



Kingdom of the Netherlands



# Sector study on Nanotechnology

in Turkey and the Netherlands for increased collaboration



■ ■ Prepared by: E-Co Consulting & Coaching  
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## GLOSSARY OF INSTITUTIONAL ABBREVIATIONS AND ACRONYMS

|                |   |
|----------------|---|
| <b>ARBIS</b>   | Researcher Information System                                     |
| <b>HTSM</b>    | Centre of Expertise High Tech Systems & Materials                 |
| <b>KOSGEB</b>  | Small and Medium Enterprises Development Organization of Turkey   |
| <b>OECD</b>    | Organisation for Economic Co-operation and Development            |
| <b>SUNUM</b>   | Sabancı University Nanotechnology Research and Application Centre |
| <b>TRL</b>     | Technology Readiness Level  |
| <b>TUBITAK</b> | The Scientific and Technological Research Council of Turkey       |
| <b>UNAM</b>    | National Lab at Bilkent University                                |
| <b>WIPO</b>    | World Intellectual Property Organization                          |
| <b>WOS</b>     | Web of Science  |

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# MANAGEMENT SUMMARY

Nanotechnology concerns with the study and use of matter at the supramolecular scale for commercial and research purposes. The U.S. took the lead with launching the first government programme in aid of research around the technology, soon followed by other G20 countries. Global nanotechnology industry was valued at \$5 billion in 2021 and is forecasted to reach \$23.6 billion by 2026 with an extremely high growth rate of 35.5% between 2021-2026. Although Turkey has caught up with modern countries in terms of academic excellence, the country was still a decade late in building up its research capabilities and struggling to realise its full potential, which can be further fostered by creating demand for nanotechnology solutions in the private sector.

The Netherlands, on the other hand, is ranked fourth in Europe for public investment in the nanotechnology sector, just behind the United Kingdom, Germany, and France. There are several consortia being funded for the sole purpose of improving cooperation between research centres, and incentivising commercialisation both in the Netherlands and Turkey. Governments are announcing further grant schemes to incentivise entrepreneurs, due to the sector's high capital cost and relatively long payback period. In 2021, TUBITAK announced TUBITAK 1004, a funding programme specifically targeted towards supporting SMEs working on nanosensors or scalable nanostructured technologies. Low cost of labour, high academic quality and supportive innovation ecosystems make Turkey an ideal location for foreign entities to invest in nanotechnologies as a trial before replicating commercialised products in costlier economies, therefore minimising their risks.

The recommendations in this report are based on both secondary and primary research –for the latter, we performed eight interviews in total, five within the Turkish nanotechnology sector, and three within the Dutch nanotechnology sector. The interviews with the Turkish contacts yielded similar findings to our secondary research, confirming our desk research.

The qualitative analysis of the interviews shows that both countries have capable research centres, highly skilled workforce, and supportive government systems. However, long payback periods, high initial investment and patent races are overarching factors threatening the nanotechnology sector in both countries. Additionally, brain drain is a considerably high threat to Turkey in terms of human resources. In the presence of these threats, there are sector-specific weaknesses such as lack of synergy between research centres, commercial demand, and key specificity in research areas. Distrust in local technologies and research dependency on imports for raw material are indicated as other weaknesses in the Turkish nanotechnology sector.

However, these threats can be overcome by strong incentive schemes and operating costs that are relatively low compared to that of Western Europe. The nanotechnology sector presents untapped opportunities in the commercial sector, with growing interest from venture capitalists and lack of monopolies. In the light of these findings, there are specific collaboration areas & opportunities between the Netherlands and Turkey in the fields of energy (solar power, flexible displays and sensors), agriculture & environment (wastewater treatment technologies), and health.

# 1

## INTRODUCTION

The following report is prepared by E-CO Consulting & Coaching for the Netherlands Innovation Network Turkey, part of the Consulate General of the Kingdom of the Netherlands.

The purpose of the report is to understand the progress made thus far in the nanotechnology sector in Turkey, the key factors involved in its success, the key actors, as well as the opportunities and challenges faced by the sector in the past, present, and possibly in the future. The report highlights the possible opportunities where collaboration between the two countries is possible in academics and commercial fields. It lays the foundation for a strategic plan for the Netherlands Innovation Network to position itself with relevant institutions and organisations in the Netherlands and Turkey.

In the 2000s, many countries in the world including the USA, Russia, Japan, Germany, China, South Korea, the Netherlands, and Greece established nanotechnology clusters to maximise their benefits from this fast-growing market. Currently, new products with enhanced properties are on the market from a broad range of players in consumer electronics, packaging, composites, biomedicine, healthcare, and coatings. Amid the COVID-19 crisis, the nanotechnology industry was valued at \$5.5 billion in 2021 and is forecasted to reach \$23.6 billion by 2026.

The Ministry of Industry and Technology in Turkey, in collaboration with universities, private sector, public institutions and research centres put forth the Nanotechnology Strategy and Action Plan for 2017-2018. The strategy focussed on improving the R&D infrastructure for nanotechnology and the use of nanotechnology by small- and medium-sized companies.

Turkey has attempted to integrate the results of the 2017-2018 Action Plan on nanotechnology into its technology development strategy by including it in the 'Vision 2023' strategy document (Çalıpınar & Ulaş, 2019). It defines nanotechnology as 'a field that has the power to radically change human life and economic activities with new products and markets that it will create in the next 10-15 years' and put forward a nanotechnology roadmap in line with these objectives. Nanotechnology is relatively well-funded by the Turkish government, with nanotechnology research centres having received most of the funding for the establishment of national R&D centres of excellence. A notable example would be the establishment of UNAM, which got awarded 28 million TRY for procurement of nanotechnology equipment by the National Planning Organisation (DPT). SUNUM, the nanotechnology research centre affiliated with Sabanci University, was established in 2010 with a 35 million USD investment from the Ministry of Development as well as the Sabanci Foundation.

Turkey has an advantageous position in nanotechnology, contributing to international literature with a growing number of articles. Turkey is currently ranked 25th in the number of nanotechnology articles published in the Q1 journals. Moreover, a high number of investments have been made to establish new research facilities and improve research infrastructure in the country. R&D spending has increased from 0.54% of GDP in 2001 to 1.09% of GDP in 2019, aimed to reach to 3% by 2023. Turkey sees nanotechnology and nanomaterials as key enablers for technology development and subsequent economic growth

## 1.1

# Data and Methodology

This report is prepared using a methodology involving desk research (secondary research) and qualitative analysis compiled and performed by the E-CO Consulting & Coaching team. The desk research compiled from numerous sources is referenced in the bibliography section. For primary research, we contacted both academic and commercial professionals in the nanotechnology sector in Turkey and the Netherlands, to understand first-hand their experiences and views regarding the opportunities and challenges faced by the sector. The process involved contacting relevant professionals first, then sending the interview questionnaire so that they could have time to prepare beforehand, to compile more comprehensive answers.

The descriptive analysis in the report can be divided into three parts: the first two being the individual analysis of the nanotechnology sector in Turkey and the Netherlands, and the third being the identification of the opportunities and challenges in both countries to highlight the fields where collaboration is possible and ideal to utilise local opportunities. In the individual analysis, we analysed the historical milestones, as well as the sector statistics, government policies, grant and incentive systems, and key industry players and institutions involved. The third part comprises benchmarking and identifying patterns and trends in the sector that lead to the challenges and the opportunities seen in the collaboration areas in Turkey and the Netherlands.



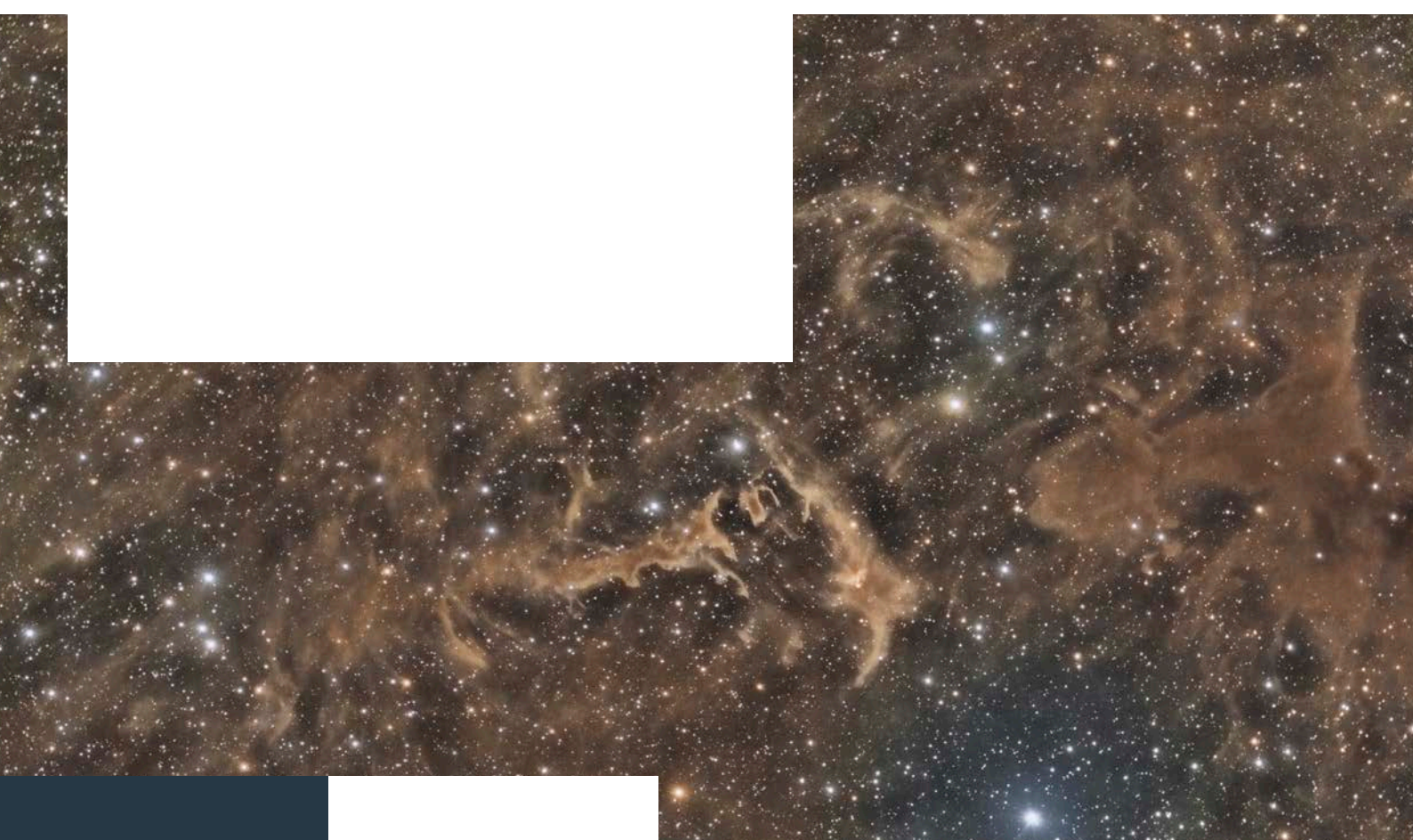
# 2

## Desk Research: Sector Analysis

### 2.1 General Description of the Nanotechnology Sector in Turkey

#### 2.1.1 Historical Milestones

Nanotechnology is the science of controlling and manipulating matter at the atomic and molecular level. In general, it is a set of techniques conducted in very small sizes (e.g., 1 nm = one billionth of a metre) to alter the compound structure of the substance studied and achieve a certain feature. The beginning of the 21st century saw important advances in the use of nanotechnology in fields such as medicine, biotechnology, computer technology, aviation, energy, space, materials, and manufacturing. The National Nanotechnology Initiative, the first official government programme aimed at increasing the speed of research, development, and commercialisation activities in the field of nanotechnology, was launched in the United States in 1999. In 2001, nanotechnology studies were included as a priority area in the European Union Framework Programme. Japan, on the other hand, is one of the leading Asian countries that invests in R&D of nanotechnology, ranking second after the USA, followed by China and South Korea. Most of the studies carried out in China focus on semiconductor manufacturing techniques and nanotechnology-based electronic devices, while South Korea conducts research on microelectronic applications and microelectromechanical systems (Roco, 2011). Aiming to take part in the nanotechnology revolution that started in the mid-20th century, Turkey has increased its investment in research in this field, supporting studies in sectors such as paint-coating, technical textiles, chemicals, automotive, construction sector, materials, and polymer composites (Körözlü, 2016). It seems that nanotechnology will continue to play a major role in the discovery of new components and the development of existing technologies, maintaining its place in science in the future.



