# NanoFabNet

international Hub for sustainable industrial-scale Nanofabrication

# NanoFabNet Implementation Roadmap for International Cooperation

NanoFabNet Report

NanoFabNet

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| Acronyms Listed in Document | |
|---|---|
| ASTM | American Society for Testing and Materials |
| BEUC | The European Consumer Organisation |
| DW | Development Workshop |
| EC | European Commission |
| ECHA | European Chemicals Agency |
| EEB | European Environmental Bureau |
| EEN | Enterprise Europe Network |
| EHS | Environment, Health & Safety |
| EMIRI | The Energy Materials Industrial Research Initiative |
| EPSA | European Pharmaceutical Students' Association |
| EUON | European Union Observatory for Nanomaterials |
| INISS-nano | International Network Initiative on Safe & Sustainable Nanotechnology |
| ILO | International Labour Organisation |
| ISO | International Organization for Standardization |
| LCS | Life Cycle Sustainability |
| MERCOSUR | Mercado Comun del Sur |
| NNCI | National Nanotechnology Coordinated Infrastructure |
| NNCO | National Nanotechnology Coordination Office |
| NSC | NanoSafety Cluster |
| OECD | Organization for Economic Cooperation and Development |
| SCCS | Scientific Committee on Consumer Safety |
| SDG | Sustainable Development Goal |
| SPIRE | Sustainable Process Industry through Resources and Energy Efficiency |
| UNEP | United Nations Environment Programme |
| WHO | World Health Organization |

# 1. Executive Summary

The aim of this report is to provide a strategy for international collaboration's outlining the continuing development of the global relations of the NanoFabNet. This **International Cooperation Roadmap** will be incorporated into the "**NanoFabNet 5-Year Strategy**" and will form a central part of the NanoFabNet membership organisation's offerings and services to the community of sustainable nanofabrication.

The NanoFabNet 5-Year Strategy will consist of six roadmaps and action plans, which are developed as part of the NanoFabNet Project:

- the NanoFabNet Strategy & Implementation Roadmap for Sustainability in Nanofabrication;
- the NanoFabNet Validation, Harmonisation & Standardisation Action Plan;
- the NanoFabNet Strategy & Implementation Roadmap on Infrastructures, Knowledge & Skills Development;
- the NanoFabNet Communication & Visibility Strategy;
- the NanoFabNet Implementation Roadmap for EU-Project Collaboration; and
- the NanoFabNet Implementation Roadmap for International Cooperation.

International cooperation is considered to be an important part of building stakeholder awareness in the field of sustainable nanofabrication and creating a global community of entities in this area. It can also foster the development of the industry, promote good practices in research and the industry, and facilitate international contacts for the NanoFabNet community.

This report includes those goals and actions that are considered to be milestones in increasing the collaboration between entities engaged in sustainable nanotechnology and nanofabrication.

The Roadmap identifies four goals for NanoFabNet's international cooperation:

1. to establish a strong integration of the EU community;
2. to establish a strong connection with international stakeholders to facilitate building a global community focused on sustainable nanotechnology and nanofabrication;
3. to develop the capacity of NanoFabNet Hub through the exchange of know-how at an international level; and
4. to monitor the mutual understanding of challenges in the field of sustainable nanofabrication and nanotechnology.

In order to achieve the goals of international cooperation outlined above, 14 specific actions have been proposed. These actions are meant to engage a wider, international community that will be able to use the NanoFabNet digital platform to improve its knowledge transfer and collaboration potential.

# 2. Foreword

## 2.1 An International Hub for Sustainable Nanofabrication - Initial Motivation

The *NanoFabNet Implementation Roadmap for International Cooperation* presented in this report has been created based on the feedback of those stakeholders who voiced their needs of the desired shape of their engagement with the EU-based and -funded NanoFabNet Project, the NanoFabNet Hub, and - possibly - its membership organisation. One of the main goals of the NanoFabNet Project is to establish long-lasting collaborations between the EU, the US, and other regions, such as Israel and Japan, which are represented on the NanoFabNet External Advisory Board (EAB) for Science, Technology, Innovation, Sustainability, Exploitation, Ethics, and Data (i.e. "International STI-SEED Board"). Relevant parts of this *NanoFabNet Implementation Roadmap for International Cooperation* will be incorporated into the overall NanoFabNet Strategy. While the overall NanoFabNet Strategy needs to remain a confidential document, this roadmap outlines the recommendations that will be released to the

sustainable nanofabrication stakeholder community in the public *EU 2030 Strategic Plan for Nanofabrication*.

The NanoFabNet Implementation Roadmap for International Cooperation emphasises its efforts to strengthen the existing linkages between EU and US stakeholders for the sake of enhancing international cooperation. This need has been voiced by key EU and US sustainable nanofabrication partners and stakeholders, incl. the US National Nanotechnology Coordinated Infrastructure (NNCI)[1], and leaders of the EU-US Communities of Research (CoRs)[2]. The recent emphasis on EU-US collaboration is evident in the development of the EU-US Nanomanufacturing Communities of Research that was coordinated by the US National Nanotechnology Coordination Office (NNCO)[3].

Many individuals involved in these efforts have sustained decades - long collaborations across the Atlantic and serve as critical stewards of the deep and lasting ties between the EU and US's nanotechnology research communities. The EU-funded NanoFabNet Project has helped reinvigorate these connections, as well as create a modern model for EU engagement with other international partners, such as China, Japan, and Australia, in science outreach and diplomacy.

One of the challenges to be addressed within the international collaboration established through NanoFabNet is alignment with the US Nanotechnology Signature Initiative on "Sustainable Nanomanufacturing"[4] and the identification or initiation of such initiatives with other stakeholders that are interested in the development of an international sustainable nanofabrication ecosystem. This and other challenges might be addressed by an increased visibility and accessibility of robust EU and US nanotechnology infrastructures, coordination among international thought leaders, alignment with international research agendas, and the continuous and timely monitoring of a common understanding of future sustainable nanofabrication challenges.

The ambition to work towards further international cooperation may be enacted according to the concept paper for the *"International Network Initiative on Safe and Sustainable Nanotechnologies" (INISS-nano)*[5]. This concept paper aims to prepare the ecosystem for global collaboration in selected fields of action (the pillars are called "Harmonisation", "Support industrial understanding", "Sharing/ facilitate sharing of resources / infrastructures", and "Ethical aspects"), aiming to enable a *"collaboration without borders*" through joint projects, joint funding initiatives, and other methods of cooperation. The concept paper was created with input from NanoFabNet's partners; some elements of the present roadmap are therefore aligned with conclusions drawn in the consensus paper (e.g. those concerning the creation of an EU-Asian support network in a field that overlaps with the sustainable nanofabrication pillars identified by the NanoFabNet).

