due to industrial confidentiality but also due underreporting (of seemingly uninteresting results) by scientists and publication policies from editors of scientific journals.
Engaging scientists with ethics	Scientists see connections between ethical concepts and particular technological cases, provided by philosophers sometimes as artificial. Furthermore the use of narratives, to describe the every-day work of a scientist is far from being self explanatory. Additionally, narratives are culture dependent.	These points are based on the feedback scientists gave when working with the ObservatoryNano Ethics Toolkit [5].
Is nanotechnology something new?	Scientists are divided about the extent to which nanotechnology is something new	According to a Delphi exercise in NanoImpactNet few experts think there is no peculiar complexity in nano particle toxicology, however the majority think there is.

Table 4: Summary of issues, terminology and difficulties for scientist in relation to nanotechnologies

4.2.2. Communication requirements – Scientists

The difficulties identified in Section 4.2.1 show that scientists as well as universities, funding agencies and other sponsors of science should be approached to discuss the importance of broader societal issues connected to basic research in nanotechnology. Scientists, as well as other experts, perceive risks different from lay people [22, 36] and even tend to take the societal perception of risk less often into account as a determining factor than for example its counterpart: perceived benefits [32].

The following table summarizes the communication requirements for scientists.

Scientists - Communication Requirements		
Topic	**Description**	**Comments**
Awareness raising of societal role	Talk to scientist about their role in society and societal implications of their work and how they can deal with them.	Use role models like George Whitesides (cf. [23] p. 59) to motivate scientists.

Institutionalize ELSA in science and engineering	Talk with universities, colleges how societal consequences and responsibilities can be better integrated and/or institutionalized in the process of research and teaching in terms of e.g. code of conducts, best practices for research and e.g. curricular supplements in undergraduate, and graduate curricular. Talk with Funding agencies and other sponsors of science about the possibilities of incorporating societal aspects into funded research projects by various venues, e.g. by asking applicants to sketch activities on societal issues of the research at hand, asking applicants to include the results in project reports, providing grant money for such a consideration of broader aspects of a research project. Since relationships between natural and social sciences for example in scientific risk assessment are prone to be affected by difficulties and misunderstandings (e.g. [39]) one should bring natural and social scientist together to learn more from each other with the aim to improve the interconnection between the sphere or science and society.	As an example EC funded research projects on Nanotechnology could be made more integrative in the sense that social sciences and natural science are as often as possible both part of one project.
Process of technology innovation	Nanotechnologies in the context of material engineering innovation (nanotechnology as an „evolution“ rather than an „revolution“). Making people conscious of a process of technology development which is constantly happening and that most people are not aware or not reflective about. Using nanotechnology communication as a way to bridge science and society (understanding of the process of innovation)	Nanotechnology should be presented as a continuous development from known technology to methods which work at smaller and smaller dimensions.

Engaging scientist with ethics	Use scientists knowledge to make comprehensive connections between their research and ethical concepts by presenting them in general terms and invite scientists to contribute examples from their work. Narratives (like Frankenstein, Daedalus, etc.) should be adapted to the cultural background of the audience and used only together with interpretations and commentaries to put the narrative into perspective and to make clear which aspects of the narrative do or do not fit well with the topic at hand.	These points are based on the feedback scientists gave when working with the ObservatoryNano Ethics Toolkit [5].
Open Data	Scientist, policy makers, regulators should have a public debate about the issue of unpublished toxicological data and its consequences for toxicological research and therefore for the completeness of regulatory risk assessment which is based on toxicological research.	
Networking with Scientists	"The best way to reach academia was through face-to-face activities. This was not limited to research questions but extended to broader information sharing and stakeholder discussions. Almost no researcher provided feedback to research protocols (e.g. via the provided web-based discussion tools) they had downloaded. In this scientific community the internet seems to be used in a passive way." [3]	This was the summary of the authors of NanoImpactNet describing their experience in international networking activities also with respect to scientist and how best to involve them in discussions.

Table 5: Summary of communication requirements for the lay public in relation to nanotechnologies.

4.3. Policy makers and regulators

In the following the term policy makers will be used to describe governments (including members of ministries) and legislators (including members of parliament which may not be part of a government). Policy makers are partly regulators, too. But here the term regulator refers mainly to regulatory agencies which are more involved in the practical application of existing regulations than in developing new ones. Policy makers and regulators are principal stakeholders involved in NanoImpactNet [3] and FramingNano [6] and also took part in a discussion at the final conference of project NanoCap [4]. Like in the case of scientists, policy makers and regulators were not asked about specific applications but deal with broader issues. Therefore the next section covers issues, terminology and difficulties of nanotechnology from the perspective of policy makers and regulators.

4.3.1. Issues, terminology and difficulties – Policy makers and regulators

According to NanoImpactNet one of the main issues in nanotechnology for policy makers and regulators is to balance precautionary regulation with innovation thrive e.g. in order to protect

public health with the desire to improve national economic prosperity [28]. Or in the words of the European Commission: "The regulatory challenge is therefore to ensure that society can benefit from novel applications of nanotechnology, whilst a high level of protection of health, safety and the environment is maintained."[29]. The authors of NanoImpactNet even go so far as to say that "legislation and regulation, both at European and national levels, cannot currently keep up with nanotechnology's leaps and bounds"[28]. The authors of NanoImpactNet suggest that as a consequence of not keeping up legislators opt for voluntary schemes in the regulation of nanotechnology to fill the gap between current legislation "which is unprepared for nanotechnologies" [28] and future nano-specific legislation. These forms of voluntary self-regulation are often described as "soft law" or "soft governance" approach.