## 2.1.2 Statistical Highlights

Countries worldwide have prioritised and allocated high budgets to nanotechnology –worldwide nanotechnology R&D expenditure, which was 8.6 billion USD in 2004, increased to 13.8 billion USD in 2010 (Palmberg, 2009). The European Union placed particular importance on nanotechnology within the framework of Horizon 2020, having allocated a budget of over 13 billion EUR for ‘Facilitators and Industrial Technologies’

Between 2003 and 2011, 244 million USD (approximately 30 million USD annually) was invested in nanotechnology research centres in Turkey, which received funding for the establishment of national R&D centres of excellence. UNAM was awarded 28 million TRY for the procurement of nanotechnology equipment by the National Planning Organisation (DPT). SUNUM, the nanotechnology research centre affiliated with Sabanci University, was established in 2010 with a 35 million USD investment from both the Ministry of Development and Sabanci Foundation. In addition, nanotechnology projects and start-ups receive support from public institutions such as TUBITAK. However, it is observed that the total amount of support is below the OECD average (DPT, 2010).

## 2.1.3 Government Policies & Strategies

Considering the developments in the world in nanotechnology, it is of great importance to expand and diversify the studies initiated in this field in Turkey. Turkey’s main aim is to level up and compete in this technology through various national programmes and investments. Another important aim is to follow the progress in academic studies carried out by public and private institutions and organisations, and to work in coordination with universities for the development of nanotechnology. Theoretical and experimental scientific studies in the field of nanotechnology have started in Turkey in the 2000s, ushering not only critical applications, but also a new perspective to old technologies in Turkey.

The policies and sectoral strategy plans in Turkey mutually aim for innovative production and stable, sustainable, and high growth of the economy. The ‘Vision 2023’ strategy plan, one of the first instances where nanotechnology was addressed in Turkey, defined nanotechnology as a field that ‘has the power to radically change human life and economic activities in the next 10-15 years with new value-added products and services it will create’. Following areas are considered as strategic technology areas in Turkey:

- Nanophotonics
- Nanoelectronics
- Nanomagnetism
- Nanomaterials
- Nanocharacterisation
- Nanofabrication
- Quantum computing at the nanoscale
- Nanobiotechnology


**Table 1: Technology Area, Policy and Strategic Aims**

| Technology Area      | Policy                              | Strategic Aims   |
|----------------------|-------------------------------------|--|
| Nanophotonics        | Basic Research                      | Development of unique products and systems containing nanostructures   |
| Nanoelectronics      | Application and Industrial Research | To be an international manufacturing centre for integrated circuit systems containing nanostructures                               |
| Nanomagnetism        | Industrial Development              |  |
| Nanomaterials        | Basic Research                      | Development and production of multifunctional nanocomposite materials  |
|                      | Application and Industrial Research | Development and production of bio-nutrient materials and catalysts   |
|                      | Industrial Development              | Development and production of nanoelectronics and nanomechanical devices with self-assembly methods                                |
| Nanocharacterisation | Basic Research                      | Developing scanning tip microscopes and atomic force microscopes, and reaching proficiency in nanocharacterisation                 |
|                      | Application and Industrial Research |  |
|                      | Industrial Development              |  |
| Nanofabrication      | Basic Research                      | Reaching competency in fabrication methods to produce nanostructures and production of integrated circuits with these technologies |
|                      | Application and Industrial Research |  |
|                      | Industrial Development              |  |

\*Source: The 'Vision 2023' Strategy Plan

## 2.1.4 Grants and incentives

Incentives for nanotechnology investments are evaluated within the scope of the Turkish R&D law. The Law no 5746 on Supporting Research, Development and Design Activities entered into force in 2008, which provides tax support and incentives, valid until 2023. These can be utilised by technology centres, R&D centres (employing at least 50 full-time R&D personnel), R&D projects, pre-competitive cooperation projects, and for techno-enterprise capital support.

R&D Tax, Corporate Tax and Income Tax deductions are applied to all R&D and innovation investments. There are tax deductions for those employed in R&D –excluding public personnel in R&D centres, the income tax is only applicable to specific percentage of their wages:

- 5% for those holding a doctorate or at least a master's degree in one of the basic sciences
- 10% for those holding a master's degree or a bachelor's degree in one of the basic sciences
- 20% for others, accrual on withholding declaration

Paperwork related to all kinds of R&D and innovation activities are exempt from stamp tax. Half of the employer's share of insurance premium is deducted from the R&D allowance and supported for a period of five years.

Techno-enterprise capital support up to 100,000 TRY is provided as a one-time grant, without any guarantee, to those who meet the eligibility criteria. However, the sum of the payments cannot exceed 50 million TRY for each calendar year. Therefore, a maximum of 500 investors per year can benefit from this support.

In addition to these, there are 1501 - TUBITAK Industry and R&D Projects Support Programme, 1501 – TUBITAK SME R&D Start-up Support Programme, provided to private sector and entrepreneurial technology companies within the scope of national programmes (TUBITAK, KOSGEB). The 1501 programme provides grants to SMEs for project-based research and technology development, and innovation activities.

Research infrastructures with their own legal entity and the aim of specialising in a certain research field have been established and supported by the Presidential Office of strategy and budget under the Law no 6550, which benefitted nanotechnology as well. Nearly 7.4 billion TRY have been allocated for the establishment and development of research infrastructures. Under the Law no 6550, these research infrastructures have been further professionalised and are granted a five-year legal status with a performance-based contract that is monitored annually. Support beyond five years is subject to re-evaluation. In 2017, the first four research infrastructures were accredited within the scope of this law, three of which focussing on nanotechnology and related fields (Turkish Era Roadmap, 2022), listed in the table below:

| Research Infrastructure   | Research Area   |
|---|---|
| Bilkent University UNAM National Nanotechnology Research Centre   | <ul style="list-style-type: none"> <li>- Nanoscience</li> <li>- Nanotechnology</li> <li>- Material Science</li> <li>- Physics</li> <li>- Biology</li> <li>- Chemistry</li> </ul>  |
| Izmir Biomedicine and Genome                                      | <ul style="list-style-type: none"> <li>- Cancer</li> <li>- Genetics and Genomics</li> <li>- Biopharmaceutical Production and Characterization</li> <li>- Cellular Therapy</li> <li>- Immunology</li> <li>- Bioinformatics</li> </ul>                    |
| Sabancı University Nanotechnology Research and Application Centre | <ul style="list-style-type: none"> <li>- Nanotechnology</li> <li>- Nanomaterials</li> <li>- Life Sciences</li> <li>- Energy, Water and Environment</li> <li>- Food and Agriculture</li> <li>- Biotechnology</li> </ul>                                  |
| Middle East Technical University MEMS Centre                      | <ul style="list-style-type: none"> <li>- Image Sensors</li> <li>- Inertial Sensors</li> <li>- RF MEMS</li> <li>- Bio MEMS</li> <li>- Power MEMS</li> <li>- Vacuum Packaging</li> <li>- IC Design</li> <li>- New Areas</li> <li>- Fabrication</li> </ul> |

To align the Turkish Research Area with that of the European Research Area (ERA), TUBITAK has designed a support mechanism for transforming these research infrastructures into centres of excellence that can compete on a global level. These centres are obliged to engage in collaboration with the industry. Such research centres are expected to build consortia with industrial partners to stimulate the commercialisation of research results. The centres have an industry steering board, and are expected to enhance their international network, research capacity, and human resources.

## 2.1.5 Key Institutions


Researchers are interested in many fields of nanotechnology ranging from agriculture, engineering, medicine, electronics, textiles to space, which require an interdisciplinary approach, therefore bringing many scientists together. Although the number of researchers in this field in Turkey cannot be fully revealed as faculty members are working in other fields as well, TUBITAK's Researcher Information System (ARBIS) shows that 2,366 faculty members identified nanotechnology as their field of interest as of 2016.

**R&D activities in nanotechnology in Turkey:** Studies are carried out in research centres established within universities; in centres established with the support of public institutions (see the Law no 6550); and within the scope of undergraduate, graduate, and doctoral programmes in which researchers from various disciplines take part. The main aim of the studies carried out within research centres is to transfer scientifically developed new methods to the industry, thus contributing to the economy, especially important in terms of Public-University-Industry cooperation in Turkey. The research centres, where studies are conducted in the field of nanotechnology in Turkey, are shown in the table 2.



Although the number of researchers in this field in Turkey cannot be fully revealed as faculty members are working in other fields as well, TUBITAK's Researcher Information System (ARBIS) shows that 2,366 faculty members identified nanotechnology as their field of interest as of 2016.




**Table 2: Institutions and their respective research centres active in nanotechnology**


| University                           | Research Centre  |
|--------------------------------------|--|
| Adnan Menderes Üniversitesi          | Nanoteknoloji Uygulama ve Araştırma Merkezi  |
| Anadolu Üniversitesi                 | Seramik Araştırmaları Merkezi  |
| Anadolu Üniversitesi                 | Nanoboyut Araştırma Laboratuvarı   |
| Anadolu Üniversitesi                 | İleri Teknolojiler Uygulama ve Araştırma Merkezi   |
| Atatürk Üniversitesi                 | Nanobilim ve Nanoteknoloji Uygulama ve Araştırma Merkezi                                       |
| İhsan Doğramacı Bilkent Üniversitesi | Ulusal Nanoteknoloji Uygulama ve Araştırma Merkezi (Malzeme Bilimi ve Nanoteknoloji Enstitüsü) |
| İhsan Doğramacı Bilkent Üniversitesi | Hareket Algılayıcı ve Mikrosistem Teknolojileri Araştırma Merkezi                              |
| Boğaziçi Üniversitesi                | Yaşam Bilimleri ve Teknolojileri Uygulama ve Araştırma Merkezi                                 |
| Cumhuriyet Üniversitesi              | Nanoteknoloji Merkezi  |
| Çanakkale Onsekiz Mart Üniversitesi  | Nanobilim ve Nanoteknoloji Araştırma Merkezi   |
| Dokuz Eylül Üniversitesi             | Elektronik Malzemeler Üretimi ve Uygulama Araştırma Merkezi                                    |
| Dokuz Eylül Üniversitesi             | İleri Biyomedikal Ar-Ge Merkezi  |
| Ege Üniversitesi                     | Güneş Enerjisi Enstitüsü   |
| Erciyes Üniversitesi                 | Nanoteknoloji Araştırma ve Uygulama Merkezi  |
| Gazi Üniversitesi                    | Fotonik Araştırma Merkezi  |
| Gazi Üniversitesi                    | Nanotıp İleri Teknolojiler Uygulama ve Araştırma Merkezi                                       |
| Gebze Teknik Üniversitesi            | Nanomanyetizma ve Spintronik Araştırma Merkezi   |
| Gebze Teknik Üniversitesi            | Nanoteknoloji Araştırma ve Uygulama Merkezi(Nanoteknoloji Enstitüsü)                           |
| Hacettepe Üniversitesi               | Nanotıp Bilim Merkezi  |
| İstanbul Teknik Üniversitesi         | Mekatronik Eğitim ve Araştırma Merkezi   |
| İstanbul Teknik Üniversitesi         | Nano/Mikro Elektro Mekanik Sistemler Laboratuvarı  |

