ENRICH

EUROPEAN NETWORK OF RESEARCH AND INNOVATION CENTRES AND HUBS, USA

# US Innovation Market Guide on Nanotechnologies

GAC GROUP · SBDC | FOX Small Business Development Center TEMPLE UNIVERSITY · DLR Deutsches Zentrum für Luft- und Raumfahrt · spi · RCISD · NCURA Supporting Research...together

# Disclaimer

# Executive Summary

This market guide is a product of ENRICH in the USA, which is a European Network of Research and Innovation Centers and Hubs. Promoted by the European Commission (EC) through Horizon 2020, ENRICH in the USA acts as a central contact point for European research and innovation actors seeking to grow and reinforce collaboration across the Atlantic. The mission of the Network is to provide standardized as well as various tailor-made, research & innovation internationalization support services to European researchers and innovators, to accelerate access to the United States (US) market and maximize chances of success.

This market guide provides relevant information on the US innovation and market landscape in regard to Nanotechnologies.

The market guide identifies US key innovation hubs/facilitators and industry related centers, as well as the US main Nanotechnology market opportunities and barriers. The Market guide also provides some of the key Nanotechnology related networks and events and assesses the existing funding initiatives and programs at both federal and state level that promote Nanotechnology innovation. Overall, this market guide aims to be an effective tool for EU research and business representatives in the Nanotechnologies related fields to gain knowledge on the US Nanotechnology innovation and market landscapes, and therefore facilitate their initial approaches to establishing innovation and business collaborative activities with their US counterparties.


**Figure 1 - Initial Approaches for Establishing Collaborative Innovation and Business Activities**



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**Importance of Nanotechnology innovation to the EU and the US**

Nanotechnology is described by the EC as a key enabling technology with a great potential for addressing societal challenges, such as energy supply and healthcare[1]. On the US side, the National Nanotechnology Initiative (NNI) of the US Government defines it as the science, engineering and technology conducted at the Nanoscale (around 1 to 100 nanometers).

The Nanotechnology market has significantly contributed to new solutions to science and engineering fields. The interdisciplinary characteristic of Nanotechnology allows it to have a wide range of applications among different sectors[2]. Consequently, the importance of Nanotechnology applications to the global economy has been growing during the last decades, and it is expected that Nanotechnology applications will have a Compound Annual Growth Rate (CAGR) of around 36.4% between 2021 and 2030[3]. According to the EC, it was estimated that the Nanotechnologies industry in 2015 was worth more than $1 trillion (€900 billion) and is still growing.

The Nanotechnologies market growth is also reflected at the policy level between the EU and the US, which includes Nanotechnologies as one of the main thematic collaboration priorities between the regions. Cooperation between the EU and the US in Nanotechnology was established at the end of 1999 through an EU-USA Agreement on Scientific and Technological Co-operation, and through an agreement for cooperative activities in materials science. Since then, several agreements have been launched between both regions, including cooperation procedures on Nanotechnology[4].

**Innovation ecosystem**

In 2018, the US total spending on R&D is expected to reach around $717 billion (€676.81 billion), which represents about 2.8% of the US Gross Domestic Product (GDP) [5]. For the NNI, the Fiscal Year of 2023 projected a total budget of $1.99 billion (€1.88 billion) with a special focus on innovation and promoting competitiveness, economic growth and national security. The main agencies were the ones with the largest investment for 2023, representing around 95% of the total budget: National Science Foundation (NSF) - fundamental research and education across all disciplines of science and engineering; Department of Health and Human Services, National Institutes of Health (HHS/NIH) - Nanotechnology-based biomedical research at the intersection of life and physical sciences; Department of Energy (DOE) - fundamental and applied research providing a basis for new and improved energy technologies; Department of Defense (DOD) - science and engineering research advancing defense and dual-use capabilities; and Department of Commerce, National Institute of Standards and Technology (DOC/NIST) - fundamental research and development of measurement and

[1] https://ec.europa.eu/jrc/en/research-topic/Nanotechnology
[2] https://www.iberdrola.com/innovation/Nanotechnology-applications
[3] Global Nanotechnology Market Analysis & Trends - Industry Forecast to 2025, Accuray Research LLP, 2016
[4] https://eur-lex.europa.eu/EN/legal-content/summary/scientific-and-technological-cooperation-between-the-eu-and-the-united-states.html
[5] https://ncses.nsf.gov/pubs/nsf23320#:~:text=U.S.%20R%26D%20Increased%20by%20%2451,Billion%20%7C%20NSF%20%2D%20National%20Science%20Foundation



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fabrication tools, analytical methodologies, metrology, and standards for Nanotechnology. Thus, Nanotechnology plays an important role in several areas of the US market, namely within high-tech and manufacturing industries[6].

When analyzing the US Nanotechnology innovation system, European SMEs should first identify the most relevant innovation hubs, facilitators and industry related RDI centers for the sector. The innovation ecosystem is the term used to describe the numerous participants and resources that are needed for the innovation process[7]. From the assessment of the US Nanotechnology innovation and industry communities' landscape, it is clear there is a particular concentration of innovation hubs/facilitators and industry related RDI centers in the states of California, Illinois, Massachusetts, New York, North Carolina and Texas[8,9].

Innovation hubs are ecosystems comprised by SMEs, large industries, startups, researchers, accelerators, and investors[10] that aim to foster relationships between these entities and to act as a bridge between research and market needs[11]. Currently, Nanotechnology innovation hubs are focused on applications for healthcare, electronics, energy, transportation and aerospace. Another interesting fact is that Nanotechnology innovation is strongly dependent on industry-academia cooperation, with leading actors from several areas from both the research and the industry side[12].

Innovation facilitators support, promote and accelerate the innovation process. Thus, organizations such as business accelerators, incubators, science parks and specialized consulting firms are considered innovation facilitators, playing a key role in the Nanotechnology innovation process. Within the context of Nanotechnology, science parks are very important for the development and deployment of innovative Nanotechnology applications in the market[13].

Industry related RDI centers are entities that promote the cooperation between industry, researchers and innovation facilitators, and thus supporting the development of new Nanotechnology applications and solutions. In the US, most Nanotechnology solutions seem to be developed through cooperation between industries and universities or research centers[14]. Thus, the US has witnessed the emergence of several industry-related centers that promote new entrepreneurial ventures and solutions within the context of Nanotechnology.

[6] https://www.nano.gov/sites/default/files/pub_resource/NNI-FY23-Budget-Supplement.pdf Nanotechnology
[7] https://www.researchgate.net/publication/282122544_Innovation_Ecosystems_Implications_for_Innovation_Management
[8] https://www.greenbiz.com/article/five-cities-lead-country-Nanotech-development
[9] Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century (2013), Chapter: 7 The New York Nanotechnology Initiative, National Research Council, 2013
[10] https://run-eu.eu/innovation-hubs/
[11] http://americanjobsproject.us/system/innovation-ecosystem/
[12] Working Texas Style, Chapter 12: Nanotechnology, 2013
[13] Processes of Innovation in the Field of Nanotechnology, Anna Butzin, 2007
[14] Working Texas Style, Chapter 12: Nanotechnology, 2013



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**Market landscape**

The US is the world's leading country in the number of companies of Nanotechnology-related firms[15]. In 2014, the US invested around $6 billion (€5.4 billion) in Nanotechnology among governments, corporations and private investors. Moreover, the revenue from nano-related products in 2022 was $173.06 billion (€164.44 billion), which shows the great potential of this technology from the business side[16]. As the market for Nanotechnology applications is quite spread among sectors and areas, this analysis concentrates on segments within each sector that have a strong focus on Nanotechnology applications. Thus, the segments considered for the analysis are as follows: Pharmaceutical and Medicine Manufacturing, Electronic Computer Manufacturing, Storage Battery Manufacturing, Paint and Coating Manufacturing, and Aerospace Product and Parts Manufacturing. Taking this into account, the states of California, Florida, Texas and New York were identified as the main business areas of Nanotechnology in the US. Other states such as Massachusetts, New Jersey and Illinois also seem to have a high concentration of manufacturers.

**Networks and events**

Nanotechnology is an area that is constantly advancing and innovating. Thus, it is highly recommended that EU researchers and industry representatives contact key US Nanotechnology-related networks and attend Nanotechnology events and conferences located in the US. The knowledge gained through relevant networks, events and conferences is used to decide the most effective approach to establishing contacts with the US community and developing new cooperation opportunities.

**Initiatives and programs**

The US Nanotechnology innovation system is supported by a set of specific federal, state and private initiatives and programs that prioritize research and innovation areas that can lead to technological breakthroughs. The NNI funds the majority of Nanotechnology efforts and programs at the federal level, involving the Departments of Health and Human Services (HHS), National Science Funding (NSF), Department of Energy (DOE), and Defense (DOD) covering 95% of the NNI's R&D Nanotechnology total budget. In terms of private-level funding, there are different solutions available through different institutions spread around the country. These are normally focused on the state level and act as a complement to the R&D funding available through the NNI. Although there are several programs and initiatives at both public and private levels, it is important to note that information related to funds and grants for European representatives is difficult to find. In most cases, the European innovators and business representatives interested in US Nanotechnology-related initiatives and programs need to contact the program officers to know specific details about international eligibility.

[15] OECD, Key Nanotechnology Indicators, http://oe.cd/kni, May 2017
[16] Nanotechnology Update: U.S. Leads in Government Spending Amidst Increased Spending Across Asia, LuxResearch, 2015



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# ENRICH in the USA Summary

ENRICH is the European Network of Research and Innovation Centers and Hubs. Started in April 2017, ENRICH in the USA is a H2020-funded initiative whose mission is to establish a Network of European Research and Innovation Centers and Hubs throughout the United States of America (USA). ENRICH in the USA acts as a central contact point for European research and innovation actors seeking to grow, reinforce collaboration, as well as find commercialization paths across the Atlantic. To do so, ENRICH in the USA is leveraging a network of vetted European and US Partners (entities - including "Ambassadors") and Experts (persons - including "Mentors") as defined below.

The Ambassadors are stakeholders (entities) already supporting R&I actors, and willing to join forces on outreach, funding, programs, and curriculums; this group includes Angel Networks, Venture Capital Firms, Corporate Investors, Corporate Open Innovation Teams, University Incubators, Equity-based accelerators, Clusters, Region, State and Country Government agencies and more. They can also support ENRICH in the USA via sponsorship (cash or in-kind).

Vetted by approved Ambassadors and the ENRICH in the USA team, Experts are individuals who are usually employees of Ambassadors with skills and industry experience. It includes Consultants/Service Providers (i.e., accountants, lawyers, etc.), Angel investors, as well as Mentors. Mentors are volunteering their time to support EU innovators (i.e., review pitches, collaterals, participation in meetings, etc.).

ENRICH in the USA targets to serve the following actors:

- Accelerators
- Businesses
- Clusters
- Entrepreneurs
- Funding Agencies
- Incubators
- Networks
- R&D institutes and labs
- Research managers and administrators
- Research Parks
- SME's
- Start-ups
- Universities
- University Associations

The ENRICH in the USA includes the following entities:

- **One Headquarter in the US** (at Temple University, Philadelphia)
- **Two physical Centers:**
  - **San Francisco Center**: ENRICH West Coast Hub at EAEC
  - **Boston Center**: ENRICH East Coast Hub at CIC
- **Five Associate Hubs across the US** and plans to expand the ENRICH in the USA Network beyond these first five Hubs, over four years.

The ENRICH in the USA Network is built on local US experience and strong existing ties between the EU and USA, while providing new researcher- and entrepreneur-serving capabilities which that address the resource gaps necessary to enable access for all EU Member States and Associated Countries. A variety of services are proposed for researchers and entrepreneurs engaged by the Network during

the pilot phase, then the Centers' pilot activities will be evaluated to inevitably retain the initiative's most successful components to ensure a sustainable plan for ENRICH in the USA in the future.

Piloted services targeted various, commercially viable technology maturity levels, both research-oriented and market-oriented, besides research connection symposia, business matchmaking opportunities, working visits and innovation tours to US organizations to explore technology/product partnerships and/or business development middle/long term opportunities, pitching to potential investors, entrepreneurial boot camps, workspace access, hands-on business acceleration programs, and more will all be included.

**ENRICH in the USA Consortium:**

**Coordinator:** GAC Group (GAC), France

**Partners:**

> German Aerospace Center (DLR), Germany
> Temple University SBDC (Temple), USA
> European Business and Innovation Center Network (EBN), Brussels - Partner in Phase 1 (2017-2020)
> International Business Innovation Association (InBIA), USA - Partner in Phase 1 (2017-2020)
> European American Enterprise Council (EAEC), USA - Partner in Phase 1 (2017-2020)
> INTRASOFT International (INTRA), Luxembourg - Partner in Phase 1 (2017-2020)
> Sociedade Portuguesa de Inovação (SPI), Portugal
> Regional Center for Information and Scientific Development (RCISD), Hungary
> National Council of University Research Administrators (NCURA), USA

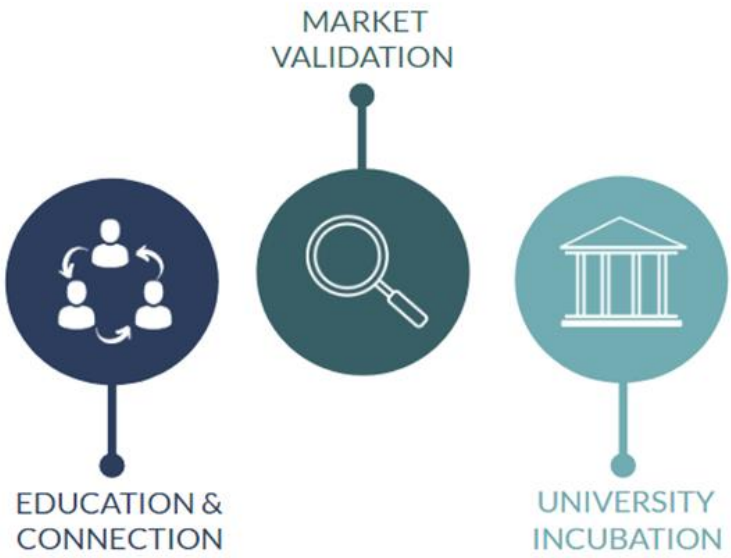


Figure 2 – ENRICH in the USA Services



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# List of Abbreviations

**Table 1 – List of Abbreviations**

| Abbreviation | Explanation |
|---|---|
| **AMO** | Advanced Manufacturing Office |
| **APOMA** | American Precision Optics Manufacturers Association |
| **ARPA-E** | Advanced Research Projects Agency-Energy |
| **CADMIM** | Center for Advanced Design and Manufacturing of Integrated Microfluidics |
| **CAEML** | Advanced Electronics through Machine Learning |
| **CAGR** | Compound Annual Growth Rate |
| **CARD** | Center for Advanced Research in Drying |
| **CDC** | Centers for Disease Control and Prevention |
| **CENN** | Center of Excellence in Nanoelectronics and Nanotechnology |
| **CiiT** | Center for Innovative Instrumentation Technology |
| **CNSE** | College of Nanoscale Science and Engineering |
| **CRADA** | Cooperative Research and Development Agreement |
| **CTRC** | Cooling Technologies Research Center |
| **DEP** | Massachusetts Department of Environmental Protection |
| **DOC** | US Department of Commerce |
| **DOD** | US Department of Defense |
| **DOE** | US Department of Energy |



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| Abbreviation | Explanation |
|---|---|
| **EC** | European Commission |
| **EDA** | Economic Development Agency |
| **EERE** | Office of Energy Efficiency and Renewable Energy |
| **EMN** | Energy Materials Network |
| **EPO** | European Patent Office |
| **ESCA** | European Secretariat for Cluster Analysis |
| **ES2** | Center for Energy-Smart Electronic Systems |
| **ETIC** | Emerging Technologies and Innovation Center |
| **EU** | European Union |
| **E2TAC** | Energy and Environmental Technology Applications Center |
| **FFRDC** | Federally funded research and development centers |
| **FOA** | Funding Opportunity Announcement |
| **FY** | Fiscal Year |
| **GDP** | Gross Domestic Product |
| **GPT** | General-Purpose Technology |
| **HHS** | Department of Health and Human Services |
| **HPC** | High-Performance Computing |
| **HPC4Mfg** | High Performance Computing for Manufacturing |
| **IANT** | International Association of Nanotechnology |
| **ICBN** | Conference on Biotechnology and Nanotechnology |



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| Abbreviation | Explanation |
|---|---|
| **iCLEAN** | Incubators for Collaborating & Leveraging Energy and Nanotechnology |
| **ICNMS** | International Conference on Nano and Materials Science |
| **IC2NAM** | International Conference on Nanoscience, Nanotechnology & Advanced Materials |
| **IEDM** | IEEE International Electron Devices Meeting |
| **IIN** | International Institute for Nanotechnology |
| **IQT** | In-Q-Tel |
| **ISTC** | Illinois Science Technology Coalition |
| **IUCRC** | Industry–University Cooperative Research Centers |
| **LETN** | Lehigh Emerging Technologies Network |
| **MIT** | Massachusetts Institute of Technology |
| **NASA** | National Aeronautics and Space Administration |
| **NCN** | Network for Computational Nanotechnology |
| **NCNA** | NanoAccelerator |
| **NCNano** | Northern California Nanotechnology Initiative |
| **nCORE** | Nanoelectronic Computing Research |
| **NIH** | National Institutes of Health |
| **NIOSH** | National Institute for Occupational Safety and Health |
| **NIST** | National Institute of Standards and Technology |
| **NNCI** | National Nanotechnology Coordinated Infrastructure |
| **NNI** | National Nanotechnology Initiative |



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| Abbreviation | Explanation |
|---|---|
| **NNMI** | National Network for Manufacturing Innovation |
| **NNN** | National Nanomanufacturing Network |
| **NSF** | National Science Foundation |
| **NSIs** | Nanotechnology Signature Initiatives |
| **NSTI** | Nano Science and Technology Institute |
| **NTRC** | Nanotechnology Research Center |
| **NWs** | Nanowires |
| **NYSERDA** | New York State Energy Research Development Authority |
| **NYU-Poly** | Polytechnic Institute of New York University |
| **OECD** | Organization for Economic Cooperation and Development |
| **OGS** | Office of Grants Services |
| **OISE** | Office of International Science and Engineering |
| **ONAMI** | Oregon Nanoscience and Microtechnologies Institute |
| **ORNL** | Oak Ridge National Laboratory |
| **OSTP** | Office of Science and Technology Policy |
| **PON** | Program Opportunity Notice |
| **RC** | Research Coordinator |
| **RFP** | Request for Proposals |
| **RFQ** | Requests for Quotation or Qualifications |
| **RIF** | Rapid Innovation Fun |



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| Abbreviation | Explanation |
|---|---|
| **RTI** | Research Triangle Park |
| **RTNN** | North Carolina Research Triangle Nanotechnology Network |
| **R&D** | Research and Development |
| **R&I** | Research and Innovation |
| **SBIR** | Small Business Innovation Research |
| **SME** | Small and Medium-sized Enterprise |
| **SPRING** | Strategic Partnership for Research in Nanotechnology |
| **SRCco** | Semiconductor Research Cooperation |
| **STTR** | Small Business Technology Transfer |
| **SUNY** | State University of New York |
| **TIA** | Technology Investment Agreement |
| **UIUC** | University of Illinois at Urbana-Champaign |
| **US** | United States |
| **USDA** | United States Department of Agriculture |
| **UT** | University of Texas |



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# 1 Introduction

**Context**

This market guide, which has been developed in the context of the ENRICH in the USA network[17], aims to provide relevant information on the United States (US) landscape concerning the Nanotechnology innovation ecosystem and market. It provides information on the US Nanotechnology innovation ecosystem and market, including the leading regions from an innovation and market perspective; the key innovation hubs/facilitators; a sample of the main research networks/ professional organizations; as well as important funding programs and initiatives at both federal and state levels.

The market guide can be an effective source and tool to gain knowledge on the US related to Nanotechnology fields and:

- To identify the US leading regions from an innovation and market perspectives;
- To identify potential approaches for developing collaborative partnerships with US facilitators of innovation and/or businesses;
- To identify relevant US networks and conferences that can be used as a conduit to meet potential innovation and market partners; and
- To identify and assess the opportunity to access US funding programs related to Nanotechnology in order to propose potential partnerships with US organizations.