For the authors of the DEEPEN project soft law approaches are not necessarily an expression of helplessness due to the pace of technology development. Instead soft law is "an attempt to intervene at earlier stages in the development of nanotechnology so as to ensure international best practice and a more socially robust governance framework"[2]. Soft Law is furthermore consistent with the "ambition to enable continued innovation in nanotechnology, while at the same time anticipating the need for more stringent approaches in the future."[2].

This issue of how to balance regulation with innovation is also of huge importance for Civil Society Organisations (CSOs) and industry. The two perspectives on soft law mentioned in the last two paragraphs correspond to the views of these two stakeholder groups. While CSOs tend to see the soft law approach as inappropriate and a sign of passivity of policy makers and regulators, industry tends to see it as progressive way forward assuring that innovation takes place under regulation, through voluntary chosen regulation.

The European Commission (EC) has come forward with a code of conduct for responsible nanosciences and nanotechnologies research [31]. On the one hand CSOs criticise this from of soft governance as ineffective while on the other Arie Rip and Clare Shelly Egan, co-workers in the DEEPEN project, point out that what is important about soft law approaches "is not whether they are effective or not (because the goals they pursue may not be appropriate), but whether they stimulate critical reflection on background issues, and thus provide openings for longer-term changes."[30]. Therefore soft governance can be seen as helping opening up a conversation about regulation in an early state of technology development.

However, EU regulation of nanotechnology and nanomaterials is not limited to soft law approaches. Nanomaterials in products for example fall generally under the regulatory authority of REACH, the European Community Regulation on chemicals and their safe use as the EC pointed out:

> "Consumer products that are not governed by specific legislation have to meet the requirements of the General Product Safety Directive. Community regulation in these areas contains provisions in relation to health and safety of consumers, workers, patients and users, but not necessarily in relation to environmental protection. To the extent that nanomaterials contained in such products qualify as substances under REACH, they are subject under REACH to an assessment on their environmental impact.
>
> Virtually all product legislation imposes a risk assessment and the adoption of risk management measures. Nanomaterials are not excluded from this obligation."[29].

Another issue related to the balancing of regulation and innovation is the question about the adequacy of current regulation to deal with the risks of nanotechnology. This is also an issue for

scientist, CSOs, and industry. On the European level, the EC sees current regulation as generally appropriate:

> "Overall, it can be concluded that current legislation covers to a large extent risks in relation to nanomaterials and that risks can be dealt with under the current legislative framework. However, current legislation may have to be modified in the light of new information becoming available, for example as regards thresholds used in some legislation."[29]

Project FramingNano found that is a position that is strongly supported by scientists, too (cf. Section 4.2.1).

At the final NanoCap [4] conference two panel discussions took place, one discussion focused on "nano at the workplace" and the other on "nano and the environment". Both panels included representatives from industry, EC, European Parliament (EP) and academia. At one panel discussion a representative of the EC answered the call for new nano-specific regulation by pointing out that scientific evidence is needed for policy making. Until evidence is available the Chemical Agents Directive (CAD) is in place to take care of safety issues at the workplace by putting legal responsibility to deal with risks from nanotechnology for workers on the shoulders of employers. In the same panel discussion however, a member of the European parliament (EP) saw loopholes in the current legislative framework picking the example of the above mentioned CAD. It is correct that the CAD obliges employers to perform a risk assessment in case a substance is identified to be hazardous. However, where hazard data are lacking a substance can not be identified as hazardous and no risk assessment or management will take place. Therefore this member of EP called for an amendment of the CAD to require employers to implement risk reduction when hazards are still unknown, e.g. when no hazard data exists.

Section 4.2.1 discussed among others the issue of scientific toxicological data which is only selectively published by academics and industry. This has also implications for policy makers and regulators. The issue of publication bias and missing industrial and academic data has been a largely discussed topic for past decades in the medical sector, where drug trial data is selectively published by drug companies and academics with a considerable amount of unpublished data preventing a more complete evaluation of the drug at hand. During this discussion the practice of keeping scientific results unpublished was even described as scientific misconduct [40].

The topic of hidden data can also be raised in the (eco)toxicological area in general and in nanotechnology in particular with a similar potential to become a scandalizer. Nanoproducts are let on the market based on selectively published data or on selectively provided data to regulators under the seal of confidentiality. However, the scientific community of toxicologists and regulators might not have the full picture concerning the toxicology of a product class since there might be much more data about toxicological effects in industrial data bases. If environmental or human health problems with nanoproducts would arise and it would emerge that regulators or a company had the data which could have shown that a problem existed had this data be published and discussed within the scientific community it would raise questions about responsible policy making and regulation of nanotechnology. While publication bias and missing data in medicine is widely discussed under experts, though not yet resolved, the corresponding issue in toxicology might even be farer from a resolution, since there is almost no empirical research about for example publication bias in toxicology [41].

The following table summarizes issues and difficulties for policy makers and regulators.