| University                       | Research Centre   |
|----------------------------------|---|
| İstanbul Teknik Üniversitesi     | Nanobilim ve Nanoteknoloji İleri Araştırmalar Merkezi                             |
| İstanbul Üniversitesi            | İleri Litografik Yöntemler Laboratuvarı   |
| İstanbul Üniversitesi            | Cerrahpaşa Nanoteknoloji ve Biyoteknoloji Enstitüsü                               |
| İnönü Üniversitesi               | Bilimsel ve Teknoloji Araştırma Merkezi   |
| İzmir Yüksek Teknoloji Enstitüsü | Uygulamalı Kuantum Araştırma Merkezi  |
| Koç Üniversitesi                 | Mikro-nano Teknolojileri Araştırma Merkezi (Yüzey Bilimleri ve Teknoloji Merkezi) |
| Marmara Üniversitesi             | Nanoteknoloji ve Biyomalzemeler Uygulama ve Araştırma Merkezi                     |
| Mustafa Kemal Üniversitesi       | Teknoloji Araştırma ve Geliştirme Merkezi   |
| Ömer Halisdemir Üniversitesi     | Nanoteknoloji Uygulama ve Araştırma Merkezi                                       |
| Orta Doğu Teknik Üniversitesi    | Güneş Enerjisi Araştırma Merkezi  |
| Orta Doğu Teknik Üniversitesi    | Merkez Laboratuvarı   |
| Orta Doğu Teknik Üniversitesi    | Mikro Elektronik Mekanik Sistemler Uygulama ve Araştırma Merkezi                  |
| Sabancı Üniversitesi             | Nanoteknoloji Uygulama ve Araştırma Merkezi                                       |
| Selçuk Üniversitesi              | İleri Teknoloji Araştırma ve Uygulama Merkezi                                     |
| TUBITAK                          | Marmara Araştırma Merkezi (Malzeme Enstitüsü)                                     |

\*Source: YÖK, 2016

## Ranking

We ranked institutions by their publication status on the Web of Science database, searching nanotechnology as keyword and Turkey as country. The search yielded 696 publications, which we then classified according to their corresponding institutions and calculated the total number of publications for each institution.

 **Table 3:**  
**Institutions ranked according to their publication status**

| University                       | Publication Status |
|----------------------------------|--------------------|
| Hacettepe University             | High               |
| Istanbul University              | High               |
| Istanbul Technical University    | High               |
| Ege University                   | High               |
| Middle East Technical University | High               |
| Sabancı University (SUNUM)       | High               |
| Yildiz Technical University      | High               |
| Ataturk University               | High               |
| Bilkent University (UNAM)        | High               |
| Gazi University                  | High               |
| Dokuz Eylul University           | High               |

\*Please see the complete list in Appendix 5.3  
(publication status compared to other institutions)

The number of Turkish patents in the field of nanotechnology were retrieved from the World Intellectual Property Organization (WIPO) database by searching nanotechnology as keyword and Turkey as country, obtaining 300 internationally registered patents.

 **Table 4:**  
**The number of nanotechnology patents by institution/organisation**

| Institution/Organisation*     | Count |
|-------------------------------|-------|
| Sabancı University (SUNUM)    | 21    |
| Istanbul Technical University | 12    |
| Yeditepe University           | 7     |
| Koc University                | 6     |
| Yildiz Technical University   | 6     |
| Arcelik Anonim                | 5     |
| Bilkent University (UNAM)     | 5     |
| Ege University                | 5     |
| Kuantag Nanoteknolojiler      | 4     |
| Bayer MaterialScience         | 4     |
| Ozyegin University            | 4     |
| Hacettepe University          | 4     |

\*Please see the complete list in Appendix 5.4

Both tables present a clear picture of the ability and success of the research centres in Turkey. When the publication and patent tables are compared, it is observed that some universities with high publications are not at the top of the patent list, which may point to insufficiency of their ecosystems for the commercialisation of scientific outputs.



## 2.1.6 Collaboration in the EU Framework Programmes

Since nanotechnology is a cross-cutting theme and often an enabler of other technological applications, it is difficult to determine where in the EU framework programmes specific Turkish institutions are or were active based on their research in nanotechnology. It is worth mentioning that Turkey fully participated in Horizon 2020 and is also participating in Horizon Europe.

It is seen that the European Research Council (ERC) grants are more often awarded to either Bilkent University/UNAM or Koc University's projects related to nanotechnology. Unfortunately, there were few EU framework projects on nanotechnology, where both Turkish and Dutch organisations worked together, thus requiring substantial improvement, considering there are currently no bilateral funding programmes between the Netherlands and Turkey.

International collaboration can be further facilitated through the EUREKA programme that stimulates international industrial innovation collaboration. The EUREKA XESC cluster is especially compelling for nanotechnology since it focusses on nanoelectronics, photonics, and other relevant research areas. It is also funded by Turkey and the Netherlands amongst other countries. XESC is the continuation of the two previous EUREKA clusters: PENTA, which focussed on nanoelectronics, and EURIPES2 on smart electronic systems. Turkish industrial partners such as Arcelik (Beko), Vestel, Tat Gida, Otokar and others were exclusively active in the latter, and it remains to be seen how they will be involved in XESC.

## Conclusion

Although Turkey belatedly caught up with trends in nanotechnology, the country currently has a well-defined national strategy that is supported by various national support mechanisms focussing on basic research as well as entrepreneurship. Policies regarding developing national research infrastructures led to substantial investments in nanotechnology laboratories and research centres. Combined with the metrics of academic and entrepreneurial output, both UNAM and SUNUM, the nanotechnology research centres of Bilkent University (Ankara) and Sabanci University (Istanbul) respectively, are the most outstanding institutions for potential partnerships with Dutch institutions active in nanotechnology, followed by Middle East Technical University (Ankara), Istanbul Technical University and Koc University (for example its Surface Science & Technology Centre).



## 2.2 General description of the nanotechnology sector in the Netherlands

### 2.2.1 Historical Milestones

Nanotechnology is more than the buzzword it was a decade ago. Constant investment in research and publications has seen the sector through a complete revolution and allowed high returns similar to that of manufacturing industries. Social acceptance and safety regulation are in place, driving its further use in more daily processes. The Dutch government has always prioritised leading in cutting-edge technologies –it is with this attitude that the country has the seventh highest GDP per capita in Europe, higher than market giants like Germany and France. In line with their policies, the Dutch government has been heavily investing in material science since the 1970s and is similarly investing in nanotechnology as well. Between 2004 and 2010, public investment in the sector was mostly limited to the subsidies under the BSIK programme (government resolution on investment subsidies for knowledge infrastructure). In an assessment on nanotechnology carried out by the Rathenau Institute, the Netherlands was ranked fourth in Europe for public investment behind the United Kingdom, France, and Germany, and the ninth in the world.

The Netherlands is situated centrally when charted for nanotechnology activity and technology development strength, on a positive trajectory to becoming categorised as a leader in the future (see Exhibit 1 - Appendix). This trajectory is the result of constant commitment to establishing platforms for collaboration. First, NanoNed was introduced, a consortium of nine industrial and scientific partners with the total budget amounting to 235 million EUR funded by the Dutch Ministry for Economic Affairs (and Climate Policy). The Netherlands Nanotechnology Initiative (the successor to NanoNed) comprised 117 large, medium, and small-sized enterprises thirteen universities, six teaching hospitals and nine large technological institutes (Onderzoek Nederland 2009).

## 2.2.2 Statistical Highlights

The Dutch government was agile in identifying the potential in the nanotechnology sector early on. Nanotechnology is now used by many companies, especially large innovative companies in the Netherlands to differentiate their products by integrating it into their R&D departments and production processes, enabling them to be more efficient, reducing cost of production, and competing for market share in high-tech (ASML, Philips, NXP, Thermo-Fisher, ASMI and Malvern-Panalytical), food (Friesland Campina, Unilever, Danone), chemistry (DSM, Akzo) as well as healthcare, pharma and life sciences (Philips, Janssen Pharma, Roche, Galapagos). Currently the export potential of SMEs alone (with <250 full-time employees) is estimated to be greater than a billion euros. There are more than 8,000 employees working in nanotechnology-related high-tech SMEs that would not have existed without the advancement in the nanotechnology sector.

## 2.2.3 Government Policies & Strategies

Nanotechnology has been declared a priority by the Dutch government. The nanotechnology ecosystem is well equipped in the Netherlands and well connected within Europe as well. It has been built over the last decade thanks to strong collaboration between public and private stakeholders, most of which are part of MinacNed and well connected with larger industrial partners. These key players cluster under Nano4Society, a collaborative ecosystem focussing on addressing challenges in agri-food, health, energy, and security through nanotechnology.

These players work closely with NanoLabNL, which sets up most of the research infrastructure needed for the ecosystem. NanoLabNL is a network of laboratories that is the de facto national facility for the use of universities, research institutes, start-ups, and the industry. This facility seems to echo the Turkish efforts to build a network of research infrastructures and national centres of excellence. NanoLabNL focusses on the following technologies: characterisation/metrology, etching, deposition, integration, lithography, and materials/growth.

Currently, initiatives such as Quantum Delta, an ecosystem established to develop and research quantum computing, received major national funding to further develop quantum technology and its ecosystem. Other initiatives such as Photondelta, an ecosystem driving the development and application of integrated photonic chips, are actively seeking international partners to collaborate with.

High-tech SMEs, which can carry out multi-disciplinary projects in cooperation with information institutions, large companies, and social organisations, constitute the second driving force of the sector's growth.

## 2.2.4 Grants and Incentives

The Netherlands is financing three programmes regarding nanotechnology:

1. Microsystems, materials science, and microelectronics
2. Electronic devices, circuits, and systems
3. Molecular nanotechnologies

 **Table 5:**  
**Grants awarded in nanotechnology between 2020-2023**

| Million Euro  | 2020 | 2021 | 2022 | 2023 |
|---|------|------|------|------|
| Industry <sup>1</sup>   | 140  | 150  | 160  | 170  |
| TNO<br>(The Netherlands Organisation for Scientific Research) | 4    | 4.5  | 5    | 5    |
| NLR   |      |      |      |      |
| NWO<br>(The Dutch Research Council) <sup>2</sup>              | 25   | 25   | 25   | 25   |
| Universities/UAS  | 20   | 20   | 20   | 20   |
| Departments and regions                                       | 15   | 15   | 15   | 15   |
| Grand Total   | 200  | 210  | 225  | 235  |

\*1. Investment in SMEs (<250) is M€100, with a yearly increase of 10%. About 10% is available for PPP.