Therefore, it is the hope of the market guide authors that the information is useful in assisting EU research organizations and Small and Medium Enterprises (SMEs) in their efforts to develop stronger ties to the US Nanotechnology innovation ecosystem and market.

**Nanotechnology industry**

The European Commission (EC) describes Nanotechnology as a key enabling technology with a great potential for addressing societal challenges, such as energy supply and healthcare[18]. Moreover, the EC defines nanotechnologies as the "design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanometer scale"[19]. In parallel, the National Nanotechnology Initiative (NNI) from the US Government defines Nanotechnology as the science, engineering and technology conducted at the nanoscale – which is of around 1 to 100 nanometers. Thus, according to the NNI, nanoscience and Nanotechnology can be used across a large range of fields such as chemistry, biology, physics, materials science and engineering[20]. Within this context,

[17] https://enrichintheusa.com/useful-links-and-materials
[18] https://ec.europa.eu/jrc/en/research-topic/Nanotechnology
[19] NANOTECHNOLOGIES: Principles, Applications, Implications and Hands-on Activities, Directorate-General for Research and Innovation, Industrial technologies (NMP), 2013
[20] https://www.nano.gov/



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Nanotechnology applications are defined as the use and development of materials, devices and systems at the nanoscale[21].

Nanotechnology has had a significant impact on the global market and in the fields of science and engineering by changing the researchers' mindset and influencing future technologies and solutions[22]. Furthermore, Nanotechnology is considered a General-Purpose Technology (GPT) (i.e. similar to electricity and computing) that is used in all sectors – allowing it to have interdisciplinary uses[23]. Thus, Nanotechnology has a broad impact on nearly every sector of the economy[24]. The market for aerospace technology was estimated to be worth $1.20 trillion in 2021, and it is anticipated to grow at a compound annual growth rate (CAGR) of 15.89% to reach $29.16 trillion by 2027. Moreover, there has been a continuous investment in Nanotechnology, mostly from China and the US, which has translated into a larger number of manufactured nanomaterials integrated into final consumer products (e.g. clothing, cosmetics, food products,[25, 26]). This market trend is also reflected at the policy level between the EU and the US, which includes Nanotechnology as one of the main thematic collaboration priorities.

Considering the recent Nanotechnology developments, three areas stand out in terms of global market share by application or product, which account for more than 70%: electronics, energy and healthcare (biomedical). It is also relevant to highlight that the cosmetic industry is one of the most recent adopters of Nanotechnology, while the automotive sector has captured around 5% of the global market share[27, 28]. These developments allow the improvement of existing products from different industries as well as the development of new processes and innovative methods. In addition, NNI provides examples of growing applications of Nanotechnology and its benefits in several areas, highlighting electronics and IT, medical and healthcare, energy, environmental remediation and future transport[29].

As such, the Nanotechnology industry is highly complex, encompassing two segments: Nanotechnology components and applications. In terms of the Nanotechnology market by components, it is relevant to note that the highest market share is captured by the nanomaterials. On the other hand, nanotools account for the second highest share, while nanodevices have the lowest share of the Nanotechnology market[30]. This market guide will focus on different sector applications of

[21] The Maturing Nanotechnology Market: Products and Applications, Andrew McWilliams, 2016
[22] https://ec.europa.eu/health/scientific_committees/opinions_layman/en/nanotechnologies/l-3/1-introduction.htm#0p0
[23] https://econpapers.wiwi.kit.edu/downloads/KITe_WP_53.pdf
[24] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9865684/
[25] https://www.jainuniversity.ac.in/blogs/Nanotechnology-one-of-the-fastest-growing-markets-in-the-world
[26] Global Nanotechnology Market Analysis & Trends - Industry Forecast to 2025, Accuray Research LLP, 2016
[27] Gupta, Vaibhav, Sradhanjali Mohapatra, Harshita Mishra, Uzma Farooq, Keshav Kumar, Mohammad Javed Ansari, Mohammed F. Aldawsari, Ahmed S. Alalaiwe, Mohd Aamir Mirza, and Zeenat Iqbal. 2022. "Nanotechnology in Cosmetics and Cosmeceuticals—A Review of Latest Advancements" Gels 8, no. 3: 173.
[28] Global Nanotechnology Market 2018-2024: Technological Advancements in Nanotechnology & Increased Government Support and R&D Spending, RNCOS E-Services Private Limited, 2018
[29] https://www.nano.gov/sites/default/files/pub_resource/NNI-2021-Strategic-Plan.pdf
[30] Global Nanotechnology Market 2018-2024: Technological Advancements in Nanotechnology & Increased Government Support and R&D Spending, RNCOS E-Services Private Limited, 2018



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Nanotechnology, considering its three components. Within this context, and considering the several studies analyzed, the main Nanotechnology market applications can be categorized as the following[31] [32].

- **Nanotechnology for Healthcare:** the application of Nanotechnology in human healthcare (nanomedicine). Nanotechnology solutions provide new ways of improving medical diagnosis, drug delivery (pharmaceutical), therapy and regeneration[33, 34].
- **Nanotechnology for Electronics:** the use of Nanotechnology in electronic components (nanoelectronics), namely in computing[35]. In particular, semiconducting inorganic nanowires (NWs), carbon nanotubes, nanofibers, nanofibers, quantum dots, graphene and other materials have been extensively explored in the framework of nanoelectronics. Moreover, Nanotechnology is essential to the advancement of integrated electronics, namely by increasing computational power, reducing device scale, and limiting energy consumption[36].
- **Nanotechnology for Energy:** applications at several levels, including in the optimization of materials and components, and the development of sources of conversion, storage (batteries), transport and use of energy[37].
- **Nanotechnology for Transportation:** application at several areas of transportation, with a particular focus on the automotive sector: Fuel Cells, Power Systems, Heat Transfer, Lighting and Displays, among others[38].
- **Nanotechnology for Aerospace:** the application of Nanotechnology in the areas of space and defense, which held the majority share of the aerospace Nanotechnology market in 2021[39].

**Importance of Nanotechnology market to the EU and US**

Nanotechnology applications and investment has grown strongly in the past decades, being applied in several new products and materials. According to the Organization for Economic Cooperation and Development (OECD), the US is the country with the highest percentage of Nanotechnology R&D in the business enterprise sector between 2018 and 2021, followed by Russia and France[40]. Moreover, high investment funding has been applied to Nanotechnology over the last decade, with around $67.5 billion (€60 billion) being spent. In terms of the funding being applied to Nanotechnology in 2015, it is relevant to note that the EU leads at the global level, while the US is in the third position just behind

[31] https://www.nano.gov/about-Nanotechnology/applications-Nanotechnology
[32] Global Nanotechnology Market 2018-2024: Technological Advancements in Nanotechnology & Increased Government Support and R&D Spending, RNCOS E-Services Private Limited, 2018
[33]https://www.sciencedirect.com/science/article/pii/S2414644723000337
[34]https://www.forbes.com/sites/forbestechcouncil/2022/07/20/three-ways-Nanotechnology-is-changing-the-healthcare-industry/?sh=4bc6dbe75be8
[35] Global 2017 Market Report for Nanoelectronics (Nanotechnology in Electronics) - Research and Markets, Future Markets, Inc, 2017
[36] Nanotechnology for Consumer Electronics, Hannah M. Gramling, Michail E. Kiziroglou, Eric M. Yeatman, 2017
[37] Application of Nanotechnologies in the Energy Sector, Volume 9 of the series Aktionslinie Hessen-Nanotech of the Hessian Ministry of Economy, Transport, Urban and Regional Development, 2008
[38]https://www.businesswire.com/news/home/20110617005245/en/Research-Markets-Nanotechnology-Automotive-Transportation-Industry-Applications
[39] https://www.nano-di.com/aerospace-and-defense Nanotechnology
[40] http://www.oecd.org/sti/biotech/Nanotechnology-indicators.htm



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China. It is relevant to note that Nanotechnology funding, including Nanotechnology applications, is hidden within other programs most of the time, nano making it difficult to precisely estimate the total value invested in the industry.

At the EU level, the amount of funding has increased exponentially between 2016 and 2020, with countries such as Sweden, Germany and Belgium taking the lead in Nanotechnology national funding. Moreover, this investment is shifting from nanoscience to applications, leading to an increased impact of the technology at the market level[41]. In the US, the NNI has been providing large investments in Nanotechnology since 2001, having a cumulative total of $40 billion (€38.01 billion) since the inception of this initiative. Evidently, Nanotechnology has a big importance to both the EU and the US, being considered a priority for both the market and research sides[42].

[41] Nanotechnology Funding: A Global Perspective, Tim Harper, Científica Ltd, 2015
[42]https://www.nsf.gov/crssprgm/Nano//reports/NNI-at-20-years_JNR-2023-PREPRINT-(MC-Roco).pdf



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# 2 US innovation ecosystem

The US is the world leading country in terms of R&D investment, with a total spending on R&D in 2022 of $791.9 billion (around €744.83 billion), which represents 3.4% of its Gross Domestic Product (GDP)[43, 44, 45]. The R&D programs are mainly supported by Industry ($587.7 billion, nearly €553.44 billion), the Federal Government ($153.3 billion, nearly €144.36 billion), Academia ($24.1 billion, nearly €22.7 billion), Nonfederal Government ($5.9 billion, nearly €5.59 billion), and non-profits organizations ($21 billion, nearly €19.78 billion)[46]. Moreover, according to the latest data available, in 2021 the US R&D investment represented a third of the global R&D investment[47].

In the Fiscal Year of 2023, the Federal Budget for the NNI was $1.9 billion (€1.88 billion), targeting the support of innovation and promoting competitiveness, economic growth and national security. The budget allocated to the NNI is divided among several federal organizations. The following organizations have the largest investments from the NNI (95%): NSF (fundamental research and education across all disciplines of science and engineering); HHS/NIH (Nanotechnology-based biomedical research at the intersection of life and physical sciences); DOE (fundamental and applied research providing a basis for new and improved energy technologies); DOD (science and engineering research advancing defense and dual-use capabilities); and DOC/NIST (fundamental research and development of measurement and fabrication tools, analytical methodologies, metrology, and standards for Nanotechnology).

Nanotechnology plays an important role in several sectors of the economy, particularly in the "High Tech" or "Knowledge and Technology-Intensive" manufacturing industries[48]. These high-tech industries accounted for 15% of the manufacturing sector and added $511 billion (€460 billion) to the US GDP. Another important fact is that at the end of 2021, from a total of 23,750 published patent applications related to Nanotechnology that were filed with the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO), the US had the greatest share of the total patent applications for the two (46%)[49].

Innovation ecosystems are used to describe several actors and resources which are part of the innovation process[50]. This includes researchers, universities, venture capitalists, industry companies, SMEs, startups, accelerators, incubators and investors[51]. Considering the multiplicity of actors that the innovation ecosystem encompasses, this market guide focuses on the leading Nanotechnology

[43] https://www.statista.com/statistics/732247/worldwide-research-and-development-gross-expenditure-top-countries/
[44] https://fas.org/sgp/crs/misc/R44307.pdf
[45] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=US
[46] https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
[47] https://fas.org/sgp/crs/misc/R44283.pdf
[48] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017
[49] https://statNano.com/news/70323/Top-20-Countries-in-Holding-Nanotechnology-Patents-in-2021
[50] https://www.researchgate.net/publication/282122544_Innovation_Ecosystems_Implications_for_Innovation_Management
[51] https://www.idiainnovation.org/what-is-an innovation ecosystem #:~: text=An%20 innovation%20ecosystem % 20is %20 made, to %20transformative%20impact%20at%20scale.



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innovation hubs, facilitators of innovation and industry-related R&D centers to identify the US regions that contribute most to the Nanotechnology innovation process.

Thus, the analysis of the Nanotechnology innovation ecosystem should first describe the innovation hubs and facilitators, as well as the industry-related RDI centers that are most relevant for this area. This analysis allows the EU research and innovation community to identify key US Nanotechnology organizations that provide support to the advancement of Nanotechnology and its application in several sectors.

## 2.1. Innovation Hubs

Innovation hubs can be described as ecosystems that comprise several actors, including SMEs, large industries, startups, researchers, accelerators, and investors[52]. Thus, a successful innovation hub promotes R&D activities, facilitates the development of new technologies and incubates early-stage companies[53]. Moreover, innovation hubs promote cooperation within their ecosystem and act as a bridge between research activities and market needs.

The US is home to some of the world's most recognized innovation hubs. The San Francisco Bay Area is internationally recognized for its world class high-tech companies and numerous highly innovative startups. This innovation hub promotes world leading technological trends as well as important advances in technology[54]. In recent years, Boston and New York have also emerged as world leading innovation hubs due to their combination of funding with highly talented professionals, which can lead to important innovation breakthroughs[55, 56].

Nanotechnology hubs are one of the key drivers of science and engineering related to nano-applications within the US. Several companies and innovation facilitators focused on Nanotechnology applications for healthcare, electronics, energy, transportation and aerospace are establishing their activities in innovation hubs across the US. Therefore, the Nanotechnology innovation hubs support the exchange of knowledge, foster the development of new technologies, facilitate capital attraction and promote research-industry partnerships that can lead to breakthroughs in the area.

As the Nanotechnology industry is relatively new, companies are not tied to any region in specific. However, Nanotechnology workers are usually people with graduate degrees, which leads companies to locate themselves close to universities and research centers, where they can find highly educated workers and suitable infrastructure to develop their activities[57]. Taking this into account, the

[52] https://www.mckinsey.com/industries/public-sector/our-insights/building-innovation-ecosystems-accelerating-tech-hub-growth
[53] http://americanjobsproject.us/system/innovation-ecosystem/
[54] https://medium.com/@RussellMoopa/silicon-valley-innovation-hub-of-the-world-1925278c6289
[55] https://www.forbes.com/sites/noahkirsch/2016/10/18/why-boston-is-the-next-hub-for-innovation/#75ab33693d6a
[56] https://www.crowdspring.com/blog/startups-entrepreneurs-best-startup-cities-us/
[57] Working Texas Style, Chapter 12: Nanotechnology, 2013



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Nanotechnology innovation process is strongly dependent on market-research cooperation, with leading actors from several areas on both the research and the industry side.

The US major innovation hubs for Nanotechnology are primarily concentrated in California, Illinois, Massachusetts, New York, North Carolina and Texas[58, 59]. The identified hubs are focused on at least one of the five areas: Healthcare, Electronics & Computers, Energy, Transportation and Aerospace.

Figure 3 presents an overview of the US leading Innovation hubs in the Nanotechnology related fields.

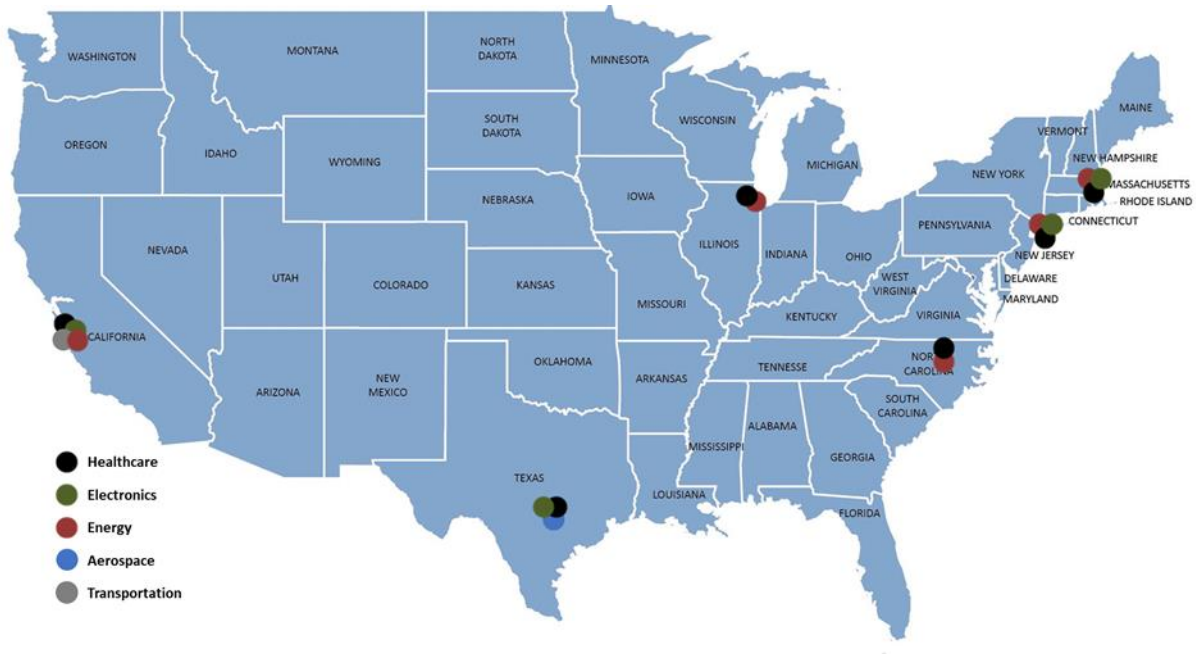


**Figure 3 - US Mapping of the leading Innovation Hubs focused on Nanotechnology-related products**

**New York City, New York**

**Applications:** Healthcare (biomedicine), Electronics & Computers (in particular, microelectronics and semiconductors), Energy

New York has been continuously investing to transform the region into a leading center of Nanotechnology R&D[60]. In particular, New York has been developing large-scale investments in

[58]https://www.greenbiz.com/article/five-cities-lead-country-Nanotech-development
[59] Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century (2013), Chapter: 7 The New York Nanotechnology Initiative, National Research Council, 2013

[60] **Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century, National Research Council, 2013**



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university research infrastructure and collaborative agreements with the private sector in Nanotechnology. One example is the $85 million (€76.5 million) investment to create the Center of Excellence in Nanoelectronics and Nanotechnology (CENN) in collaboration with IBM. It is also relevant to highlight the investment in the Tech Valley cluster on Nanotechnology, which is based near Albany[61]. New York State is among the leading states in Nanotechnology nationwide. Tech Valley is an internationally renowned hub of Nanotechnology R&D[62].

At the same time, New York has a very strong high-tech industry sector, with a large pool of important players from the industry side. Allied with this, New York features a strong base of academia-industry cooperation, with good access to funding for new projects and high education levels. Within this context, New York encompasses a large set of world-leading organizations that are committed to exploring new opportunities within the application of nanotechnologies[63]. Moreover, the effort developed by the State University of New York (SUNY) at Albany as one of New York's Innovation Hubs led it to become one of the most prominent centers of Nanotechnology research at the global and regional levels[64].

However, there is a concern at the policy level that New York is still behind in terms of attracting venture capital, compared with other states such as California. Thus, the New York State Innovation Venture Capital Fund was created to attract new and innovative startups to the region[65]. Furthermore, there are several Nanotechnology-related innovative companies based in the state of New York, which contribute strongly to the market development in the region[66, 67].

**San Jose, California**

**Applications:** Healthcare, Electronics & Computers, Energy, Transportation

The California ecosystem is composed of a set of different relevant research and commercial Nanotechnology institutions. For example, the University of California has several quality Nanotechnology research programs[68, 69]. At the policy level, California has been a national leader in developing policy frameworks for new technologies. Moreover, many companies opt for California when trying to find new opportunities within the technological and scientific areas. Thus, California is

[61] Advances in the Theory and Practice of Smart Specialization, 2017
[62] Empire State Development Corporation International Division
[63] https://www.azoNano.com/article.aspx?ArticleID=3120
[64] Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century, National Research Council, 2013
[65] Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century, National Research Council, 2013
[66] https://www.azoNano.com/article.aspx?ArticleID=3120
[67] New York's Nanotechnology Model: Building the Innovation Economy: Summary of a Symposium, National Research Council, 2013
[68]https://cnsi.ucla.edu/about-us/what-is-cnsi/
[69] https://californiaNanoeconomy.org/



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growing as an important player in Nanotechnology, not only at the US level but also worldwide[70, 71]. In California, Nanotechnology has a significant and important impact on the high-tech economy, with increasing emphasis on the commercialization of nano-related products and services[72]. Back in 2018, California housed around 22% of the total of US Nanotechnology companies, receiving a total of 23% of the US venture capital. This is mainly related to the high concentration of academia-, research- and innovation-related entities located in Silicon Valley, indicating strong ties between research and industry[73].