As all communities, including those addressing sustainable nanofabrication issues, were affected by the COVID-19 pandemic, the importance of and need for digital channels and remote business models was significantly raised. New practices for international cooperation have been strengthened and further developed. The created good practices should be maintained in the future NanoFabNet Hub.

The change in attitude towards digital tools that was caused by the COVID-19 pandemic is reflected in the community-building initiatives already undertaken by NanoFabNet. The change of the originally planned physical workshop to a virtual format has allowed for a larger number of participants worldwide to attend the workshop and provide input and feedback to the NanoFabNet team on the

[1] National Nanotechnology Coordinated Infrastructure (NNCI) (accessed: 2. January 2022)

[2] EU-US Nanomanufacturing Communities of Research (COR) (accessed: 10. January 2022)

[3] National Nanotechnology Coordination Office (NNCO) (accessed: 10. January 2022)

[4] 'Signature Initiative on 'Sustainable Nanomanufacturing: Creating the Industries of the Future Nanomanufacturing' (accessed: 14. December 2021)

[5] A. Falk, et al. International Network Initiative on Safe and Sustainable Nanotechnologies (INISS-nano) (accessed: 14. December 2021)

current project activities. The virtual pub-quiz was well received and facilitated the process of getting to know the participants in a more relaxed atmosphere, albeit in a virtual environment.

### 2.2 Understanding sustainable Nanofabrication

The concept of sustainable nanofabrication and what exactly it means to the NanoFabNet Project is widely explained in the NanoFabNet's '*Report on the Concepts and Disciplines of Sustainability in Nanotechnology & Nanofabrication*[6], wherein the following concepts were identified as the three main pillars of sustainability in nanotechnology and nanofabrication (see Figure 1):

a) Environment, Health, & Safety issues in Nanotechnology and Nanofabrication;

b) Life Cycle Sustainability Issues in Nanotechnology and Nanofabrication; and

c) Ethics & Governance Issues in Nanotechnology and Nanofabrication.

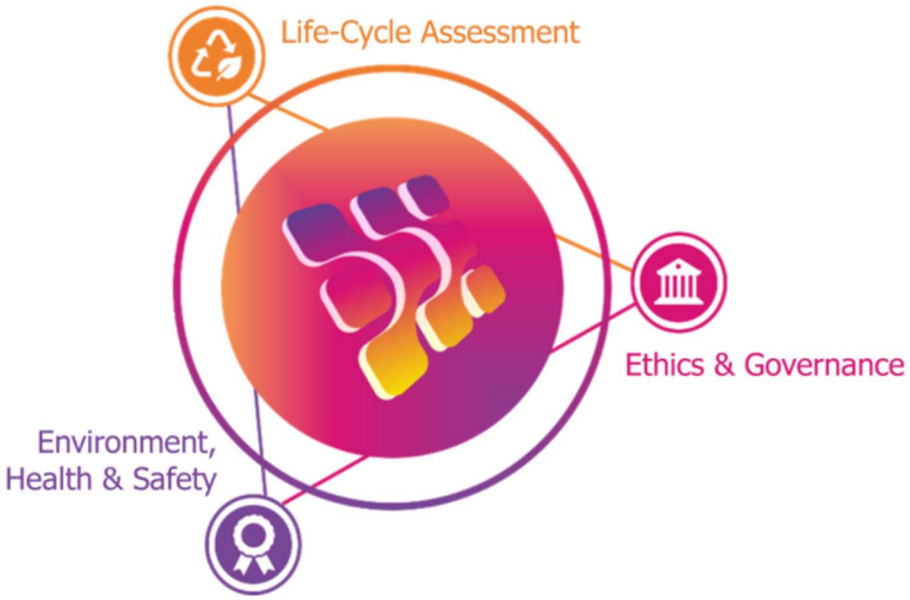


*Figure 1 Schematic illustration of the three pillars of the NanoFabNet's concept of sustainable nanofabrication.*

Sustainable development in nanofabrication is one of the factors that has a significant impact on the development of nanotechnology. This aspect is in the scope of research activities and can be considered in two ways. On the one hand, research activities are undertaken to develop sustainable nanomaterial production methods. On the other hand, it may be considered how sustainable nanomaterials might counter environmental change and support achieving European Green Deal policy goals.

Nevertheless, there is a significant gap in ethical and governance issues in nanotechnology and nanofabrication in the international environment. The possible ways to address this problem are presented in the *NanoFabNet Strategy & Implementation Roadmap for Sustainability in Nanofabrication*.[7] This report specifically identifies the dimensions concerning sustainability in nanofabrication ("raising awareness of sustainability", "compliance with regulation and legislation", "implementation of sustainability indicators", and "building support and engagement about sustainability criteria") and recommends specific actions that should be enacted to address those issues.

[6] Report on the Concepts and Disciplines of Sustainability in Nanotechnology & Nanofabrication

[7] NanoFabNet Strategy & Implementation Roadmap for Sustainability in Nanofabrication (accessed 17. January 2022)

### 2.3 Overview and Methodology of the Roadmap

The ***NanoFabNet Implementation Roadmap for International Cooperation*** aims to outline the continuing development of the global relations of the NanoFabNet.

The roadmap includes a series of core activities that address its goals:

- to set and describe a clear vision of what NanoFabNet aims to achieve in relation to international cooperation;
- to establish an active dialogue with NanoFabNet's stakeholders and analyse their feedback concerning their needs, as well as challenges or barriers that may be encountered when talking about international cooperation in the field of sustainable nanofabrication;
- to establish a mapping of the current landscape of international cooperation dealing with sustainable nanotechnology and nanofabrication; and
- to identify activities and actions, by which the NanoFabNet Hub will help the stakeholders to improve their cooperation via a constant, active dialogue with them.

The *NanoFabNet Implementation Roadmap for International Cooperation* has been created using information that has been provided by the mapping process, the listing of those institutions focused on the sustainable nanofabrication field, and active dialogue with NanoFabNet stakeholders during a series of interviews.

### 2.4 Understanding international Cooperation

International cooperation has a significant role in the modern world. It has evolved largely since the acceleration of globalisation processes after World War II and nowadays is even more accessible thanks to remote networking tools and platforms, whose access rates have increased largely due to the COVID-19 pandemic that affected more traditional tools, such as in-person meetings, networking sessions, conferences, and industrial trade fairs.