\*2. The NWO budget will be granted based on projects through different NWO grant schemes, in competition with other fields. The budget is based on historic trends in the distribution of projects that have been awarded as well as the research themes in this roadmap in comparison to others.

Source: Dutch Roadmap Nanotechnology (2020, p. 12)

## 2.2.5 Industry Players and Key Institutions

Nanotechnology has a history involving various partners, partly due to the research programmes such as NanoNedNL, NanoNextNL and MicroNed. A selection of the partners is listed below:

 Table 6:  
Industry Players and Key Institutions

|                              |  |
|------------------------------|--|
| (Nanotechnology) initiatives | NanoNed, NanoNextNL, MinacNed, NanoLabNL, TopFIT, OnePlanet, hDMT (organ on a chip), HighTech to Feed the World (HT2FtW)   |
| Knowledge institutes         | 4TU (University of Eindhoven, Twente University, Wageningen University, University of Delft), Radboud, RUG, AMOLF TO2 institutes (TNO, Holst Centre, QuTech, etc.), Saxion, Fraunhofer, RIVM |
| Governments                  | Holland High Tech, HTSM, Ministries, RVO, ROM's, Chamber of Commerce   |
| Private organisations        | Companies: MinacNed and NanoNextNL, like ASML, Friesland Campina, Lionix, Micronit, NXP, Malvern Panalytical, Philips, Shell, Thermo Fisher Eindhoven, Unilever, 90+ MKB                     |

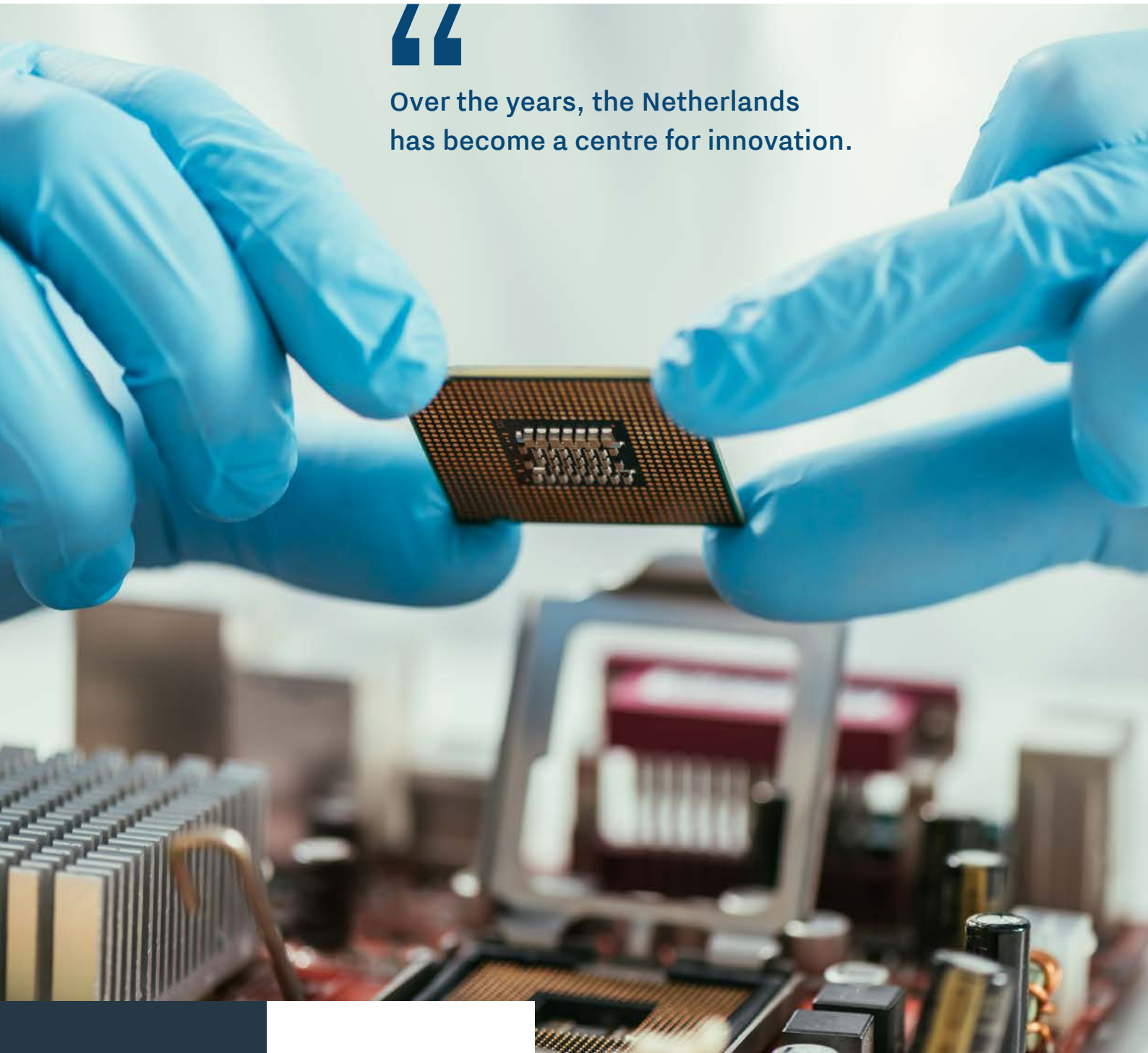
Source: Dutch Roadmap Nanotechnology

## 2.2. The Netherlands's Position in the World

Over the years, the Netherlands has become a centre for innovation. Often called the 'Silicon Valley of embedded systems and nanotechnology', the Netherlands leads in high-tech equipment, components and materials, home to the R&D facilities of international sector giants like Philips, Bosch, Boeing, Fujifilm, Smith & Associates, BrainCorp, and ASML. The Netherlands also boasts numerous robust public-private partnerships and collaborative R&D ecosystems. The government believes in that "innovation creates opportunities" and has thus derived the concept of top sectors –once identified, special incentive schemes and collaboration efforts have been introduced to further encourage innovation and commercialise ideas into successful technologies.



Over the years, the Netherlands  
has become a centre for innovation.



# 3

## Challenges and Opportunities

### 3.1 Trends in the Nanotechnology Sector

The most applied areas of use in the field of nanotechnology around the world are as follows:

#### Nanobiotechnology

Nanobiotechnology is the application of nanotechnologies in biological fields. Chemists, physicists, and biologists view nanotechnology as a sub-field, open to collaboration and contribution from their respective fields i.e., the hybrid field of nanobiotechnology uses biological starting materials, biological design principles or has biological or medical applications.

#### Nanoelectronics

The term nanoelectronics refers to the use of nanotechnology in electronic components, which are often only a few nanometres in size. However, the smaller electronic components are, the harder they are to manufacture.

#### Nanocensors

The term nanosensor is not clearly defined. Most definitions refer to a sensing device (with at least one dimension smaller than 100 nm) to collect information at the nanoscale and convert it into data for analysis.

Nanosensors are not necessarily reduced to nanoscale but could be larger devices that make use of the unique properties of nanomaterials to detect and measure events at the nanoscale. For instance, nanostructures of smaller size than the de Broglie wavelength for electrons in noble metals such as silver or gold cause intense absorption in the visible/near-UV region that is absent in the spectrum of the bulk material.

#### Food and Agriculture

Combined with nanotechnology, food engineering provides opportunities previously not thought of. Genetically Modified Seeds can be further specialised to increase yield, with improved resistance to different environmental challenges including pests and extreme weather conditions.

#### Energy

Nanotechnologies provide the potential to enhance energy efficiency across all fields of the industry and leverage renewable energy production through new technological solutions and optimised production technologies. Nanotechnology innovations could impact every single part of the value chain in the energy sector: energy sources, energy conversion, energy distribution, energy storage, and energy usage.

#### Nanomedicine

Nanomedicine is the comprehensive monitoring, control, construction, repair, defence, and improvement of all human biological systems, working at the molecular level, using engineered nanodevices and nanostructures. It is the science and technology of diagnosing, treating, and preventing disease and traumatic injury; relieving pain, and preserving and improving human health, using molecular tools and molecular knowledge of the human body. The molecular machine systems can be used to address medical problems, utilising molecular knowledge to maintain and improve human health at the molecular scale.

## 3.2 Challenges and Opportunities in the Turkish Nanotechnology Sector

We conducted a series of interviews with industry experts across academic and commercial players to understand the nanotechnology sector's challenges and opportunities.

The Managing Director at Quantag Nanotechnologies understands the ins and outs of the nanotechnology sector. He indicated an increased interest from multiple venture capitalists in RS Research, a start-up developing nanotechnology-based drug delivery platforms. The start-up received a funding of 12 million USD in a Series A investment round, led by GEN Ilac in December 2021. The investor acknowledged the opportunity of high returns from investing in this technology sector. One would assume that this high return would be enough to spring a sudden wave of investment, but the sector has very high maintenance and capital cost, resulting in a long payback period and making a longer breakeven point. Turkey already has ample supply of highly skilled human resources, but this is a double-edged sword – brain drain is evident due to lack of opportunities in the commercial market. Patents are hard to obtain and there is always a risk of others winning the race to land the first patent. Quantag Nanotechnologies commercialised its first product in 2000 and currently holds more than fifteen patents. The company develops tagging products by using quantum dots, with applications in industries such as oil and security.

Another commercial perspective comes from the Chief Technology Officer at Nanografi Co. Inc. The company was established in 2011 as a start-up and finalised a commercialised product by the second half of 2014. The company produces nano and micro particles such as Graphene, Fullerene, Carbon Nanotubes as well as 3D printer materials. According to the company, the Turkish government is very supportive of start-ups and has launched several funding programmes specifically geared towards nanotechnology. For example, Nanokomp, an R&D start-up producing thermoset-based prepreg tapes and composite rods, was funded by ITU ARI Teknokent and TUBITAK.

TUBITAK established the 1004 grant programme for nanosensors and functionalised, scalable nanostructure technologies in February 2021. The nanotechnology sector is an industry fit for investment because of the current lack of any monopolies. 'Creating and commercialising products is difficult', the CTO stated. One of the great challenges that companies see in the nanotechnology sector is the lack of local demand from the private sector due to companies leaning towards intermediaries and exporting their products. Another challenge that companies face is the increased dependency on importing raw material, which renders their business model vulnerable to macroeconomic changes. Nanografi is exporting 97% of their production volume, indicating the lack of local commercial demand.

There are numerous research projects with a TRL (Technology Readiness Level) of 3-6, thanks to government support and incentive systems as well as effective research centres established by different Universities, an example of which is SUNUM (Sabancı University Nanotechnology Research and Application Centre). The director of SUNUM reflected on the opportunities and challenges currently faced by the nanotechnology sector. One opportunity is that Turkey is strategically and geographically well-placed as the low labour cost makes Turkey a great testing site to trial technologies. As for the sector's challenges, she highlighted lack of trust in local ideas as well as preference over foreign research and ideas, and reservation towards local researchers. This misconception needs to be addressed for the sector to fully thrive while international collaboration can further add credibility to research publications. There is a need to focus on more niche areas, and cooperation must be incentivised to provide synergy among the research centres. Fortunately, there are steps taken already to improve cooperation, e.g., the 'Strategic Research Partnership', a collaboration agreement that Hacettepe University signed with Bilkent UNAM in 2017. Similarly, SUNUM and UNAM signed a collaboration agreement in 2019 to develop synergies between research programmes and allow use of infrastructure. According to the SUNUM's partnership map, SUNUM, UNAM and Hacettepe University can carry out national academic studies as project stakeholders.

