TNO Annual Report 2022

TNO innovation for life

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In 2022, TNO again created many new innovations and achieved technological breakthroughs in long-term projects. The highlights are described throughout this report under the heading ‘Game changers’.

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Preface by the CEO

Dear business contact,

Early last century, renowned theoretical physicist and Nobel laureate Hendrik Antoon Lorentz recommended to the Dutch government the creation of an applied research institute. This led to the founding of the Netherlands Organisation for Applied Scientific Research, or TNO, in 1932. Our objective was clearly established from the start: to make scientific knowledge suitable for use by companies and public authorities. In 2022, TNO was able to look back proudly on nine decades of innovation with an impact on society. Our celebrations included a TNO90 event for contacts and colleagues.

Our 90th anniversary also prompted us to set ourselves big ambitions. The world around us is changing rapidly, which means TNO must also become more agile. Speed and close proximity to the market are key factors here. The question is not so much whether there will be an innovation, but who will be first to create it. It is increasingly a race to reap the economic, military, and geopolitical benefits in this way and create a sustainable society. For this reason, TNO works with 'moonshots': clear goals that we want to achieve by 2030. This makes the impact TNO wants to achieve very specific. Our firm intention to do so in a sustainable way is demonstrated by our continued commitment to the United Nations Global Compact and its principles for sustainable business practices.

These are great plans but, strictly speaking, an annual report should only look back at the year just ended. In June 2022, I took over from Paul de Krom as the new CEO of TNO. I spent my first few months listening to colleagues and honing my vision for our organisation. In this preface, I did not want to deny you a glimpse of my own ambitions for TNO. The pages that follow will tell you exactly what you need to know about our achievements in 2022. In a fully integrated annual report, with an entirely new corporate identity and a fresh layout, to make even clearer the crucial contribution to society that TNO continues to make. Onwards to 100!

On behalf of the Executive Board,

Tjark Tjin-A-Tsoi, CEO

'The question is not so much whether there will be an innovation, but who will be first to create it. It is increasingly a race to reap the economic, military, and geopolitical benefits in this way and create a sustainable society.'

Game changer

Envision

Much remains to be done to meet the 2030 Climate Targets. The switch to sustainable energy sources has a crucial role to play in this. Fortunately, increasing numbers of individuals and companies in Europe are using solar energy. However, there are still some 60 billion m^2 of unused roof area in the EU available for solar panels, for example. In addition to all the roofs, there is an equally large façade area in Europe.

Since 2017, TNO has therefore coordinated the H2020 project ENVISION, in which several European partners are collaborating on solutions to extract solar energy and heat from the entire surface of buildings. This includes the roofs, walls, and even windows. These solutions enable energy-positive buildings, which provide more energy than they consume. In 2022, ENVISION was nominated for the prestigious European Sustainable Energy Award of the European Commission.

Partners: AkzoNobel, Electricité de France, Pillington, RINA Consulting, Bergamo Technologie, University of Genoa, Emergo Hout & Bouw, NBA Architecten (and others)

Unit: Building, Infrastructure & Maritime

TNO key figures

Relationship capital

Number of PPPs

1,000 ▼ 2.7%

2021: **1,028**

Revenue of PPPs
(in millions of €)

176.5 ▼ 2.7%

2021: **181.4**

Intellectual capital

Professors

42 ▼ 8.7%

2021: **46**

Publications

1,013 ▼ 10.3%

2021: **1,129**

Patents

876 ▲ 0.9%

2021: **868**

First filing*

55 ▼ 5.2%

2021: **58**

Human capital

Employees
(as at 31 December)

3,897 ▲ 6.7%

2021: **3,652**

Recruitment
(New staff in 2022)

631 ▲ 57%

2021: **403**

Internships

401 ▲ 0.8%

2021: **398**

Physical capital
(in millions of €)

Tangible fixed assets

233.4 ▲ 6.1%

2021: **219.9**

Investments

56.5 ▲ 28.1%

2021: **44.1**

Natural capital

Carbon footprint
(kilotonnes of CO_2-eq)

176 ▲ 8.6%

2021: **162**

EcoVadis score

48/100

2021: **38/100**

Financial capital

Revenue (SMO and market)
(in millions of €)

590.7 ▲ 5.5%

2021: **559.9**

Research hours
(million)

3.2 ▲ 2.1%

2021: **3.1**

Total increase in value of TNO share in spin-offs
(in millions of €)

9.3 ▼ 3.1%

2021: **9.6**

* First filing of a patent application on a specific date

The Executive Board

In 2022, the Executive Board consisted of (from left to right) Peter Werkhoven (CSO), Tjark Tjin-A-Tsoi (CEO), Susan Swarte (CFO), and Maarten Tossings (COO).

Our organisation

TNO is an independent research organisation established by law in 1932 to provide research in engineering, natural sciences, and social sciences to serve the public interest. Today, TNO connects people and knowledge to create innovations that sustainably enhance companies' competitiveness and increase well-being across society. TNO is distinguished by its unique knowledge base. The organisation has the statutory task of maintaining, strengthening, and updating the knowledge base for the government in a number of key public research areas, such as Defence and the Geological Survey of the Netherlands.

For the purpose of developing and applying knowledge, TNO receives funding from the Dutch government and carries out assignments for public and private parties. At the same time, we create new employment and economic earning power through our work.

Organisational structure
The core of TNO comprised nine units in 2022. The Managing Directors of these units report to the four-member Executive Board. The Executive Board and the units are supported by the Services Organisation. The Executive Board reports to the Supervisory Board. The Defence Research Council has specific legally defined powers with respect to the Defence, Safety & Security unit. Each TNO unit has a Strategic Advisory Council (SAC) made up of representatives from business and industry, the public sector, and knowledge institutions.

Civil society organisations and NGOs are also represented in the SAC. This council advises the unit management and, if necessary, the Executive Board on substantive priorities and identifies new developments. In this way, the council and the boards fulfil an important function within TNO's innovation strategy. The Executive Board is also assisted by internal advisory councils in areas such as Corporate Social Responsibility, Diversity & Inclusion, Integrity and Governance, and Risk & Compliance. These advisory councils help create support for TNO's sustainability policy. TNO's corporate governance is based on the TNO Act and can be found on our website, tno.nl.

TNO includes the following units:

- **Traffic & Transport**
- **Strategic Analysis & Policy**
- **Information & Communication Technology**
- **Industry**
- **Healthy Living**
- **Energy Transition**
- **Defence, Safety & Security**
- **Circular Economy & Environment**
- **Building, Infrastructure & Maritime**

Value creation

What?

Input

Relationship capital (Ecosystems)

Intellectual capital (Knowledge)

Human capital (Employees)

Physical capital (Facilities)

Natural capital (Natural resources)

Financial capital (Funding)

Why?

Added value

Mission and vision

TNO's mission is to develop innovation systems that contribute to a **safe, healthy, sustainable, and digitally connected society.**

Core values

Integrity
Independence
Professionalism
Social commitment

Strategic themes

- Safe and secure society
- Healthy society
- Sustainable society
- Digital society
- Earning power

Governance | Risk

How? (short term)

Stakeholders

Society

Public partners

Private partners

Knowledge partners

Suppliers

Employees

How? (long term)

SDGs

What?

Input: six sources of capital*
TNO wants to report in an integrated manner on how it creates value for all its stakeholders in the short, medium, and long term. We do this in accordance with the IFRS Foundation's Integrated Reporting Framework. The focus is not only on financial value, but also on how the organisation creates natural, intellectual, socially related, human, and physical value, or how it destroys that value but then replenishes it.

Relationship capital (Ecosystems)
Relationship with relevant ecosystems, shared standards and values, stakeholder trust, and brand and reputation value.