The California Innovation Hub is composed of a large set of companies which include some big players from different market sectors, namely the IBM facility in San Jose, Intel in Santa Clara and Folsom, and the Alto Research Center, a Xerox company, in Palo Alto[74].

**ENRICH in the USA Soft Landing Hubs: Initial contact points for California**

Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers of Universities dedicated to R&I in the Nanotechnology domain.

ENRICH in the USA has some Soft-Landing Hubs located near the California industry cluster. These soft-landing hubs help SMEs to venture into North America, through a low-cost strategy and temporary visas. All the tools are provided, to conduct proof of concept tests, to connect with new strategic partners and potential clients, to revamp your product development, research, and intellectual property strategy within the U.S. market. Soft-landing hubs also ease access to local funding opportunities and grants to support research and commercialization efforts. Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers of Universities dedicated to R&I in the Nanotechnology domain, namely: CalPoly University – CIE, Citris Foundry at UC Berkeley, Galvanize – San Francisco and Santa Clara University.

**CalPoly University – CIE**

Cal Poly is a highly rated public university located in San Luis Obispo, California. It is one of two polytechnical universities in California, with the other located in Pomona. It is a large institution with an enrollment of 19,685 undergraduate students.

Admission is competitive as the Cal Poly acceptance rate is 28%. The university has six colleges that offer 65 undergraduate degrees and 39 Master's degrees. Popular majors include Business,

[70] https://www.azoNano.com/article.aspx?ArticleID=3146
[71]https://edurank.org/engineering/Nanotechnology/california/
[72] California Council on Science and Technology, Nanotechnology in California, California Council on Science and Technology, 2010
[73]https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/SAS/CDPH%20Document%20Library/Nano%20in%20California%20slides_ada.pdf Nanotechnology
[74] https://www.azoNano.com/article.aspx?ArticleID=3146



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Mechanical Engineering, and Biology. Cal Poly was ranked 115 out of 650 in a list of the best colleges in America by Forbes in 2019.

The CIE HotHouse is a community space created through the efforts of Cal Poly, the city and county of San Luis Obispo, the business community, and the Cal Poly Center for Innovation and Entrepreneurship (CIE). It is an off-campus location that houses CIE programs. The goal of the HotHouse is to support students and community members as they work to create new innovations and start business ventures.

**Citris Foundry at UC Berkeley**

The University of California, Berkeley is a public land-grant research university in Berkeley, California. Established in 1868 as the University of California, it is the state's first land-grant university and the first campus of the University of California system. Its fourteen colleges and schools offer over 350 degree-programs and enroll some 31,000 undergraduate and 12,000 graduate students. Berkeley is ranked among the world's top universities by major educational publications.

When it comes to Research, from expeditions to Egypt in the late 1800s to stem cell research and artificial intelligence today, Berkeley has been at the forefront of research throughout its history. Here students can work side-by-side with Nobel Laureates, Fields medal winners, Fulbright Scholars, and MacArthur fellows.

Uniquely situated across multiple UC campuses, the CITRIS Foundry is ideally positioned to help new generations of innovators and entrepreneurs bridge the gap from lab to market and actualize rigorous, validated solutions to society's biggest challenges. The Foundry's Incubator offers guidance, education, and a home-base to de-risk entrepreneurship for early-stage founders, especially supporting those who have been historically marginalized, allowing innovators to confidently identify pathways to success and reach the next stage of development and investment for their emerging technology venture.

CITRIS FOUNDRY is part of CITRIS as one of its programs. Citris Banatao Institute departments focus on health research, energy, robots, policy lab, and enterprise innovation represented by Citris Foundry.

**Galvanize – San Francisco**

Galvanize helps to build and scale companies or projects with a custom co-working solution. Companies can get access to mentors, workshops, talent, and resources.

- Upskill & train teams: With custom curriculums, businesses can upskill their technical talent and accelerate business growth.



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- Hire bootcamp graduates: At no cost, Galvanize's partnerships team connects organizations with job-ready software engineering talent graduating from their coding bootcamps.
- Hire trained veterans: As a VA VET TEC Preferred Provider, Galvanize matches talented, job-ready Veterans to open roles.
- Access corporate resources: Galvanize has the resources to help companies upskill or reskill their organizations, find efficiencies, and onboard talents.

**Santa Clara University**

Santa Clara University (SCU) is partnering with tech companies to bring smart solutions to its campus. Thus, in 2017 USC have adopted smart parking technology (which includes sensors to keep track of open spaces in parking garages; up to the minute information about the status of parking spaces), but also a system that detects pedestrians crossing the streets and automatically activates warning lights.

Additionally, SCU has been working towards energy savings, to the extent that photovoltaics, solar thermal systems, and wind turbines have been gradually installed on the campus as part of the Green Power Program, a program that aims to prevent the emission of over 21,545 tons of carbon dioxide each year and at the same time provide smart energy solutions to the campus.

**Austin, Texas**

**Applications:** Healthcare, Electronics & Computers (semiconductors), Aerospace

The research and commercial environment of Nanotechnology in Texas is one of the most prominent at the US state level. Besides companies involved in Nanotechnology-related businesses, Texas has a large range of universities that offer well-respected Nanotechnology research programs and initiatives, as well as academic programs[75]. On the research and academia side, the Texas innovation hub is composed of more than 20 universities which include Nanotechnology in their research programs and four specific research centers[76]. Texas is positioned to become a key industrial player in the Nanotechnology field, namely through the establishment of several companies and a large network of research universities[77].

Due to the initial Nanotechnology infrastructural developments through science departments of universities, Nanotechnology companies, especially the smaller ones, tend to be located near the universities of Rice, UT-Austin, UT-Arlington and UT-Dallas. On the other hand, with the private investment being relatively diminished, federal and state funding becomes a critical source to support

[75] https://www.Nanowerk.com/news2/newsid=29029.php
[76] https://www.semiconductors.org/u-s-semiconductor-ecosystem-map/
[77] Working Texas Style, The Texas Workforce Commission, 2013



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the Texas Nanotechnology sector[78]. Moreover, Houston is home to one of the largest semiconductor and computer company hubs worldwide, which fits the Nanotechnology innovation sector applications[79].

**Boston, Massachusetts**

**Applications:** Healthcare, Electronics & Computers, Energy

Massachusetts is at the forefront of Nanotechnology research in the US, particularly in nanomanufacturing. Thus, several cooperative projects have been promoted between research institutions and industry organizations, generating technological advancements in bringing new commercial Nano-related products to the market. Massachusetts Institute of Technology (MIT) is one good example of an academic institution that has been providing new research and commercial opportunities in the Nanotechnology field. Moreover, MIT will construct a new facility named "MIT.Nano", which aims to be a hub of nanoscience and Nanotechnology RD&I[80].

At the state level, the Massachusetts Department of Environmental Protection (DEP) has been very active in ensuring the safe use of Nanotechnology, particularly towards clean air and water treatment, recycling waste, and management of toxic materials, among others[81]. Harvard University is one of the six NSF-designated Nanotechnology centers, leading to several technological breakthroughs and patents for Nanotechnology applications[82]. In addition, it is relevant to highlight the progress developed through the University of Massachusetts Amherst, which has been promoting Nanotechnology R&D in the region. The University of Massachusetts Amherst will open this year (2023) the Nanotechnology Center (MassNanoTech) in 2023, which will offer programs in the areas of Nanotechnology, nanoelectronics, components, nanocompostic materials, among others[83], [84].

[78] Working Texas Style, Chapter 12: Nanotechnology, 2013
[79] http://www.areadevelopment.com/HighTechNanoElectronics/oct08/Nano-tech-centers-clusters.shtml
[80] https://mitNano.mit.edu/
[81] https://www.azoNano.com/article.aspx?ArticleID=3133
[82] http://www.areadevelopment.com/HighTechNanoElectronics/oct08/Nano-tech-centers-clusters.shtml
[83]https://www.photonics.com/Articles/UMass_Amherst_to_Launch_Nanotechnology_Center/a18083
[84]https://www.umass.edu/massNanotech/



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**ENRICH in the USA Soft Landing Hubs: Initial contact points for Massachusetts**

Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers of Universities dedicated to R&I in the Nanotechnology domain.

ENRICH in the USA has a Soft-Landing Hub located near the Massachusetts industry clusters. These soft-landing hubs help SMEs to venture into North America, through a low-cost strategy and temporary visas. All the tools are provided, to conduct proof of concept tests, to connect with new strategic partners and potential clients, to revamp your product development, research, and intellectual property strategy within the U.S. market. Soft-landing hubs also ease access to local funding opportunities and grants to support research and commercialization efforts. Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers of Universities dedicated to R&I in the Nanotechnology domain, namely: Northeastern University and its Innovation Campus at Burlington, Massachusetts (ICBM).

**Northeastern University and its Innovation Campus at Burlington, Massachusetts (ICBM)**

Northeastern University's unique, customizable research-partnership model offers:

- Co-location of industry, government, and Northeastern research laboratories and access to university faculty and PhD students
- Joint project planning and management to speed progress toward goals
- Flexible IP policies that benefit all participants
- Customized training and educational programs to give teams a competitive edge
- Expertise in areas that include novel materials and devices; manufacturing; national security, cybersecurity, and intelligence; drug analysis and testing; structural testing of materials and designs; large-structure design and testing; and data analytics, systems modeling, and network science
- Rigorous, ITAR-compliant protocols and practices in a secure environment
- A venture creation center with a wet lab, recently tripled in square footage to accommodate 40 companies

**Chicago, Illinois**

**Applications:** Healthcare, Energy

Illinois is becoming one of the leading states in the US for Nanotechnology due to its composed infrastructure, diversity and the number of research institutions, human capital and a cluster for companies and start-ups. Currently, Illinois is looking to attract more private investment to the state, expanding its resources and available infrastructure for supporting Nanotechnology start-ups. Within this context, there has been an increase in research centers from Illinois on developing new Nanotechnology-related activities in the state. At the academic level, universities and research



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facilities are promoting the development of new Nanotechnology ideas and trying to enhance the involvement of students in Nanotechnology-related activities[85].

Illinois is well positioned to focus on four sectors with substantial growth potential: energy, clean water, personalized medicine, and advanced manufacturing.

**Raleigh, North Carolina**

**Applications:** Healthcare, Energy

North Carolina is becoming a leader in Nanotechnology at the state level. The constant public investment in the region is promoting the research and innovation development of the industry. Within this context, the North Carolina Department of Commerce developed a roadmap for investment in Nanotechnology in 2006. Thus, there are several universities, research facilities and industry players that compose the Nanotechnology innovation ecosystem in North Carolina.

Moreover, North Carolina has a strong focus on private investment in Nanotechnology, driven by the new innovations that come from the academia side and feed Nanotechnology companies[86]. Thus, North Carolina is looking to Nanotechnology as a way of obtaining and sustaining reputation in science and technology innovation[87]. With the North Carolina government support, the Research Triangle Park (RTI) was founded. It provides links to universities and business leaders not only within the state but also with other institutions at the international level[88]. RTI combines scientific and technical knowledge to develop new methods, technologies and programs that support different innovation fields, including Nanotechnology.

## 2.2. Innovation facilitators

Innovation is deeply responsible for the US economic growth[89]. The US entrepreneurial ecosystem is based on flexibility, diversity, creativity, and novelty, being supported by a set of public and private programs[90]. Innovation facilitators in the US support, promote and accelerate the innovation process. Within this context, organizations such as business accelerators, incubators, science parks and specialized consulting firms are considered innovation facilitators, playing an important role in the Nanotechnology innovation process.

[85] https://www.azoNano.com/article.aspx?ArticleID=3210
[86] https://www.azoNano.com/article.aspx?ArticleID=3173
[87] https://www.azoNano.com/article.aspx?ArticleID=3173#:~:text=Nanotechnology%20Companies,ground%20for%20new%20Nanotech%20companies.
[88] https://www.rti.org/about-us
[89] https://www.uschamberfoundation.org/enterprisingstates/assets/files/Executive-Summary-OL.pdf
[90] https://www.researchgate.net/publication/266392166_A_Review_of_the_Entrepreneurial_Ecosystem_and_the_Entrepreneurial_Society_in_the_United_States_An_Exploration_with_Global_Entrepreneurship_Monitor_Dataset



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Accelerators support early-stage innovative companies through programs that offer education, mentorship, access to capital and investment, office space and supply chain resources during a fixed period[91]. During the accelerating process, early-stage companies are often grouped with other early-stage financing organizations, such as incubators, angel investors and seed-stage venture capitalists to attract investment[92]. Incubators support early-stage innovative companies and often provide affordable working spaces, shared offices and services, management training, marketing support and access to finance. Overall, incubators support early-stage innovative companies reducing their costs and growing their businesses faster[93,94].

Science parks are areas, often created or supported by a college or university, where companies involved in scientific work and new technology are located[95]. Science parks are catalyzers for innovation and promote university-business collaborations, which are likely to lead to important advances in technology. In addition, science parks provide an ecosystem that supports early-stage businesses' incubation and acceleration[96].

Nanotechnology is a relatively new technology, which is applied in several sectors and aspects of the industrial ecosystem. Thus, Nanotechnology supported manufacturing is rapidly growing, becoming a key aspect in industrial innovation[97]. Moreover, considering the close connection of Nanotechnology with the development of new innovative products, science parks play an important role in the development and deployment of innovative Nanotechnology applications.

Specialized consulting firms can act as important facilitators of innovation. These firms provide services that help startups to promote the creation of strategic partnerships, to promote research and technology transfer, and to foster entrepreneurship. Moreover, specialized consulting firms play a crucial role in applying their entrepreneurial approach, business experience, and fundamental scientific knowledge to support technology advances that can benefit Nanotechnology-related start-ups.

Thus, based on desk research, this market guide identifies five leading facilitators of innovation in the Nanotechnology industry.

**NCNano – The Northern California Nanotechnology, California**

The Northern California Nanotechnology Initiative (NCNano) is an initiative focused on promoting the Nanotechnology economy of Northern California. California has always been on the forefront of

[91]https://smallbiztrends.com/2016/08/business-accelerator-differ-incubator.html
[92]https://hbr.org/2016/03/what-startup-accelerators-really-do
[93]https://www.entrepreneur.com/encyclopedia/business-incubator
[94]https://www.british-business-bank.co.uk/finance-hub/what-is-a-business-incubator/
[95]https://dictionary.cambridge.org/dictionary/english/science-park
[96]https://www.iasp.ws/our-industry/definitions
[97] Processes of Innovation in the Field of Nanotechnology, Anna Butzin, 2007



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cutting-edge technology, entrepreneurial initiatives, and hi-tech projects, which position the region as one of the leading Nanotechnology hubs at the global level. Thus, NCNano will promote greater access to large equipment, core facilities and research investment to facilitate the development of nanoscale biotechnology, molecular electronics, advanced materials, and manufacturing technologies.

http://www.ncNano.org/

**Magnify, the California NanoSystems Institute Incubator at UCLA, California**

Magnify is a business incubator and accelerator held within the California NanoSystems Institute at UCLA that supports the development of technology startups and new ideas through Nanotechnology applications. The incubator is at UCLA's Court of Sciences, promoting entrepreneurial activities in Los Angeles. Magnify includes a co-working laboratory and office space, allowing fast development of startups and facilitating their access to capital and new market opportunities.

https://magnify.cnsi.ucla.edu/

**NanoAccelerator (NCNA), North Carolina**

The NanoAccelerator (NCNA) is a center for startups that have innovative technology in Nanotechnology. Thus, NCNA aims to promote business and commercial development for startup companies. The accelerator is technology-focused, putting a big emphasis on the commercialization aspect of the solutions presented. It provides technical support and different resources such as financial advice, lab space, equipment, etc.

http://www.quartekcorp.com/NanoAccelerator.html

**iCLEAN Incubator at SUNY Polytechnic Institute, New York**

The Incubators for Collaborating & Leveraging Energy and Nanotechnology (iCLEAN) is an initiative funded in part by the New York State Energy Research Development Authority (NYSERDA). The incubator is established at the Energy and Environmental Technology Applications Center (E2TAC) at the College of Nanoscale Science and Engineering (CNSE). The main aim of the incubator is to promote the emergence of new technologies and to create positive energy innovations and solutions that can be replicated on a global scale.

https://sunypoly.edu/

**Ohio Third Frontier, Ohio**

The Ohio Third Frontier is an initiative promoted by several members within the Ohio Development Services Agency, the Governor's advisor, and the Ohio Board of Regents, among others. It provides



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funding to technology-based universities, non-profit organizations and companies within Ohio that promote innovation. Thus, the Ohio Third Frontier promotes the acceleration of different startups and early-stage technology companies. Moreover, its portfolio includes high-potential companies from the Nanotechnology field.

https://weare.techohio.ohio.gov/

**In-Q-Tel (IQT), Washington DC**

IQT is a nonprofit investor that focuses on the acceleration and support of cutting-edge technologies to the US Government, supporting start-ups, new ventures and businesses. Within the large range of services provided, IQT supports new ventures in developing strategic needs assessments, solutions and market surveys, due diligence, solution transfers and strategic investments. Thus, IQT provides a large portfolio of investment actions, which includes support on Nanotechnology-related entities and innovations[98].

https://www.iqt.org/

## 2.3. Industry related RDI centers

Cooperation between industry, researchers and innovation facilitators is key in promoting the development of new Nanotechnology applications and solutions. As previously mentioned, Nanotechnology solutions can be applied in many areas of the innovation ecosystem. Thus, several industry-related centers have emerged in the US to promote new entrepreneurial ventures and solutions within the context of Nanotechnology.

Most Nanotechnology R&D solutions are developed through the cooperation between industries and universities or research centers. There is often geographical proximity between universities, research centers and companies that pursue related R&D and innovation actions[99]. Most SMEs and large companies of the Nanotechnology industry, which depend on the knowledge and research from research organizations, are often included as members or partners of industry-related R&D centers. Some Nanotechnology-related RDI centers are highlighted in Table 2. These centers have been selected through desk research. Even though some of the identified centers are not located in the aforementioned innovation hubs (e.g. Industry/University Cooperative Research Center for Advanced Knowledge Enablement), they are still important contributors to the Nanotechnology innovation ecosystem.