\*3 <https://sunum.sabanciUniversity.edu/partnerships>



The factors that support and increase technology-based entrepreneurship in nanotechnology are academic studies of nanotechnology, commercialisation structures, and R&D support mechanisms in Turkey. Some examples include:

- Nanodev Scientific is an UNAM spin-off company that manufactures advanced optical and biomedical characterisation devices. Nanodev's revenues come from a wide range of high-tech products including surface plasmon resonance systems, biomedical detection systems, and advanced microscopes.
- E-A Teknoloji Ltd is an UNAM spin-off company established in 2010. E-A Teknoloji enjoys success in producing and marketing medical optical fibres for endovenous laser operations. Optical fibres have long been used in the treatment of varicose veins, usually produced in European countries.
- Grafen Co fabricates carbon-based nanomaterials for application in a wide range of materials to enhance their thermal, electrical, mechanical, and chemical properties. The start-up raised 12 million USD in a Series A funding round.
- RS Research develops nanotechnology-based drug delivery platforms. Its proprietary platform uses 'plug-and-play' nanocarriers for the targeted delivery of drugs. Its pipeline includes candidates for non-small cell lung cancer, bone cancer, breast cancer and ovarian cancer. The start-up received a funding of 12 million USD in a Series A investment round led by GEN Ilac in December 2021.
- Funded by Plug and Play Tech Center, IGNIS manufactures fire retardant nano-capsules that burst and release extinguishing agents after encountering fire. The nano-capsules are claimed to be self-activating, adhesive, and human-friendly.
- Funded by ITU ARI Teknokent and TUBITAK Nanokomp provides research and development to produce thermo-set-based prepreg tapes and composite rods.



As well, postgraduate programmes, research centres and Technology Transfer Offices within universities ensure the continuous development of the nanotechnology sector in Turkey. The opportunities laid out within the scope of Turkey's Nano technology Strategy and Action Plan (2017-2018) are as follows:

- Increasing funding opportunities
- Carrying out nanotechnology studies
- Engaging in the intermediate products market
- Utilising international researchers
- Exploring the Middle East market
- Implementing reverse brain drain policies

- Since this action plan
- TUBITAK has launched the funding programme 1004 for funding nanotechnology research,
  - Research centres' nanotechnology publication and patent output have increased,
  - The government launched the International Leader Researchers Programme.

Nanotechnology is trending in the scientific and applied fields in Turkey and the world, included as a priority area in the former's strategy plans and roadmap. The challenges of the sector include that the use of risk capital is not wide spread; national companies are unable to compete with international companies, and the production process of nanotechnological products is heavily dependent on foreign countries.

Another interview is conducted with the representative of Arcelik, which is the largest manufacturing company in Turkey. It is stated that although Arcelik has ample financial resources, for the low level TRL products, the company still needs national & international grants due to high risk, while participating in such consortia has long term benefits for the company in terms of future collaboration opportunities. Arcelik participated in four nanotechnology projects as part of the EU's 7th Framework Programme, and three H2020 projects. In a H2020 project titled 'Biobased self-functionalised self-reinforced composite materials based on high performance nanofibrillar PLA fibres', Arcelik collaborated with Universiteit Maastricht from the Netherlands as well as other international public and private entities.

In another H2020 project titled 'New generation of nanoporous organic and hybrid aerogels for industrial applications: from the lab to pilot scale production', Arcelik joined forces with Koç University (Turkey) in a consortium headed by Technische Universitat Hamburg (Germany). In the previous 7th Framework Programme, Arcelik collaborated with PROMOLDING BV from the Netherlands in a project on new biomass-based composite materials and their processing. In another one, Arcelik collaborated with Alfa Polimer Inovasyon Plastik Sanayi ve Ticaret to develop halogen-free flame retardant materials, as part of the 7th Framework Programme.

### 3.3 Challenges and Opportunities in the Dutch Nanotechnology Sector

In addition to secondary research, interviews were held with academic professionals to identify opportunities and challenges present to innovators.

The Dutch government has excelled in the incentive system they built to enable the commercialisation of publications and thus fostering successful start-ups. In one of our interviews with TUE, it is stated that there is a possibility for projects to acquire almost seven years of funding for infrastructure and employees. The programme NanonextNL itself has a pool of 200 million EUR. In total, the grant pool (including government sponsored incentive schemes) exceeds over one billion euros including tax rebates, grants, and other deductibles. Nanonextnl programme has been reorganised as the Nano4Society programme, which utilises nanotechnology for developing solutions to address major social transitions and creating social impact and economic value in the field of care, security, energy, agriculture, water, and food.

The sector does come with its challenges, with policies and standards on sustainability so high. The toxic waste that is produced in nanotech production and research is a major hurdle that in turn requires further investment in safety protocols and waste protocols. The investment in machinery and high labour costs are already high, therefore it is crucial to manage investors' expectations. The sector offers high returns but on a very high capital cost, meaning the payback period is relatively longer compared to other industries. Human capital is a challenge as well, where the Netherlands has substantial gaps in the active workforce of the high-tech industry.



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## 3.4 Collaboration Areas in Turkey and the Netherlands

According to HTSM's (Centre of Expertise High Tech Systems & Materials) report (November 2020), there are four main themes outlined by the Netherlands on nanotechnology, all of which are compatible with the European Green Deal:

1. Health and health services
2. Energy and sustainability
3. Agriculture, water, and food
4. Security

### Healthcare

- Personalised medication with lab/organ on a chip enabled by nanofabrication and microfluidics technology
- DNA analysis and synthesis techniques through nanopores and nanomachines;
- Self-management by (home) health monitoring enabled by nanotechnology detectors (wearables, insideables, disposables), developed by nanophotonics and nanoelectronics
- Animal as well as animal-free testing for drug development enabled by nanotechnology
- Organ on a chip
- Targeted drug delivery through nanofabricated particles and needles
- Enhanced (medical) imaging by nanoparticles and detectors with higher resolution through nanofabrication
- Virus (SARS COV-2) related research, such as virus detection, antibody research, drug delivery and vaccine development through nanomaterials, nanophotonics, and microfluidics

### Energy and Sustainability

- Energy conversion through nano-electrochemistry and nano-structured surfaces
- Batteries and solar cells powered by nanolayers, nanomaterials and nano-patterned surfaces; -CO<sub>2</sub> capture through nanomembranes
- Low energy consumption electronics (Green ICT) enabled by next-generation electronics and photonics

## Agriculture, Water and Food

- Sustainable food production and monitoring of food products through nanosensors
- Modulation of the properties of ingredients at the nanoscale
- Efficient absorption of food, management of allergies and digestive problems by understanding food body interactions at the nanometre scale, and 3D nano-printing
- Water filtration by means of membranes through nano-patterns and structures
- Environmental monitoring by nanotechnology-based sensors (drugs, pollution, viruses, etc.)
- Remote sensing by drones and satellites through nanotechnology-based sensors

## Safety

- Quantum computing and encryption enabled by qubits built with nanofabrication (new materials, new patterns, new architectures) and nanoscale connectivity & electronics
- Data storage technology (DNA encoding) through nanofabrication, and readout by nanosensors such as nano-molecular motors
- Safe-by-Design: risk management, risk analysis and toxicity of nanotechnology
- Forensics research through nanotechnology-based sensors

## Nanotechnologies in the Netherlands can roughly be divided into:

- Nanofabrication and testing infrastructure
- Nanomanufacturing
- Nano inspection and metrology
- Nanomaterials, processes, and principles
- Software, control, and algorithms for nanotechnologies

The Turkish Nanotechnology Strategy and Action Plan (2017-2018) identifies the following obstacles to cooperation and coordination: a lack of coordination between the public, industry, and universities; hurdles experienced by small companies in reaching out to universities, and a lack of a virtual platform. At this point, Turkey needs to tackle these issues promptly to prevent further difficulties from arising in the nanotechnology sector.

## SUNUM - Specialised Research Areas

- Advanced materials
- Nanobiotechnology, nanomedicine
- Nanoelectronics, nano optics
- Micro/nanofluidics, micro/nano-electromechanical systems
- Renewable energy systems

## UNAM - Specialised Research Areas

- Nanophotonic devices
- Quantum materials, devices, and sensors
- Computational nanoscience
- Micro/nanofluidics and lab-on-a-chip systems
- Viscoelastic fluids and micro/nanoparticle migration
- Hemorheology and point-of-care diagnostics
- Computational and theoretical soft matter
- Novel therapeutics and diagnostics for Cardiometabolic Syndrome
- Micro Nano Integrated Fluids (MiNI) Research Laboratory
- Tumor immunology and microenvironment
- Nanoelectromechanical systems and microfluidic-integrated microwave sensors
- Ultrafast fibre lasers and nonlinear feedback-driven laser-material interactions
- Micro/nano-scale platforms for precision health

## Hacettepe University - Specialised Research Areas

- Bedside rapid diagnostic kits and lab-on-a-chip systems
- Nanomedicine applications
- Microfluidics
- Surface modification at the nanoscale
- Tactile sensors
- Magnetic nanomaterials
- Superconductivity and magnetism
- Spintronic devices
- Thin films

# 4

## Conclusion

It is apparent from the findings in this report that collaboration efforts should be directed towards nanotechnology applications in renewable energy, agri-food, and health as well as surface technologies and nanoelectronics. It would be recommended to initiate a dialogue between the Dutch and Turkish nanotechnology research communities to explore specific research topics and collaboration opportunities. The Dutch National Research Council (NWO) currently offers funding as part of the Dutch Science for Diplomacy Fund to Dutch research organisations for developing matchmaking activities with their Turkish peers, with calls usually opening in the first two months of the year. NWO has already pledged to organise a workshop together with its Turkish counterpart TUBITAK to identify specific topics of interest explore specific ways of collaboration (e.g., staff exchange, joint educational programmes, better coordination of consortium forming activities in EU framework programmes, viability of outsourcing laboratory work, potential for bilateral programming, etc.)

### 4.1 Overall Conclusion and Recommendations

Turkey has made massive leaps in academic research despite a late start. National centres of excellence that were set up under the Law no 6550, such as SUNUM and UNAM, are undertaking fundamental research and acting as incubators to start up ideas. Such national centres of excellence can also function as a soft-landing spot, as they are well-connected nationwide. In the meantime, the government is discerning the potential in the nanotechnology sector through new incentive schemes such as the TUBITAK1004, which was launched in February 2021. Although the number of grant recipients is low, it is thought to increase in the future.

The Netherlands, on the other hand, is making strides and continues to profit from its well-established framework for research and innovation. Home to many research and development centres of multinational companies, the country provides the best opportunity to fast-track ideas and technologies to be commercialised and incorporated in products to gain market edge. Therefore, the Netherlands offers prospects for Turkish nanotechnology start-ups in need of access to the European and/or the international market.

### 4.2 Potential Collaboration Areas

Thematic areas of collaboration can be found in renewable energy, agri-food, health as well as surface technologies and nanoelectronics, where further dialogue between Dutch and Turkish research institutes is needed to identify specific areas of collaboration. Moreover, other forms of collaboration can be explored as Turkish institutions deliver qualitative research at competitive prices. Further discussions should be initiated around staff exchange, joint educational programmes, better coordination of consortium forming activities in EU framework programmes.

Furthermore, Turkish nanotechnology ecosystems can utilise the Netherlands as their springboard towards European and international markets, for which institutional arrangements between Dutch and Turkish facilitators are strongly needed.