Policy makers /regulators - issues, terminology and difficulties		
Topic	**Description**	**Comments**
Balancing regulation with innovation – risk with benefit	There is disagreement on how sufficient regulation of nanotechnology looks like. While industry and European Commission say that current legislation is sufficient and balances in an adequate way economic value with acceptable risks, members of the European Parliament or civil society organisations call for much stricter regulation.	
Open Data	What is the impact of publication bias in toxicology on regulatory risk assessment?	
Public expectations towards responsibilities of industry and policy makers / regulators	The public expects generally a proactive role in regulating and supervising industry activities (cf. for example [12]).	When policy makers point out that governance formats put the responsibility for safe nanoproducts on the shoulders of industry this may not be comprehensive enough for broader parts of the public. Simply saying that industry is responsible can be interpreted as an attitude of laissez faire or, even worse, as inviting disaster.

Table 6: Summary of issues, terminology and difficulties for policy makers and regulators in relation to nanotechnologies

4.3.2. Communication requirements – Policy makers and regulators

Policy makers are confronted with the wicked problem, mentioned in Section 4.1.3, of confronting very diverse interests from industry, science and CSOs and expectations of the general public. They can hardly hope to reach to policy or regulation regime that will be universally welcomed. One can summarize the communication requirements for the stakeholder group in three points, as done in the following table.

Policy makers and regulators - Communication Requirements		
Topic	**Description**	**Comments**
Explain the process of policy making	Policy makers should be encouraged to discuss with and explain to the public about the process of policy making, the trade off and dilemmas and why the current regulation is how it is.	Such a discussion should be conducted on the basis of concrete examples to exemplify the constant issue of trade off and interconnectivity between policy, science, economy and society.
Open Data	Scientist, policy makers, regulators should have a public debate about the issue of unpublished toxicological data and its consequences for toxicological research and therefore for the completeness of regulatory risk assessment which is based on toxicological research.	
Explore public participation in policy making	Bring together policy makers, CSOs and members of the lay public to discuss to what extend public participatory activities can be translated into policy making.	As a preliminary action policy makers and regulators should be regularly be reminded of the shortcomings of the information deficit model. Explaining and providing information will not make go away dissents in the public, just as it does not make go away dissents between politicians, parties and interest groups during policy making in general.

Table 7: Summary of communication requirements for policy makers and regulators in relation to nanotechnologies

4.4. Civil Society Organisations (CSOs)

Civil society organisations in this analysis include trade unions, environmental NGOs, and consumer organisations. From the analysed projects in this report NanoCap [4], NanoImpactNet [3] and FramingNano[6] dealt with the views of and communication with CSOs. As in the case of scientist, policy makers and regulators the discussions with CSOs, were about larger issues and not a individual applications. Therefore the next section deals directly with these issues.

4.4.1. Issues, terminology and difficulties – CSOs

Project NanoCap [4] worked on the basis of working conferences, position discussions and workplace visits with the goal to organise a structured discussion between environmental NGOs, trade unions, academia and other stakeholders and support trade unions and NGOs in

developing their position statements about nanotechnology. As a general result Trade Unions (TU) and environmental NGOs agree that nanotechnologies might have a positive potential for improvement regarding the creation of new jobs and keeping the environment clean. However, TU and NGOs also stress that the precautionary principle has to be applied strictly to ensure that workers, humans and the environment are not exposed to potential hazards. Therefore they call for binding legislation and thorough risk analysis and underline that voluntary codes of conducts, preferred by the industry and policy makers are not enough to enforce the precautionary principle in such a strict way that is needed to ensure the safe and responsible development of nanotechnology. Trade Unions presented their positions and perspective in form of an ETUC (European Trade Union Confederation) Resolution, which are summarized in the following table.

Positions of European Trade Union Confederation resolution on nanotechnology	
Topic	**Positions**
Precautionary Principle	- Preventive actions must be taken where uncertainty and lack of knowledge prevail.
Marketing and Legislation	- The REACH principle "No data -> No market" must be applied to all nanomaterials independent of their tonnage. - Voluntary codes of conduct may be useful but cannot replace legislation and nanotechnology need proper legislation.
Workers Protection	- Workers and their representatives must be involved in work place risk assessment. - Obligatory implementation of risk reducing measures for workers by employers when hazards of (nano)substances used are still unknown (i.e. precautionary principle).
Research and Development	- Budget for health & environmental risk research must be increased to at least 15% of the public research budget for nanotechnology. - Mandatory inclusion of an health & safety assessment for all nanotechnology research projects.
Terminology	- Standardised terminology for nanomaterials is urgently needed.
Consumer protection	- There has to be registration of production, import and use of nanomaterials. - There has to be mandatory labelling of all consumer products if they contain manufactured nanoparticles which could be released under reasonable and foreseeable conditions of use and disposal.

Table 8: Summary of the European Trade Union Confederation laid out in a resolution on nanotechnology.

Similarly environmental organisations represented at the NanoCap conference presented their list of positions on nanotechnology summarized in the following table.