[98] https://www.iqt.org/
[99] Working Texas Style, Chapter 12: Nanotechnology, 2013



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**Table 2 – A sample of Industry connected RDI Centers in the Nanotechnology related fields**

| Industry Connected RDI Center | Examples of Academic Partners/Members | Examples of Industry Partners/Members | Location | Fields | Internet link |
|---|---|---|---|---|---|
| TechLink center at Montana State University's Office of Research and Economic Development | Montana State University's Office of Research and Economic Development | The American Precision Optics Manufacturers Association (APOMA)[100] | Bozeman, Montana | Electronics | https://techlinkcenter.org/ |
| NanoHub.org at Purdue University | Purdue University | General Electric (US)[101]<br>Gordon and Betty Moore Foundation (US)[132]<br>Rock Health (US) [132]<br>Salesforce (UK) [132]<br>Samsung Strategy and Innovation Center (US) [132]<br>Vital Connect (US) [132]<br>Voalte (US) [132] | San Francisco, California | Electronics, Energy | https://Nanohub.org/ |
| Center for Innovative Instrumentation Technology (CiiT) at University of Illinois | University of Illinois at Urbana-Champaign | | Urbana, Illinois | Electronics (microelectronic sensors) | https://research.illinois.edu/researchunit/center-innovative-instrumentation-technology#:~:text=Urbana%2C%20Illinois%2C%2061801-,Overview,Safety%20S |

[100] http://www.apoma.org/
[101] http://centerfordigitalhealthinnovation.org/about-us/



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| Industry Connected RDI Center | Examples of Academic Partners/Members | Examples of Industry Partners/Members | Location | Fields | Internet link |
|---|---|---|---|---|---|
| | | | | | ensors%2C%20and%20Mobile%20Systems. |
| NanoMFG at the University of Illinois at Urbana-Champaign (UIUC) | University of Illinois at Urbana-Champaign (UIUC)<br>University of California at Berkeley | | Champaign, Illinois | Healthcare, Electronics, | http://Nano.illinois.edu/ |
| Center for Advanced Research in Drying (CARD) at University of Illinois and Worcester Polytechnic Institute | University of Illinois at Urbana-Champaign<br>Worcester Polytechnic Institute | Hershey's<br>PEPSICO<br>Mondelez<br>Flint Hills resources<br>Ingredion<br>Kimberly-Clark | Worcester, Massachusetts<br>Champaign, Illinois | Energy, Transportation | http://www.dryingresearch.org/ |
| Advanced Electronics through Machine Learning (CAEML) at University of Illinois | University of Illinois at Urbana-Champaign<br>Georgia Tech<br>NC State University | Samsung<br>Intel<br>IBM<br>Hewlett Packard<br>Nvidia<br>Lockheed Martin<br>Global Foundries | Urbana, Illinois | Electronics | https://publish.illinois.edu/advancedelectronics/ |



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| Industry Connected RDI Center | Examples of Academic Partners/Members | Examples of Industry Partners/Members | Location | Fields | Internet link |
|---|---|---|---|---|---|
| | | CISCO<br>Analog Devices<br>Cadence<br>Qualcomm<br>Sandia National Laboratories<br>Synopsys<br>XILINX | | | |
| Center for Advanced Design and Manufacturing of Integrated Microfluidics (CADMIM) at University of California, Irvine | University of California, Irvine<br>University of Illinois at Chicago<br>University of Cincinnati | ALine, Inc.<br>Beckman Coulter<br>DuPont Pioneer<br>ESI Group<br>Genentech<br>Genomics Institute of the Novartis Research Foundation<br>GlaxoSmithKline<br>KWS SAAT SE<br>Los Alamos National Lab<br>VTT Technical Research Center of Finland, Ltd. | University of California, Irvine<br>University of Illinois Chicago | Health | http://www.inrf.uci.edu/cadmim/ |



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| Industry Connected RDI Center | Examples of Academic Partners/Members | Examples of Industry Partners/Members | Location | Fields | Internet link |
|---|---|---|---|---|---|
| Center for Energy-Smart Electronic Systems (ES2) at Binghamton University | Binghamton University: The State University of New York<br>The Georgia Institute of Technology<br>University of Texas at Arlington<br>Villanova University | Bloomberg<br>CDAC<br>Comcast<br>Commscope<br>Corning, Inc.<br>Engineered Fluids<br>Evolve Incorporated<br>Facebook<br>Future Facilities<br>Huawei<br>Innovative Technomics<br>LiquidCool Solutions<br>Logicare<br>Mestex<br>NYSERDA<br>Panduit<br>QuantaCool<br>Verizon<br>Vertiv<br>Xilinx | Binghamton University: The State University of New York<br>The Georgia Institute of Technology<br>University of Texas at Arlington<br>Villanova University | Electronics, Energy | https://www.binghamton.edu/es2/ |
| Cooling Technologies Research Center (CTRC) at Purdue University | Purdue University | Apple<br>Ford<br>Intel<br>Du Pont<br>Qualcomm<br>Toyota<br>Delphi | Purdue University | Electronics, Energy | https://engineering.purdue.edu/CTRC/ |



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| Industry Connected RDI Center | Examples of Academic Partners/Members | Examples of Industry Partners/Members | Location | Fields | Internet link |
|---|---|---|---|---|---|
| | | LG<br>Nokia<br>Sony<br>Samsung<br>Philips<br>Boeing | | | |
| Oregon Nanoscience and Microtechnologies Institute (ONAMI) | Oregon Research Universities | ZAPS Technologies<br>NANO3D Systems<br>Northwest UAV<br>Pacific Light Technologies<br>Shoei Electronic Materials<br>AbSci<br>Cascade Prodrug<br>DesignMedix<br>Dune Sciences<br>Floragenex | Corvallis, Oregon | Healthcare, Energy | http://onami.us/ |
| MATTCENTER | University of Massachusetts | | Boston, Massachusetts | Healthcare, Energy, Electronics | http://www.mttc.org/ |



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# 3 US market landscape

In the US, Nanotechnology has significantly impacted the country's economy. The US is the world's leading country in terms of Nanotechnology-related firms, with a considerable number of firms in the area when compared with other countries[102]. In 2014, the US invested around $6 billion (€5.4 billion) in Nanotechnology from governments, corporations and private investors, corresponding to 33% of the total amount at the global level. Moreover, the revenue from nano-related products has increased 90% from 2012 to 2014, which shows the great potential of this technology from the business side[103].

The NNI and the Office of Science and Technology Policy (OSTP) have been collaborating in the Nanotechnology field to promote significant advancements at the national level. Thus, a set of Nanotechnology Signature Initiatives (NSIs) have been agreed upon, which identify focus areas of national importance and support enhanced coordination and cooperation among actors[104]. These NSIs allow the acceleration of nanoscale science and technology from the research and the market point of view. Therefore, the number of manufactured products through the application of Nanotechnology has been increasing over the years[105].

Due to the US market size and complexity of the Nanotechnology industry, namely because of the several applications in a diverse number of sectors and areas, this market guide identifies the leading US regions for the areas based on the geographical concentration of manufacturers involved within the identified Nanotechnology applications, as well as the key considerations to be taken into account by EU businesses interested in accessing the US Nanotechnology market.

## 3.1. Market overview

The US has the world-leading Nanotechnology market, having the highest investment funding in Nanotechnology over the last decade[106]. According to some studies, revenue from nano-enabled products has been exponentially growing at the world level – from $339 billion (€305 billion) in 2010 to more than $1 trillion (€900 billion) in 2013. There are now more than 60 countries worldwide that have launched national Nanotechnology programs and initiatives, with governments and industry players investing millions in research and innovation[107]. The US has witnessed a revenue of $318 billion (€286 billion) alone in 2013[108]. Furthermore, the US dominates the world's Nanotechnology industry in terms of research and product development[109].

[102] OECD, Key Nanotechnology Indicators, http://oe.cd/kni, May 2017
[103] Nanotechnology Update: U.S. Leads in Government Spending Amidst Increased Spending Across Asia, LuxResearch, 2015
[104]https://www.energy.gov/eere/amo/articles/national-Nanotechnology-initiatives-signature-initiative-sustainable
[105] El-Kady, M.M.; Ansari, I.; Arora, C.; Rai, N.; Soni, S.; Verma, D.K.; Singh, P.; Mahmoud, A.E.D. Nanomaterials: A Comprehensive Review of Applications, Toxicity, Impact, and Fate to Environment. J. Mol. Liq. 2023
[106] http://www.oecd.org/sti/biotech/Nanotechnology-indicators.htm
[107] https://www.materialstoday.com/Nanomaterials/comment/the-Nanotechnology-race-between-china-and-usa/
[108] https://www.nsf.gov/news/news_summ.jsp?cntn_id=130586
[109] Working Texas Style, Chapter 12: Nanotechnology



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The US Nanotechnology market can be divided into several stages that compose the value chain. This market guide will focus on Nanotechnology components and applications. The components related to nanomaterials are produced at nanoscale, while the Nanotechnology applications refer to products that incorporate nanoscale materials or have nanostructured features. This includes final products and subassemblies included in end-use products. Moreover, an intermediary level exists between the stages of production and application, which are the nanoscale intermediaries, which incorporate nanoscale materials or have nanostructured features[110]. Considering this, the main key segments identified within the Nanotechnology industry are considered from the application perspective. The application of Nanotechnology in the US market is mostly dominated by healthcare (nanomedicine), electronics & computers, energy, transportation (automotive) and aerospace sectors.

In the healthcare sector application (nanomedicine), the global market accounted for a total of almost $224 billion (€212.52 billion) in 2022 and it is expected to grow exponentially until 2030. Nanomedicine is used in the diagnosis, treatment, monitoring, and control of biological systems. Additionally, the market is driven by new technologies for drug delivery, the increasing popularity of nanomedicine, more funding and support at the governmental level and cost-effective therapies. Therapeutics accounted for the highest share in revenue in 2016 by products[111, 112].

In terms of electronics & computers, it is important to highlight that Nanotechnology can be incorporated into a large range of products, namely display screens, computers, memory storage and optoelectronic devices, among others[113]. In the US, the nanoelectronics market has shown a trending growth at the industry level[114].

Nanotechnology applications in energy can potentially improve energy efficiency and renewable energy production in different industries and branches. Nanotechnology is applied to five areas of the energy value chain: energy sources, energy conversion, energy distribution, energy storage (including batteries), and energy usage[115]. In terms of market volume from Nanotechnology-based products, it is estimated that the market segment with the highest CAGR at the global level between 2009 and 2014 was the micro-energy harvesting for energy autarkic sensors and switches (e.g. electromagnetic induction, thermoelectric, photovoltaics, piezoelectric) and nano-optimized batteries[116].

Regarding Nanotechnology applications in transportation (automotive), there has been a high demand from automotive manufacturers to use new technologies that are able to offer higher cost-

[110] Jeevanandam J, Barhoum A, Chan YS, Dufresne A, Danquah MK. Review on Nanoparticles and Nanostructured materials: history, sources, toxicity and regulations. Beilstein J Nanotechnol. 2018
[111] Healthcare Nanotechnology (Nanomedicine) Market: Information by Application (Drug Delivery, Biomaterials, Active Implants), Disease (Cadiovascular Diseases, Oncological Diseases) ans Region - Forecast Till 2031, Straits Research, 2023 Nano
[112] Nanomedicine Market Analysis By Products, (Therapeutics, Regenerative Medicine, Diagnostics), By Application, (Clinical Oncology, Infectious diseases), By Nanomolecule (Gold, Silver, Iron Oxide, Alumina), & Segment Forecasts, 2018 – 2025, 2017
[113]https://www.Nanobay.com/news/blog/172-tips-and-tricks/9299-how-Nanotechnology-is-going-to-shape-the-electronics-industry
[114]https://www.sharewise.com/us/news_articles/United_States_Nanoelectronics_Market_Analysis_Report_20172022__antynaraw_20180201_0936
[115] https://www.nanowerk.com/Nanotechnology-in-energy.php
[116] Nanotechnology in the sectors of solar energy and energy storage, IEC Project Team, 2014



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effectiveness vehicle performance. Thus, Nanotechnology is highly relevant in the Nanotechnology automotive sector, namely in the next-generation battery market and in tire production and paintings and coatings[117, 118]. It is estimated that the revenues from Nanotechnology in the automotive market have reached around $6 billion (€5.4 billion) in 2015[119]. Moreover, companies such as Toyota, General Motors, Ford, and Rolls Royce are taking a lead in developing innovation in these areas[120].

Regarding the aerospace sector, the application of Nanotechnology solutions represents a big opportunity for one of the most important heavy industries at the global level[121]. This industry application allows for lighter construction materials and more efficient engines[122]. Moreover, the global CAGR of aerospace Nanotechnology is expected to grow 5.75% from 2017 to 2021[123].

## 3.2. Leading regions

Considering the size of the US Nanotechnology industry, there are states that can be considered leading regions from a market perspective. As previously stated, Nanotechnology applications comprise several areas and sectors, and specifically different products and services. Consequently, to analyze the leading US market regions, it is necessary to describe the main target groups for each Nanotechnology application. Within this context, the following target groups are analyzed: pharmaceutical and medicine, electronics and computers, batteries, paints and coatings, and aerospace.

Thus, the geographical concentration of the different businesses was identified based on North American Industrial Classification Codes (NAICs) codes. NAICs codes are standardized and used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the US economy[124]. The NAICs codes group businesses into industries based on the similarity of their production processes, covering all economic activities. Thus, it facilitates the collection, tabulation, presentation, and analysis of data related to businesses[125]. Considering the US Nanotechnology market, this market guide used five different NAICs codes: NAICS 32541 (Pharmaceutical and Medicine Manufacturing), NAICS 334111 (Electronic Computer Manufacturing), NAICS 335911 (Storage Battery Manufacturing), NAICS 325510 (Paint and Coating Manufacturing) and NAICS 336412/3 (Aerospace Product and Parts Manufacturing).

[117] https://www.businesswire.com/news/home/20110617005245/en/Research-Markets-Nanotechnology-Automotive-Transportation-Industry-Applications
[118] Nanotechnology and Tyres – Greening Industry and Transport, OECD Publishing, 2014
[119] http://what-when-how.com/Nanoscience-and-Nanotechnology/Nanotechnology-and-automotive-parts-current-status-and-future-prospects/
[120] https://www.businesswire.com/news/home/20110617005245/en/Research-Markets-Nanotechnology-Automotive-Transportation-Industry-Applications
[121] https://Nanocongress.Nanotechconferences.org/events-list/Nanotechnology-in-aerospace
[122] https://www.azoNano.com/article.aspx?ArticleID=3103
[123] Global Aerospace Nanotechnology Market 2017-2021, Technavio, 2017
[124] https://www.census.gov/naics/#:~:text=Introduction%20to%20NAICS,to%20the%20U.S.%20business%20economy.
[125] 2017 North American Industrial Classification Codes Manual, Executive Office of the President, 2017



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In this context, manufacturers and suppliers from the identified sectors were considered the main target markets for businesses commercializing nano-enabled products. Thus, the regions with a higher concentration of equipment manufacturing and suppliers for each segment seem to represent important market opportunities for businesses providing nano-enabled products. Among those regions, there are four states which particularly stand out: California, Florida, Texas, and New York.

Although there are other sectors that may also represent important opportunities for the EU businesses related to nanotechnologies, the scope of this report is based on demonstrating the various avenues that EU businesses can take to approach the US market.

**Pharmaceutical and medicine manufacturing**

Nanotechnology applications in healthcare allow the development of new equipment and medical solutions. As previously described, solutions concerning therapeutics accounted for the highest share of revenue in the sector for 2016. Within this context and considering the influence of nanotechnologies in medical treatments and therapeutics, it is relevant to analyze the pharmaceutical and medicine manufacturing segment[126, 127]. Thus, from a market perspective, the US states and cities with the highest geographical concentrations of pharmaceutical and medicine manufacturers may represent the areas with more Nanotechnology applications for pharmaceutical and medicine manufacturing opportunities across the country.

This market guide provides an overview of the US states and cities that have a higher geographical concentration of pharmaceutical and medicine manufacturing, as well as the states and cities that have manufacturers which individually invest an average of $10,000 (€9,000) or more in technology annually. In the US, there are 3,630 pharmaceutical and medicine manufacturers. Figure 4 highlights the areas with higher concentrations of pharmaceutical and medicine manufacturers.

[126] Nanomedicine Market by Modality - Global Opportunity Analysis and Industry Forecast, 2017-2023, Allied Analytics LLP, 2017
[127] Nanomedicine Market Analysis By Products, (Therapeutics, Regenerative Medicine, Diagnostics), By Application, (Clinical Oncology, Infectious diseases), By Nanomolecule (Gold, Silver, Iron Oxide, Alumina), & Segment Forecasts, 2018 – 2025, 2017



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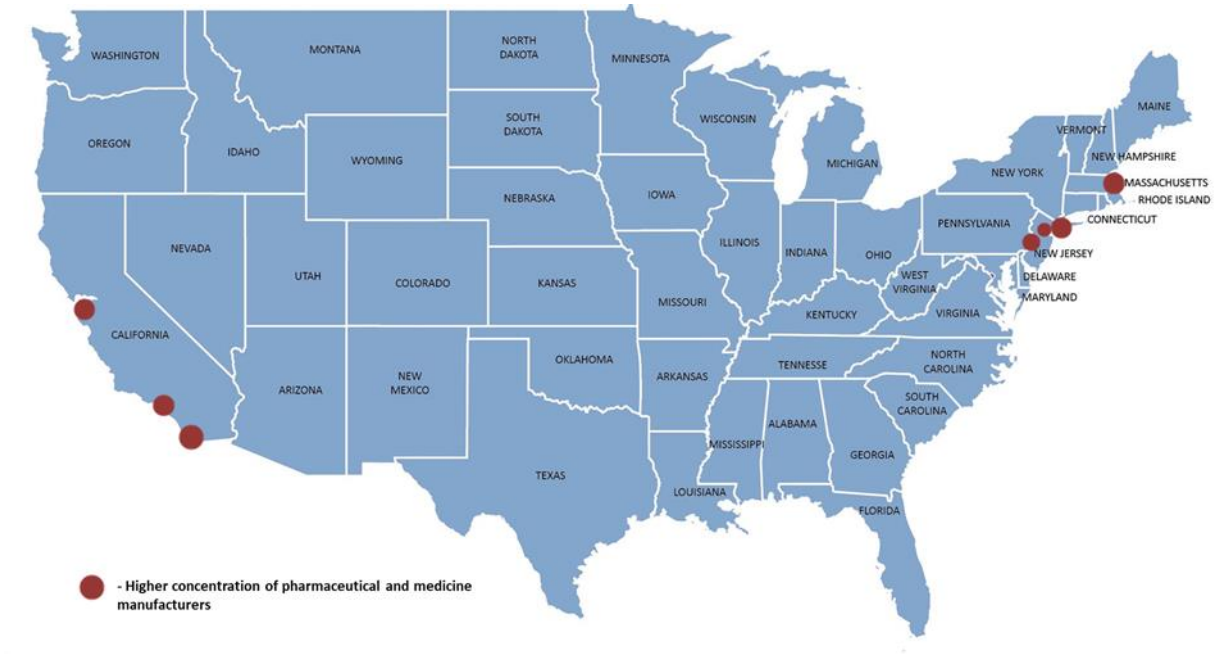


**Figure 4 - Location of the US areas with higher concentration of pharmaceutical and medicine manufacturers**

Figure 4 shows the US states and cities with the highest concentrations of pharmaceutical and medicine manufacturers. California and New Jersey are the states with the highest geographical concentration of pharmaceutical and medicine manufacturers, with the city of San Diego being the city with the highest concentration of manufacturers at the national level. Moreover, it is relevant to note that both California and Massachusetts have two cities each in the top five cities with the highest concentration of manufacturers at the national level – San Diego, San Francisco, Cambridge, and Waltham respectively. Therefore, the states of California and Massachusetts represent important markets for pharmaceutical and medicine manufacturers. In addition, it is relevant to highlight the City of New York, as it is one of the cities with the highest concentration at the national level. In this case, the City of New York might have a high concentration of pharmaceutical and medicine manufacturers due to the fact that it is the area where those companies have their headquarters, e.g. organizations such as Pfizer and Bayer have offices in New York to deal with R&D and administrative aspects.



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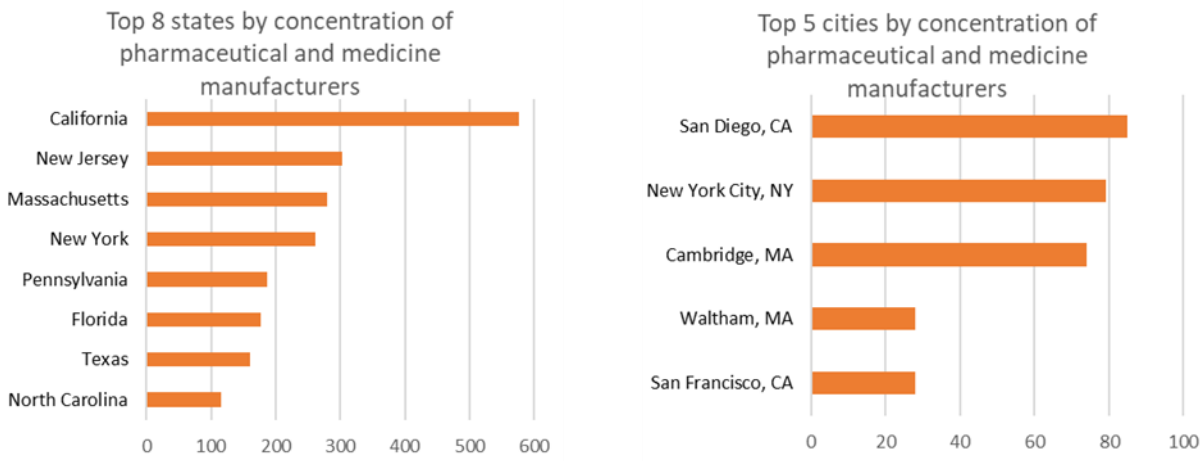


**Figure 5 - US states and cities with the highest concentration of pharmaceutical and medicine manufacturers**

Figure 6 shows the US states and cities with the highest concentration of pharmaceutical and medicine manufacturers that spend on average per manufacturer over $10,000 (€9,000) in technology per year. Around one third (33%) of the pharmaceutical and medicine manufacturers spend annually on average between $10,000 (€9,000) and $50,000 (€45,000) on technology. Also, around one third (36%) of pharmaceutical and medicine manufacturers spend over $50,000 per year on technology.