### 4.3 Instruments for Collaboration

A bilateral dialogue for collaboration can be initiated between NWO and TUBITAK, where the NWO Science for Diplomacy Fund can incentivise funding of matchmaking activities. NWO and TUBITAK have already agreed to organise a workshop to this effect, with preparations underway.

Moreover, it can be concluded that cooperation in the EU framework programmes is currently underutilised, which the aforementioned matchmaking workshop and activities could help align the Dutch and Turkish research priorities for collaboration in Horizon 2020. Other programmes, such as EUREKA and Eurostars, should be duly explored as well.

### 4.4 Final Words About Human Capital

Shortage in skilled workforce and brain drain have been identified as a challenge in the Netherlands and Turkey, respectively. Our final recommendation is initiating discussions around how the exchange and circulation of talent between the Netherlands and Turkey can be improved, rather than attracting Turkish talent to the Netherlands.



“

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## 5

# Bibliography

Bati Akdeniz Kalkinma Ajansi - baka.gov.tr. (n.d.). Retrieved November 26, 2021, from <https://www.baka.gov.tr/uploads/5187ar-gekanunutesvikleri.pdf>.

Benefits and applications. National Nanotechnology Initiative. (n.d.). Retrieved November 26, 2021, from <https://www.nano.gov/you/nanotechnology-benefits>.

Berger, M. (2021, July 2). Nanotechnology examples and applications. Nanotechnology. Retrieved November 26, 2021, from <https://www.nanowerk.com/nanotechnology-examples-and-applications.php>.

Calipinar, H., & Ulas, D. (2019). Development of nanotechnology in the world and nanotechnology standards in Turkey. *Procedia Computer Science*, 158, 1011–1018. <https://doi.org/10.1016/j.procs.2019.09.142>

Development of nanotechnology in the ... - sciencedirect.com. (n.d.). Retrieved November 26, 2021, from <https://www.sciencedirect.com/science/article/pii/S1877050919313134>.

Ec.europa.eu. (n.d.). Retrieved November 26, 2021, from [https://ec.europa.eu/programmes/erasmus-plus/project-result-content/fa99e2f2-8dc4-46ff-be46-ab650fbc33/ErasmusPlus\\_KA1\\_2020\\_LearningMobilityOfIndividuals\\_Projects\\_Overview\\_2021-11-23.xls](https://ec.europa.eu/programmes/erasmus-plus/project-result-content/fa99e2f2-8dc4-46ff-be46-ab650fbc33/ErasmusPlus_KA1_2020_LearningMobilityOfIndividuals_Projects_Overview_2021-11-23.xls).

ERC funded projects. ERC. (n.d.). Retrieved January 15, 2022, from [https://erc.europa.eu/projects-figures/erc-funded-projects/results?items\\_per\\_page=50](https://erc.europa.eu/projects-figures/erc-funded-projects/results?items_per_page=50)

European cooperations. PhotonDelta. (n.d.). Retrieved January 15, 2022, from <https://www.photondelta.com/engage-with-us/european-cooperations/>

Focus Areas & Technologies. NanoLabNL. (2021, March 7). Retrieved January 15, 2022, from <https://nanolabnl.nl/technologies/#misc>

High tech systems. NFIA. (2021, August 18). Retrieved November 26, 2021, from <https://investinholland.com/doing-business-here/industries/high-tech-systems/>.

The effects of nanotechnology ... - dergipark.org.tr. (n.d.). Retrieved November 26, 2021, from <https://dergipark.org.tr/tr/download/article-file/374979>.

Nano Science, Technology and Industry Information. STATNANO. (n.d.). Retrieved November 26, 2021, from <https://statnano.com/>.

Nanotechnology in a developing country – applications and ... (n.d.). Retrieved November 26, 2021, from [https://www.who.int/ifcs/documents/forums/forum6/ppt\\_nano\\_alo.pdf?ua=1](https://www.who.int/ifcs/documents/forums/forum6/ppt_nano_alo.pdf?ua=1).

Nanotechnology in the Netherlands: Market report - azonano.com. (n.d.). Retrieved November 26, 2021, from <https://www.azonano.com/article.aspx?ArticleID=3514>.

Nanotechnology. Nanotechnology | Holland High Tech. (n.d.). Retrieved November 26, 2021, from <https://www.hollandhightech.nl/nanotechnology>.

Ministerie van Economische Zaken, L. en I. (2020, September 10). Encouraging innovation. Enterprise and innovation | Government.nl. Retrieved November 26, 2021, from <https://www.government.nl/topics/enterprise-and-innovation/encouraging-innovation>.

PricewaterhouseCoopers. (n.d.). Türkiye'de Ar-Ge Ve Tasarım teşvikleri. PwC. Retrieved November 26, 2021, from <https://www.pwc.com.tr/turkiye-de-arge-ve-tasarim-tesvikleri>.

Programma krijgt 615 miljoen euro uit nationaal groeifonds. Quantum Delta NL. (2021, April 14). Retrieved January 15, 2022, from <https://quantumdelta.nl/quantum-delta-nl-programma-krijgt-615-miljoen-euro-uit-nationaal-groeifonds-2/>

Ranking the nations on nanotech: Hidden havens and false threats. Lux Research. (n.d.). Retrieved November 26, 2021, from <https://members.luxresearchinc.com/research/report/4832>.

Sabancı University Nanotechnology Research and Application Center (SUNUM). SUNUM. (n.d.). Retrieved January 15, 2022, from <https://sunum.sabancıUniversity.edu/hakimizda/vizyon-misyon>

XECS - Welcome. Xecs website. (2021, December 20). Retrieved January 15, 2022, from <https://eureka-xecs.com/>

Turkish Era roadmap. (n.d.). Retrieved January 15, 2022, from [https://era.gv.at/public/documents/4071/Turkish\\_National\\_Roadmap\\_on\\_European\\_Research\\_Area\\_May\\_2019.pdf](https://era.gv.at/public/documents/4071/Turkish_National_Roadmap_on_European_Research_Area_May_2019.pdf)

<https://www.yeyeagency.com/nanotechnology-in-turkey/>  
<https://www.azonano.com/article.aspx?ArticleID=3533>  
<https://statnano.com/country/turkey>  
<https://www.dailysabah.com/education/2019/03/30/new-program-brings-turkish-scientists-home>  
<https://www.techleap.nl/blog/global-startup-ecosystem-report-2021-key-takeaways-for-the-dutch-ecosystem/>

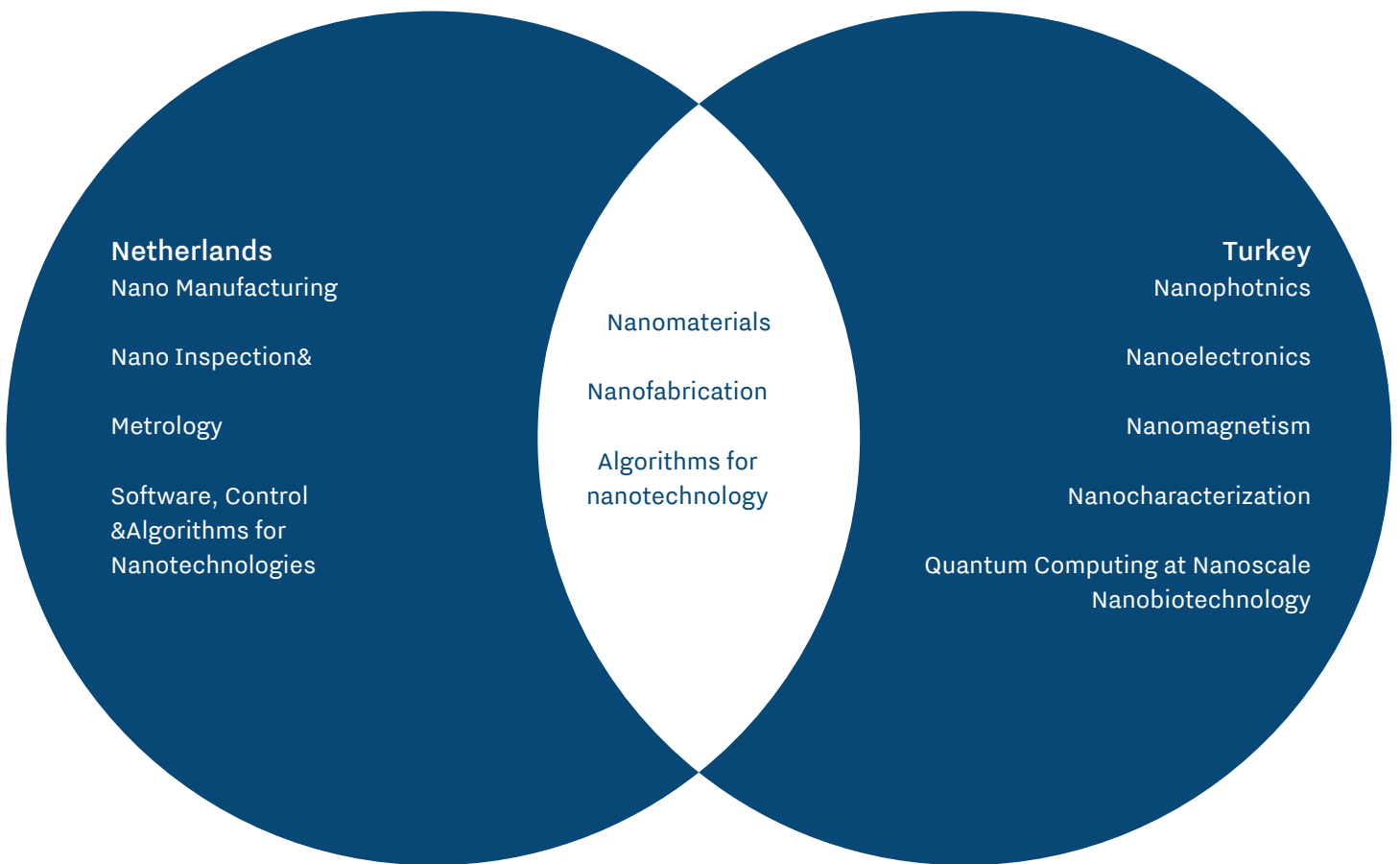
Collaboration in Nanotechnology, Retrieved January 17, 2022, from <http://unam.bilkent.edu.tr/en/2019/07/24/collaboration-in-nanotechnology/>

Turkey's Promising biotech startup raises \$12M in Series A Investment Round, Retrieved January 2017 2002 from <https://rsresearch.net/2021/12/17/0sabah/>