Positions of Environmental NGOs represented at the NanoCap conference	
Topic	**Positions**
Policy and regulation	- Much more work is needed on EU policy level to improve health and environmental protection and build a governance structure that must be firmly based on the precautionary principle and cradle-to-cradle product sustainability. - A clear, harmonised and internationally accepted definition of nanotechnologies should be adopted. - Nanomaterials should be defined and treated as new class of substances. - Existing legislation needs to be amended to address nanotechnology more explicitly and comprehensively. - Current voluntary codes for safe development should become mandatory. - There must be a strict application of the no data -> no marketing principle. - Development of a pre-market registration and approval framework. - Traceability of nanotechnology, materials and products must be possible and information to consumers must be provided through product labelling. - There has to be full lifecycle analysis prior to commercialisation.
Research and Development	- Research and development should be driven by societal needs but not marketability. - Identification of the limitations of existing safety assessment and urgent need for additional eco/toxicological studies and protocols in order to assess health and environmental impacts. - Sustainability assessment tools for technologies should be developed. - All nano-related research projects receiving EU funding should be required to include a sustainability assessment of their topic and appropriate decision making mechanisms for dealing with it. - A research strategy towards safer development should be developed.

Public awareness, public participation & decision making	- Transparent and effective communication of risks of nanotechnologies to society is needed. - A EU-wide public debate on nanotechnology and nanomaterials is needed
Developing countries and emerging economies	- Nanotechnologies should be used to meet internationally agreed poverty reduction goals. - It must be assured that no new risks to environment, health or society are created in developing countries. - Nanoproducts should not substitute products traditionally produced by developing countries - Nanoproducts should not become expensive alternatives to existing effective local technologies

Table 9: Summary of the positions of Environmental NGOs represented at the NanoCap conference.

The issues of these lists can be summarised by a conclusion of project NanoImpactNet: CSOs definitely want the application of the precautionary principle and nano-specific law [33]. The main issue is therefore about regulation of nanotechnology with regard to two main points: transparency and application of precautionary principle. Transparency should exist from research and development to the end user via traceability and labelling. The precautionary principle should strictly applied in all areas of regulation, from work place safety to market admission, from research funding (e.g. no funding for research that can not come up with a comprehensive sustainability assessment) and workplace safety to product development and marketing ("no data, no market").

During a panel discussion at the final NanoCap conference one representative for the environmental NGOs commented on the question of how to decide whether risks are acceptable by distinguishing two cases. First, if there is no sufficient data the precautionary principle should be applied in the sense: no data -> no market. Second, if there is sufficient data the acceptability should be decided by public debate.

The analysis of the project FramingNano concerning the positions toward the need of nano-specific regulation came to result that CSOs strongly support the fourth of the four major positions: Existing regulation is not adequate at all. Nanotechnology and Nanomaterials should be subject to mandatory, nano-specific regulations (Section 4.2.1 and [6]).

The following table summarizes the above issues and corresponding difficulties.

CSOs - issues, terminology and difficulties		
Topic	**Description**	**Comments**
Balancing regulation with innovation – risk with benefit	- While CSOs want nano-specific laws and regulations this will not be possible without a broader scientific basis which is currently being build but will take some time. - In balancing economic value with acceptable risk CSOs assign very light weight to the economic value. - CSOs often stress that they want to prevent another asbestos scandal. However, can a second asbestos scandal be prevented completely?	As an interest group is it legitimate not to emphasize a balanced perspective. These points are mentioned as difficulties not to call for their eradication but only as remainder that they unbalanced views make negotiations more difficult.
Good science – bad science	CSOs call for research that is only driven by societal needs. However, there are very different views about what society needs, and which view is the "correct" one? Additionally, the predominant drivers of scientific activities in basic research lay mainly in the individual characters of scientists like their curiosity and interest and not so much in the question of societal needs. To call for research that is only driven by societal needs would be a huge paradigm shift begging the questions who can foresee or should decide what the society needs and what not and which research is the most suitable to fulfil these needs. The Problem works both ways: research and development which is not driven by societal needs can have considerable spin offs which can benefit society (e.g. the internet). But just the other way round well meaning attempts to meet societal needs by science can be a waste of resources and have large negative effects on society (e.g. Lysenko agriculture).	At the level of applied sciences there are of course economic and political drivers (e.g. in product development in industrial R&D or the arms races for chemical or nuclear weapons). But the basic difficulties remain the same: how to decide what society/costumers need/want and what research/product development is the best to fulfil these needs and wishes.

Mandatory sustainability assessments	CSOs in the NanoCap project on the one hand called for the development of sustainability assessment for new technologies. Therefore these assessment tools are not available yet. On the other hand the CSOs in the NanoCap project demanded that all future EU funded research-projects have to include sustainability assessments.	This is a difficult situation for applicants since they would probably have to develop the tools for the assessment themselves from scratch. As a result a number of different assessment tools might be used make if difficult to compare and evaluate the sustainability assessment during the grant application process.
Defining Nanotechnology	NGOs call for a clear definition of nanotechnology and demand that nanomaterials as a whole should be defined as new class of substances. It seems however that there is note yet a scientific basis to do this.	There is for example the issue of naturally produced nano particles. Should they put in the same new class of substances as manufactured or functionally coated or engineered ones? Another issue: should free nanoparticulate matter be treated the same way as fixed ones, e.g. in surface structures.
Importance of nanotechnology	NGO called for a EU wide discussion but were not very present for example in the discussion during the NanoImpactNet project. The authors of NanoimpactNet noted that "Attracting NGOs and CSOs to NanoImpactNet stakeholder workshops has proved relatively difficult. (…) The important NGOs with nano policy positions were notable by their absence WWF, Friends of the Earth, GreenPeace, and the European Trade Union Congress, to name but a few, have been very unresponsive." [34]	"Nanomaterials are not currently proven to be […] therefore nanotechnology is relatively low down on the current list of threats […] dominated by the direct effects of climate change and overpopulation, which are far more existential, newsworthy and offer extensive fund-raising possibilities."[34]

Zero risk	A representative of consumer organisations stated during a NanoCap discussion that "There should be no acceptance of risk in cosmetics and food" [4].	There is always a trade off between new products and technologies and large experience about theirs risks. As long as there are new products there will be the lack of knowledge about possible long term effects.