At the national level, the State of California has the highest technology expenditure of pharmaceutical and medicine manufacturers. Thus, the city of San Diego is also the US city with the highest technology expenditure. Moreover, it is relevant to highlight that New Jersey is the second state with the highest technology expenditure in the sector; although it does not have any city represented among the top five cities within the technology expenditure value category.

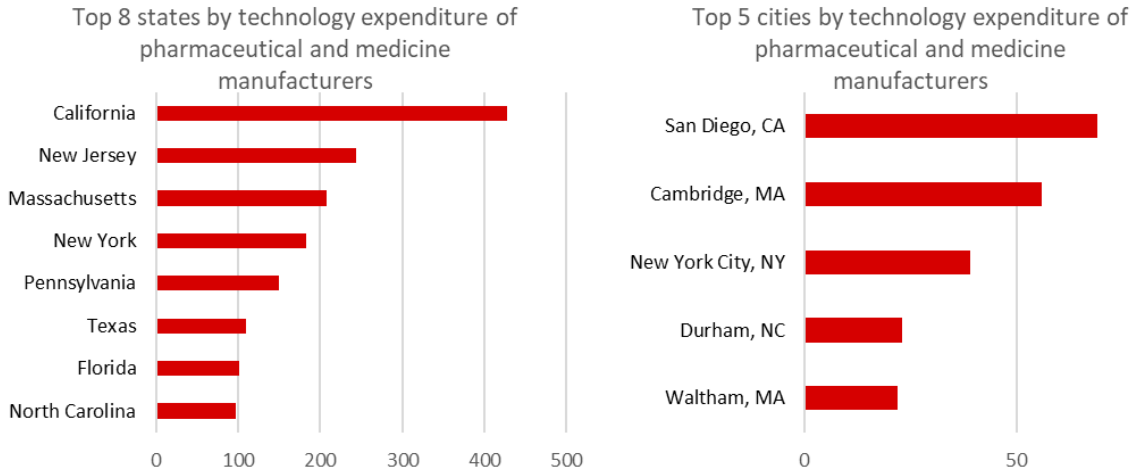




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**Figure 6 - US states and cities with the highest concentration of pharmaceutical and medicine manufacturers that spend annually on average over $10,000 in technology**

**Nanotechnology for electronics & computer products**

Nanotechnology applied to electronics and computer products is very much related to electronic computer manufacturing. Therefore, electronics and computer equipment manufacturers correspond to key markets where Nanotechnology is applied, and innovative products are developed.

This market guide provides an overview of the US states and cities that have a higher geographical concentration of electronic computer manufacturing, as well as the states and cities that have manufacturers, which individually invest an average of $10,000 (€9,000) or more in technology annually. In the US, there are 1,912 electronic and computer manufacturers (primary and secondary manufacturers). This includes primary and secondary manufacturers, which means that there might be companies that may not have computer manufacturing as a focus but are related to the area (secondary manufacturers). Figure 7 highlights the areas with higher concentrations of electronic computer manufacturing.

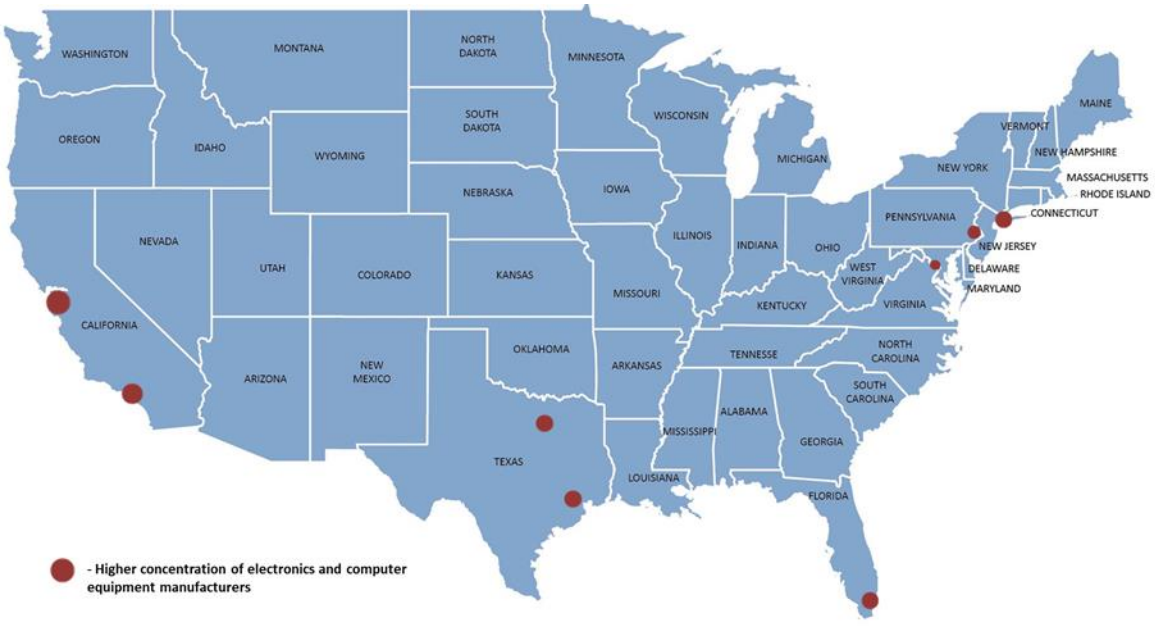


**Figure 7 - Location of the US areas with higher concentration of electronics and computer equipment manufacturers**

Figure 8 indicates US states and cities with the highest concentration of electronics and computer equipment manufacturers. US electronics and computer equipment manufacturers are primarily located in the high-population regions of the country and, therefore, concentrated in the states of



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California, Florida, New York, and Texas. This indicates that these four states are important areas for finding market opportunities related to Nanotechnology for electronics and computers.

California is the state with the highest concentration of electronics and computer equipment manufacturers, with two cities (Fremont and San Jose) occupying the top two positions. On the contrary, it is relevant to note that although Phoenix is ranked among the top 10 cities in terms of geographical concentration, its state (Arizona) is not among the US states with the highest concentrations of electronics and computer equipment manufacturers.

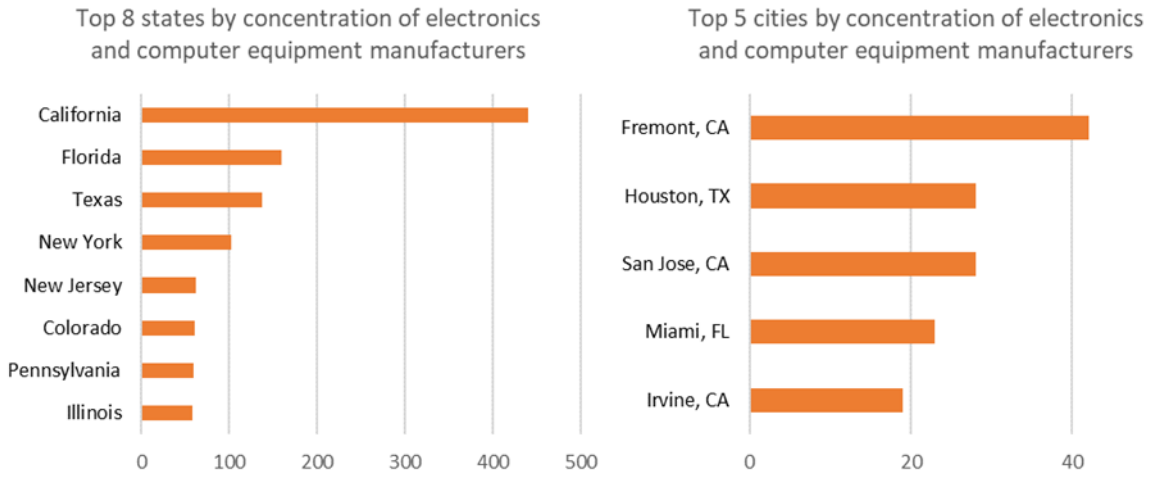


**Figure 8 - US states and cities with the highest concentration of electronics and computer equipment manufacturers**

The technology expenditure of electronics and computer equipment manufacturers is a key indicator in terms of measuring the advancements in new solutions that perceive the utilization of Nanotechnology. Thus, it allows us to measure the predisposition of the market to invest in nano-enabled electronic products, such as computers. From a market perspective, the states and cities with the highest concentration of electronics and computer equipment manufacturers that spend on average per manufacturer over $10,000 (€9,000) in technology per year represent important areas in terms of business opportunities.

Within this context, Figure 9 shows the US states and cities with the highest concentration of electronic and computer equipment manufacturers that spend on average over $10,000 (€9,000) in technology per year. Around one-third (34%) of electronic and computer equipment manufacturers spend annually on average between $10,000 (€9,000) and $50,000 (€45,000) on technology. On the other hand, around one quarter (22%) of electronic and computer equipment spend over $50,000 per year on technology. From these, 93 of the electronic and computer equipment manufacturers that spend



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over $50,000 on technology per year are in California, while 35 are in Texas. The other 287 are across the country.

California is the state with the highest technology expenditure of electronic and computer equipment manufacturers. Moreover, three cities located in California (Fremont, San Jose, and Irvine) are the top three cities with the highest technology expenditures. On the other hand, although the state of Arizona is not among the top eight states, Phoenix is among the top 10 cities with the highest technology expenditure of electronic and computer equipment manufacturers.

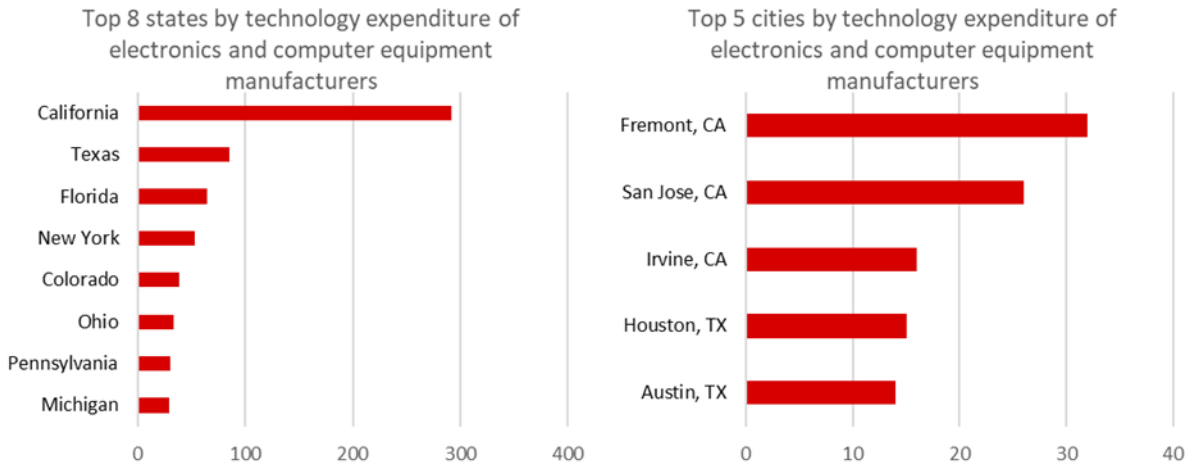


**Figure 9 - US states and cities with the highest concentration of electronics and computer equipment manufacturers that spend annually on average over $10,000 in technology**

**Nanotechnology for energy products (batteries)**

Nanotechnology applications for batteries allow new energy efficiency and renewable energy solutions in different industries and branches. Among the distinct set of solutions, the application of Nanotechnology in energy storage systems, namely for storage batteries, has been one of the main focuses., From a market perspective, the US states and cities with the highest geographical concentrations of storage batteries' manufacturers may represent the areas with more Nanotechnology applications for energy-related market opportunities across the country.

Within this context, this document provides an overview of the US states and cities that have a higher geographical concentration of storage batteries manufacturing, as well as the states and cities that have manufacturers, which individually invest an average of $10,000 (€9,000) or more in technology annually. In the US, there are 727 storage battery manufacturers. Figure 10 highlights the areas with higher concentrations of storage battery manufacturers.



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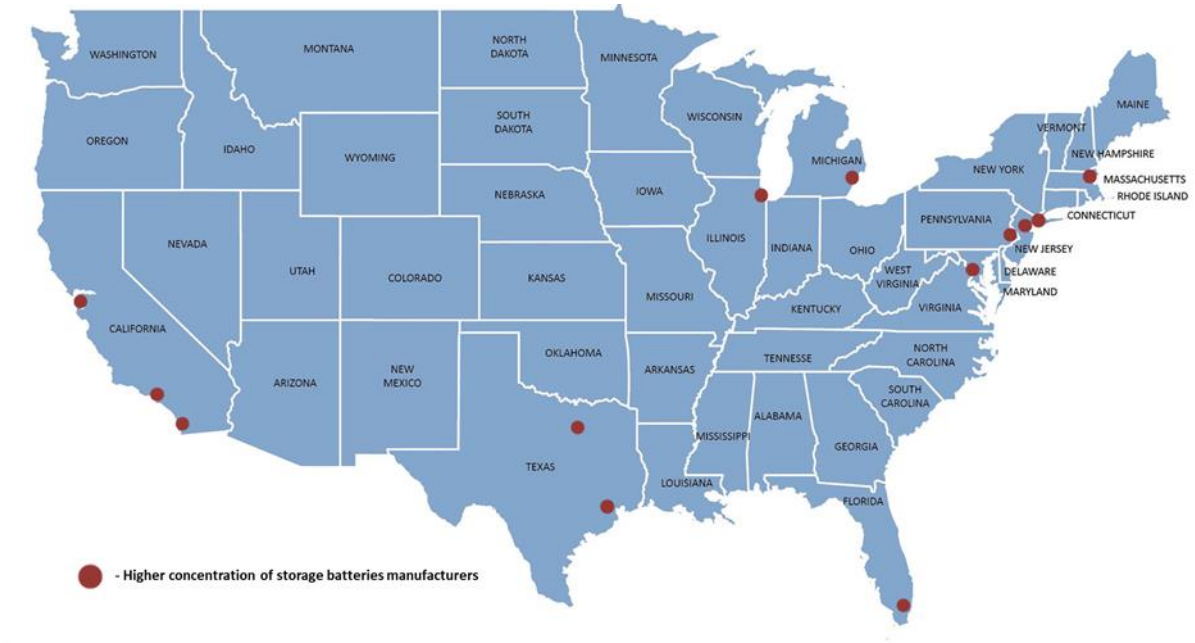


**Figure 10 - Location of the US areas with higher of concentration of storage batteries manufacturers**

Figure 11 indicates US states and cities with the highest concentrations of storage battery manufacturers. Illinois and Texas are the states with the highest geographical concentration of storage battery providers, with the cities of Chicago and Houston being the top two cities in terms of concentration of storage battery manufacturers. Therefore, the states of Illinois and Texas represent an important market for storage battery manufacturers. Moreover, it is relevant to highlight the city of Milwaukee, which has one of the highest concentrations of storage battery manufacturers, showing its importance to the market. However, Wisconsin is not ranked within the top ten states in terms of geographical concentration.



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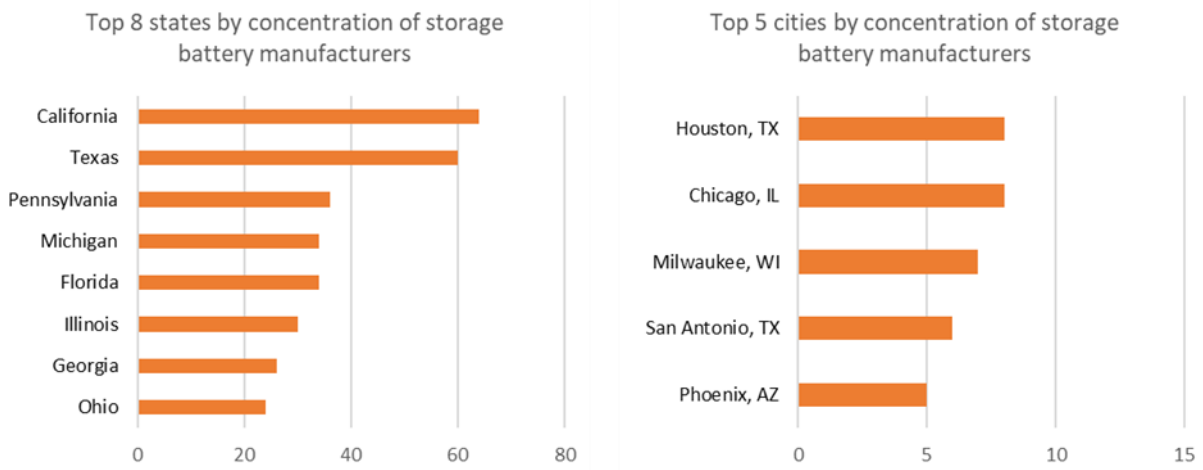


**Figure 11 - US states and cities with the highest concentration of storage batteries manufacturers**

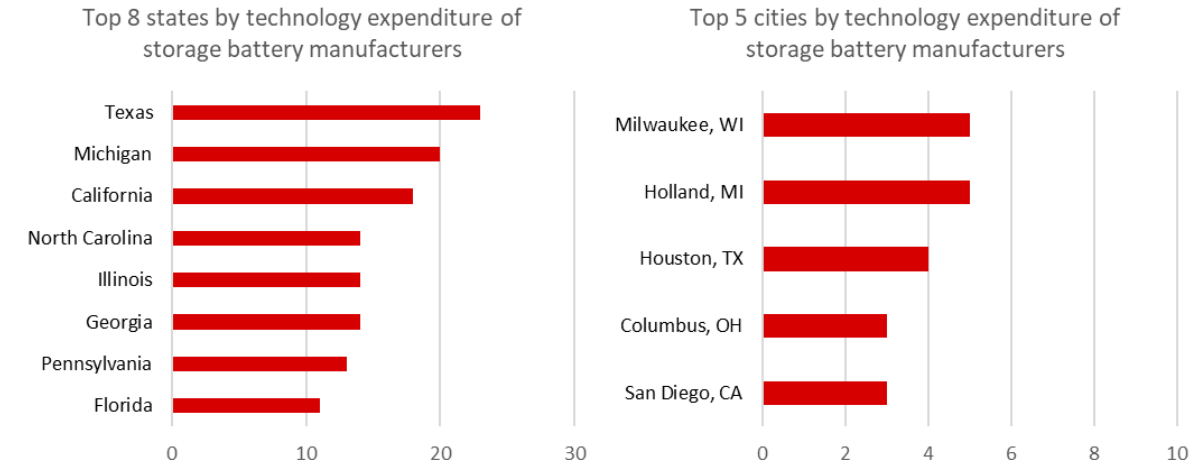


Figure 12 shows the US states and cities with the highest concentration of storage battery manufacturers that spend on average per manufacturer over $10,000 (€9,000) in technology per year. Around one-third (29%) of the storage battery manufacturers spend annually on average between $10,000 (€9,000) and $50,000 (€45,000) on technology. On the other hand, only around 11% of storage battery manufacturers spend over $50,000 per year on technology.

Texas is the state with the highest technology expenditure of storage battery manufacturers. However, the top two cities with the highest technology expenditure are not located within the state of Texas. Moreover, it is relevant to note that Wisconsin is not among the top states in terms of technology expenditure, although the city of Milwaukee is within the top five cities with the highest technology expenditure. It is also relevant to highlight the lower number of US businesses in the battery manufacturing sector when compared with the area of electronics and computer products.