Intellectual capital (Knowledge)
Knowledge-based intangible assets, such as know-how, IP, and patents, as well as organisational knowledge about 'orchestrating innovation'.

Human capital (Employees)
Competences, skills, motivation, experience, and work capacity of our diverse group of employees.

Physical capital (Facilities)
Facilities used by TNO to develop knowledge. These include the buildings, as well as installations and machinery.

Natural capital (Natural resources)
Water, land, air, and minerals used by TNO in its processes and the impact TNO has on the environment (e.g. nitrogen).

Financial capital (Funding)
The way in which TNO funds its research, but also the capital available to TNO to invest in facilities.

The 'Organisation of our research' section discusses developments regarding our most important types of capital: knowledge, employees, and facilities. The 'Sound financial management' section discusses the key elements of our financial capital.

Types of research
TNO develops high-quality scientific knowledge by conducting **Early Research** and **Shared Research** programmes in which knowledge is developed or further developed to higher levels of applicability ('Technology Readiness Level' or TRL). This precompetitive and public-private knowledge development is financed by state funding and focuses to a great extent on research areas identified in the Dutch government's Mission-driven Top Sectors and Innovation Policy.

Knowledge acquired in this way forms the basis which, at a later stage, can be applied in a number of areas to solutions (competitive or otherwise) on an exclusive basis for clients through **Contract Research** and **Technology Transfer**. Contract Research is involved if questions from clients and partners concern specific, potentially competitive applications of TNO knowledge and where there is customisation. This research is fully paid for by the client. In this way, knowledge developed by TNO is brought to market through its clients' products and services. In Technology Transfer, TNO also brings knowledge to market by leveraging its 900 or so active patent families in the form of licences to existing companies and by setting up spin-offs based on TNO knowledge.

(*) In the annual report, we focus on these various sources of capital. In each case, we display the icon of the relevant capital source shown here.

Why?

Mission and vision

TNO's mission is to develop innovation systems that contribute to a **safe, healthy, sustainable, and digitally connected society.** In doing so, we tackle challenges such as safeguarding our sovereignty and security (including cyber security) and the transition from treatment to preventive care. TNO also works on developing a sustainable energy supply, the circular use of raw materials, and IT technology that respects public values and fundamental rights. We bring together people and knowledge to generate demonstrable impact on these challenges. The earning power of the Dutch economy is inextricably linked to this work. TNO also continues to be a trusted partner for public authorities through its statutory duties, policy advice, and applied research. TNO's achievements in tackling the above-mentioned challenges are described on the dedicated theme pages elsewhere in this report.

Core values

There are four core values that determine how TNO employees should do their work.

- **Integrity:** decisions are made on the basis of the most accurate information possible; in addition, TNO employees think and act honestly and sincerely and are committed to ethical standards and values.
- **Independence:** results are achieved without improper influence from commercial or other interests.
- **Professionalism:** acting professionally with clear work processes within the time limits and the budget.
- **Social commitment:** TNO staff fulfil a social role through their work.

How? (short term)

Stakeholders

In the short term, TNO creates value for a variety of stakeholders:

Stakeholder	Value created
Society	Demonstrable impact with innovations applied to create a safe, healthy, sustainable, and digital society.
Public partners	Sustainable knowledge development used for public policy and which is applied to meet societal challenges.
Private partners	Product, service, and process innovation for greater earning power and innovative applications for more sustainable operations.
Knowledge partners	Better knowledge development through collaboration on both research and the knowledge organisation.
Suppliers	Generating revenue and encouraging responsible and sustainable business practices.
Employees	Self-development with equal opportunities, resulting in engaged and motivated employees who contribute to societal impact.

The 'External developments' section discusses the main trends at our public, private, and knowledge partners.

How? (long term)

SDGs

Through its work, TNO contributes to achieving the United Nations' Sustainable Development Goals (SDGs). The SDGs are a universal reflection of the societal challenges the world is facing. The 2022-2025 Strategic Plan links the societal themes TNO is working on with the SDGs most relevant to them. These are the topics on which TNO can achieve the greatest societal impact thanks to its knowledge and position.

Representation of the TNO strategy themes and SDGs contributed to.

TNO joined the United Nations Global Compact (UNGC) in 2020 and it has committed itself to the 10 universal principles of sustainable business practices. This is described in the 'Sustainable and responsible business practices' section.

A comprehensive stakeholder analysis was carried out during 2020 when the 2022-2025 Strategic Plan was being determined. A materiality assessment was carried out at the end of 2022. Based on desk research, peer and media research, and its own strategy, TNO drew up a list of 16 material themes, including definitions. These themes were tested for relevance and impact in a group of 'internal' decision-makers (Executive Board, Supervisory Board, management of units, and Service Organisation), as well as by 'external' stakeholders (clients, suppliers, TNO employees, and other stakeholders).

The resulting materiality matrix helps TNO determine which themes it should focus on in strategy formation, reporting, and disclosure. The preliminary results of the assessment show that the most material themes are close to the TNO strategy: 'Impactful Innovations', 'Collaboration in the Knowledge Chain', and 'Integrity & Compliance'.

The 'Strategy' section describes the main points of the 2022-2025 Strategic Plan with the results achieved in 2022.

The main business risks identified by management in 2022 are in the areas of 'Impactful Innovations' (Right-to-Play), 'Excellent Knowledge Base' (scientific quality and insufficient facilities), 'Healthy Business Model' (balance between public and private funding), and 'Talent Development' (insufficient suitable employees available or motivated). This only partially corresponds to the main material themes.

Game changer

Perfusion of organs for better drug development

A good prediction of ADME (Absorption, Distribution, Metabolism, and Excretion) is of great importance in drug development. Without this knowledge, drugs cannot be tested on humans. ADME processes are currently mostly studied in cells or laboratory animals, but this work translates insufficiently to humans. Many drugs fail in the clinical stage of development, mainly because of side effects and lack of efficacy. Better predictive models in which to study how human organs interact with substances administered from outside are therefore in high demand.

Normothermic organ perfusion of the liver and kidneys, for example, offers an excellent solution. Using pressure-controlled perfusion machines, TNO has developed a model in which we can keep these organs functional outside the body and study drug uptake. This enables us to predict how a drug will behave in humans. Ultimately, this will result in cost reductions and more effective and accelerated drug development. It is also a good step towards developing drugs without tests on animals.

Unit: Healthy Living

External developments

Events in the outside world affect TNO in many ways. They also affect the way TNO positions itself in the national and international knowledge infrastructure and beyond. After all, we set ourselves the goal of ensuring that our innovations and recommendations have as great an impact as possible on society. In the following overview, we look at general trends worldwide and developments in the public and private sectors and in the knowledge chain.

General trends

Geopolitically but also nationally, the war in Ukraine that began in February 2022 created great uncertainty. There were energy shortages and a worldwide rise in the importance of – and spending on – defence and security. Although the COVID pandemic slowly subsided, it did affect the way we work, prompting the question of how organisations deal with hybrid working, for example. These changes in work practices helped fuel the continuous progress of digitalisation, but there were also calls from society for better data privacy, cyber security, and the responsible use of AI.

Historically high inflation and increased energy prices led to rapid rises in public spending to mitigate the effects. Furthermore, weaknesses in national economies and supply chains were exposed by shortages of raw materials and human resources. This has led to a call for greater 'strategic autonomy' in certain areas of Europe and specifically in the Netherlands. There is also an ever greater need to invest in the energy transition, better air quality, and circular materials, particularly as businesses and society are lagging behind in efforts to meet climate targets. At the same time, the rise of countries such as China, South Korea, and India, each with its own growing industries, is not making this process any easier.