NanoFabNet was created to be a stakeholder-driven initiative; feedback obtained from stakeholders is, therefore, a very important factor in the creation of the NanoFabNet Hub and its international cooperation strategy. The consortium partners have pointed out several different possibilities of how international relations can be shaped.

During the 2nd Development Workshop, which was conducted in January 2021 as an online meeting, participants were asked to share their feedback on the question *"What should the NanoFabNet Hub facilitate for a stakeholder to collaborate and/or network with?",* with respect to the following three areas:

- EU-Projects;
- Organisations on EU level; and
- International Organisations & Collaborations.

The results of the stakeholder poll are presented in the Table 1 below. In summary, the following results were obtained:

All three areas are important to project stakeholders, they outline the need for cooperation between the EU, the US, and Asia-based institutions in the standardisation of nanofabrication. It was suggested to create or engage in an Ad Hoc group within the OECD Working Party on Manufactured Nanomaterials Safer Innovation Approach (WPMN)[8], provide contacts to international organisations, and include or create incubators and accelerators for nano.

[8] Organisation for Economic Co-operation and Development Moving Towards a Safe(r) Innovation Approach (SIA) for More Sustainable Nanomaterials and Nano-enabled Products (accessed 22. December 2021)

Some participants have suggested that manufacturers of nano-related equipment, as well as national and international institutes and agencies with the necessary facilities and equipment, may benefit from international collaboration.

Participants of the workshop are aware of the most important international institutions which address two important working areas for NanoFabNet's standardisation and sustainability; these are (a) the Organisation for Economic Cooperation and Development (OECD) and (b) the International Organization for Standardization (ISO) and its European- and US-level bodies the European Committee for Standardisation and the American Society for Testing and Materials (ASTM International) [9] respectively.

An important aspect of international collaboration that was identified in the course of the NanoFabNet Project is the need for partnership with organisations like the OECD, or ISO, in order to provide information on regulatory barriers and challenges that nanomaterials manufacturers might face.

*Table 1 Summary of the comments and postings received during a whiteboard exercise that asked the participating stakeholders "What should the NanoFabNet Hub facilitate for you to collaborate and/or network with?" (dedicated 'EU and international collaboration'-session at the 2nd NanoFabNet Development Workshop that was, held on the 20. – 21. January 2021).*

| What should the NanoFabNet Hub facilitate for you to collaborate and/or network with | | |
|---|---|---|
| **EU-Projects** | **Organisations on EU-level** | **International Organisations & Collaborations** |
| • bridging ongoing Horizon Projects in Europe<br>• bridging also with non-EU initiatives if relevant<br>• identify relevant or complementary EU projects<br>• list of EU projects<br>• national projects of relevance<br>• NMBP-13 projects on risk governance<br>• Green Deal Projects (call ongoing)<br>• NanoSafety Cluster (NSC)<br>• SUNSHINE, Gov4Nano (Wp4 Portal)<br>• GRACIOUS Project | • Scientific Committee on Consumer Safety (SCCS) Representatives<br>• European Chemicals Agency (ECHA) Representatives<br>• European Pharmaceutical Students' Association (EPSA) Representatives<br>• European Union Observatory for Nanomaterials (EUON)<br>• The Energy Materials Industrial Research Initiative (EMIRI)<br>• Enterprise Europe Network (EEN) sector group for nano<br>• Sustainable Process Industry through Resources and Energy Efficiency (SPIRE)<br>• European level NGOs<br>• National Authorities<br>• Trade Unions<br>• European Technology Platforms (Advanced Materials, etc.) | • collaboration among EU, US, and Asian countries in standardization of nanofabrication<br>• Mercado Comun del Sur (MERCOSUR)<br>• OECD Working Party on Manufactured Nanomaterials (WPMN) Ad Hoc Group<br>• World Health Organisation (WHO)<br>• International Labour Organisation (ILO)<br>• United Nations Environment Programme (UNEP)<br>• incubators and accelerators for nano<br>• national and international institutes and agencies with facilities and equipment<br>• manufacturers of nano equipment |

[9] American Society for Testing and Materials (accessed 13. January 2022)

| What should the NanoFabNet Hub facilitate for you to collaborate and/or network with | | |
|---|---|---|
| **EU-Projects** | **Organisations on EU-level** | **International Organisations & Collaborations** |
| | • ECOS_NGO working on Standardization<br>• EEB – European Environmental Bureau (NGO)<br>• The European Consumer Organisation (BEUC)<br>• one contact point for relevant organisations | |

## 3. Mapping the international Players of Sustainability in Nanotechnology and Nanofabrication

Mapping the existing international players in the area of sustainable nanotechnology and nanofabrication is an important part of establishing = the NanoFabNet Hub's future development goals, especially in terms of internationalisation, communication, and cooperation. The need for wider international cooperation and networking has been reflected in the partners' and stakeholders' responses (see chapter 4). Building a community for sustainability in nanotechnology and nanofabrication is one of the goals of the NanoFabNet Hub. Strong international cooperation is seen as an accelerator of sustainable nanofabrication development. The possible added value of cooperation with non-EU based partners has been highlighted many times during NanoFabNet workshops and interviews.

The goal of this mapping process is to identify those entities that may strengthen and widen the sustainable nanofabrication field. The mapping of institutions that are interested in aspects related to sustainable nanofabrication shapes a landscape, within which some institutions may contribute to one or more of the pillars of NanoFabNet's sustainable nanofabrication concept. The mapping process has identified 42 institutions around the globe. The list is presented in the ANNEX – A1: List of Institutions related to the Fields of Sustainability, Nanofabrication, or both.

Identifying leading global institutions who are working on at least one of the pillars of NanoFabNet's Sustainable nanofabrication concept is an important part of creating the contact point for people and other entities searching for partners.

The mapping results are divided amongst (a) EU-based institutions, and (b) those based outside the EU. Many Europe-based institutions have strong, existing international networks; the most active initiatives and organisations in this area are:

- EuroNanoLab[10];
- NanoSafety Cluster[11]; and
- EURAMET[12].

The list of institutions in ANNEX – A1 is a non-exhaustive list of institutions (academic, research, private) whose mission areas are connected to sustainable nanofabrication in a scope that overlaps

[10] EuroNanoLab (accessed: 10. January 2022)

[11] NanoSafety Cluster (accessed: 10. January 2022)

[12] EURAMET (accessed: 10. January 2022)

with NanoFabNet Project's understanding of this term (see ANNEX – A1: List of Institutions related to the Fields of Sustainability, Nanofabrication, or both).