Table 10: Summary of issues, terminology and difficulties for CSOs in relation to nanotechnologies

4.4.2. Communication requirements – CSOs

As the authors of NanoImpactNet report CSOs are generally interested in the topic of nanotechnology, they like to be informed and they appreciate researchers that accept to participate in discussions with the general public. [3]. However, describe their communication with CSOs the same authors point out that except for the specific stakeholder events there were very few active contributions of these groups. The website of the project was their most preferred way to stay informed. However, many representatives of CSOs contacted the NanoImpactNet team to ask about specific questions or invite to meetings and public events organized by the CSOs.

Along the lines of the difficulties mentioned in Section 4.4.1 communication with CSOs should focus on critical review of their, in part, conflicting points.

CSOs - Communication Requirements		
Topic	**Description**	**Comments**
Societal needs and acceptable risks	CSOs should be asked to provide clear criteria what they consider to be for example societal needs and acceptable risks and how these criteria can be met, e.g. when a public research funding organisation has to decide on an grant applicant.	
Nanotechnology – evolution or revolution	Conversations with CSOs should also include the topic of the process of technology innovation.	CSO should be asked about their views about why nanotechnology, in their view, deserves for example completely new regulations and why this is not the case for innovations for example in chemical engineering.

Table 11: Summary of communication requirements for the CSOs in relation to nanotechnologies.

4.5. Industry

Industry was one important stakeholder in the projects NanoImpactNet [3] and NanoCap [4]. Like for the stakeholder groups of scientist, policy makers, and CSO, industry too did not discuss individual applications. However, project NanoImpactNet chose food contact material and nanomedicine as two applications areas that might become sources for future nano-controversies and discussed them with different stakeholders. Leaving applications aside the next section will discuss therefore the broader issues that are connected to industry.

4.5.1. Issues, terminology and difficulties – Industry

During the stakeholder discussions of project NanoImpactNet there were two main issues with which industry was concerned: transparency and regulation. Transparency includes various sub-points: product labelling, providing information to the public and sharing scientific data.

During the stakeholder discussions of project NanoImpactNet all stakeholders including academia, civil society, industry, governmental agencies and regulators agreed that transparency, open communication and knowledge sharing would benefit everybody[3].

However, there are considerable differences in the details and the industry in particular has here various diverging views from other stakeholders like scientists or CSOs.

Industry representatives asserted that they already give sufficient information to competent authorities which they consider to be organisations with the expertise to handle such volume and complex information. It was pointed out that NGOs never ask for 1,000 page REACH submissions and that is was certainly too much information for the man in the street. Industrial transparency involves communication and education, as well as active participation in forums and dialogue with laymen and government. However, this does not go so far as divulging the detail of its manufacturing processes which remain confidential business information. Companies in general hesitate to publish material that they are not legally required to publish. Of course, freely given data builds trust, however much is classified as confidential business information.

As mentioned in Section 4.2.1 there is the issue of sharing scientific data between academia and industry. While academia calls for access to the data of industry studies, industry is not ready for full disclosure due to issues of commercial confidentiality and economic competition. Companies see no reason why they should disclose information about the direction of their research and therefore give clues to competitors. This is true for positive results, which should be kept secret to become a special formula as well as for negative results like toxic dead ends. Companies do not want to support competitors by saving them money in research and development.

With respect to regulation industry believes that sufficient regulation and safeguard exist and prefer voluntary nano-specific reporting about products. Industry does not want nano-specific legislation or reporting requirements. When it comes to voluntary regulation or industry standards the large companies point out that this allows them to have one global set of working guidelines across all their operations and not have to be subject to numerous national or regional legislative requirements. Companies believe that they know how to handle chemical, medical, and food safety risks, whether the product is based on nanotechnology or not, thus they wish to stay under the oversight of REACH, the European Medicines Agency (EMA) and the European Food Safety Authority (EFSA).

Representatives of industrial giants are very visible and go to great length to avoid being perceived as irresponsible or unsustainable. During project NanoImpactNet such

representatives pointed out that large companies are doing everything legally required in the development of nanomaterials, and more [34]. They argued that because they make no safety concessions, the fact that an ingredient is nano makes no difference [34].

However, there was recognition that smaller companies might not follow accepted industrial codes of conduct, either through lack of capacity or lack of regulation, thus their actions would perhaps have to be supervised in some way [34]. There is a worry that one nano-scandal will put other nanotechnology applications at the mercy of bad publicity and hastily conceived laws[34].