All this has resulted in an accumulation of trends that call for management and policy. According to TNO, innovation not only provides the solution to societal challenges but also drives the economy. During major transitions, however, new needs arise and with them new opportunities for innovation. It is clear that TNO can make an important contribution, but the speed of change requires a constant strategic view on the future and accelerated innovation.

According to the latest final 2020 figures, total R&D spending in the Netherlands just reached the EU27 average at 2.31% of GDP, but it was behind leaders with similar innovation systems, such as Sweden (3.49%), Belgium (3.38%), and Austria (3.22%), as well as industrial powerhouses such as South Korea (4.81%), the US (3.45%), Japan (3.26%), and Germany (3.13%).[1]

[1] These figures are from Eurostat, December 2022.

As a member of the Knowledge Coalition[2], TNO supports the aim of a gradual increase in total R&D spending up to 3% of GDP, to be achieved within a 10-year period. Only in this way can the Netherlands continue to compete with international frontrunners and maintain its competitiveness and, by extension, earning power.

Developments supported by the public sector

Societal issues are becoming increasingly complex and affect a multitude of factors. A public stimulus is often needed in order to tackle these challenges. The role of government with regard to innovation is changing and is becoming more mission-driven and managerial in both the Netherlands and Europe. The boundaries between public and private responsibilities and innovation chains are shifting and blurring. This means that – even more than in the past – different parties, both public and private, need to collaborate earlier in the development chain.

In the Netherlands, the beginning of 2022 saw the publication of the fourth Rutte government's coalition agreement, which gave a substantial boost to education and science. It is gratifying that the government plans to make up the backlog of funding for applied research facilities in the coming years with an injection of €500 million. Because other additional spending is mainly on academic education and research, the ratio between funding for academic research and applied research in the Netherlands will unfortunately become even more skewed than it already is.

Government funding and programme funding from ministries

The substantive relationship between TNO and various line ministries is being increasingly strengthened. In 2022, TNO was asked by ministries to take on a substantive directing and programming role, for example through the Ministry of the Interior and Kingdom Relations in the context of the Zero-Emission Construction programme. But additional specific research programmes are also carried out for and with ministries such as Infrastructure and Water Management and Justice and Security, on the basis of a strategic relationship and the corresponding agreement frameworks.

TNO has traditionally had a number of statutory tasks, including work commissioned by the Ministry of Defence and management of the Geological Survey of the Netherlands. In addition, TNO works to support and provide input for policy processes with facts and science-based insights (evidence-based policymaking).

Moreover, implementing organisations of the government, such as the armed forces and the police, are supported in innovation related to their operations, thus aiding them to perform their duties more effectively and efficiently. These tasks ensure that developments originating from the government are closely monitored.

Intensification of defence spending due to war in Ukraine

In response to the war in Ukraine, the fourth Rutte government's coalition agreement structurally increased the Dutch defence budget by €2 billion. On Budget Day 2022, the government made an additional structural payment of €3 billion. The Ministry of Defence is using the additional investment to improve the operational readiness, combat power, and agility of the armed forces for innovation and for collaboration with EU and NATO partners. This virtually doubles the defence budget for the coming years and the Netherlands will fulfil NATO agreements on defence budget levels for the first time since the end of the Cold War.

A substantial share of R&D work for the Ministry of Defence is outsourced to TNO. A larger defence budget therefore results in a significant increase in Ministry of Defence orders for TNO. This applies both to the specific knowledge that TNO acquires and maintains on behalf of the Ministry of Defence and to TNO's contributions to the Ministry's materiel projects. TNO will have to grow substantially in capacity in the coming years to meet the increased demand for R&D. It started recruiting more staff as early as the end of 2021 and this will continue in the years ahead.

R&D grant scheme

The manufacturing industry of the mobility sectors (automotive, maritime, and aviation) suffered badly from the effects of the COVID crisis. This put strong pressure on investment in research and development projects, which are especially important for future earning power and the transition to climate-neutral mobility. RDM – the R&D grant scheme for mobility-related industries (Subsidieregeling R&D Mobiliteitssectoren) – is part of the COVID crisis support and recovery package. In 2021, a one-off budget of €150 million was made available for projects to be implemented in the 2022-2025 period. TNO is involved in six of the eight RDM proposals selected, which concern, among other things, engines based on hydrogen technology, electric transport, methanol as an energy step for shipping, the reduction of shipping emissions, and digitalisation for airport surroundings.

[2] The Knowledge Coalition is a partnership in the field of Dutch research and innovation, comprising the universities (UNL), universities of applied sciences (VH), University Medical Centres (NFU), the Royal Netherlands Academy of Arts and Sciences (KNAW), the Netherlands Organisation for Scientific Research (NWO), the Confederation of Netherlands Industry and Employers (VNO-NCW), Small & Medium-Sized Enterprises in the Netherlands (MKB-Nederland), and the institutions for applied research (TO2 Federation).

National Growth Fund
In addition to the new financial incentives in the coalition agreement, the fourth Rutte government has decided to maintain the National Growth Fund (NGF), which has existed since 2021, with a few changes. With the NGF, the Netherlands is investing €20 billion between 2021 and 2025 in projects that will ensure long-term economic growth. One of the priority areas of the fund concerns 'Research, Development, and Innovation' proposals. It is clear that applied research can contribute to this very area, which is why TNO is closely involved in proposals from both the first and second rounds of the NGF.

In the second NGF round, TNO was involved in 13 of the approved Research, Development, and Innovation proposals. This is expected to provide TNO with a total of around €250 million of additional funding for research over the next five to seven years. TNO is therefore preparing to expand its research capacity for that period. The largest proposal to which TNO contributed in the second round is NXTGEN HIGHTECH, a partnership to which the NGF awarded a total of €450 million in funding. This proposal is described in more detail on the 'Digital society' theme page. In 2022, the Dutch government also gave final approval to the first phase of Circular Plastics NL and invested €124 million from the NGF (see 'Sustainable society' theme page).

The launch of NGF projects in both the first and second rounds has been delayed. As this is a new tool, the Ministry of Economic Affairs and Climate Policy, as the ministry responsible for implementation, has had to set up many new procedures for granting subsidies. TNO assumes this process can be greatly accelerated in the coming years. In 2022, TNO was again closely involved in drafting a large number of proposals for the third round of the NGF.

Horizon Europe
Research and innovation do not stop at the borders of the Netherlands. TNO also strengthens the knowledge base of the Netherlands by working closely with leading international knowledge partners, companies, and public authorities. The knowledge that TNO develops or acquires in the process benefits Dutch industry and helps resolve societal issues in the country.

After being awarded more than 350 Horizon 2020 projects in the period 2014-2021, TNO has been very active and successful in 2022, the first year of Horizon Europe, winning 50 projects totalling €26.8 million. The eighth European framework programme, Horizon Europe 2021-2027, is an important tool for TNO to create valuable new networks, which enable the shared development of knowledge with European partners.

Knowledge security
In 2022, there was again a strong focus, political and otherwise, on improving knowledge security. TNO actively participated in the Ministry of Education, Culture and Science-led steering group and working group on knowledge security with representatives of the knowledge institutions. In early 2022, the National Knowledge Security Guidelines were published, to which TNO contributed. In this way, the knowledge institutions (and therefore also TNO) got to work on this issue.

Developments supported by the private sector

As well as developing innovations for the benefit of society, TNO aims to strengthen the earning capacity of the Dutch economy. A great deal of R&D, developed by TNO or elsewhere, helps Dutch industry position itself for new products and services. In addition, companies make up a large share of TNO's clients and partners, so what happens in the private sector affects the organisation.

Alongside their own and outsourced R&D, companies also apply other forms of innovation. Large companies make more frequent use of 'corporate venturing' (investing in start-ups) to access innovations. Companies are also becoming increasingly international in their innovation methods. In recent years, R&D investments have increasingly been optimised globally.