# 6

## Annexes

### 6.1 A Matrix Indicating the Collaboration Areas Between Turkey and the Netherlands



## 6.2 Nanotechnology Publications Count

| Institution   | Publication Count |
|---|-------------------|
| Hacettepe University  | 43                |
| Istanbul University Faculty of Engineering                            | 21                |
| Istanbul Technical University   | 20                |
| Ege University  | 16                |
| Middle East Technical University Department of Biology and Science    | 16                |
| Sabanci University Nanotechnology Research & Application Centre SUNUM | 16                |
| Yildiz Technical University   | 15                |
| Ataturk University  | 13                |
| Bilkent University  | 13                |
| Gazi University   | 12                |
| Dokuz Eylul University  | 11                |
| Ankara University   | 10                |
| Koc University  | 10                |
| Marmara University  | 10                |
| Hacettepe University Nanotechnology & Nanomedicine                    | 8                 |
| Yildirim Beyazit University   | 8                 |
| Erzurum Technical University  | 8                 |
| Yeditepe University   | 7                 |
| Van Yuzuncu Yil University  | 7                 |
| Istanbul University Cerrahpasa Faculty                                | 6                 |
| Akdeniz University  | 6                 |
| Bahcesehir University   | 5                 |
| Kastamonu University  | 4                 |
| Izmir Institute of Technology   | 4                 |
| Anadolu University  | 4                 |
| Bogazici University   | 4                 |
| Bartın University Faculty of Forestry                                 | 3                 |
| Cankiri Karatekin University Faculty of Science                       | 3                 |
| Izmir Katip Celebi University   | 3                 |
| Gaziosmanpasa University Faculty of Education                         | 2                 |
| Yeni Yuzyil University Istanbul                                       | 2                 |
| Near East University Department of Orthodontology                     | 2                 |
| Cankiri Karatekin University Faculty of Engineering                   | 2                 |
| Canakkale Onsekiz Mart University Department of Chemistry             | 2                 |

| Institution   | Publication Count |
|---|-------------------|
| Erciyes University Department of Textile Engineering                            | 2                 |
| Namik Kemal University Department of Biomedicine Engineering                    | 2                 |
| Mugla Sitki Kocman University Faculty of Science                                | 2                 |
| Gaziantep University Faculty of Engineering                                     | 2                 |
| Cyprus Int University Faculty of Engineering                                    | 2                 |
| Sirnak University Faculty of Engineering  | 2                 |
| Cyprus International University Department of Energy Systems Engineering        | 2                 |
| Izmir University  | 2                 |
| Adnan Menderes University   | 2                 |
| Mugla University Faculty of Education   | 1                 |
| Gumushane University Faculty of Economy & Adm Sciences                          | 1                 |
| Mugla Sitki Kocman University Faculty of Education                              | 1                 |
| Bezmialem Vakif University Faculty of Health Sciences                           | 1                 |
| Kilis 7 Aralik University Department of Science Education                       | 1                 |
| Balikesir University Architecture   | 1                 |
| Suleyman Sah University Department of International Business & Finance          | 1                 |
| Mustafa Kemal University Department of Food Engineering                         | 1                 |
| Adiyaman University Faculty of Dentistry  | 1                 |
| Acibadem University Department of Electrical Engineering                        | 1                 |
| Bulent Ecevit University Department of Biomedicine Engineering                  | 1                 |
| Ankara Numune Training Hospital   | 1                 |
| Turkish Armed Forces Foundation Ankara  | 1                 |
| Sincan Devlet Hastanesi   | 1                 |
| Turkish Ministry of Education   | 1                 |
| Usak University Department of Mathematical Science & Nanotechnology Engineering | 1                 |
| Necmettin Erbakan University Faculty of Education                               | 1                 |
| Yon Time Architecture Co Istanbul   | 1                 |
| Dumlupinar University Faculty of Arts & Science                                 | 1                 |
| Sakarya University Faculty of Engineering                                       | 1                 |
| Yozgat Bozok University Faculty of Education                                    | 1                 |
| Tokat Gaziosmanpasa University Department of Mathematics and Science Education  | 1                 |
| Izmir Bozyaka Training Hospital   | 1                 |

| Institution   | Publication Count |
|---|-------------------|
| Tekirdag Namik Kemal University Corlu Faculty of Engineering          | 1                 |
| Nevsehir Haci Bektas Veli University Faculty of Arts & Science        | 1                 |
| KTO Karatay University Department of Met & Mat Engineering            | 1                 |
| UEKAE BILGEM Science & Technology Research Council Turkey             | 1                 |
| Izmir Katip Celebi University Izmir                                   | 1                 |
| T Tekstil Research Centre   | 1                 |
| Baskent University Faculty of Engineering                             | 1                 |
| Mardin Artuklu University School of Health                            | 1                 |
| Kirsehir Ahi Evran University Vocational School                       | 1                 |
| Suleyman Demirel University Department of Chemical Engineering        | 1                 |
| Namik Kemal University Department of Environmental Engineering        | 1                 |
| Mersin University Department of Mathematics                           | 1                 |
| Bayburt University School of Engineering                              | 1                 |
| Near East University Faculty of Engineering                           | 1                 |
| Gaziantep University Faculty of Science & Literature                  | 1                 |
| Baskent University Department of Pharmaceutical Technologies          | 1                 |
| Tekirdag Namik Kemal University Faculty of Arts & Science             | 1                 |
| Antalya Bilim University Health Services Vocational School            | 1                 |
| Afyon Kocatepe University Bolvadin Vocational School                  | 1                 |
| Erzincan University Department of Biology                             | 1                 |
| Bartın University Department of Biotechnology                         | 1                 |
| Ahi Evran University Faculty of Engineering Architecture              | 1                 |
| IMEC Environmental Health & Safety                                    | 1                 |
| Manisa Celal Bayar University Faculty of Arts & Science               | 1                 |
| Robert Coll Istanbul  | 1                 |
| METU NCC Departments of Electronics & Electrical Engineering          | 1                 |
| Cumhuriyet University Faculty of Engineering                          | 1                 |
| Duzce University Faculty of Engineering                               | 1                 |
| Namik Kemal University Corlu Faculty of Engineering                   | 1                 |
| EA Teknol LLC   | 1                 |
| Usak University Faculty of Engineering                                | 1                 |
| Cumhuriyet University Department of Chemistry                         | 1                 |
| Kirsehir Ahi Evran University Department of Agriculture Biotechnology | 1                 |
| Dumlupinar University Department of Biochemistry                      | 1                 |

| Institution  | Publication Count |
|--|-------------------|
| Ibrahim Cecen University Faculty of Agricultural Sciences                      | 1                 |
| Istanbul Aydin University Department of Mechanical Engineering                 | 1                 |
| Balikesir University Faculty of Science & Literature                           | 1                 |
| Yuzuncu Yil University Faculty of Fisheries                                    | 1                 |
| Munzur University Department of Computer Engineering                           | 1                 |
| Pamukkale University Department of Chemical Engineering                        | 1                 |
| Mehmet Akif Ersoy University Faculty of Engineering & Architecture             | 1                 |
| Namik Kemal University Department of Textile Engineering                       | 1                 |
| Manisa Celal Bayar University Department of Bioengineering                     | 1                 |
| Eskisehir Osmangazi University Faculty of Arts & Science                       | 1                 |
| Istanbul Altinbas University Faculty of Pharmacy                               | 1                 |
| TC Istanbul Aydin University Health Services Vocational School                 | 1                 |
| Bilecik Seyh Edebali University Department of Bioengineering                   | 1                 |
| Kocaeli University Faculty of Technology                                       | 1                 |
| Sakarya University Faculty of Medicine   | 1                 |
| Namik Kemal University Corlu Faculty of Engineering                            | 1                 |
| TOBB University Economy & Technology Micro & Nanotechnology Graduate Programme | 1                 |
| Middle East Technical University METU MEMS Centre                              | 1                 |
| Sakarya İl Özel İdaresi Erenler  | 1                 |
| Mersin University Department of Environmental Engineering                      | 1                 |
| Mersin University Department of Engineering                                    | 1                 |
| Cukurova University Faculty of Agriculture                                     | 1                 |
| Baskent University Faculty of Dentistry  | 1                 |
| Recep Tayyip Erdogan University Faculty of Engineering                         | 1                 |
| Dumlupinar University Department of Biochemistry                               | 1                 |
| Erciyes University Department of Biomedicine Engineering                       | 1                 |
| Karabuk University Department of Energy systems Engineering                    | 1                 |
| Baskent University Department of Biomedicine Engineering                       | 1                 |
| Karabuk University Faculty of Technology                                       | 1                 |
| Bezmialem Vakif University School of Medicine                                  | 1                 |
| Uludag University Department of Textile Engineering                            | 1                 |
| Gebze Tech University Department of Environmental Engineering                  | 1                 |
| Suleyman Demirel University Faculty of Agriculture                             | 1                 |

| Institution   | Publication Count |
|---|-------------------|
| Istanbul Aydin University   | 1                 |
| Adana Alparslan Turkes Science & Technology University Faculty of Engineering         | 1                 |
| Ozyegin University CEEE   | 1                 |
| Gaziantep University Department of Textile Engineering                                | 1                 |
| Necmettin Erbakan University Science & Technology Research & Application Centre BITAM | 1                 |
| Atilim University Department of Chemical Engineering & Applied Chemistry              | 1                 |
| Tokat University Department of Electronics & Electrical Engineering                   | 1                 |
| Karabuk University Energy Systems Engineering   | 1                 |
| Kastamonu University Faculty of Forestry  | 1                 |
| Maltepe University Faculty of Medicine  | 1                 |
| University Eskisehir Osmangazi Faculty of Agriculture                                 | 1                 |
| Bezmialem Vakif University Faculty of Pharmacy  | 1                 |
| Nanotechnology & Integrated Bioengineering Centre                                     | 1                 |
| Suleyman Demirel University Faculty of Forestry                                       | 1                 |
| Suleyman Demirel University Mineral Met Recovery & Recycling Research Group           | 1                 |
| Erciyes University Department of Chemistry  | 1                 |
| Batman University Faculty of Arts & Science   | 1                 |
| Turkish Ministry of Health  | 1                 |
| Gulhane Military Medicine Academy Department of Dentistry                             | 1                 |
| European University Lefke Faculty of Agricultural Sciences & Technology               | 1                 |
| Igdir University Faculty of Engineering   | 1                 |
| Nigde University Ayhan Sahenk Faculty of Agricultural Sciences & Technology           | 1                 |
| Nigde Omer Halisdemir University Department of Physics                                | 1                 |
| Bingol University Faculty of Science & Arts   | 1                 |
| Nigde Omer Halisdemir University Faculty of Engineering                               | 1                 |
| Sinop University Department of Mechanical Engineering                                 | 1                 |
| Cyprus International University Faculty of Pharmacy                                   | 1                 |
| Trakya University Department of Biophysics  | 1                 |
| Gaziosmanpasa University Faculty of Dentistry   | 1                 |
| Suleyman Demirel University Faculty of Dentistry                                      | 1                 |
| Gebze Tech University Department of Chemical Engineering                              | 1                 |
| Gaziantep University  | 1                 |
| Istanbul University Cerrahpasa Faculty of Vet Medicine                                | 1                 |



| Institution  | Publication Count |
|--|-------------------|
| Kocaeli University Faculty of Dentistry  | 1                 |
| Engn Fac Department of Food Engineering  | 1                 |
| Altinbas University Faculty of Medicine  | 1                 |
| Sivas Cumhuriyet University Department of Chemical Engineering                     | 1                 |
| Selcuk University Department of Biotechnology                                      | 1                 |
| Cyprus International University Biotechnology Research Centre                      | 1                 |
| MIT Department of Computer Science & Electrical Engineering                        | 1                 |
| North Carolina State University College of National Resources                      | 1                 |
| Canakkale Onsekiz Mart University Department of Food Engineering                   | 1                 |
| Siirt University Department of Chemical Engineering                                | 1                 |
| Kerman University Medical Sciences and Pharmaceutical Research Centre              | 1                 |
| Basaksehir Cam & Sakura City Hospital  | 1                 |
| Cyprus International University Institute of Graduate Studies & Research           | 1                 |
| Canakkale 18 Mart University Department of Animal Science                          | 1                 |
| Sirnak University Rectorate  | 1                 |
| Izmir Biomedicine & Genome Centre  | 1                 |
| YTU Faculty of Mechanic Engineering  | 1                 |
| Erciyes University Department of Textile Engineering                               | 1                 |
| Eastern Mediterranean University Faculty of Pharmacy                               | 1                 |
| Istanbul Tech University Molecular Biology Biotechnology & Genetic Research Centre | 1                 |
| Koc University Surface Sciences & Technology Centre KUYTAM                         | 1                 |
| Near East University Faculty of Dentistry  | 1                 |
| Kazan Fed University Department of Theoretical Physics                             | 1                 |
| Canakkale Onsekiz Mart University Faculty of Engineering                           | 1                 |
| Ankara University Stem Cell Institute  | 1                 |
| Cyprus International University Environmental Research Centre                      | 1                 |
| NanoBMT Nanobiyomedtek Biomedicine & Biotechnology                                 | 1                 |
| Abant Izzet Baysal University Department of Biology                                | 1                 |