## 4. The Needs and Barriers of International Cooperation in Sustainability in Nanotechnology and Nanofabrication

International cooperation is considered to be an important factor in the development of sustainability in nanotechnology and nanofabrication. NanoFabNet Hub aspires to become a propagator of such cooperation through its tools and activities.

Identifying the needs of NanoFabNet stakeholders in the area of international cooperation was the purpose of the interviews that took place during the preparation of this report.

According to the results of the interviews, the needs indicated in connection with international cooperation focus on (a) exchanges of knowledge, and (b) building a community in the sustainable nanofabrication area.

Sustainable nanofabrication issues concern many different fields of business and research. So far, there has been no place that brings these areas together, supports the exchange of knowledge, and matches the community members with each other.

According to the results of the interviews, there is also a need to build a community where people may share the outcomes of their work, acquire information and skills, or find partners or collaborators for new projects.

According to stakeholders' opinions the biggest barrier in building international cooperation is the number of tools available to support cooperation such as: conferences; partner search engines; research databases and project databases. These available tools are not reliable and complex to meet users' needs.

There are plenty of tools used to support cooperation, however, they are scattered throughout the internet and are focused on a specific institution or country. Although nearly every entity has its own set of tools, it is not easy to find specific information. There is no place that gathers all of this data together on the international level.

Respondents also identified specific barriers concerning the exchange of knowledge. It is hard to find information on ongoing research and projects or to get support and help with solving issues concerning sustainable nanofabrication. Taking the above information into account, NanoFabNet Hub aims to build a strong international community that enhances integration, cooperation, and the exchange of knowledge inside of this community.

The results of interviews are presented in the ANNEX – A2: Summary of the interviews and polls. It presents findings of the interviews with NanoFabNet stakeholders.

## 5. Implementation Roadmap for International Cooperation

### 5.1 NanoFabNet's international Cooperation Development Goals

Considering all the information provided in this document and the conclusions derived from the analyses presented in this document, the following four main goals of international cooperation have been identified for the NanoFabNet:

1. to establish a strong integration of the EU community
2. to establish a strong connection with stakeholders based outside the EU to facilitate building a global community focused on sustainable nanotechnology and nanofabrication
3. to develop the potential of NanoFabNet Hub through the exchange of knowledge at an international level

4. to monitor the mutual understanding of challenges in the field of sustainable nanofabrication and nanotechnology

Actions that were identified in the process of articulating a vision and which require key enablers are:

- **Partnerships & Collaborations**: these are crucial to unlocking the full potential of international collaboration. International partnerships will develop long-term relations between stakeholders and will also contribute to the development of a well-integrated community.
- **Data & Knowledge Generation**: to achieve the goals of any international project, it is important that the actions undertaken are data - driven and the information and services provided are the most timely or state-of-the-art resources.
- **Innovation**: sustainable nanofabrication often requires new technologies and products to be developed. In order to actually increase the efficiency of research and innovation (R&D) projects, it is worthwhile to collaborate internationally in the field of sustainable nanofabrication.

### 5.2 Opportunities and Actions

To improve international collaboration in the field of sustainable nanofabrication, the NanoFabNet has identified a number of goals, activities, and actions that might be implemented and carried out through the NanoFabNet Hub or undertaken by NanoFabNet Consortium partners before the Hub's launch, if possible. The expected outcomes of the different actions will help the community to overcome the identified challenges in meeting its goals.

The NanoFabNet digital platform may be used by all stakeholders of nanofabrication. This digital platform will enhance the collaboration and knowledge exchange between partners through its functionalities, services, and stored data. The platform will be a one-stop shop to obtain all important information and help needed in the area of sustainable nanofabrication.

The international cooperation goals and activities that will be undertaken to meet those goals are presented in the tables below. All the actions listed below should be conducted by NanoFabNet and its members.

*Table 2 International cooperation goals – Goal N°1: To establish an integrated EU community for sustainable nanofabrication.*

| **GOAL 1. To establish an integrated EU community for sustainable nanofabrication** |
|---|
| A well - integrated community may benefit from networking activities and advance the development of sustainable nanofabrication. The benefits of international cooperation are obvious and perceived by all stakeholders. |
| ***Sub-Goal 1.1: To create a European community in sustainable nanofabrication***<br>**Specific Action 1:** The NanoFabNet digital platform will maintain a calendar of upcoming events in the area of nanofabrication and nanotechnology where the community can meet and exchange their views. The database of European stakeholders will also be provided.<br>**Outcome:** Improving the process of exchanging research results and increasing international cooperation. |
| ***Sub-goal 1.2: To facilitate the creation of new partnerships and the implementation of international projects***<br>**Specific action 2:** The NanoFabNet Hub will organise regular online meetings where researchers and other participants may find potential partners for their activities.<br>**Outcome:** The number of international projects and partnerships in the field of sustainable nanofabrication will increase. |

*Table 3 International cooperation goals – Goal N°2: To establish a strong connection with stakeholders based outside the EU to facilitate the building of a global community focused on sustainable nanotechnology and nanofabrication.*

| **GOAL 2. To establish a strong connection with stakeholders based outside the EU to facilitate the building of a global community focused on sustainable nanotechnology and nanofabrication** |
|---|
| Enhancing international cooperation gives the opportunity for sustaining a deep and lasting relationship between the nanotechnology research communities through joint forces, in order to fulfil the NanoFabNet Project Mission of creating a strong international community for sustainable nanofabrication.<br>Existing EU-US synergies and collaborations should be included, in order to strengthen them and further broaden their impact. |
| ***Sub-Goal 2.1: To create a global community in sustainable nanofabrication***<br>**Specific Action 3:** The NanoFabNet Hub will promote and support good practices in the collaboration between EU-US nanofabrication initiatives (i.e., the establishment of joint EU-US research programs, the exchange of young scientists, the mobility of researchers, and the twinning of existing projects) and extend them to other countries.<br>**Outcome:** The NanoFabNet Hub will become an international and inclusive, member-driven, digitally enhanced platform that will support the worldwide implementation of good practices of sustainable nanofabrication and high-quality services. |
| ***Sub-goal 2.2: To be able to connect between communities working in the field of sustainable nanofabrication***<br>**Specific action 4:** The NanoFabNet Hub will repetitively perform mapping and monitoring activities to identify the sustainable nanofabrication landscape in national and international ecosystems worldwide.<br>**Outcome:** The NanoFabNet Hub will have the most up-to-date information on sustainable nanofabrication capabilities world-wide and will be able to reach out with its mission to initiatives, projects, and countries that would be the most willing to participate in the further development of the NanoFabNet Hub's achievements in implementing sustainable nanofabrication good practices. |
| ***Sub-goal 2.3: To strengthen EU-US collaborations***<br>**Specific action 5: The** organisation of webinars and/or workshops focused on sharing good practices and state-of-the-art knowledge in the field of sustainable nanofabrication.<br>**Specific action 6:** Participation in webinars and workshops in the field of sustainable nanofabrication, especially those organized by NNCO (3) and NNCI (1), for example, within the EU-US Nanomanufacturing CoR.<br>**Outcome:** The webinars/workshops will provide access to experts, as well as state-of-the-art information related to the areas of expertise of NanoFabNet Hub and raise the awareness of US stakeholders about NanoFabNet Hub. This will enable the participants' projects to save time when looking for experts or good practices that could support or help them to solve some of the challenges they face in their day-to-day work. |