In practice, current Dutch private spending on R&D in particular lags behind in an international comparison. With an intensity of 1.54%, the Netherlands scores just above the EU average of 1.52%, but clearly below its 'peers', such as Sweden (2.52%), Belgium (2.49%), and Austria (2.24%), as well as major industrial powers such as South Korea (3.81%), the US (2.60%), and Germany (2.09%).[3]

Private spending in the Netherlands is dominated by a limited number of large companies (some of them international), such as ASML, Philips, Janssen, KPN, and DSM. The top five in this group account for some 27% of total private spending and the top 10 for 33%. Overall, these companies already spend a lot on research compared to their international peers, making further growth in this group unlikely. Increasing research intensity must therefore be achieved through innovation in the Dutch economic structure by stimulating new activity in research-intensive sectors.

[3] These figures are from Eurostat, December 2022.

In July, the Minister of Economic Affairs and Climate Policy wrote in her Industry Letter[4] that 'industry drives our innovative economy by developing and applying digital and other key enabling technologies' and that the Netherlands should strive internationally for 'open strategic autonomy'. She also stated that 'we are facing a major remodelling of Dutch industry. The government wants the Netherlands to become a leader in making industry more sustainable and achieving the solutions needed to achieve this, such as technological innovation and a circular economy, and to compete internationally, we will have to distinguish ourselves even more durably through innovation with knowledge and skills'.

It is precisely in this context that TNO has a clear role to play, as we explicitly link the four societal challenges from the TNO strategy to strengthening the earning power of the Dutch economy. These are often two sides of the same coin: sensors, models or tools that contribute to resolving societal issues can at the same time put Dutch industry in a position to commercialise products and services.

Small and medium-sized enterprises

The labour shortages and increased energy prices that have affected the Netherlands (and many other Western countries) since 2022 are also hitting small and medium-sized enterprises (SMEs). This in turn has repercussions on society, as SMEs are responsible for 70% of Dutch employment. In this context, there will be particular emphasis on SMEs over the next few years. The bulk of private R&D in the Netherlands is currently being carried out by a limited number of large companies, particularly in the high-tech sector. The additional growth in private R&D spending that is needed in the Netherlands will have to come mainly from SMEs or from new industrial activity and new sectors.

TNO aims to increase its contribution to the innovative and competitive capacity of SMEs. TNO currently does not have a clear position in relation to these companies, the conditions for investment resources (e.g. state funding) are not as well aligned, and the related decision-making is often too slow for the diverse and dynamic SMEs. However, TNO's technological knowledge, facilities, broad orientation, and national coverage could play a major role in the national challenges facing SMEs.

For these reasons, TNO is stepping up its SME programme. For example, joint projects offer SMEs the opportunity to use TNO's existing research infrastructure, thus substantially reducing innovation costs for SMEs. It also increases the chances of success of research projects, thanks to the specific knowledge and experience of researchers at applied research institutions. TNO's offering and demand from SMEs are brought together in a highly accessible manner in the TNO Innovation Hub platform.

Knowledge chain developments

The knowledge and innovation system is also changing. Complex national and international innovation systems and ecosystems are emerging in which government, knowledge institutions, and companies work together. Furthermore, universities are focusing more on the second and third flows of funds and foreign research institutions are occasionally active in the Netherlands with temporary or regional funding.

In addition, facts as well as 'alternative facts' spread rapidly through social media. With the help of open data, more people than ever before have access to research material. In consequence, the authority of knowledge institutions can no longer be taken for granted. The independence of institutions is more likely to be called into question, especially when they make an important contribution to policy choices. This underlines the need for knowledge institutions such as TNO to supply top-quality knowledge that has been developed independently and objectively.

Many partners in the knowledge chain are located in the Netherlands (see below). However, TNO is also active at European level, for instance in the Horizon Europe and Digital Europe programmes and through the European Defence Fund. In addition, in 2022, TNO intensified bilateral cooperation with several fellow institutions across Europe, including Germany's Fraunhofer Gesellschaft and France's CEA.

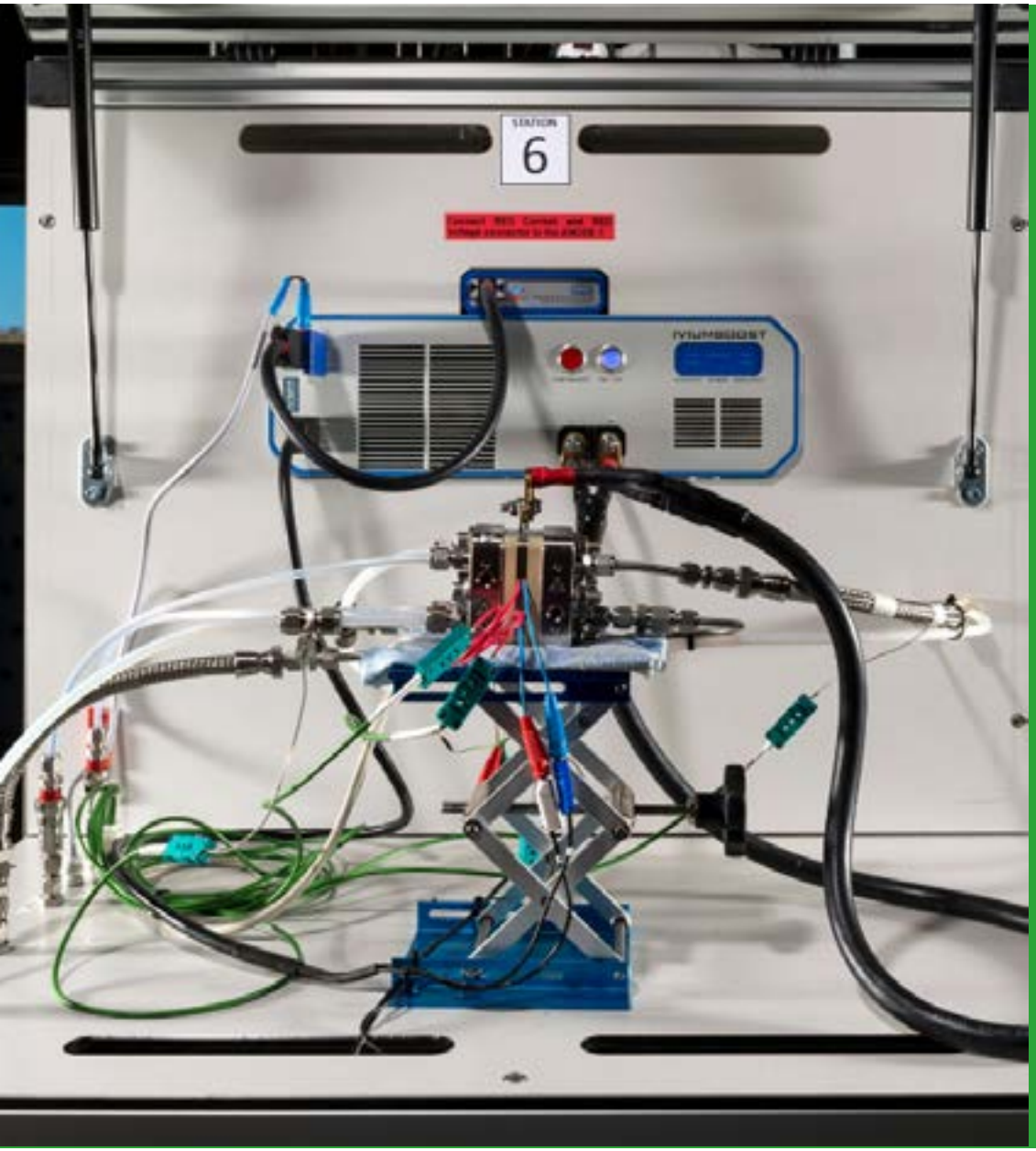
TO2 Federation

TNO collaborates in the TO2 Federation with the other four Dutch applied knowledge institutions: Deltares, MARIN, NLR, and Wageningen University & Research. Because the portfolios of the various institutions are complementary, there is collaboration between them in various fields and projects. Some great examples of such collaboration are highlighted in the annual TO2 impact report. There is also the jointly organised annual TO2 Day, where the impact of applied research is illustrated on the basis of a theme.