## 6.3 Nanotechnology Patent Count List

| Organisation                 | Count |
|------------------------------|-------|
| SABANCI UNIVERSITESI         | 21    |
| ISTANBUL TEKNİK UNIVERSITESI | 12    |
| YEDİTEPE UNIVERSITESI        | 7     |
| KOC UNIVERSITESI             | 6     |
| YILDIZ TEKNİK UNIVERSITESI   | 6     |
| ARCELİK ANONİM               | 5     |
| BILKENT UNIVERSITESI         | 5     |
| EGE UNIVERSITESI             | 5     |
| KUANTAG NANOTEKNOLOJILER     | 4     |
| BAYER MATERIALSCIENCE        | 4     |
| OZYEGIN UNIVERSITESI         | 4     |
| HACETTEPE UNIVERSITESI       | 4     |
| ATATURK UNIVERSITESI         | 3     |
| T.C. ERCİYES UNIVERSITESI    | 3     |
| BORTEK BOR                   | 3     |
| NANOBİZ TEKNOLOJİ            | 3     |
| NOKIA CORPORATION            | 3     |
| ASELSAN ELEKTRONİK           | 3     |
| VESTEL ELEKTRONİK            | 3     |
| TUBİTAK KALEM                | 2     |
| ERCİYES UNIVERSITESI         | 2     |
| ORTA DOĞU TEKNİK UNİ         | 2     |
| CUKUROVA UNIVERSITESI        | 2     |
| MALTEPE ÜNİVERSİTESİ         | 2     |
| GAZİ UNIVERSITESI            | 2     |
| TÜRKİYE ŞİŞE SAN.            | 2     |
| ASELSAN ELEKTRONİK           | 2     |
| ERDEM GURSAN                 | 2     |
| ISTANBUL KÜLTÜR UNIVERSITESI | 2     |
| NANOBİZ NANOBIYOTEKNOLOJİK   | 2     |
| GALIBOFF PLASTİK             | 2     |
| BAHCESEHIR UNIVERSITESI      | 2     |
| TUBİTAK                      | 2     |
| SELÇUK ÜNİVERSİTESİ          | 2     |

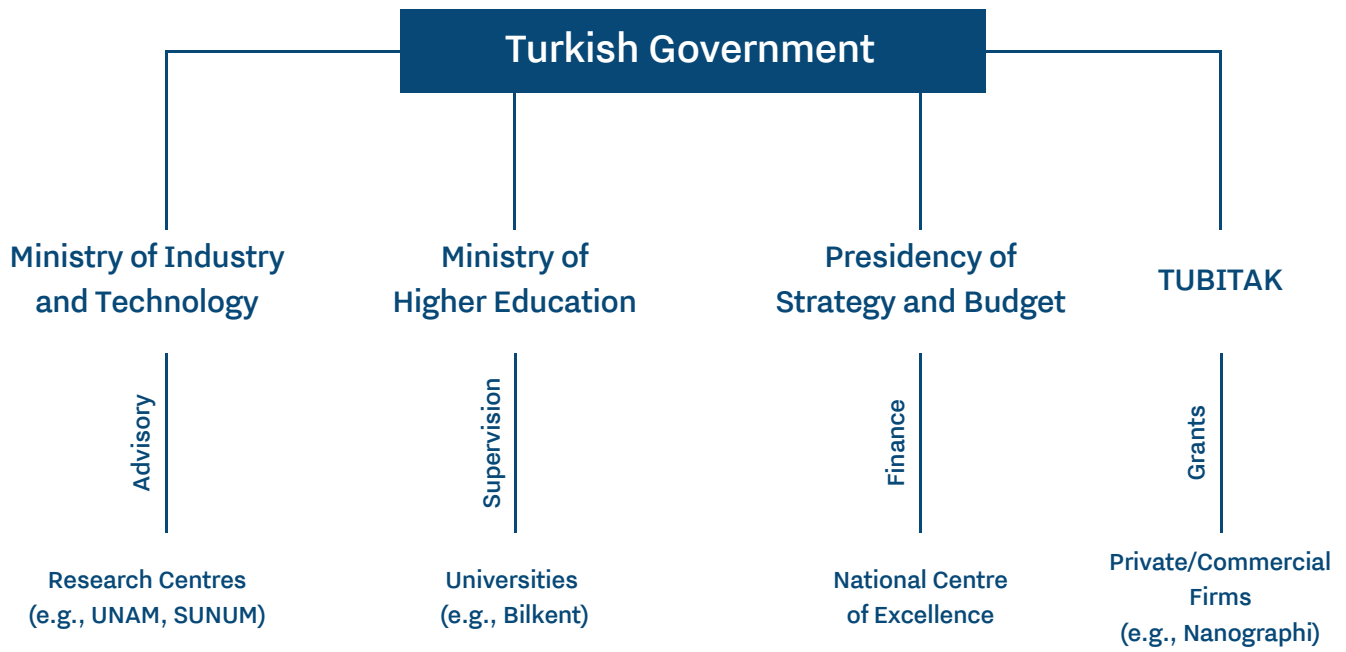
| Organisation                  | Count |
|-------------------------------|-------|
| SANKO TEKSTİL                 | 2     |
| GENERAL ELECTRIC              | 2     |
| BOGAZICI UNIVERSITESI         | 2     |
| NNT NANO                      | 1     |
| INNOVCOAT NANOCOATINGS        | 1     |
| IZMIR TEKNOLOJI               | 1     |
| BEZMİALEM VAKIF UNI           | 1     |
| TURKIYE PETROLLERI            | 1     |
| AFS BORU                      | 1     |
| BEZMİALEM VAKIF UNIVERSITESI  | 1     |
| ESKİSEHIR TEKNİK UNIVERSITESI | 1     |
| BURSA ULUDAĞ                  | 1     |
| ENTOVEST İLAÇ                 | 1     |
| ISTANBUL MEDİPOL UNIVERSITESI | 1     |
| AKDENİZ UNIVERSITESI          | 1     |
| BİRLEŞİK AKILLAR              | 1     |
| İZMİR YÜKSEK TEKNOLOJİ ENS.   | 1     |
| ANADOLU UNIVERSITESI          | 1     |
| ROKETSAN A.Ş.                 | 1     |
| CELAL BAYAR UNIVERSITESI      | 1     |
| FIRAT UNIVERSITESI            | 1     |
| BURSA TEKNİK                  | 1     |
| VERTRATECH KİMYA              | 1     |
| AKSA AKRİLİK                  | 1     |
| BOYTEKS TEKSTİL               | 1     |
| TURKIYE ENERJİ                | 1     |
| ULUSAL BOR                    | 1     |
| S.K. PHARMACEUTICALS          | 1     |
| AKSA AKRİLİK                  | 1     |
| KAT MEKATRONİK                | 1     |
| GRAFEN TEK YAZILIM            | 1     |
| KIRPART OTOMOTİV              | 1     |
| İZMİR EĞİTİM                  | 1     |
| KORDSA GLOBAL                 | 1     |

| Organisation                     | Count |
|----------------------------------|-------|
| ATEZ YAZILIM                     | 1     |
| ONDOKUZ MAYIS UNIVERSITESI       | 1     |
| INOVENSO TEKNOLOJI               | 1     |
| ESKISEHIR OSMANGAZI UNIVERSITESI | 1     |
| ENERAMA ÇEVRE                    | 1     |
| ESKİŞEHİR OSMANGAZI UNI          | 1     |
| FILKIM FILTRE                    | 1     |
| RS ARASTIRMA                     | 1     |
| TURKIYE SISE                     | 1     |
| BSH BOSCH                        | 1     |
| SELEKTIF TEKNOLOJI               | 1     |
| DR. ŞEYDA                        | 1     |
| ENTEKNO ENDÜSTRİYEL              | 1     |
| ANKARA ÜNİVERSİTESİ              | 1     |
| İSTANBUL SABAHATTİN              | 1     |
| GAZIANTEP UNIVERSITESI           | 1     |
| AFYON KOCATEPE UNIVERSITESI      | 1     |
| EPG (ENGINEERED)                 | 1     |
| NEVRUZOGLU                       | 1     |
| TASCI MADENCILIK                 | 1     |
| YISSUM RESEARCH                  | 1     |
| BANERJEE                         | 1     |
| ÜSKÜDAR ÜNİVERSİTESİ             | 1     |
| YENBU MAKINE                     | 1     |
| GAP GUNEYDOGU                    | 1     |
| AKIN TEKSTIL                     | 1     |
| FUNIKA TEKNOLOJI                 | 1     |
| HIDRA ENERJİ                     | 1     |
| AKDENİZ KİMYA                    | 1     |
| SOLENA ENERJİ                    | 1     |
| HDO PLASTIK                      | 1     |
| TURKIYE SAGLIK                   | 1     |

## 6.4 SWOT Analysis of the Nanotechnology Industry in Turkey



## 6.5 Institutional Map of the Nanotechnology Sector in Turkey



## 6.7 Questionnaire Template

### Sector study on nanotechnology in Turkey

#### Semi-structured interview form

**Contracting Authority:** The Kingdom of the Netherlands, Minister of Economic Affairs & Climate Policy

**Contractor:** E-CO Consulting & Coaching

**Aim:** The main aim of this sector study is to understand the level of progress towards nanotechnology in Turkey. The sector study also aims to discover collaboration opportunities for Dutch universities and research institutes and match the Dutch potential with Turkish interest.

This extra effort is intended to lead to more cooperation (knowledge exchange) between Turkey and the Netherlands. The results will guide the Netherlands Innovation Network in developing a strategy to position Dutch organizations in Turkey, for example, product development, and R&D or knowledge exchange.

This interview will take a maximum of 45 minutes.

Thank you for your participation.

#### A) Information of the person interviewed

Name and surname:

Institution served by:

Position:

Total industry experience:

Interview date and time:

#### B) Interview questions and notes

Q1: Could you briefly tell us about your work and experience in the sector?

Q2: Could you please evaluate the Turkish/ Dutch nanotechnology sector in general terms and with all its dynamics holistically?

Q3: Could you please evaluate the public policies, grant and incentive system related to the sector?

Q4: What do you think about the position of the Turkish/ Dutch nanotechnology sector in the world?

- Opportunities:
- Threats:
- Advantages:
- Weaknesses:

Q5: Do you think there are collaborative working areas & opportunities with other countries regarding the nanotechnology sector? If yes, could you give some examples. (For example, what do you think we can do in collaboration with the Netherlands/ Turkey?)



Kingdom of the Netherlands

# Sector study on Nanotechnology

in Turkey and the Netherlands for increased collaboration

■ Prepared by: E-Co Consulting & Coaching

■ Date: March 2022