With respect to the issue of labelling, industry representatives stated that labelling a product as containing nanomaterials give very little effective information other than size, and it certainly does not educate the consumer on risk. They argue, for instance that a 'contains nanomaterials' label gives as much (or as little) information as 'contains molecules'; it is education that is needed. During a session of NanoImpactNets 2010 conference all stakeholders (regulators, policy makers, industry and CSOs) discussed how to inform the public about nano-enhanced food contact materials and agreed that labelling without education is futile; information must be given, but not viewed as a warning [35]. Furthermore, simply making industrial information on engineered nanoparticles and materials available to other stakeholders would not necessarily educate those stakeholders. Industry pointed out, that if size became a determining factor in assessment or labelling, then certain materials, even if their nano and bulk formulations exhibit identical properties, would come under two different regulatory regimes. Thus size alone should not become a new determining factor of risk necessitating a new regulatory agency.

Concerning the issue of regulation and how strict the precautionary principle, e.g. in the form of "no data, no market", should be applied one industry representative stated at one NanoCap panel discussion, that "we cannot wait for scientific evidence" [4]. Current EU and national legislation handles the risk properly, i.e. present legislation would be sufficient to deal with potential risks of nanotechnology. Additionally the voluntary codes of conduct do work well and further improve safety and responsible development and marketing of nanotechnological products.

Industry is often confronted by CSO with the concern about the possibility of having another "asbestos case"[3]. During NanoCap panel discussion the industry representative pointed out that it is not an asbestos area anymore and that multinationals would have different attitudes these days. Industry would manage risks by working with nanomaterials in closed systems. The industry representative admitted, however, that production in general takes place in closed systems while applications of the nanoproducts normally do not and that it is impossible to implement conditions comparable to a closed system along the whole production chain [4]. One can add that the exposure risk of finished products is different since the nanomaterials are embedded inside another material therefore the need for protection from exposure is different at the various stages of product development.

Project DEEPEN looked at industry from an ethical perspective and engaged industry representatives in focus groups and semi-structured interviews to gain insight in their views about ethical and societal issues concerning their activities. The main focus laid on the issue of responsible development. The interview and discussions looked at industries perception of the term "responsible development" and what it means for industry, especially in the case of nanotechnology. E.g. the question if nanotechnology is something so new that it demands an

[3]Asbestos is a mineral that became popular among builders in the late nineteenth century thanks to its sound absorption, resistance to fire, heat, electrical and chemical influences and affordability. In the 1960 the link between asbestos exposure and cancer was convincingly made resulting in strong measures to remove the mineral from products and buildings.

exceptionally new and special way if one wants to assure responsible development. This question is similar to the question that came up as important issue with the stakeholder groups of scientists, policy maker and regulators and CSOs: is nanotechnology something so completely new that it requires a completely new form of legislation, regulation and risk assessment procedure. Here project DEEPEN asked from an ethical perspective: is nanotechnology something so completely new that it requires a completely new form of responsible development? Does nanotechnology demands industry to think in new ways about their moral responsibility in developing products with this new technology?

The participating representatives of industry were from companies working in different industrial domains and using different nanotechnology tools. These industrial domains included the chemical industry, the beverage and food sector, micro- and nanoelectronics and the biomedical sector. There were striking differences in emphasis of the special importance of "responsible development" in the field of nanotechnology between the different domains. Representatives from the chemical industry and the beverage and food sector were very conscious and pro-active in relation to responsible development of nanotechnology. In contrast the representatives from the biomedical sector and from nanoelectronics tend to say that nanotechnology is not an exception to their routine of responsible development. But for industry in general nanotechnology is not something special which demands out of itself and its uniqueness a new approach in responsible development. In fact nanotechnology happens to be just the next step in the development of technology:

- "a natural step in the development"
- "the next step [is] to control materials at an ever smaller scale" [23]

In this sense nanotechnology is just business as usual, is more a continuous development than a completely new technology or even revolution, in contrast to the way nanotechnology is sometimes viewed and discussed in the public. It is this way of presenting nanotechnology as something completely new and revolutionary that prompts industrial special attention and effort concerning the topic nanotechnology. During the DEEPEN project interviewees from a chemical company explain their extra effort (having a special nanotechnology spokesman and management team) as a

- "response to the outside world"
- "I mean the outside world makes a lot of fuss about nanotechnology and so we need to have contact where you can ask questions and that's the idea, **nothing more than that**." [emphasis added] [23]

A respondent from a technology company stated that:

- "[…] by raising issues that are so broad [e.g. societal and ethical questions of nanotechnology] […]…calling us a nanotechnology industry when we are doing the same thing we've done all along brings you under a somewhat dark-cloud umbrella […] we are suddenly engaged in ethical conversations in things we've been doing for years, which have – as far as we're aware – nothing other than ordinary safety implications."