[4] 'Het verschil maken met strategisch en groen industriebeleid' (Making a difference with strategic and green industrial policy), 8 July 2022

Universities
Collaboration within the knowledge chain, including with universities and universities of applied sciences, produces practical results. There are numerous examples in this context, including PhotonDelta with the University of Twente and Eindhoven University of Technology, Chemelot with Maastricht University (including BMC and Brightsite), Solliance and Helmond Automotive with Eindhoven University of Technology, CITC with Radboud University Nijmegen, and QuTech with Delft University of Technology. Notably, Chemelot made strides in 2022 with plasma technology for recycling plastics. Another project involves the tandem solar cells developed by TNO, Eindhoven University of Technology, imec, and Delft University of Technology.

Strategic Programme: Customer Excellence
The changing needs of society, economy, and the environment require a clear understanding of the corresponding needs of our customers and partners. In this way, TNO can create innovations that help society further and strengthen the earning power of the Dutch economy. The 'Customer Excellence' programme therefore aims to increase TNO's impact by offering value propositions that better match the needs of our customers and partners. In addition, the programme will focus on optimising the sales process for both customers and TNO, thereby improving internal and external processes and other matters. To achieve this, the programme focuses on three key priorities: 1) 'customer insight and segmentation', allowing TNO to better identify the needs of customers and partners; 2) 'brand and value proposition', which leads to stronger (added) value propositions that are in line with those needs; and, finally, 3) 'the customer journey', which provides insight into how customers experience their interaction with TNO, what their specific needs are at different points in time, and what can be optimised in that respect.



Game changer

Electrolysers for green hydrogen

We currently emit a large amount of CO_2 during the production of hydrogen. Much remains to be done to stimulate the production and use of green hydrogen, which is produced entirely from solar and wind. Electrolysis, the splitting of water into oxygen and hydrogen, with electricity from wind and solar is the main option. Electrolysis is where solar power was 20 years ago: we are still at the beginning of this technology. Scarce materials, such as iridium and platinum, are currently required in the process.

In a lab experiment, TNO tested an electrolyser cell with promising results: by applying an ultra-thin catalyst layer, we can reduce the use of iridium in electrolysers by a factor of 200. This makes the technology more sustainable, cheaper, and thus more widely applicable, which is important because it is currently hard for green hydrogen to compete with grey hydrogen obtained from natural gas. By scaling up green hydrogen production, TNO is contributing to the energy transition.

Unit: Energy Transition

Strategy 2022-2025

The TNO Act requires TNO to develop a new strategy every four years. The 2022-2025 Strategic Plan was presented to the Minister of Economic Affairs and Climate Policy in May 2021, so 2022 marked the first year of this new strategy period. A wide range of stakeholders were consulted to develop the TNO strategy, including companies, public authorities, universities and knowledge institutions, and employees. The results of this consultation process have been incorporated into the strategy that is currently being implemented.

Core tasks

It is important to distinguish between TNO's two core tasks or roles because they involve different dynamics and KPIs. They can be described as follows:

- The first core task is to support the Dutch government in carrying out statutory government tasks in the public interest. This is TNO operating in its capacity as an independent and reliable research institute. Through research and advice, TNO works on the one hand to provide facts and science-based insights as input for policy processes. On the other hand, TNO supports the effective and efficient execution of government tasks through research, consultancy, testing, and innovation. This ranges from research for the Ministry of Defence to mapping the subsurface and from policy advice for all ministries to supporting the energy transition.
- TNO's second core task is to strengthen the earning power of the Dutch economy and increase employment through applied research, valorisation, innovation, and collaboration. TNO innovates on behalf of both private and public organisations. In addition, TNO develops intellectual property, for which licences are granted. TNO also founds new companies (spin-offs) based on technological innovations, in addition to other forms of valorisation. This is how TNO supports the pursuit of a competitive, innovative, and dynamic knowledge economy that will ensure prosperity in the Netherlands well into the future and provide the financial and economic capacity necessary to finance solutions to major societal challenges.

Demonstrable impact

TNO continuously works to build a strong knowledge base and specifically follows relevant scientific and technological trends. TNO chooses to continue focusing mainly on translating scientific insights into practical applications. A major trend in this context is the stronger emphasis that universities have also come to place on impact and valorisation. TNO sees this as an opportunity to seek and strengthen collaboration. Various collaboration models are conceivable and will be explored together with the universities. TNO has an explicit ambition to greatly increase its impact. Our unique knowledge and infrastructure built up over the past decades provide an excellent basis for tackling the important and complex societal challenges that we face.

Strategic change programmes
In April 2022, the Executive Board decided to put three topics at the centre of TNO's change agenda. These are designed to increase innovation across disciplines, improve collaboration, and achieve impact based on client-focused thinking and working.
The strategic change programmes – (1) Systems Innovations, (2) Customer Excellence, and (3) Vital Organisation – are explained in separate boxes throughout this annual report.

Valorisation and implementation
Scientific insights, technical inventions, and even 'demonstrators' are not in themselves innovations with impact. To facilitate this impact, TNO focuses on the difficult last steps to the successful market launch of a product or service. This does not mean to say that we must or can do it alone. We often collaborate with companies and public authorities that have extensive knowledge of the relevant end markets and value chains. In addition, the research portfolio (upstream) focuses even more strongly on promising valorisation (downstream).

Focus and mass
TNO can gain in strength, effectiveness, and efficiency by bringing greater coherence and focus to its research portfolio, thereby organising greater mass in areas where TNO wants to make an impact. A first major step has been taken by defining the four themes around which TNO primarily wants to be active: safety and security, health, sustainability, and digitalisation. There is also a focus on enabling technologies, for example the high-tech manufacturing industry, which is booming in the Netherlands with companies such as ASML and VDL. To make it clear, both internally and externally, which impact goals are being pursued, specific 'moonshots' have been developed, which should lead to results before 2030. These are described here.

Progress on strategic priorities in 2022

In 2022, TNO's strategic priorities were: (1) developing system solutions; (2) creating innovation ecosystems; (3) achieving technological breakthroughs; and (4) dynamic innovation.

(1) Developing system solutions
The complexity of today's societal challenges and the transitions required for them is overwhelming. Creating breakthroughs on these issues requires a deep understanding of the various systems involved, their structure, and their dynamics. One reason why efforts on innovation do not have the anticipated impact is that while these innovations have short-term effects within their own domain, they do not take into account the consequences for the greater whole.

An example is encouraging the use of electric cars. While this will bring down nitrogen emissions in the short term, over time it may also lead to tightness on the electricity grid. And if the power generation needed for electric transport cannot be entirely 'green', the net result could actually be increased emissions. Innovation in one area sometimes requires just as much innovation in numerous other areas.

Innovations as such can therefore have an unwanted and unexpected negative impact as part of the greater whole or are simply not designed to bring about broader systemic change. Fragmented approaches will therefore not be sufficient to create breakthroughs and solve society's major challenges. TNO needs to invest in its ability to offer system innovations.