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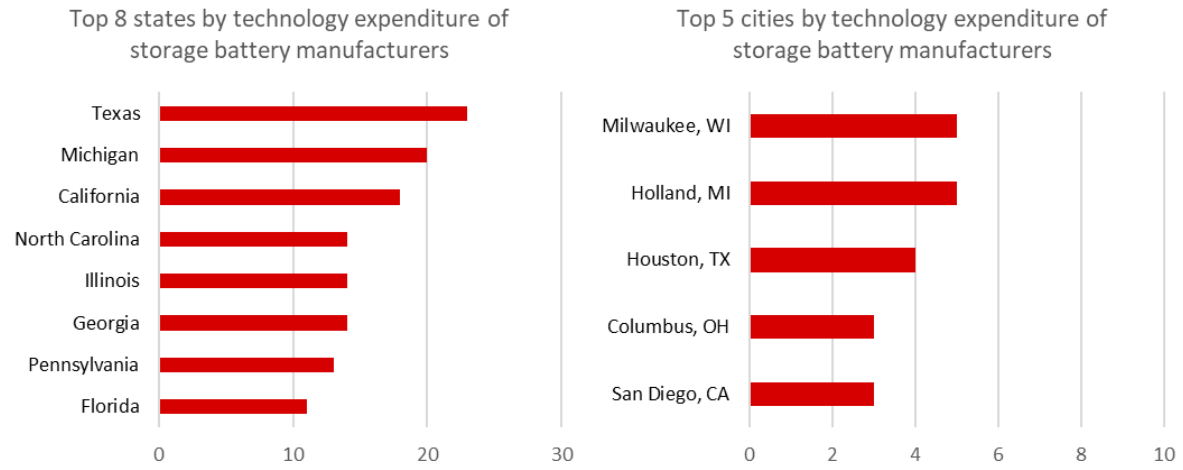


**Figure 12 - US states and cities with the highest concentration of storage batteries manufacturers that spend annually on average over $10,000 in technology**

**Nanotechnology for painting and coating**

Nanotechnology applications for developing paintings and coatings in the automotive sector have been a focus of many manufacturers[128]. From a market perspective, the US states and cities with the highest geographical concentrations of painting and coating manufacturers may represent the areas with more Nanotechnology applications for automotive market opportunities across the country.

This market guide provides an overview of the US states and cities that have a higher geographical concentration of painting and coating manufacturers, as well as the states and cities that have manufacturers which individually invest an average of $10,000 (€9,000) or more in technology annually. In the US, there are 3,000 paint and coating manufacturers. Figure 13 highlights the areas with higher concentrations of paint and coating manufacturers.

[128] https://www.azoNano.com/article.aspx?ArticleID=3031



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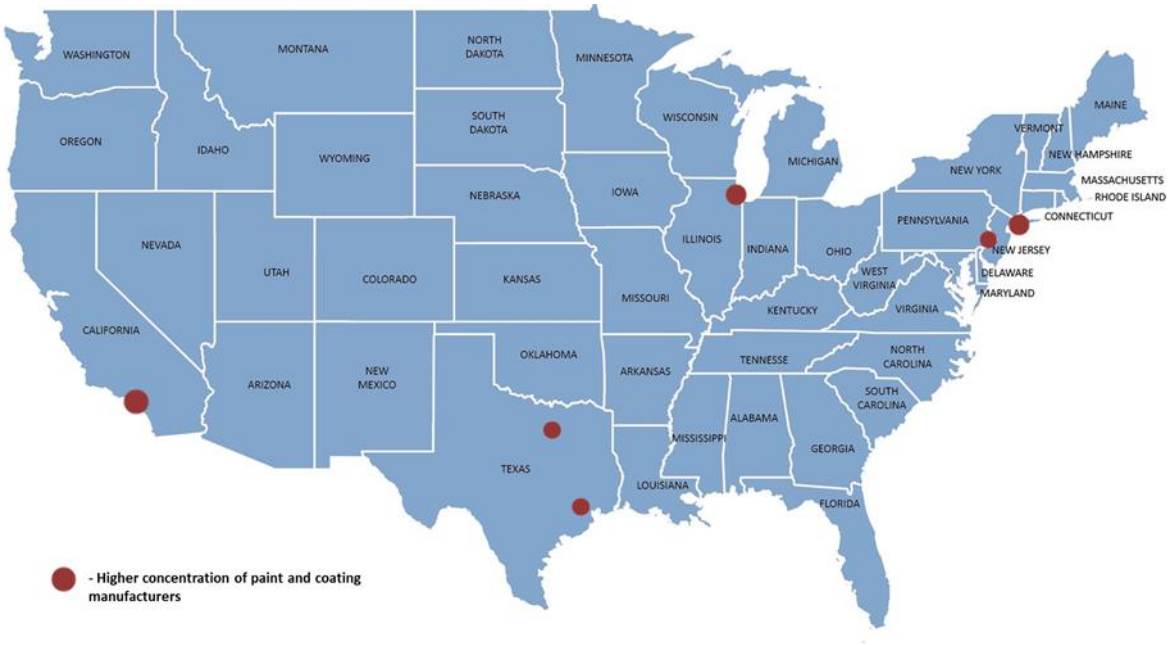


**Figure 13 - Location of the US areas with higher of concentration of paint and coating manufacturers**

Figure 14 indicates US states and cities with the highest concentrations of paint and coating manufacturers. US paint and coating manufacturers are primarily located in the high population regions of the country and, therefore, concentrated in the states of California, Florida, and Texas. This indicates that these three states are important areas to find market opportunities related to Nanotechnology for paint and coating. California is the state with the highest geographical concentration of paint and coating manufacturers. However, in terms of city concentration, Houston has the highest number of US businesses in the paint and coating manufacturing sector. Therefore, the state of Texas represents an important market for paint and coating providers. Moreover, it is relevant to note that although Missouri is not within the top states in terms of business concentration, it currently includes two cities (Kansas City and St. Louis) in the city ranking, showing the strong focus of these cities in the paint and coating sector.



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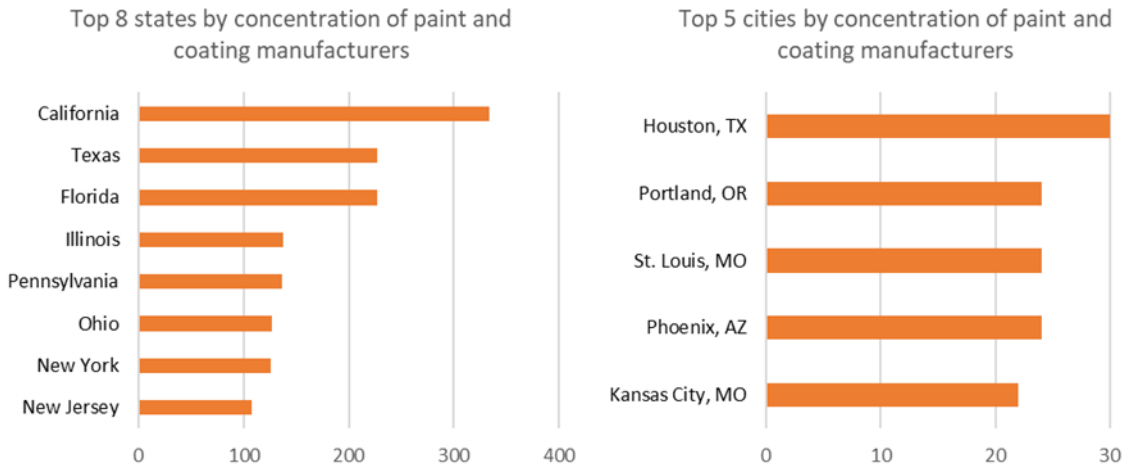


Figure 14 - US states and cities with the highest concentration of paint and coating manufacturers

Figure 15 shows the US states and cities with the highest concentration of paint and coating manufacturers that spend on average over $10,000 (€9,000) in technology per year. Around 15% of the paint and coating manufacturers spend annually on average between $10,000 (€9,000) and $50,000 (€45,000) on technology. On the other hand, around 5% of paint and coating manufacturers spend over $50,000 per year on technology.

Illinois is the state with the highest technology expenditure of paint and coating manufacturers. However, the top four cities with the highest technology expenditure are not located within the state of Illinois. Chicago holds the fifth position in terms of highest technology expenditure. Moreover, it is relevant to note that Missouri is not among the top five states in terms of technology expenditure, although the cities of Kansas City and St. Louis are both within the top five cities with the highest technology expenditure.

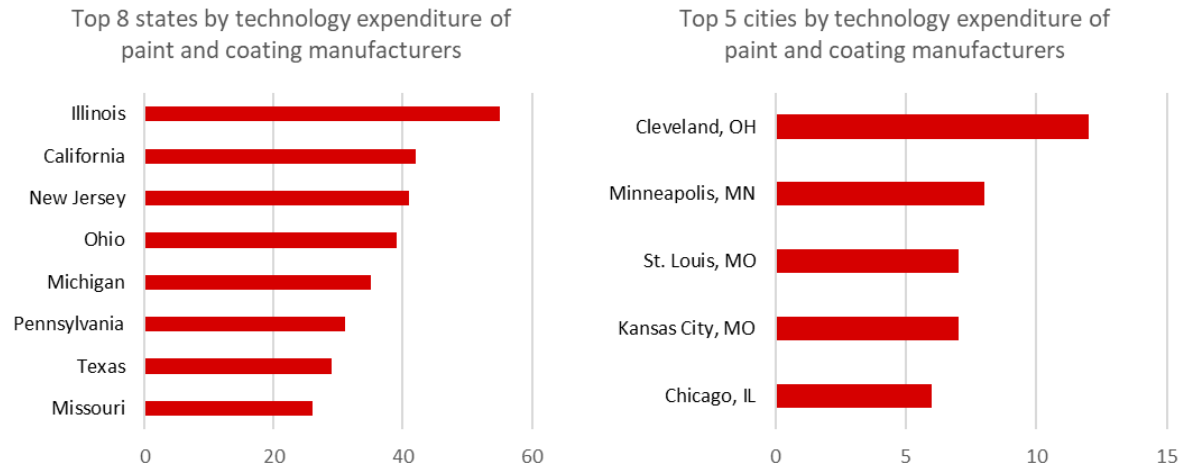




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**Figure 15 - US states and cities with the highest concentration of paint and coating manufacturers that spend annually on average over $10,000 in technology**

**Nanotechnology for aerospace manufacturing**

Nanotechnology applications for the aerospace industry focus on creating new products that can reduce costs and increase safety and comfort. Thus, Nanotechnology solutions have been applied to the aerospace industry, improving properties that improve the mechanical and electrical performance or that can deliver additional functionalities[129]. From a market perspective, the US states and cities with the highest geographical concentrations of aerospace product and parts manufacturing may represent the areas with more Nanotechnology applications for aerospace market opportunities across the country.

This market guide provides an overview of the US states and cities that have a higher geographical concentration of aerospace engine, engine and auxiliary parts manufacturers, as well as the states and cities that have manufacturers which individually invest an average of $10,000 (€9,000) or more in technology annually. In the US, there are 1,983 aerospace products and parts manufacturers. Figure 16 highlights the areas with higher concentrations of manufacturers.

[129] https://www.businesswire.com/news/home/20170118005690/en/Global-Market-Nanotechnology-Aerospace-2017---Research



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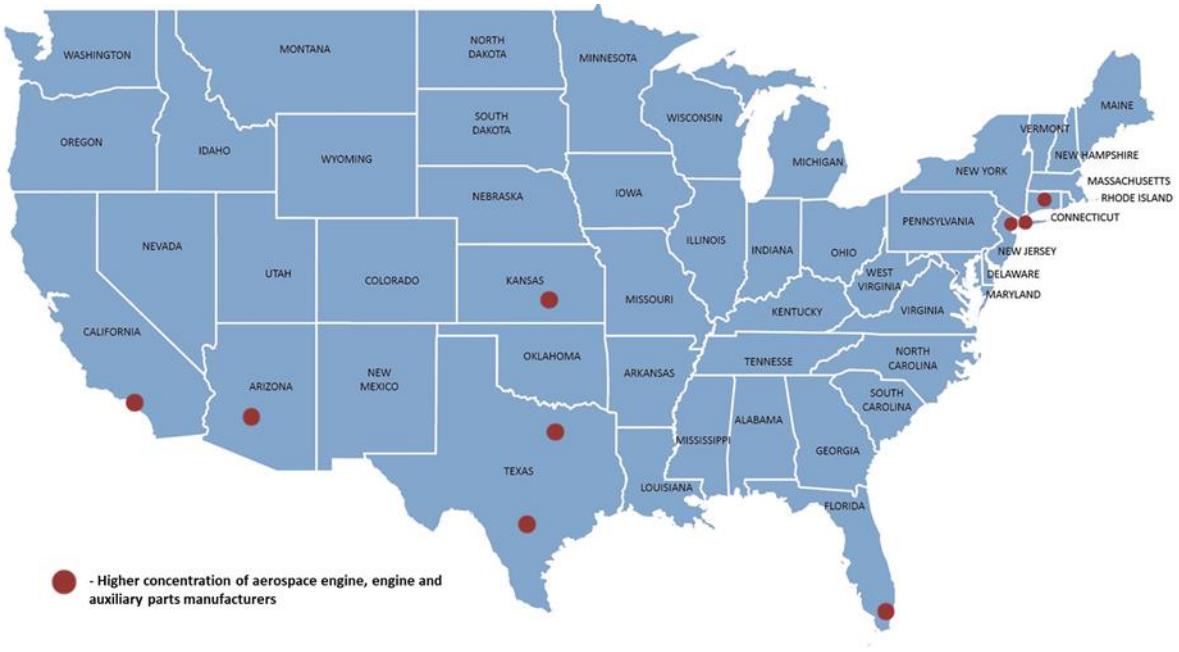


Figure 16 - Location of the US areas with higher of concentration of aerospace engine, engine and auxiliary parts manufacturers

Figure 17 indicates US states and cities with the highest concentrations of aerospace engines, engine and auxiliary parts manufacturers. US aerospace manufacturers are primarily located in the high-population regions of the country and, therefore, concentrated in the states of California, Texas, and Florida. This indicates that these three states are important areas for finding market opportunities related to Nanotechnology for aerospace solutions. California is the state with the highest geographical concentration of aerospace engine, engine and auxiliary parts manufacturers. However, in terms of city concentration, Wichita has the highest number of US businesses in the aerospace engine, engine and auxiliary parts sector. Therefore, the state of Kansas represents an important market for aerospace engines, engine and auxiliary parts providers. Moreover, it is relevant to note that although Arizona is not among the top states in terms of business concentration, the city of Phoenix is in the second position in terms of city ranking, showing its strong focus in the aerospace engine, engine and auxiliary



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parts sector.

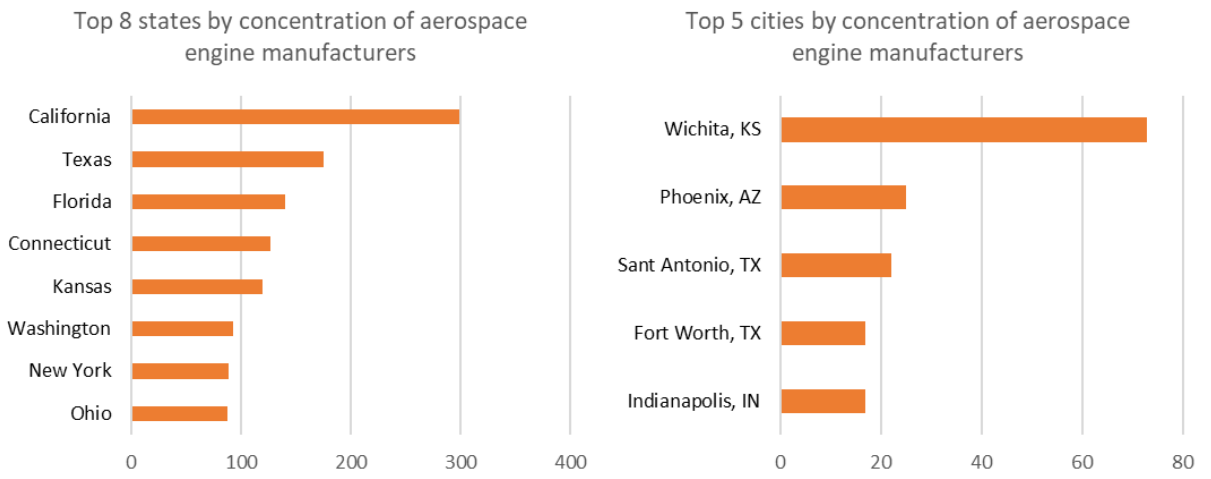


**Figure 17 - US states and cities with the highest concentration of aerospace engine, engine and auxiliary parts manufacturers**

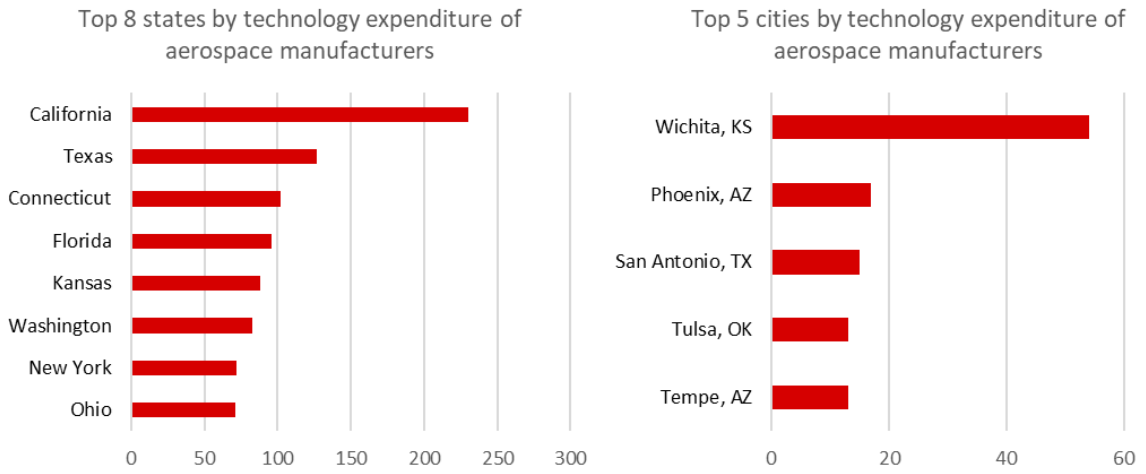


Figure 18 shows the US states and cities with the highest concentration of aerospace engine, engine and auxiliary parts manufacturers that spend on average over $10,000 (€9,000) in technology per year. Around one quarter (25%) of aerospace engine, engine and auxiliary parts manufacturers spend annually on average between $10,000 (€9,000) and $50,000 (€45,000) on technology. On the other hand, around 51% of aerospace engine, engine and auxiliary parts manufacturers spend over $50,000 per year on technology. Thus, it is important to highlight the high share (more than half) of US businesses in the aerospace engine, engine and auxiliary parts manufacturing that spend more than $50,000 per year in technology, showing a high concentration of innovation actions in the sector.



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California is the state with the highest technology expenditure of aerospace engine, engine and auxiliary parts manufacturers. However, the top ten cities with the highest technology expenditure are not in California. Wichita holds the first position in terms of highest technology expenditure, followed by Phoenix and San Antonio. Moreover, it is relevant to note that Arizona is not among the top five states in terms of technology expenditure, although the cities of Phoenix and Tempe are both within the top five cities with the highest technology expenditure.