*Table 4 International cooperation goals – Goal N°3: To develop the potential of NanoFabNet Hub through the exchange of knowledge at an international level.*

| **GOAL 3. To develop the potential of NanoFabNet Hub through the exchange of knowledge at an international level** |
|---|
| To translate its good practices in building collaborative relationships with well-developed, sustainable nanofabrication EU and US ecosystems in less subject - engaged markets. The countries that have been identified as those that have already undertaken actions overlapping with the NanoFabNet Project within their nation-wide networks (cf. Table 6 in Annex 1) are, among others, Canada, South Africa, Australia, Japan, South Korea, and Israel. To increase the overall dissemination of NanoFabNet's sustainable nanofabrication concept and community's achievement in the field, as well as to develop the hub into a truly international and inclusive community. |
| ***Sub-goal 3.1: To enable the individual stakeholder's access to easy and organised information about the international landscape of sustainable nanofabrication. This means, in particular, information on EU-funded projects (e.g. project start and ending dates, partners, the main aim, expected outcomes, results, etc.), including specific capabilities and/or expertise resulting from the different projects***<br>**Specific action 7**: The NanoFabNet Hub will create the digital contact point for individual stakeholders that seek information about sustainable nanofabrication; this will be achieved through the NanoFabNet digital platform with a repository of EU-funded projects related to the sustainable nanofabrication field. The repository will contain all relevant information about the EU-funded projects within it.<br>**Outcome:** Users will save time when searching for information that might help them familiarize themselves with the landscape of sustainable nanofabrication and its players, in particular, the efforts undertaken by EU-funded projects, as well as the researcher teams responsible for the project outcomes. |
| ***Sub-goal 3.2: To provide access to a centralised platform where everyone can share ideas and know-how on sustainable nanofabrication and nanomanufacturing***<br>**Specific action 8**: The NanoFabNet digital platform will provide a functionality that enables networking and the exchange of information between users.<br>**Outcome**: The NanoFabNe*t* Hub will allow stakeholders from around the world to communicate, meet, network, and collaborate digitally. This will help produce new opportunities for collaboration among the different stakeholders of varying origins (e.g. industry, academy, civil groups, associations, etc.). |
| ***Sub-goal 3.3: To develop and provide a repository of research infrastructures related to the field of sustainable nanofabrication***<br>**Specific action 9*:*** The *NanoFabNet* digital platform will combine European and US repositories of the research infrastructures involved in the sustainable nanofabrication field to US stakeholders, and incorporate the largest US infrastructures and knowledge bases into the NanoFabNet Hub database when created. It will contain all relevant information about those research infrastructures (capabilities, type of services, type of equipment, etc.).<br>**Outcome:** This repository of sustainable nanofabrication - related research infrastructures will permit the user to save time and gain confidence when looking for the right research infrastructure it might need to perform a specific activity in an EU-funded and US-based project. |

*Table 5 International cooperation goals – Goal N°4: To monitor the mutual understanding of challenges in the field of sustainable nanofabrication and nanotechnology.*

| **GOAL 4. To monitor the mutual understanding of challenges in the field of sustainable nanofabrication and nanotechnology** |
|---|
| One of the biggest challenges of the international ecosystem in the field of sustainable nanofabrication, including standardisation, harmonization, and validation, is that each international organisation (i.e., the OECD, ISO, or ASTM International[13]) sets up their own definitions and standards. It introduces chaos and difficulties, especially for those who act on an international level. Monitoring the mutual understanding of challenges in the field of sustainable nanofabrication and nanotechnology through the digital platform would enable a wider reach to the recipients. As the NanoFabNet Hub aims to be a one-stop shop for all those seeking information on sustainable nanofabrication, efforts should be made to unify the community and enhance the productivity of its collaboration. |
| ***Sub-goal 4.1: To enable a knowledge transfer between the NanoFabNet and key international organisations, as well as the dissemination of their achievements from working in the field of sustainable nanofabrication***<br>**Specific action 10:** The NanoFabNet Hub will incorporate into its database references the most important documents from the field of sustainable nanofabrication that are released by key international organisations, such as the OECD, the ISO, et al.<br>**Outcome:** The NanoFabNet Hub will become an international and inclusive, member-driven, digitally - enhanced community that will support and develop good practices and high-quality services in the implementation of sustainable nanofabrication worldwide.<br>**Specific action 11:** The NanoFabNet Hub will participate in and co-organise events disseminating achievements made in the field of sustainable nanofabrication.<br>**Outcome**: The NanoFabNet Hub will become an internationally recognisable platform. The events will be an important dissemination channel for the NanoFabNet Hub activities. |
| ***Sub-goal 4.2: To become an international support in setting sustainable nanofabrication standards worldwide***<br>**Specific action 12:** NanoFabNet Hub representatives and partners will take part in high-level workgroups within key international organisations, such as the OECD, the ISO, et al., in particular by co - creating input into harmonisation and standardisation activities.<br>**Outcome:** The NanoFabNet Hub will have an impact on setting sustainable nanofabrication standards.<br>**Specific action 13:** The NanoFabNet Hub will continue its engagement to connect and integrate EU, US, and Asian sustainable nanofabrication ecosystems.<br>**Outcome:** The NanoFabNet Hub will leverage its activities by a continuous engagement in the development of initiatives, especially by adding value through its expertise in the digital enablement of international cooperation and the sharing of infrastructure information.<br>**Specific action 14:** The NanoFabNet Hub will provide a continuous and timely monitoring of the common understanding of those challenges that will be addressed in the future development of sustainable nanofabrication.<br>**Outcome:** The NanoFabNet Hub will become an international determinant of development directions in the field of sustainable nanofabrication and nanomanufacturing. |

[13] American Society for Testing and Materials (accessed 12. January 2022)

## 6. Conclusions

The NanoFabNet project aims to create a strong international hub for sustainable nanofabrication. Efforts have been made in order to create a vision of the international stakeholder's engagement within the NanoFabNet Hub, which is to be as a result of this project in 2022. This report provides the NanoFabNet International Collaboration Roadmap. It designates four goals for its international cooperation:

1. to establish a strong integration of the EU community;
2. to establish a strong connection with other stakeholders to facilitate building a global community focused on sustainable nanotechnology and nanofabrication;
3. to develop the capacity of NanoFabNet Hub through the exchange of know-how at an international level; and
4. to monitor mutual understandings of challenges in the field of sustainable nanofabrication and nanotechnology.