TNO has the unique ability to record many perspectives from different domains (experts, networks, mental models, and partners' needs) and understand a complex system (its structure and behaviour) by identifying various systemic leverage points. Based on these leverage points, TNO can design effective interventions that can initiate or support desired transitions.

Strategic Programme: Systems Innovation
The introduction of technical solutions into organisations, value chains, and complex social systems is often much slower than one might expect. The fact that new inventions affect a system as a whole is often overlooked and an integrated review should be conducted. In many cases, social, institutional, infrastructural, and legal innovation fails to keep pace with technical innovation. Many disparate elements have to come together simultaneously before a technology that looks like a game changer on paper lives up to that expectation in practice. As TNO's main goal is achieving real-world impact, it is working intensively to understand such systemic changes and how they can be accelerated. The strategic programme develops methodologies, tools, and templates, organises courses, manages a community of practice, establishes profiles for systems thinkers, and provides system solutions for pilot projects.

Thanks to its expertise, independence, and multidisciplinarity, TNO is ideally placed to develop a vision for the future with respect to socially relevant issues and thus provide input to the public debate. For that purpose, TNO develops white papers that focus on innovative insights. The approach is to provoke, inspire, and mobilise, always based on facts and always properly substantiated. Examples can be found on the strategic theme pages. A great deal of TNO research makes the news. An overview of TNO in the media in 2022 can be found here.

(2) Creating innovation ecosystems
Innovation requires more than just knowledge development. This is especially the case for system innovations that address the major challenges facing society. Real change requires the participation of many different parties: private individuals, public authorities, the business community, knowledge institutions, and educational institutions. Innovation then takes place in innovation ecosystems: clusters of companies, public authorities, organisations, and knowledge institutions working together to develop knowledge and arrive at new products and processes.

These kinds of innovative ecosystems do not emerge by themselves. A party is needed to bring together the other participants, ensure a common strategy, and consistently push for that strategy to be implemented. TNO is in an ideal position to play such a role, being independent, impact-oriented, and multidisciplinary. To play this role even more emphatically over the next few years, TNO is strengthening the following areas: 'orchestrating innovation' competences, knowledge of the 'human factor' in innovation (how people adopt innovations), and stakeholder intimacy.

Good examples are our Joint Innovation Centres, such as Holst, which collaborates with imec, or ESI, in which 10 industrial partners are represented. In addition, 2022 saw the launch of the Zero-Emission Construction knowledge and innovation programme, in which TNO is working with the Ministries of the Interior, Infrastructure and Water Management and Economic Affairs and Climate Policy, the Construction and Technology Innovation Centre (BTIC), the Top Sector Logistics, and parties from the construction industry. Among other things, it focuses on the design and application of lighter and sustainable building materials and prefabricated homes.

(3) Achieving technological breakthroughs
Innovation based on new technologies and methods is still the key to solving societal challenges and creating opportunities for the economy. TNO is constantly making choices in its portfolio of technologies and methodologies. The choices to be made for the Netherlands and for TNO lie not between but within the clusters of key enabling technologies mentioned in the Mission-Driven Top Sectors and Innovation Policy.

In 2022, TNO again created many new innovations and achieved technological breakthroughs in long-term projects. For example, the James Webb Space Telescope arrived at its final destination at the end of January. For this project, led by NASA, ESA, and CSA, TNO provided the optical specifications for the MIRI spectrometer, the tool that enables the telescope to observe the furthest galaxies. TNO supplied the SmallCAT laser communication system for the Norwegian spacecraft NORSAT-TD. The objective of this mission is to increase the data transmission capacity of small satellites through direct laser communication with the Earth. Other highlights of innovative technology are described under the heading 'Game changer' throughout this annual report.

(4) Dynamic innovation
The world in which TNO operates is changing, partners and clients are asking new questions, and employees are coming up with groundbreaking ideas. To have a chance of success, an organisation must be involved in development and move with the times in this rapidly changing external environment, and also give employees the opportunity to realise their full potential. TNO is developing in the following areas to enable dynamic innovation: new business models, short-cyclical innovation, digitalisation, and a data-driven and agile organisation.

In 2022, in addition to continuing the Technology Transfer programme, which produced a further five spin-offs, TNO launched a pilot project using new business models to carry out innovation projects with start-ups. Furthermore, TNO participated in a number of investment funds to be able to invest in innovation through start-ups together with partners and within the legal framework.

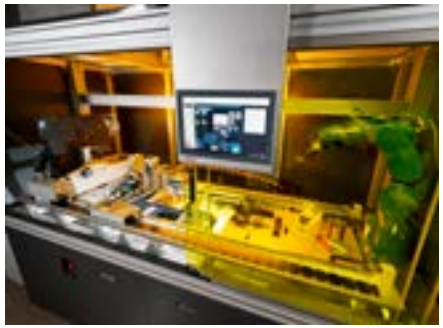
The spin-offs set up in 2022 are:

Aircision
Aircision focuses on laser communication between ground stations using Free Space Optics (FSO). The continuous trend towards more data communication means that new technology is needed to continue enabling this growth. FSO is a promising technology for this purpose as it means that fixed infrastructure with fibre optics is not needed everywhere.

Newton Energy Solutions (NES)
NES works on highly efficient heat storage. The company's heat storage device can be connected to either a stand-alone boiler tank or additions to existing equipment, such as solar panels or heat pumps. This technology enables households to store the energy they produce themselves and use it at a later date. Energy storage is crucial in the transition to sustainable energy sources.

TouchWaves
TouchWaves focuses on the personal well-being market. This market has developed significantly in recent years with the rise of yoga, meditation, and mindfulness. Breathing plays an important role in these practices. The team at TouchWaves integrates haptic feedback technology into clothing, which can influence breathing and thus improve body awareness.

FononTech
This spin-off offers unique and scalable solutions that enable the production of next-generation microelectronics. 'Impulse Printing' is a pioneering additive manufacturing technology that solves the most complex 3D interconnection challenges. Impulse Printing enables high-throughput microLED assembly at low cost and high efficiency.



Movanta
A thermochemical conversion technology is being developed at Movanta that converts wet biomass into 'biocrude' under high pressure and temperature. This can be used in biofuel for ships and aircraft, for example. It can also be used to produce hydrogen and burned directly to generate heat and electricity. A major advantage over competing technologies is that low-grade wet biomass streams, such as sewage sludge and household waste streams, are suitable for this purpose. These waste streams are now often incinerated.

The ability to carry out research projects tailored to an urgent need requires TNO – in consultation with partners and clients – to deploy part of its financial resources to work completed within a short cycle. It is important that TNO employees have the competences to work in this way and that the organisation and management facilitate a short-cyclical approach. A number of units developed a short-cyclical way of working in 2022, which can be applied to projects that require quick solutions.

Following on from Brains4Corona (2020) and Brains4Nitrogen (2021), Brains4Neighbourhoods was completed last year. This involved harnessing the innovative power of combined research groups to tackle urgent problems at the neighbourhood level. One of the initiatives focused on energy poverty and achieving a quick and cheap solution to poorly insulated houses using secondary windows.

What still went wrong?
In 2022, TNO was successful in bringing DIY secondary windows to the general public through the Brains4Neighbourhoods project. In this way, we achieved immediate social impact. Unfortunately, things did not work out as well for the short-cycle solution (Torwash) that emerged from the Brains4Nitrogen project in 2021. Despite the dire nitrogen problem, we also failed to gain traction in implementing this innovation in 2022.

Strategic theme:

Healthy society

Improving people's health, both physically and mentally: that is our ambition. With opportunities for all children to grow up healthy and benefit from good health later in life. With active and healthy individuals using their talents and thereby contributing to a productive society. This requires innovation and continuous renewal in healthcare. The Dutch government has drawn up a number of missions for the coming years, with the aim that by 2040, all people in the Netherlands will live at least five years longer in good health. And the health gap between the lowest and highest economic groups should have been reduced by 30%. To achieve these goals, TNO is working with partners on unique technology and knowledge, such as effective prevention and behavioural intervention, personalised analogue and digital health and lifestyle interventions, better drug development, a healthy, innovative work environment, and a healthy living environment.