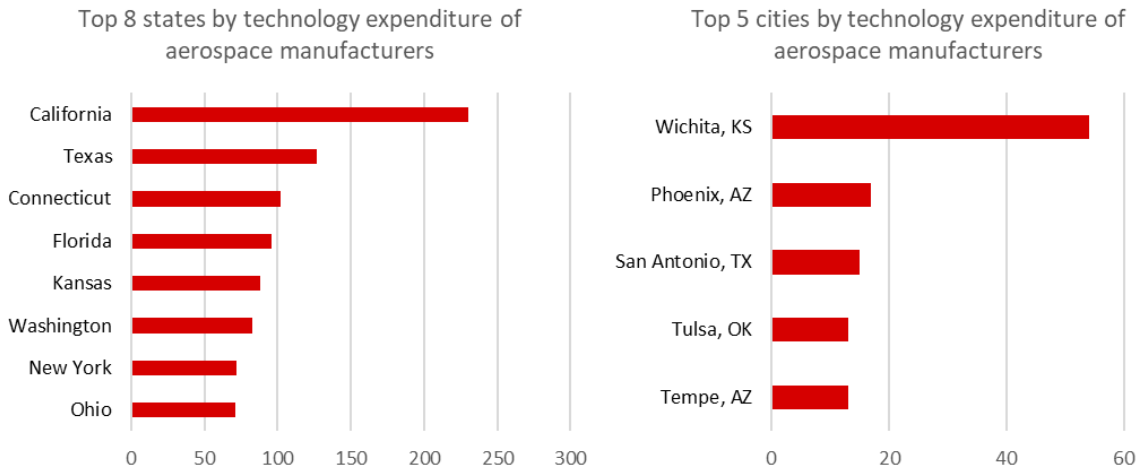


**Figure 18 - US states and cities with the highest concentration of aerospace engine, engine and auxiliary parts manufacturers that spend annually on average over $10,000 in technology**



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## 3.3. Market considerations

### 3.3.1. Opportunities

**Large and growing market**

As previously stated, the US has the world-leading market in Nanotechnology. Over the last decade, the US has been the country with the highest investment at the global level[130]. Moreover, there has been a large focus on both the commercial and the research and product development sides[131]. Thus, and considering the budget allocated to NNI, this trend is expected to be maintained throughout the next years. The interdisciplinary aspect of Nanotechnology, its broad impact and innovative solutions that bring to products and applications (e.g. nanomedicine, computers, batteries, among others) can explain the rapid growth of the industry.

**New applications and Nanotechnology "mainstreaming"**

The impact of Nanotechnology at the market level can be seen in several user products and new applications (e.g. coatings, anti-bacterial clothing, cosmetics, and food products)[132]. Moreover, it has influenced future technologies and solutions at the research and commercial levels. Thus, it is expected that new applications arise through further R&D investment in Nanotechnology and that the current innovations will be scaled to more products and services at the global level. With the continued Federal investment at the US level through the NNI, it is expected that new discoveries and applications are achieved to maintain the US as the leading market for Nanotechnology research and innovation[133].

**Opportunities at several stages of the value chain**

As previously described, Nanotechnology has cross-sectoral applications Nanotechnology, where it is useful in several sectors and stages of the value chain. This interdisciplinary aspect of Nanotechnology provides an opportunity for a large range of companies and businesses to include Nanotechnology solutions in their product development processes. Particularly, in the US, the corporate spending for Nanotechnology R&D was the highest at the global level, covering a wide variety of applications[134]. Hence, Nanotechnology opportunities at several levels of the value chain should be explored within the US market.

[130] http://www.oecd.org/sti/biotech/Nanotechnology-indicators.htm
[131] Working Texas Style, Chapter 12: Nanotechnology
[132] https://ec.europa.eu/health/scientific_committees/opinions_layman/en/Nanotechnologies/l-2/1-introduction.htm#:~:text=Nanotechnology%20has%20already%20been%20embraced,some%20medical%20products%20and%20medicines.
[133] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017
[134] Economic Research Working Paper No. 29 – Economic growth and breakthrough innovations: A case study of Nanotechnology, WIPO, Lisa Larrimore Ouellette, 2015



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### 3.3.2. Barriers

**Nanotechnology development costs**

The Nanotechnology industry is a relatively new market for both consumers and producers. Thus, development costs associated with Nanotechnology solutions might require relatively high investments for SMEs and start-ups[135]. Taking this into account, the commercialization of Nanotechnology products will likely require large investments and funding for start-ups and SMEs.

**Regulatory requirements**

Nano-enabled products or services may contain different attributes than those of conventionally manufactured products. Consequently, several regulatory actions have been taken by US agencies and entities to regulate Nanotechnology applications. Currently, the main authorities involved in regulating nano-enabled products are the US Environmental Protection Agency (EPA) and the US Food and Drug Administration (FDA)[136]. For example, the EPA has a Significant New Use Rule (SNUR) which states that nanoscale materials have a proper regulatory review, including stakeholders who will manufacture, import, or process nanoscale materials[137]. On the other hand, the FDA has been implementing several actions that support the innovation and safe use of Nanotechnology in FDA-regulated products[138]. The manufacturing and processing of nanoscale materials need to be compliant with the regulatory requirements from their respective sector's regulatory agencies (e.g. food, energy, health, etc.). Thus, the potential restrictions due to regulatory requirements might be seen as a barrier when entering the US Nanotechnology market.

[135] https://globenewswire.com/news-release/2017/01/19/909415/0/en/Nanotechnology-Market-to-Cross-USD-12-Billion-in-Revenue-by-2021-as-Commercialization-of-Technologies-Across-Industry-Verticals-Increases-IndustryARC-Analysis.html
[136] http://www.chemsafetypro.com/Topics/USA/Regulations_of_Nanomaterials_in_USA.html
[137] https://www.dummies.com/education/science/Nanotechnology/organizations-involved-in-Nanotechnology-regulation/
[138] https://www.fda.gov/scienceresearch/specialtopics/Nanotechnology/ucm301114.htm



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# 4 Recognized networks and events

Networks and events are crucial to enhance the connection between researchers and between academia and industry at both national and international levels. They provide great opportunities for researchers and industry representatives from Nanotechnology-related fields to share knowledge and experience.

Networks and events are often used as sources of information and knowledge towards a specific area or sector. Thus, as the Nanotechnology sector is continuously advancing and changing and as it is considered to have a broad and fundamental impact on every industry[139], EU researchers and industry representatives are recommended to contact key US Nanotechnology-related networks and attend events located in the US.

The knowledge gained through relevant networks and events provides support on deciding the most effective approach to establish contacts with the US community to develop innovation and industry collaborative opportunities.

[139] Global Nanotechnology Market 2018-2024: Technological Advancements in Nanotechnology & Increased Government Support and R&D Spending, RNCOS E-Services Private Limited, 2018



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## 4.1. Innovation and market networks/associations

The concept of innovation/market networks has been developed by considering innovation as a collaborative phenomenon[140]. Innovation/market networks are collaborative platforms composed of individuals, small and large corporations, startups, academic, and government institutions that aim to create new ideas, products, services, or business models[141]. Within this context, innovation/market networks can promote linkages between different types of organizations related to Nanotechnology, to promote new applications to the market.

Moreover, innovation/market networks can support the development of innovation in SMEs and startups, promoting flexibility, lowering the expenditures from single expenses for innovation purposes and offering more opportunities for collaborative innovation processes. Thus, innovation/market networks can help SMEs and startups to reach innovation targets, access complementary resources, attract investment and advance technologies[142, 143].

On the other hand, a professional association is a body of individuals engaged in the same profession, formed usually to control entry into the profession, maintain standards, and represent the profession in discussions with other bodies[144, 145]. Professional associations are a crucial segment of the US Industry. In 2013, membership organizations alone employed over 1.3 million people in the US[146].

Table 3 provides a brief description of some of the main research networks/professional associations in Nanotechnology related applications.

[140] http://www.emeraldinsight.com/doi/full/10.1108/JBIM-03-2015-0042
[141] https://innolytics.net/innovation-network/
[142] https://www.redalyc.org/journal/4991/499151081004/html/
[143] https://www.oecd-ilibrary.org/sites/f5539f94-en/index.html?itemId=/content/component/f5539f94-en
[144] https://www.vocabulary.com/dictionary/professional%20association
[145] http://www.dictionary.com/browse/professional-association
[146] http://www.thepowerofa.org/wp-content/uploads/2012/03/PowerofAssociations-2015.pdf



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**Table 3 – Examples of key US Nanotechnology related networks and associations**

| Network | Main goal | Internet link |
|---|---|---|
| **International networks and associations** | | |
| International Association of Nanotechnology (IANT) | The International Association of Nanotechnology (IANT) is a non-profit with the goal of fostering scientific research and business development in Nanoscience and Nanotechnology for society's benefit. | http://www.iaNano.org/aboutus.htm |
| IEEE Nanotechnology Council | IEEE Nanotechnology Council aims to support the theory, design and development of Nanotechnology and its scientific, engineering and industrial applications. The Council is responsible for sponsoring recognized international conferences and relevant publications. | https://ieeenano.org/ |
| **Federal networks and associations** | | |
| National Nanomanufacturing Network (NNN) | The National Nanomanufacturing Network (NNN) is an alliance of academic, government and industry partners which aim to cooperate in strengthening Nanomanufacturing in the US. NNN works as an open network of centers, leaders, experts and stakeholders from the Nanomanufacturing community. | https://www.internano.org/nnn |
| National Network for Manufacturing Innovation (NNMI) | The National Network for Manufacturing Innovation (NNMI) is a US initiative in advanced manufacturing. NNMI is composed of public-private partnerships focused on manufacturing. The main aim is to bring together innovative manufacturers, university engineering schools, community colleges, federal agencies, non-profits, and regional and state organizations to invest in manufacturing technologies with broad applications, namely Nanotechnology. | https://www.manufacturing.gov/ |
| Nano Science and Technology Institute (NSTI) | The Nano Science and Technology Institute (NSTI) advances and integrates Nanotechnologies through training, conventions, publishing, and research services. NSTI produces the annual Nanotech conference and expo, which is the largest gathering of the Nanotechnology industry in the US. NSTI was founded in | https://www.nsti.org/ |



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| Network | Main goal | Internet link |
|---|---|---|
| | 1997 as a merger between different scientific societies. It is headquartered in Austin, Texas and has offices in Cambridge, Massachusetts, and Danville, California. | |
| National Nanotechnology Coordinated Infrastructure (NNCI) | The National Nanotechnology Coordinated Infrastructure (NNCI) was established in 2015 as the latest version of an initiative from the NSF to provide Nanotechnology resources to researchers in the US. | https://www.nnci.net/ |
| The American Precision Optics Manufacturers Association (APOMA) | The American Precision Optics Manufacturers Association (APOMA) aims to promote new opportunities for the precision optics industry. APOMA represents different manufacturers within the industry, as well as with academic associates. | http://www.apoma.org/ |
| **State networks and associations** | | |
| North Carolina Research Triangle Nanotechnology Network (RTNN) | The North Carolina Research Triangle Nanotechnology Network (RTNN) is an innovation hub focused on transformative Nanotechnology research, education, and commercialization. The RTNN offers access to its Nanotechnology facilities within the research triangle area for researchers across the US. | https://www.rtnn.ncsu.edu/ |
| NCN@Illinois - Network for | The Network for Computational Nanotechnology (NCN) at the University of Illinois is based at Purdue University. The project aims to connect theory, experiments, and computation to support innovation in Nanotechnology solutions. | https://nanohub.org/groups/ncn |



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| Network | Main goal | Internet link |
|---|---|---|
| Computational Nanotechnology | | |
| Lehigh Emerging Technologies Network (LETN) | The Lehigh Emerging Technologies Network (LETN) is composed of a diverse group of businesses, education actors, government and economic development and services members. The main aim is to discover new applications of technology, develop research and educational activities, promoting the commercialization of new materials' technologies. | https://www.nanowerk.com/nNanotechnology-labs.php?url2=Lehigh_nanotech_Network.php |
| Rhode Island Consortium for Nanoscience and Nanotechnology | Rhode Island Consortium for Nanoscience and Nanotechnology was established in 2010 as a joint entity between the University of Rhode Island and Brown University. The consortium aims to develop the state of Rhode Island's competitiveness in Nanoscience and Nanotechnology, promoting industry-university cooperation. Its focus areas are Nanomaterials, Nanohealth, Nanotools and Nanoenergy. | https://web.uri.edu/Nano/ |



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## 4.2. Innovation and market events

Conferences and other networking events provide an important platform where Nanotechnology innovators and researchers can present and discuss high-quality research and technological advances. Nanotechnology conferences are also an excellent opportunity to foster collaboration between researchers, professionals, and industry members, share knowledge and discuss the development and deployment of technologies.

Due to the importance of Nanotechnology, there are several conferences and other networking events focused on this field in the US. The conferences and other networking events identified show an emphasis on the healthcare area, with several events focusing on this topic. Moreover, it can be concluded that most Nanotechnology-related conferences and other networking events are not specified in a particular area or topic, but more on the Nanotechnology industry. In timeline distribution, the conferences and events focused on Nanotechnology seem well distributed throughout the year.

Regarding the geographical distribution of the US Nanotechnology related conferences and other networking events, there is a high degree of concentration in the northeast region, more particularly in New York and Massachusetts, as well as in the state of California.



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**Table 4 – Nanotechnology related innovation and market events**

| Date | Conference/ Event title | Interval | Location | Areas | Internet link |
|---|---|---|---|---|---|
| 04 January 2024 | International Conference on Nanoscience, Nanoengineering and Nanotechnology for Energy Applications | Annual | Chicago, Illinois | Energy | https://www.researchfora.net/event/index.php?id=2194885nano |
| 28 February 2024 | International Conference on Nanotechnology in Ocular Drug Delivery (ICNIODD-24) | Annual | San Francisco, California | Healthcare | https://itar.in/conf/index.php?id=2156910 nano |
| 12 March 2024 | International Conference on Agricultural Nanotechnology and Applications (ICANA-24) | Annual | San Diego, California | Food, Agriculture | https://isit.org.in/event/index.php?id=2246540 |
| 22-23 April 2024 | 18. International Conference on Nanotechnology for Environment and Energy | Annual | Boston, Massachusetts | Energy | https://waset.org/nNanotechnology-for-environment-and-energy-conference-in-april-2024-in-boston?utm_source=conferencei |



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| Date | Conference/ Event title | Interval | Location | Areas | Internet link |
|---|---|---|---|---|---|
| | | | | | ndex&utm_medium=referral&utm_campaign=listing |
| 20-21 May 2024 | International Conference on Nanotechnology | Annual | Las Vegas, Nevada | Not specified | https://waset.org/nNanotechnology-conference-in-may-2024-in-las-vegas |
| 03 June 2024 | International Conference on Plant and Biotechnology (ICPNB-24) | Annual | Washington DC, Columbia | Agriculture | https://www.researchfora.net/event/index.php?id=2280047 |
| 07-08 June 2024 | International Conference on Agricultural Nanotechnology and Nanomaterials | Annual | San Francisco, California | Agriculture | https://waset.org/agricultural-Nanotechnology-and-Nanomaterials-conference-in-june-2024-in-san-francisco |
| 20-21 September 2024 | 4th International Conference on Materials Science & Nanotechnology | Annual | Orlando, Florida | Not specified | https://materialscience.averconferences.com/ |



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| Date | Conference/ Event title | Interval | Location | Areas | Internet link |
|---|---|---|---|---|---|
| 08-09 October 2024 | The Advanced Materials Show USA | Annual | Pittsburg, Pennsylvania | Not specified | https://advancedmaterialsshowusa.com/about/ |
| 28-30 October 2024 | 9th Edition of World Nanotechnology Conference (Nanotechnology 2024) | Annual | Baltimore, Maryland | Not specified | https://nNanotechnology.magnusconferences.com/ |
| 09-10 December 2024 | International Conference on Nanotechnology, Optoelectronics and Photonics | Annual | New York, New York | Electronics | https://waset.org/nNanotechnology-optoelectronics-and-photonics-conference-in-december-2023-in-new-york |



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# 5 US innovation initiatives and programs

The US governmental funding system is highly decentralized and comprises several actors, such as agencies of federal and state governments, universities, the private sector, and non-profit organizations[147]. The US government has identified the importance of Nanotechnology for innovation at the multidisciplinary level. Funding Nanotechnology-related initiatives and programs is currently a priority for both public and private entities, which are focused on fostering the commercialization of Nanotechnology.

The NNI is an initiative from the US Government established in 2001 responsible for the development of Nanotechnology innovation and R&D. NNI targets the promotion of world-class Nanotechnology R&D, fosters technology transfer, develops educational resources and a skilled workforce, and supports the responsible development of Nanotechnology. The budget for the Fiscal Year of 2019 for the NNI was of $1.4 billion (€1.2 billion), allocated among different federal organizations[148]. Thus, the initiatives funded within the NNI are considered in the analysis of US innovation initiatives and programs for Nanotechnology.

A review of the US funding initiatives and programs at both public and private levels was conducted to identify some examples of relevant innovation initiatives and programs in the Nanotechnology related fields. There are several initiatives at the federal level that provide support to Nanotechnology innovation. Thus, some of the main programs and agencies at the federal level that focus on Nanotechnology are described within this section. It is relevant to highlight that additional public and private initiatives and programs exist, which are not described within this report. The following subsections provide descriptions of the initiatives and programs. Annex 1 provides a summary table of the initiatives and programs detailed in this chapter.

## 5.1. Public initiatives/programs

In the US, Nanotechnology research and innovation development is supported by a set of public initiatives and programs. At the federal level, the US Department of Health and Human Services, NSF, DOE, and DOD are the entities primarily responsible for initiatives and programs that promote innovation in the Nanotechnology-related fields[149] (Figure 19).

[147] https://www.investopedia.com/ask/answers/13/federal-government-fund-ngos.asp
[148] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017
[149] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017



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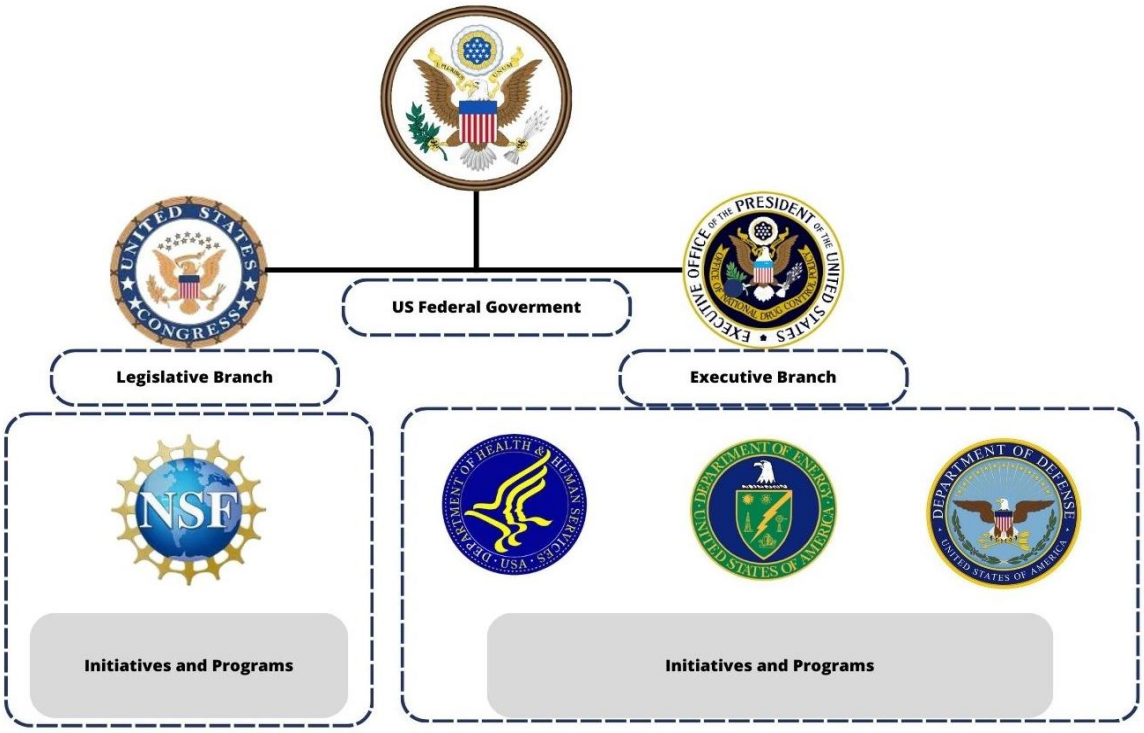


**Figure 19 - US Government Organizational Chart highlighting the main sponsors of innovation programs in Nanotechnology related fields**

A review of the US Federal Government innovation initiatives and programs was conducted to identify some of the most relevant ones in fields related to Nanotechnology. Although this market guide only provides federal initiatives and programs established by its main sponsors, it is important to highlight that there are several initiatives and programs in fields related to Nanotechnology promoted by several other US departments and entities. These include the US Department of Commerce, the US Department of Agriculture and the National Aeronautics and Space Agency[150].