Specific actions have been proposed to engage a wider, international community. The proposed actions are also focused on improving the transfer of knowledge and collaboration between stakeholders through the NanoFabNet digital platform.

International cooperation is an important element in building stakeholder awareness in the field of sustainable nanofabrication. It can foster the development of the industry, promote good practices in research and industry, and facilitate international contacts for the NanoFabNet community.

## 6. Bibliography

‘Signature Initiative on ‘Sustainable Nanomanufacturing: Creating the Industries of the Future Nanomanufacturing’: https://www.nano.gov/sites/default/files/pub_resource/Nanomanufacturing_NSI_Highlight_Document.pdf

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# ANNEX – A1 List of Institutions related to the Fields of Sustainability, Nanofabrication, or both

The table below presents a non-exhaustive list of institutions (academic, research, and private) covering areas connected to sustainable nanofabrication as part of their mission statements. The table is divided into three types of entities, depending on their scope of activities:

- International;
- EU-based institutions; and
- based outside the EU.

*Table 6 Non-exhaustive list of institutions related to the field of sustainable nanofabrication*

| Region | Entity Name | Country* | Type of entity | Website | Nanotechnology and Nanofabrication scope of activity | Pillar of the NanoFabNet Concept of Sustainable Nanofabrication addressed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 EHS | 2 LCS | 3 Gov., Ethics & Regulation |
| INTERNATIONAL | Sustainable Nanotechnology Organization (SNO) | - | NGO | http://www.susnano.org/ | X | X | X | X |
| | The International Network for Sustainable Nanotechnology (N4SN) | - | Network | https://network4sustainablenano.org/ | X | X | | |
| | International Network 4 Sustainable Nanotechnology | - | Network | https://network4sustainablenano.org/ | X | X | X | X |
| | ISO International Organization for Standardization | - | Policy-informing/making body | https://www.iso.org/ | | X | | X |
| | Organisation for Economic Co-operation and Development (OECD) | - | Policy-informing/making body | https://www.oecd.org/ | | X | | X |
| | DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA) | - | Network | https://www.teriin.org/projects/dtd-rna/ | X | X | X | |

| Region | Entity Name | Country* | Type of entity | Website | Nanotechnology and Nanofabrication scope of activity | Pillar of the NanoFabNet Concept of Sustainable Nanofabrication addressed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 EHS | 2 LCS | 3 Gov., Ethics & Regulation |
| EU-BASED | NanoSafety Cluster | - | Cluster | https://www.nanosafetycluster.eu/ | X | | | X |
| | BioNanoNet (BNN) | Austria | NGO | https://www.bnn.at/ | X | X | X | X |
| | Nanotechnology Industries Association (NIA) | Belgium | Network | https://nanotechia.org/ | X | X | | X |
| | The Central European Institute of Technology (CEITEC) | Czech Republic | R&D Institution | https://www.ceitec.eu/ | X | X | X | |
| | Interdisciplinary Nanoscience Center (iNANO) | Denmark | Higher Education / R&D Institution | https://inano.au.dk/ | X | | | |
| | Centre Européen de Recherche et d'Enseignement de Géosciences de l'Environnement (CEREGE) | France | R&D Institution | https://www.cerege.fr/en | X | X | | |
| | Institut Catholique d'Art et Metiers (ICAM) | France | Higher Education / University | https://en.icam.fr/ | X | | | X |
| | Laboratoire National de Métrologie et d'Essais (LNE) | France | R&D Institution | https://www.lne.fr/en | X | X | | X |
| | DIALOGIK gemeinnützige Gesellschaft für Kommunikations- und Kooperationsforschung mbH | Germany | Policy-informing/making body | https://www.dialogik-expert.de/en | | | | X |
| | Karlsruhe Institute of Technology (KIT) – The Research University in the Helmholtz Association | Germany | Higher Education / University | https://www.kit.edu/english/ | X | X | X | |
| | Nano\|Net | Greece | Network | http://www.nano-net.gr/ | X | X | X | X |
| | University of Milano-Bicocca | Italy | Higher Education / University | https://en.unimib.it/ | X | | X | |

| Region | Entity Name | Country* | Type of entity | Website | Nanotechnology and Nanofabrication scope of activity | Pillar of the NanoFabNet Concept of Sustainable Nanofabrication addressed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 EHS | 2 LCS | 3 Gov., Ethics & Regulation |
| | The Luxembourg Institute of Science and Technology (LIST) | Luxembu rg | R&D Institution | https://www.list.lu/ | X | X | | X |
| | NorFab | Norway | Network / R&D Institution | https://www.norfab.no/ | X | X | | |
| | NanoSpain | Spain | Network | https://www.nanospain.org/en/nanospain.php?p=h | X | X | X | X |
| BASED OUTSIDE EU | National Nanotechnology Coordinated Infrastructure (NNCI) | US | Network | https://nnci.net/ | X | X | X | X |
| | National Nanotechnology Initiative (NNI) | US | Policy-informing/making body | https://www.nano.gov/ | X | X | X | X |
| | Global Quantum Leap (GQL) | US | Network | https://www.globalquantumleap.org/ | X | | X | |
| | The Center for Sustainable Nanotechnology (CSN) (USA) | US | Network | https://susnano.wisc.edu/ | X | | X | |
| | The National Institute for Occupational Safety and Health (NIOSH) | US | Policy-informing/making body | https://www.cdc.gov/niosh/index.htm | X | X | | |
| | SmallTech Consulting | US | Consulting company | https://smalltechconsulting.com/ | X | | X | |
| | NIMS (Japan) National Institute for Materials Science | Japan | R&D Institution | https://www.nims.go.jp/eng/index.html | X | X | X | X |
| | Nanotechnology Platform Japan (NTPJ) | Japan | Network | https://www.nanonet.go.jp/ntj/english/ | X | X | X | |
| | Russell Berrie Nanotechnology Institute | Israel | Higher Education / University | https://rbni.technion.ac.il/ | X | | | |