Contributes to the SDGs:

Moonshot(s):
- Drugs developed two years faster
- Lifestyle-related diseases halved

Read more...

Game changer(s):
- Organ perfusion for better drug development

White paper(s):
- Behavioural expertise is key to effective lifestyle policy

Spin-off(s):
- TouchWaves

Project deliverables:
- Prenatal child protection

New collaborations:
- Competent NL
- Green Deal 3.0

Strategic theme: Healthy society

White paper(s):

Behavioural expertise

Together with partners from the Lifestyle4Health consortium, TNO has presented the white paper entitled 'Gedragsexpertise is de sleutel voor effectief leefstijlbeleid' (Behavioural expertise is key for effective lifestyle policies) to the Ministry of Social Affairs and Employment. In the white paper, experts call for behavioural expertise to be made a structural part of policy.

Project deliverables:

Prenatal child protection

Sometimes a child protection order is needed as early as around birth to ensure the safety of an unborn child or a newborn. This is a far-reaching decision, especially if it involves a custodial placement. TNO, together with Amsterdam UMC and youth protection, therefore developed a multidisciplinary protocol and script for working together on and implementing a child protection measure around birth. The protocol can be adapted to any regional context and serves as a national example on this theme.

New collaborations:

CompetentNL

Commissioned by the Ministry of Social Affairs and Employment and the Ministry of Education, Culture and Science, TNO, together with the Employee Insurance Agency (UWV), Cooperation Organisation for Vocational Education, Training, and the Labour Market (SBB), and Statistics Netherlands (CBS), has started developing CompetentNL: a national skills language. Part of the collaboration is the creation of a database listing all skills and their descriptions. This database can be used for many different applications in education and the labour market.

Green Deal 3.0

In 2022, parties from the healthcare sector, supported by the Ministry of Health, Welfare and Sport, worked on reaching new and better agreements on making healthcare sustainable in the Green Deal 3.0: 'Working Together on Sustainable Care'. This Green Deal addresses the sustainability transition in the healthcare sector and further specifies the actions for the coming years. TNO has also signed up to the Green Deal 3.0.

Strategic theme:

Safe and secure society

Protecting what we hold dear and ensuring that people can live together in freedom and security: this is what we stand for and the end to which we develop strategic knowledge, technology, and capabilities. Maintaining our security is essential for our freedom, prosperity, well-being, and democracy. But geopolitical developments make it clear that this safety and security cannot be taken for granted. Europe and the Netherlands must stand up more strongly for our own interests. And the threats to our safety and security are becoming more complex as technology connects everything. All these dangers generally first affect professionals working in this field, which is why our main goal is to give these professionals a head start. We do this by developing and implementing relevant knowledge and technology. In addition to our substantial contributions to Defence, we want to develop into the top institute for applied technological innovations within the justice and security domain in the Netherlands.

Contributes to the SDGs:

Moonshot(s):
- Seeing without being seen
- All drug labs unprofitable

Read more...

Game changer(s):
- TRESSPASS

White paper(s):
- Achieving a breakthrough in glaring staff shortage requires new perspective

Prizes:
- ANA Avatar Xprize fifth place
- Von Kármán Medal

Project deliverables:
- Milspace2
- 75 years of Defence Research

Strategic theme: Safe and secure society

White paper(s):

Staff shortage

The huge staff shortage we are currently experiencing, which appears unsolvable, especially in the security sector, requires a multidisciplinary systems approach, according to TNO. In March 2022, the much-discussed white paper 'Doorbraak realiseren in schreeuwend personeels-tekort vraagt nieuw perspectief' (Achieving a breakthrough in glaring staff shortage requires new perspective) was published on the subject.

Prizes:

ANA Avatar XPRIZE fifth place

I-Botics, a partnership led by TNO, won fifth place in this prestigious international competition with a robotic system that determines a human's presence in a remote location in real time. The I-Botics team competed with 17 other nominees in Los Angeles.

Von Kármán Medal

The spring of 2022 saw the presentation of NATO's highest scientific award, the Von Kármán Medal, to TNO employee Rik Schleijpen. Rik received this award for his long-standing excellent scientific contribution, leadership, and vision in multilateral collaborations in the fields of sensors, electronic warfare, and autonomy. This extremely prestigious award was unanimously supported by all NATO countries. The medal has only been awarded 60 times before in the history of NATO, with Rik joining the select company of six other Dutch winners.

Project deliverables:

MilSpace2 launch

In December 2022, the final touches were made to the two MilSpace2 satellites, which were launched on 3 January 2023. This involves a partnership between the defence ministries of the Netherlands and Norway. These nanosatellites can detect radars very accurately from space.

75 years of Defence Research

For 75 years, TNO's defence research has contributed to the security of the Netherlands and its allies. The National Defence Organisation TNO was established in 1947. This anniversary was extensively celebrated with gatherings for both employees and external partners.

Strategic theme:

Sustainable society

At TNO, our goal is to achieve a sustainable society. A society that is resilient to the changing climate and has a circular economy. A society with a sustainable living environment, sustainable energy, and sustainable industry. To this end, we have to emit fewer harmful substances, build a circular economy, and be prepared for changes in our climate. To achieve this, we at TNO focus on a sustainable living environment, sustainable energy, and a sustainable industry. We are looking for integrated solutions at system level. These are solutions that create a balance between the changing needs of society, the environment, and the economy.

Contributes to the SDGs:

Moonshot(s):
- 50% of plastic is circular
- Plastic from air and residual gases
- Fighting climate change from space
- Every surface used for sustainable electricity

Read more...

Game changer(s):
- ENVISION
- Sunsmart smart windows
- Electrolysers for green hydrogen
- Hydrogen internal combustion engines

White paper(s):
- Particulate matter
- Nitrogen
- Microplastics
- Sustainable concrete
- Offshore wind

Spin-off(s):
- Newton Energy Solutions
- Movanta

Prizes:
- Breakthrough Energy Explorer Grant
- Second prize EARTO innovation award for hydrogen engine
- Milestone award in Xprize Carbon Removal competition for Carbyon

Project deliverables:
- Electrolysers with 200x less iridium

New collaborations:
- Circular Plastics NL
- Zero-Emission Construction

Strategic theme: Sustainable society

White paper(s):

A way out of the nitrogen problem
No fewer than five different papers were published on the theme of sustainability in 2022 (see overview above). By far the most media attention focused on TNO's analysis of the nitrogen issue, which even led to parliamentary questions. To solve the problems, entrepreneurs need to gain a greater understanding of their own emissions and the possibilities they have to take measures to curb them. This requires shifting the focus from controlling deposition to controlling emissions, combined with more sophisticated measurement of emissions at the source.

Prizes:

Breakthrough Energy Explorer Grant
Breakthrough Energy, a private investment coalition founded by Bill Gates, awarded the 'Explorer Grant' to Cellcius, a spin-off of TNO and Eindhoven University of Technology. Cellcius works on thermal battery technology for energy storage and emerged from the TNO Tech Transfer programme. It is one of the first companies from the Netherlands to receive support from this fund.

EARTO Innovation Award
TNO won second prize in the 'Impact Expected' category for a hydrogen combustion engine for shipping. The innovation involves converting existing heavy fuel oil or diesel engines in cargo ships into clean hydrogen combustion engines. This can achieve a reduction in carbon emissions of nearly 100%.