Therefore the industry does not think that nanotechnology is something very special, which demands a special attention in terms of communication of societal involvement. It is not for technical aspects of the topic in itself but instead the presentation of the issue in the outside world (policy makers, media or public debate) that makes industry react. Therefore the efforts of the chemical industry in nanotechnology communication is not caused by the speciality of the technology but caused by putting the topic on a political agenda. The industry does not talk

about nanotechnology because it considers it to be something one has to discuss, but because there is a public debate about it.
Industry is cautious concerning pro-active communication about the nanotechnology used in R&D and production of products. On the one hand transparency is seen as something which lay also in the interest of the industry:

- "[…] we should open up because if we don't […] it could hinder us a lot […] if you do not participate in the discussion and end up with very strict regulations for issues that are, from say a toxicological point of view, not very sensible, which are costly and will limit the possibilities for further development also […]"[23]

On the other hand the industry fears side effects of pro-active communication, especially in relation to the risk of being the first one to be transparent:

- "Those companies that are transparent are also the focus of NGO debates because nothing is known [of what other companies are doing.]"
- "There are many companies that are not at all visible. … I would assume that they also do nanotechnology … but they do not take part in the debate."
- It may be a problem of the first company that starts communicate getting all the publicity – negative publicity – regarding their products, so who is the first one to do it?" [23]

However there was one precedent quoted, where one company successfully was transparent about nanotechnology in their products:

- "[…] like in cosmetics… a lot of companies follow the lead of L'Oréal because they have been able to communicate that nanotechnology has specific benefits for skin products…" [23]

Based on these issues found in the different projects one can identify several difficulties summarized in the following table.

Industry - issues, terminology and difficulties		
Topic	**Description**	**Comments**
Labelling and education	Industry stresses that labelling and education belong together. But it is not yet clarified where this education should take place and in which forms. What would be the criteria to say that there is an enough educated public that can 'handle' a certain form labelling of products? What form of labelling would be appropriate at which level of public literacy? There is a challenge in communicating information about products since countries and people themselves vary widely in risk perception and concern about new technologies. The same label might be viewed as warning or simply information about an ingredient dependent of the personal risk perception and acceptance of new technology.	It is not clear how there can be education (e.g. provided by scientist) or informed decision making by consumers or labelling regulators if there is no open access to data due to business secrecy.

Open Data	Unpublished industrial data poses possibly large limitations to risk assessments by regulatory agencies, since these assessments are based on the current knowledge within the scientific community and published literature.	
Nanospecific regulation	There is disagreement between industry and civil society (and in part academia) that there is a need for a completely new approach to regulate products that use or contain nanotechnology.	
Risks or Nanorisks?	Companies believe they know how to handle product risks and independent of the nature of the underlying technology. Therefore Nanotechnology is just one technology among many which can be dealt with using the established procedures for risk management. Industry has the self-perception that "it is not an asbestos era anymore" that "multinational companies have different attitudes these days". CSOs and the general public seem to have a different perception.	However, historical experience has shown that time and again unforeseen or even hidden or downplayed risks appeared. It is not clear why this era is safe from experiencing an "asbestos-case" with nanotechnology.
Large & small companies	There seem to be some difference between large multinational companies an small and medium sizes enterprises (SME) with respect to responsible development. The reports analysed did not clarify what the crucial differences in respect to responsible development are. It is not clear if this issue goes beyond the fact that SMEs have smaller budgets for risk research or the implementation of voluntary codes of conducts with high safety standards.	
Sharing visions of sustainability	Industry said, during a NanoCap panel discussion, that it wants to reach a shared vision of sustainable development [4]. While there will be consensus that sustainability is a development which keeps environment and humans healthy there will be large disagreement about which measures are sufficient to reach this goal.	As one questioner from the floor put it during a NanoCap panel discussion: "How responsible is responsible, if different actors have different definitions"[4].

Different industrial branches	Different domains in industry have different views on how important it is to deal with the ethical or societal dimension of their R&D. These differences come from different experiences the different industries have made. The chemical and food industry has suffered from lack of trust in the general public due to several incidents in the past and it is under sceptical observation from the public, policy and media. The micro-and nanoelectonics industry does not had any comparable problems of trust. And the biomedical sector emphasizes that any applications in the biomedical sector has to conform to a framework of regulation which takes into account many ethical and legal considerations, so it is already 'built-in' (the system). These different views lead to different stances. While nanoelectronics or biomedical industry do not see the need for special activities concerning the development of nanotechnology the companies from the chemical industry interviewed in the DEEPEN focus group had an extra official spokesman only for nanotechnology and a management team dealing solely with nanotechnology and corresponding Codes of Conduct.	
Nanotechnology as seen by industry and the public	Industry says: nanotechnology is just the next step in a continuous technological development. In contrast the public debate tends to speak of a revolutionary new technology that has the potential to change almost any aspect of our life in a huge way.	There may emerge an even larger gap between the perception of nanotechnology in science and industry and the public along the lines of "a continuous evolution" vs. "a completely new (and therefore potentially scary and unknown) thing."

Putting all on the table	The idea of public debate in risk and technology governance includes the discussion of all consequences of nanotechnology beneficial as well as hazardous. This puts the industry under pressure. It might be difficult to get industry involved in an open conversation when it fears scaremongering effects when it comes to discussing possible negative consequences of nanotechnology.	

Table 12: Summary of issues, terminology and difficulties for industry in relation to nanotechnologies

4.5.2. Communication requirements – Industry

Project NanoImpactNet sums up its experience in networking and communicating with industry by stating: The willingness to share research protocols was minimal (intellectual property rights and sensitivity of nano-material related hazards are mentioned as reasons). The best way to interact with industry seems to be by communicating new research protocols and research findings and inviting them to participate in workshops where new strategies and research aspects are discussed [3].