| Region | Entity Name | Country* | Type of entity | Website | Nanotechnology and Nanofabrication scope of activity | Pillar of the NanoFabNet Concept of Sustainable Nanofabrication addressed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 EHS | 2 LCS | 3 Gov., Ethics & Regulation |
| | Technion-Israel Institute of Technology | | | | | | | |
| | The Hebrew University Center for Nanoscience and Nanotechnology (HUCNN) | Israel | Higher Education / University | https://nano.huji.ac.il/ | X | X | X | |
| | Bar Ilan's Institute for Nanotechnology and Advanced Materials (BINA) | Israel | Higher Education / University | https://nano.biu.ac.il/ | X | X | | |
| | National Center for Nanoscience and Technology | China | R&D Institution | http://english.nanoctr.cas.cn/ | X | X | X | X |
| | National Engineering Research Center for Nanotechnology | China | R&D Institution | http://www.nercn.com.cn/ | X | X | | |
| | The University of Sydney Nano Institute | Australia | Higher Education / University | https://www.sydney.edu.au/nano/about.html | X | X | X | |
| | The Australian National Fabrication Facility | Australia | Network | https://www.anff.org.au/ | X | X | X | X |
| | Nano Technology Research Association | South Korea | Network | http://www.nanokorea.net/ | X | | | |
| | Nano Convergence Foundation | South Korea | NGO | https://www.nanotech2020.org/ | X | X | X | |
| | Korea Nanotechnology Research Society | South Korea | Network | https://www.kontrs.or.kr | X | X | X | X |
| | Korea Advanced Nano Fab Center | South Korea | R&D Institution | https://www.kanc.re.kr/eng/main.do | X | | | |
| | The Waterloo Institute for Nanotechnology (WIN) | Canada | R&D Institution | https://uwaterloo.ca/institute-nanotechnology/ | X | X | X | |
| | NanoCanada | Canada | NGO | https://nanocanada.com/ | X | X | | |

# ANNEX – A2 Summary of the Interviews and Polls

## 1. Introduction

As part of the NanoFabNet Implementation Roadmap for International Cooperation, fourteen individual meetings with NanoFabNet initiative stakeholders from the EU, Asia, and the USA were conducted in the period from 8 to 30 November, 2021.

One of the aims of the interviews was to diagnose the knowledge about organisations conducting activities in the field of the three pillars that form the **NanoFabNet Concept of Sustainable Nanofabrication**:

- Pillar 1 - Environment, Health & Safety issues in Nanotechnology & Nanofabrication;
- Pillar 2 - Life Cycle Sustainability in Nanotechnology & Nanofabrication; and
- Pillar 3 - Ethics & Governance issues in Nanotechnology & Nanofabrication.

The other aim was to diagnose the stakeholders' needs and opinions on what services could be provided by NanoFabNet Hub in the field of establishing partnerships with organisations outside their country.

The purpose of these interviews was to determine the need for cooperation between businesses and scientific and business environment units within the three pillars and to analyse the knowledge of organisations operating within the framework of sustainable nanofabrication.

In addition, a questionnaire was prepared, the task of which was to collect information on the tools and methods used to search for new partners, the need for international cooperation, and the areas that this cooperation would cover.

## 2. Analysis of the answers to the questions from the questionnaires concerning the NanoFabNet Pillars

The first part of the survey addresses the diagnosis of the level of knowledge of those organisations operating under the three pillars of NanoFabNet. By analysing the stakeholder responses, it can be concluded that most of them were able to name at least one organisation whose activities fall within the NanoFabNet pillars.

Analysis of the answers delivered under the first part shows that each stakeholder knows, or has cooperated with, at least one organisation operating in one of the three pillars.

During the interviews, almost everyone could recall relevant (research) organisations in their own countries. Some European institutions were mentioned as well (e.g. the NanoSafety Cluster, LIST, the French National Institute for Industrial Environment and Risks14, ICAM), but knowledge about entities based outside the EU was minimal, with interviewees able to recall only the Sustainable Nanotechnology Organization, NNCI.

Under Pillar 1, as many as 7 out of 10 people mentioned organisations operating in this area; this is the area in which stakeholders know the most organisations or institutions. The institutions listed within this area can be divided into:

- National organisations (e.g. Institut Pasteur de Lille, Institut National de Recherche et de Sécurité)
- European initiatives (e.g. INISS-Nano, NanoSafety Cluster, EuroNanoLabs)

[14] French National Institute for Industrial Environment and Risks https://www.ineris.fr/en (accessed 12. January 2022)

- International initiatives (e.g. DTD-RNA, a Asia Nano Forum[15], Sustainable Nanotechnology Organization)

Knowledge of the organisations that base their activities in the area of LCS and ethics & governance issues is significantly lower than those operating in Pillar 1: Three out of 10 respondents indicated the National Nanotechnology Coordinated Infrastructure (NNCI) as an organisation having a significant impact on legal regulations, which affects the design of nanomaterials and their life cycle. Within NNCI, several sites (Georgia Tech[16], Arizona State University[17], North Carolina State University[18], University of Texas[19]) have programmes in Societal and Ethical Implications (SEI) of Nanotechnology. Not all of these are related to the topic of ethics, as some are looking at impact, policy, and other social science issues. Pillar 2 is mainly populated by research institutes and universities (University of Milano-Bicocca[20], University of Tokyo[21]). It can be seen that the organisations operating in this pillar are, firstly, national research centers. Pillar 3 includes European initiatives with ethics and regulatory groups (e.g., Working Group G of the NanoSafety Cluster[22]) and organisations engaged in a dialogue between scientists and government bodies.

**3. Analysis of answers to questions concerning international cooperation**

An important part of the NanoFabNet project, and in particular of the NanoFabNet Implementation Roadmap for International Cooperation, is the analysis of the needs and expectations of international cooperation related to sustainability issues in nanotechnology. Most of the surveyed stakeholders see the need to establish international cooperation, in particular intercontinental cooperation. The main reasons for establishing cooperation with units from outside the country were:

- the deepening process of globalization;
- the need to create global standards and norms for the sustainable development of nanofabrication;
- the exchange of views, experiences, and know-how for the development of nanotechnology and nanofabrication; and
- need to share nanoscience and nanotechnology expertise and good practices. This need is key in efforts to create norms and standards.