## 5.1.1. National Science Foundation (NSF)

The NSF provides support through grants and cooperative agreements to universities, businesses, informal science organizations and other research organizations focused on areas that are most likely to result in considerable technological progress[151]. The NSF funds initiatives that aim to advance research that contributes to the scientific community's better understanding. The NSF supports cooperative research between universities and industry, as well as the US researchers' participation in

[150] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017
[151] https://www.nsf.gov/about/how.jsp



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international scientific and engineering research activities. Collaboration between US researchers and European researchers can be funded in almost all new proposals to NSF or in supplements to existing NSF awards. Thus, European researchers interested in collaborating with US researchers could ask their US counterparts to contact the NSF disciplinary program officer or use the Office of International Science and Engineering (OISE) Regional and Country Contacts to inquire about funding possibilities[152].

| First Approach | |
|---|---|
| **European Union OISE Regional Contact** | eeinfo@nsf.gov |
| **International Collaboration** | OISE fosters institutional partnerships throughout the global science and engineering research and education community, and it supports international collaborations in NSF's priority research areas. OISE encourages funding applicants to include an international component in proposals submitted to the appropriate research directorate[153]. |
| **Internet links** | www.nsf.gov/od/oise/country-list.jsp |

**Nanoscale Interactions Program**

The Nanoscale Interactions program aims to comprehend how nanomaterials and nanosystems interact with biological and environmental elements. The program focuses on a variety of materials, such as one- to three-dimensional nanostructures, diverse nano-bio hybrid assemblies, dendritic and micelle structures, quantum dots, and other nanoparticles. Research endeavors within this program encompass the characterization of interactions, the development of predictive tools, the exploration of transport mechanisms, the study of interactions and their impact on biological systems, simulations of nanoparticle behavior, and investigations into quantum vibronic and spin phenomena. The program actively supports exploratory research projects that delve into nanoscale interactions and quantum effects, aiming to elucidate macroscopic changes as well as physiological and metabolic processes[154].

| First Approach | |
|---|---|
| Contact | European researchers and SMEs interested in the Nanoscale Interactions program could contact the Program Specialist, Nora F. Savage. |

[152]https://www.nsf.gov/dir/index.jsp?org=OISE

[153] https://www.nsf.gov/od/oise/about.jsp

[154] https://new.nsf.gov/funding/opportunities/nanoscale-interactions-0



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| | |
|---|---|
| Email address | NOSAVAGE@nsf.gov |
| Phone Number | (703) 292-7949 |
| Internet links | https://new.nsf.gov/funding/opportunities/nanoscale-interactions-0 |

**Electronics, Photonics and Magnetic Devices program (EPMD)**

The Electronics, Photonics, and Magnetic Devices (EPMD) program is designed to facilitate groundbreaking research in novel devices. Emphasizing innovation, the program encourages investigations into emerging technologies that focus on miniaturization, integration, and energy efficiency to applications in a wide range, such as information and communications, imaging and sensing, healthcare, Internet of Things, energy, infrastructure, and manufacturing. Within its purview, the program provides support for research areas that delve into the characterization of interactions occurring at the interfaces of nanomaterials and nanosystems[155].

| First Approach | |
|---|---|
| Contact | European researchers and SMEs interested in the EPMD program could contact the Program Expert, Supriyo Bandyopadhyay. |
| Email address | sbandyop@nsf.gov |
| Phone Number | (703) 292-5392 |
| Internet links | https://new.nsf.gov/funding/opportunities/electronics-photonics-magnetic-devices-epmd-0 |

## 5.1.2. Department of Health and Human Services (HHS)

The US HHS is comprised of several agencies that provide funding for initiatives and programs to promote Nanotechnology development. Among those, there are two that can be highlighted: National Institutes of Health (NIH) and Centers for Disease Control and Prevention (CDC).

[155] https://new.nsf.gov/funding/opportunities/electronics-photonics-magnetic-devices-epmd-0



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**National Institutes of Health (NIH)**

The NIH is the largest public funder of biomedical research in the world, investing more than $32 billion (€28.8 billion) a year in R&D activities[156].

| NIH Grants and Funding | |
|---|---|
| **International Collaboration** | In general, foreign institutions and international organizations, including public and private non-profit or for-profit organizations, are eligible to apply for NIH research project grants. Foreign institutions and international organizations are not eligible to apply for Kirschstein-NRSA institutional research training grants, program project grants, center grants, resource grants, SBIR/STTR grants, or construction grants.<br>European researchers could review the Eligibility section of the Funding Opportunity Announcement (FOA) to determine whether their non-US entity is eligible to apply to that particular FOA[157]. |

**Centers for Disease Control and Prevention (CDC)**

The CDC is one of the major initiatives within the HHS. This national initiative aims to conduct and support research intended to support health, safety, and security within the community. In this context, the CDC provides grants and cooperative agreements to support research and non-research public health programs aligned with the CDC's public health mission domestically and globally. Office of Grants Services (OGS) supported 4,519 grant awards to 1,345 recipients.

**National Institute for Occupational Safety and Health (NIOSH) - Nanotechnology Research Center (NTRC):** NIOSH is a federal agency focused on worker safety and health. NIOSH manages the federal government health and safety initiative for Nanotechnology: Nanotechnology Research Center (NTRC), established in 2004. NIOSH includes a set of research programs, training and funding through the NIH grants and contracts. Currently, the agency does not have any nano-related funding opportunities announcements. It is strongly recommended to monitor the Grants.gov site to find future grant opportunities[158].

| **First Approach** | |
|---|---|
| **Information about Funding Opportunities** | European researchers interested in the NIOSH funding opportunities could contact the representative identified in the Funding Opportunities Announcements (FOAs). |

[156] https://grants.nih.gov/grants/about_grants.htm
[157] https://grants.nih.gov/grants/who-is-eligible.htm
[158] https://www.cdc.gov/niosh/topics/Nanotech/



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| | |
|---|---|
| **International Collaboration** | The eligibility criteria for NIOSH's funding opportunities and support can be found in the FOAs listed on Grants.gov. Each opportunity details all eligibility requirements and definitions. |
| **Internet link** | https://www.cdc.gov/niosh/oep/funding.html |

### 5.1.3. Department of Energy (DOE)

The DOE aims to guarantee the country's security and prosperity by addressing its energy, environmental and nuclear challenges through highly innovative science and technology solutions[159]. Among the DOE Offices, it is relevant to highlight the following in the field of Nanotechnology: Advanced Research Projects Agency-Energy (ARPA-E) and the Office of Energy Efficiency and Renewable Energy (EERE)[160].

**Advanced Research Projects Agency-Energy (ARPA-E)**

The ARPA-E aims to promote the advancement of high-potential and high-impact energy technologies, which are in a stage that is too early for private investment. The ARPA-E is focused on supporting projects that promote prosperity, national security, and environmental well-being[161]. In this context, the ARPA-E funds technology-focused and applied R&D projects that can generate real and concrete solutions to important problems in energy creation, distribution, and use. Thus, the ARPA-E promotes periodic FOAs dedicated to solving specific technical barriers of a specific energy area. The ARPA-E also issues periodic OPEN FOAs to identify high-potential projects that address a wide range of energy-related technologies, including a focus on Nanotechnology-related areas and applications. At this moment, the agency does not have any nano-related funding opportunities announcements. It is strongly recommended to monitor the Grants.gov site to find future grant opportunities[162, 163].

| First Approach | |
|---|---|
| **Information about Funding Opportunities** | European researchers interested in ARPA-E's funding opportunities could contact the representative identified in the FOAs. |
| **International Collaboration** | The eligibility criteria for ARPA-E's funding opportunities can be found in the FOAs listed on https://arpa-e-foa.energy.gov/. Each FOA details all eligibility requirements and definitions. |

[159] https://www.energy.gov/about-us
[160] https://www.energy.gov/science-innovation/clean-energy
[161] https://www.arpa-e.energy.gov/?q=arpa-e-site-page/about
[162] https://www.arpa-e.energy.gov/?q=programs/apply-for-funding
[163] https://www.Nano.gov/initiatives/funding-opportunities



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| | |
|---|---|
| **Internet link** | https://arpa-e-foa.energy.gov/ |

**Office of Energy Efficiency and Renewable Energy (EERE)**

The EERE aims to promote and sustain the US leadership in the transition to a clean energy economy. Most of EERE's funding is provided by grants or cooperative agreements. However, the EERE's funding portfolio also includes other forms of funding such as Cooperative Research and Development Agreements (CRADAs), Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) Awards, Technology Investment Agreements (TIAs) and Unsolicited Proposals. At this moment, the EERE does not have any nano-related funding opportunities announcements. It is strongly recommended to monitor the Grants.gov site to find future grant opportunities [164].

| First Approach | |
|---|---|
| **Information about Funding Opportunities** | European researchers interested in the EERE funding opportunities could contact the representative identified in the Funding Opportunities Announcements (FOAs). |
| **International Collaboration** | The eligibility criteria for EERE's funding opportunities can be found in the FOAs listed on Grants.gov and EERE Exchange. Each FOA details all eligibility requirements and definitions. |
| **Internet link** | https://www.energy.gov/eere/funding/eere-funding-opportunities#open |

**DOE Office of Energy Materials Network (EMN):** The Energy Materials Network (EMN) aims to integrate all stages of R&D and facilitate industry access to the EMN national laboratories' capacity tools. Thus, it accelerates the development cycle of materials and new products within the energy sector. Funding Opportunity Announcements (FOAs) related to the EMN are listed within the EERE Funding Opportunity Information site. At this moment, the EMN does not have any nano-related funding opportunities announcements. It is strongly recommended to monitor the Grants.gov site to find future grant opportunities.

| First Approach | |
|---|---|
| **Information about Funding Opportunities** | European researchers interested in the EMN funding opportunities could contact the representative identified in the Funding Opportunities Announcements (FOAs). |

[164] https://www.energy.gov/eere/funding/find-funding-office-eere



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| | |
|---|---|
| **International Collaboration** | The eligibility criteria for EMN's funding opportunities can be found in the FOAs listed on Grants.gov and the EERE Funding Opportunity site. Each FOA details all eligibility requirements and definitions. |
| **Internet link** | https://www.energy.gov/eere/energy-materials-network/energy-materials-network |

**High Performance Computing for Manufacturing (HPC4Mfg): The HPC4Mfg program aims to support US manufacturing companies related to high-performance computing (HPC) technology in clean energy and energy efficiency.** The program is promoted under the US DOE and led by Lawrence Livermore National Laboratory. The HPC4Mfg is sponsored by the Advanced Manufacturing Office (AMO) of the DOE. The DOE provides up to $3 million (€2.7 million) in funding support to manufacturers in modeling, simulation, and data analysis actions to promote innovation and enhanced performance in HPCs. The program includes several rounds, which seek proposals in different primary areas[165].

| **First Approach** | |
|---|---|
| Contact | European researchers and SMEs interested in the EPMD program could contact the Program Expert, Michelle Herawi. |
| Email address | hpc4ei-submissions@llnl.gov |
| Phone Number | (925) 423-4964 |
| Internet links | https://hpc4energyinnovation.llnl.gov/solicitations-summer-2023 |

### 5.1.4. Department of Defense (DOD)

The US Army, on behalf of the DOD, administers several federally funded programs focused on Nanotechnology R&D. The DOD includes several science and technology programs, as well as different departments and agencies (components). Within the component programs, there are several that focus on projects associated with research and technology at the broad level, including

[165] https://hpc4mfg.llnl.gov/index.php



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Nanotechnology. Nanotechnology plays an important role in the DOD strategy in terms of military applications. Thus, the DOD views Nanotechnology as a broad enabling technology[166].

| DOD Grants and Funding | |
|---|---|
| **International Collaboration** | The DOD foreign eligibility criteria depend on the level of sensitivity of the researchers and the specific policy of each agency. The authorizing legislation and agency policies will determine whether a foreign individual or organization may apply for a specific grant[167]. |

**Rapid Innovation Fund (RIF):** The RIF was originally established as the Rapid Innovation Program in 2011. It aimed to accelerate the development of innovative technologies into military systems. Thus, RIF supports small businesses in developing innovative technologies that meet the defense needs. In 2016, it was re-designated as the RIF. Until 2016, RIF has provided 553 contract awards (486 of those to small businesses) with a value of over $1.4 billion (€1.26 billion) invested. At this moment, the RIF does not have any nano-related funding opportunities announcements. It is strongly recommended to monitor the Grants.gov site to find future grant opportunities.

| **First Approach** | |
|---|---|
| Contact | European researchers and SMEs interested in the EPMD program could contact the Program Director, Farooq Mitha. |
| Email address | farooq.a.mitha.civ@mail.mil |
| Phone Number | (312) 986-6164 |
| Internet links | https://defenseinnovationmarketplace.dtic.mil/business-opportunities/rapid-innovation-fund/ |

## 5.2. Private initiatives/programs

There are several private funding initiatives and programs that are being implemented at the US state level. Thus, it is expected that during the next years, there will be an increase in private sector funding for R&D in Nanotechnology[168]. The investment in the Nanotechnology industry thus complements the

[166]https://foresight.org/dod_funding_nanotechnology/
[167] https://www.grants.gov/web/grants/learn-grants/grant-eligibility.html
[168] Global Nanotechnology Market (by Component and Applications), Funding & Investment, Patent Analysis and 27 Companies Pro 1file & Recent Developments - Forecast to 2024, iGATE Research, 2018



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R&D funding that is provided mainly through the NNI investments in Nanotechnology[169]. Within this context, there are several non-Federal organizations that provide funds to support Nanotechnology R&D initiatives and programs.

### 5.2.1. The Corridor's Matching Grants Research Program

The Corridor's Matching Grants Research Program is a state-funded initiative managed by the Florida High Tech Corridor Council, composed of the University of South Florida, the University of Florida, and the University of Central Florida. The program promotes the development of commercially applicable emerging technologies in the region. The program can provide up to $150,000 (€135,000) of grant funds for collaborative research projects. In terms of eligibility, the projects must involve a local industry partner and a University of South Florida Principal Investigator and support the economic development of the region. Thus, it is recommended that European applicants establish collaboration agreements with local organizations. Nanotechnology is one of the areas encouraged within the program[170].

| First Approach | |
|---|---|
| Contact | European researchers and SMEs interested in the EPMD program could contact the Program Director, Jennifer McKinley. |
| Email address | jennifer.mckinley@ucf.edu |
| Phone Number | N/A |
| Internet links | https://floridahightech.com/innovation-investments/research-grants/ |

[169] The National Nanotechnology Initiative - Supplement to the President's 2018 Budget, NNI, 2017
[170] https://floridahightech.com/innovation-investments/research-grants/



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# 6 Observations

The Market guide on nanotechnologies shows that the US is the global leader in the Nanotechnology industry in terms of R&D investments, as well as in terms of revenues towards nano-enabled products. As explained, Nanotechnology can be described within several stages of the industrial value chain. Thus, the Market guide focuses on the applications of nanotechnologies to products and services. Through this targeted analysis, the Market guide identifies a set of specific sectors within Nanotechnology application: healthcare, electronics & computers, energy, transportation, and aerospace. The application of Nanotechnology within these sectors has been growing and leading to higher revenue shares within the US market.

Through the analysis of the US innovation ecosystem, it was found there is a particularly high concentration of innovation hubs, facilitators, and industry-related RDI centers in the states of California, Massachusetts, New York, North Carolina, Illinois, and Texas. Due to the high number of sector applications in nanotechnologies, the analysis of the US Nanotechnology market is not obvious. Thus, there is a need to analyze specific segments within the identified sectors that are most likely to use Nanotechnology for developing their products or services. The segments considered for the analysis are as follows: Pharmaceutical and Medicine Manufacturing, Electronic Computer Manufacturing, Storage Battery Manufacturing, Painting and Coating Manufacturing and Aerospace Product and Parts Manufacturing. Within this context, the analysis of manufacturers within the different sectors identified California, Florida, Texas, and New York as the main states of Nanotechnology business development in the US. Other states such as Massachusetts, New Jersey and Illinois also have a particularly high concentration of manufacturers from the different segments.

In addition, as Nanotechnology is an area that is constantly advancing and innovating, it is highly recommended that EU researchers and industry representatives contact key US Nanotechnology-related networks and attend Nanotechnology events and conferences located in the US. Thus, this market guide provides a summary of some relevant networks and events that could be of support to EU researchers and industry representatives.

Regarding the US innovation initiatives and programs, the Nanotechnology area has been highly supported by public and private initiatives and programs. At the US federal level, the Nanotechnology innovation and R&D actions are managed under the NNI, which involves 20 departments and independent agencies at the US national level. At the private level, there is funding available through different institutions spread around the country, and normally with a state-level focus. This private funding acts as a complement to the R&D funding available through the NNI. Although there are several programs and initiatives at both federal and private levels, it is important to note that information related to funds and grants for European representatives is difficult to find. In most cases, the European innovators and business representatives interested in US Nanotechnology-related



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initiatives and programs need to contact the program officers to know specific details about international eligibility.

In summary, the assessment carried out demonstrates there are several relevant EU-US innovation and business cooperation opportunities in the Nanotechnology area. Both regions consider Nanotechnology a priority and are highly committed to promoting innovation and investing in this area to improve the application of Nanotechnology in consumer products and processes.



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# Annex 1: Summary of the US Public and Private Funding Initiatives and Programs

**Table A1 - Summary of the US Public and Private Funding Initiatives and Programs**

| Agencies | Programs/ Initiatives | Responsible entities | Contact Info | Internet link |
|---|---|---|---|---|
| **Federal Initiatives and Programs** | | | | |
| National Science Foundation (NSF) | Nanoscale Interactions Program | NSF | NOSAVAGE@nsf.gov | https://new.nsf.gov/funding/opportunities/nanoscale-interactions-0 |
| | Electronics, Photonics and Magnetic Devices program (EPMD) | NSF | sbandyop@nsf.gov | https://new.nsf.gov/funding/opportunities/electronics-photonics-magnetic-devices-epmd-0 |
| Department of Health and | NIH Grants | NIH | Contact the point of contact identified in the FOAs | https://grants.nih.gov/grants/about_grants.htm |



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| Agencies | Programs/ Initiatives | Responsible entities | Contact Info | Internet link |
|---|---|---|---|---|
| Human Services (HHS) | National Institute for Occupational Safety and Health (NIOSH) - Nanotechnology Research Center (NTRC) | Centers for Disease Control and Prevention (CDC) | Contact the point of contact identified in the FOAs | https://www.cdc.gov/niosh/oep/funding.html |
| Department of Energy (DOE) | Energy Materials Network (EMN) | Advanced Research Projects Agency-Energy (ARPA-E) | Contact the point of contact identified in the FOAs. | https://arpa-e-foa.energy.gov/ |
| | EERE funding opportunities | EERE | Contact the point of contact identified in the FOAs | https://www.energy.gov/eere/funding/eere-funding-opportunities#open |
| | High Performance Computing for Manufacturing (HPC4Mfg) | EERE | hpc4mfg-submissions@llnl.gov. | https://hpc4mfg.llnl.gov/ |
| Department of Defense (DOD) | Rapid Innovation Fund (RIF) | DOD | Contact the point of contact identified in the FOAs. | https://defenseinnovationmarketplace.dtic.mil/business-opportunities/rapid-innovation-fund/ |



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| Agencies | Programs/ Initiatives | Responsible entities | Contact Info | Internet link |
|---|---|---|---|---|
| **State Initiatives and Programs** | | | | |
| Florida High Tech Corridor Council | Corridor's Matching Grants Research Program | Florida High Tech Corridor Council | matchinggrants@research.usf.edu | https://floridahightech.com/innovation-investments/research-grants/ |



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