Industry - Communication Requirements		
Topic	**Description**	**Comments**
Responsible development	Industry committed itself to responsible development in general and nanotechnology in particular. Discussion with industry should aim to explore what measures are taken to ensure that possible risks of nanotechnology are properly dealt with and consequently a safely development assured.	Since the reference to asbestos is regularly used by CSOs industry should explain why "this is not an asbestos era anymore." For example by explaining what measures had been taken by industry to assure safety of their products and why these measures are suitable to prevent another asbestos case or at least that under the current industrial risk management the asbestos problem could not have occurred. One should also discuss with industry what lessons have been learned from past risk and safety issues.

Open Data	Industry stresses that it strongly in favour for transparency but in fact there are limitations regarding product labelling or data sharing due to intellectual property rights and competitions issues. Furthermore there are companies which are reluctant to openly talk about there usage of nanotechnology in their products since they fear negative publicity and prefer not to mention its use. Industry should be involved in a discussing about how transparent they can be and what the limiting factors there are.	Especially consequences of unpublished toxicological data for science and society should be discussed. For example the issue of public trust in industry. Or the issue of regulative risk assessment, in particular concerning the limitation in the knowledge due to not accessible data.

Table 13: Summary of communication requirements for industry in relation to nanotechnologies.

5. Conclusion

If there is a single guiding theme to sum the above analysis it could be the question: "Is nanotechnology something completely new and special?" The answer to this question affects almost all issues and stakeholder groups discussed above. Based on the analyzed project reports and scientific literature one can summarize the results for each stakeholder group as follows.

Industry does not see nanotechnology as something completely new but as the next natural step in a continuous development of technology. Therefore industry considers its traditional risk assessment and management tools as adequate to deal with potential risks that might be linked to the production of new products using nanotechnology. Furthermore the research data that industry produces in their R&D of nanoproducts is seen as intellectual property just as research data in any other technology. Industry will in general not share its data with the scientific community. Mandatory labelling of products as "nanoproducts" is seen critical. In fact industry does not see the need for a special labelling since nanotechnology is not regarded as something that new or special after all.

Civil society organisations (CSOs) discuss the question with respect to regulation and application of the precautionary principle. CSOs broadly see nanotechnology as something completely new and special that consequently would require nano-specific regulation and risk assessment tools. The current tools are considered not appropriate to assess risks for humans or the environment to an acceptable degree. Consequently labelling of nanotechnology products should be mandatory to ensure that consumer may chose if they want to try products with this relative new materials.

Policy makers and regulators have the challenging task to balance safety with economic and technological prosperity. They tend to look at nanotechnology like the scientists do: not at something completely new but rather as something which has new aspects but to which it is also possible to apply current tools and methodologies. In the case of policy makers these tools are legislation and regulation.

Scientists discuss this question specially in context of (eco)toxicology and human health. Are there new mechanisms by which nanoparticles harm the environment or the human bodies at cellular level? What follows from the novel aspects of nanotechnology for the scientific risk assessment? Scientists point to large gaps in their knowledge concerning new nanomaterials and their effects on the environment and human health. Most scientists believe that there are new aspects to be discovered in the field of nanotechnology, but that current tools are in general adequate to assess large parts of potential health hazards.

The question "Is nanotechnology something completely new and special?" affects the issue of discussing nanotechnology with the general public. Nanotechnology as a topic proved to be hard to get into the minds of larger parts of the public. It seems that nanotechnology is not considered something completely special, something one should know much about, it is more seen as a new, relatively abstract branch of modern science and technology. However, several studies (e.g. [1, 8, 12, 25]) suggest that when lay people are engaged they show interest in knowing what this technology can do for them, what are the benefits, added value to products they care and use. In the end, it may be that nanotechnology is not something completely special in and out of itself rather the more important issue might be that it is used as a prototype for a different approach in technology governance. Since nanotechnology is discussed with the general public over a broad range of aspects, from basic scientific principles to societal implications it can be more than just an exercise in experimental technology governance. These discussions about nanotechnology might help to raise people's awareness to a process of

technology development and its impact on society which is constantly happening in the background for decades, if not centuries. A development of which most people are not aware of or do not reflect about. Maybe with the case study of nanotechnology one can deal with the question of the relationship between technology and society more generally. From a scientific or technological perspective, nanotechnology is more a natural step in a continuous development getting to more and more accurate techniques which allow manipulation of matter at ever smaller scales. In this sense it is just a step in the continuous technological evolution that human society is experiencing for the last 10.000 years, simply on somewhat smaller scales.

Trying to discuss nanotechnology with the public is particular difficult because it is a vast area of science and technology. There are multiple aspects to it: scientific ones, technological ones, regulatory ones, economic ones, environmental ones or legal ones, to name a few. There is a variety to choose from. Since attitudes about nanotechnology are not yet polarized [7, 8, 25] it is a good time to help citizens making up their mind through balanced information about the relationship between technology and society in general and in particular for the case of nanotechnology. This report presented some points which are already in the discussion and should be discussed further.

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7. Annex

7.1. Scheme for analysing reports

Publication/Source	
Country	
Type of study / project	
Stakeholder / target groups involved	
Applications presented/discussed	
Topics/Applications in which stakeholders are interested	
Terminology of interest/ difficulty	
Communication requirements (Arranged according to stakeholders)	
Conclusion of the authors of the study concerning communication requirements	