The respondents indicated that the most important work for them and the organisations they represent is the process of building a long-term relationship, one that results in the exchange of good practices and experience between partners. Long-term international cooperation also enables greater efficiency by combining the forces of different working environments and attitudes to research. A small number of people indicated that cooperation is usually organized due to the formal requirements of specific projects.

[15] Asia Nano Forum https://www.asia-anf.org/ (accessed 17. January 2022)

[16] Georgia Tech https://www.gatech.edu/ (accessed 12. January2022)

[17] Arizona State University https://www.asu.edu/ (accessed 12. January 2022)

[18] North Carolina State University https://www.ncsu.edu/ (accessed 12. January 2022)

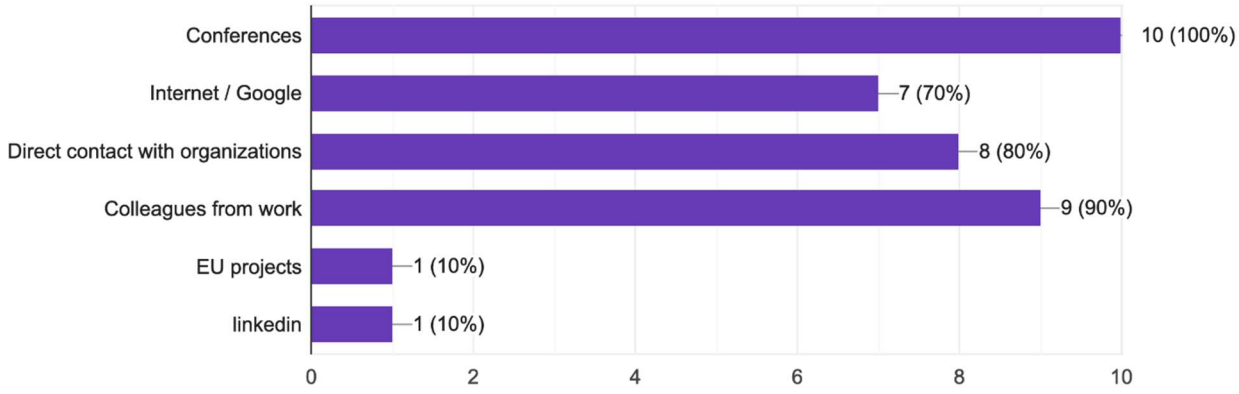
[19] University of Texas https://www.utexas.edu/ (accessed 12. January 2022)

[20] University of Milano-Bicocca https://en.unimib.it/ (accessed 12. January 2022)

[21] University of Tokyo https://www.u-tokyo.ac.jp/en/ (accessed 12. January 2022)

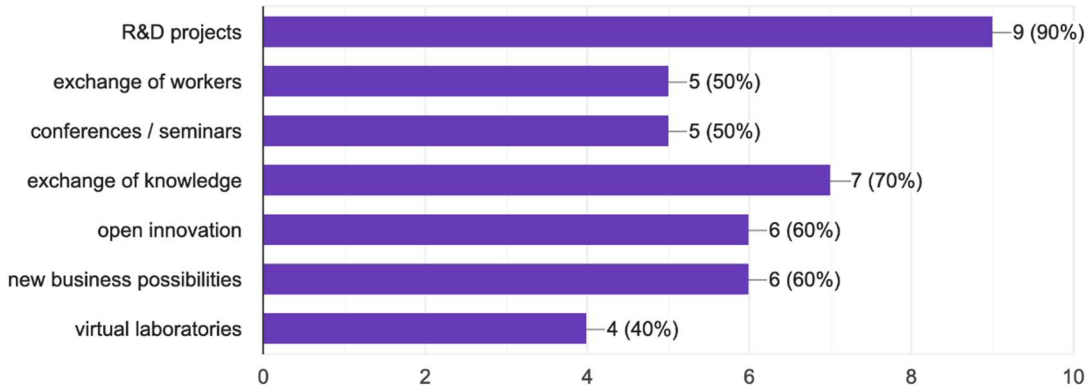
[22] https://www.nanosafetycluster.eu/nsc-overview/nsc-structure/working-groups/wgg/ (accessed 12. January 2022)

*Figure 2 Tools used to establish international relations*




International conferences are the main tool for networking between representatives of various circles (Business to Science, Science to Business). Conferences are international forums where scientists, companies, government organisations, and all nanotechnology enthusiasts meet to exchange knowledge, views, and research results. Thanks to such events, relationships are created that result in new projects and further relationships. Other ways to establish international cooperation are direct contact with organisations and contact thanks to colleagues. In surveys and interviews, the stakeholders of the NanoFabNet initiative indicated that direct/personal contacts are of key importance.

*Figure 3 The area of international cooperation in the context of the three pillars of NanoFabNet*




NanoFabNet stakeholders are most interested in cooperation in the field of R&D projects and the exchange of experience and knowledge. These two activities are crucial, due to their potential for obtaining financing and implementing a joint project based on the exchange of knowledge, equipment, and human resources. From the above-listed results, it can be concluded that the main factor motivating international cooperation is the desire to carry out joint R&D projects. Only six people have indicated that it is important for them to create new business opportunities, and only five have indicated a willingness to create platforms for employee exchange between units. Only half of the people asked saw organising conferences and seminars (from the 3 pillars of NanoFabNet) as a valuable area of cooperation.

Based on the interviews and surveys, it can be concluded that knowledge of the organisations operating within the NanoFabNet pillars varies. There is no single knowledge base on the organisations operating in the NanoFabNet areas, with a particular emphasis on their leading activities and

cooperation needs. Main stakeholders mentioned local organisations with national action and key cooperation at the European and international level.

Stakeholders agreed that cooperation is the key to the development of safe and sustainable nanotechnology. A very important aspect of the exchange of knowledge and experience is the conference and seminars devoted to nanotechnology. On the other hand, all the respondents indicated the need to create a single platform that would centralize knowledge of Nano events, organisation, infrastructure, and ongoing projects. This platform would enable cooperation at the European and international levels. The main factor influencing the establishment of cooperation is the willingness to create new R&D projects and the exchange of experience and knowledge. The created platform would be used to share knowledge and research results, which would have a positive impact on the state of knowledge and the sustainable development of nanotechnology.

NanoFabNet

international Hub for sustainable industrial-scale Nanofabrication