Xprize Milestone Award
Carbyon is a TNO spin-off that develops equipment to filter CO_2 from the air and store it underground. In April, the team behind Carbyon received the XPRIZE Milestone Award in the carbon removal category and the sum of $1 million from the Musk Foundation.

Attractive project deliverables:

Breakthrough electrolysers
Green hydrogen, produced through electrolysis using electricity from solar and wind, has a crucial role to play in the transition from fossil fuels to renewable energy. TNO has tested an electrolysis cell with 200 times less of the rare material iridium, with promising results. A patent has been filed. These results are important because scaling up electrolysis is at risk due to the very limited availability of iridium and platinum in particular.

New collaborations:

National Growth Fund Circular Plastics NL
The Dutch government has given final approval to the first phase of Circular Plastics NL and is investing €124 million from the Growth Fund. With the implementation of Circular Plastics NL, the government, companies, and knowledge institutions are making efforts to meet the circularity targets of recycling 50% of all plastics by 2030. With Circular Plastics NL, the parties will combat climate change, reduce the use of fossil raw materials, and reduce environmental pollution. And the sustainable earning power of the Netherlands will be strengthened in the process.

Zero-Emission Construction achieves initial results
The consortium that has been working on innovations in the field of Zero-Emission Construction since 2021 grew substantially in 2022, from around 50 to more than 80 companies from the construction sector, as well as knowledge institutions. TNO is a knowledge partner in a number of projects and acts as the director that shapes a programmatic and adaptive manner of innovation with all the parties. This produced the first practical results in 2022, such as the modular Natural Pavilion that attracted a lot of attention at that year's Floriade garden festival. This project also won the Innovation Award 2022 from trade magazine Cobouw.

Strategic theme:

Digital society

TNO wants to contribute demonstrably to making the Netherlands the digital leader of Europe. After all, digital technology supports and accelerates all efforts to tackle major innovation challenges. TNO develops IT technology that respects public values and fundamental rights, creates a global level playing field, and safeguards national security. We also contribute to cyber security in the Netherlands. Finally, TNO aims to support its partners and clients in the digitalisation challenge by developing techniques and tools that can be used in multiple domains.
One example is maintaining the prominence of the Dutch high-tech industry through pioneering innovations. It is just this combination of IT technologies that ensures innovation. Open infrastructures, data sharing, and AI-driven analytics require approaches that can deal with complexity. TNO achieves this by developing and integrating key supporting IT technologies from the Dutch and European digitalisation agendas.

Contributes to the SDGs:

Moonshot(s):
- Digital privacy and security for all
- Quantum technology heralds new era

Read more...

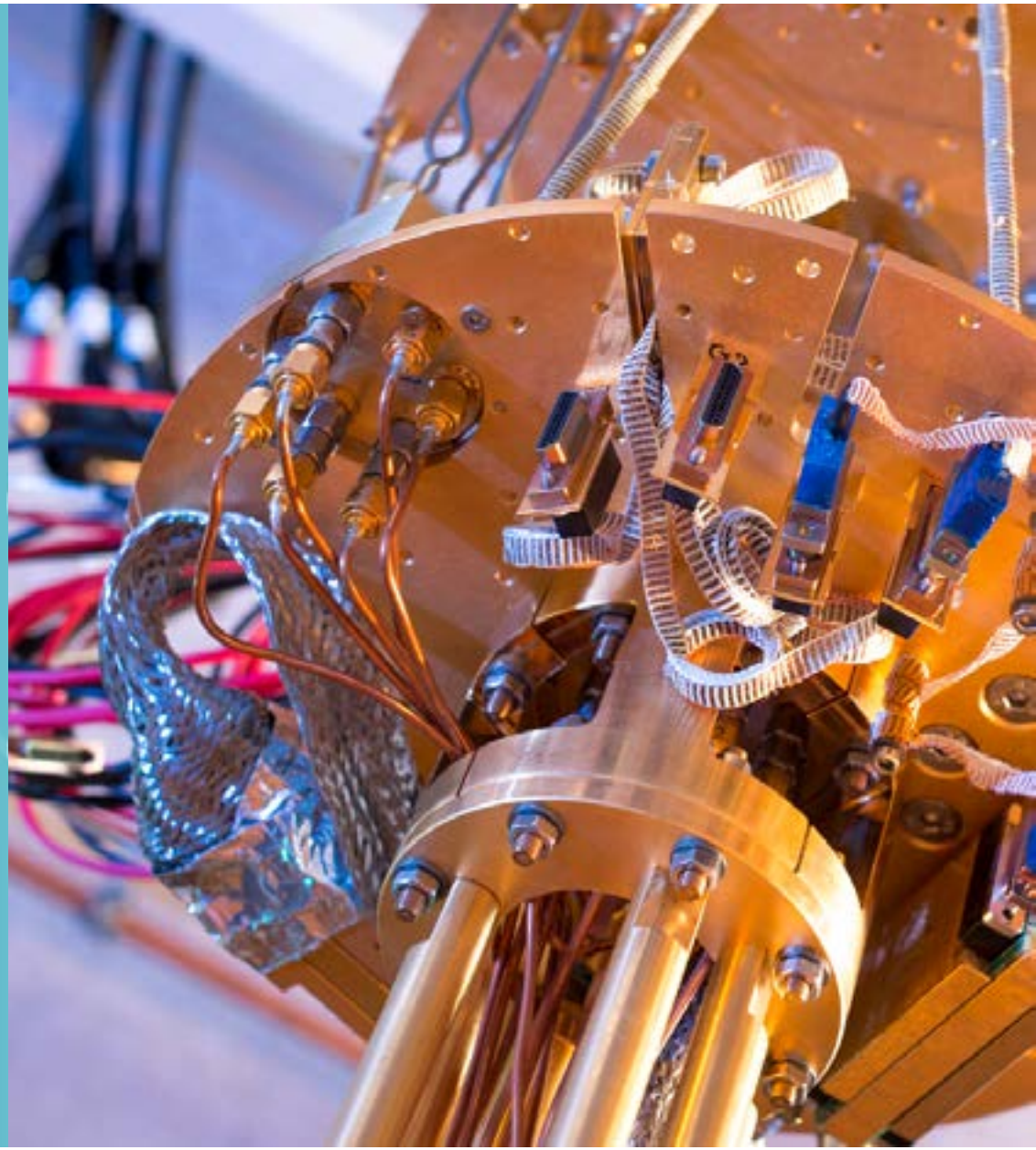
Game changer(s):
- TOmCAT
- Poverty reduction using Multi-Party Computation

White paper(s):
- Future vision of AI
- Digital sovereignty

Spin-off(s):
- Aircision
- FononTech

Prizes:
- Social XR

New collaborations:
- NXTGEN HIGHTECH
- Future Network Services
- Qu-Test



Strategic theme: Digital society

White paper(s):

Future vision of AI
In 2022, TNO celebrated its 90th anniversary. To mark this event, a number of experts from our organisation wrote about their future vision of AI. In this vision, the experts set out where they expect us to be regarding AI in 10 years' time. And they predict what the implications will be for areas such as industry, mobility, sustainability, our health, and research itself. As part of this vision of the future, TNO employees interviewed some prominent guests about their vision of AI. These guests included David Deutsch, Georgette Fijneman, Arnon Grunberg, Bas Haring, and Bram Schot.

Digital sovereignty
The surge in data use in our society is increasingly at odds with our heavy reliance on the US and Asia for digital infrastructure. In light of recent geo-political developments and the pandemic, we are acutely aware of the need for digital sovereignty. This English-language white paper describes how European cloud and technology providers can distinguish themselves from Big Tech companies.

Prizes:

Social XR
TNO received a Research Grant from Meta in 2022 to study the application of Social XR (eXtended Reality) in the work environment. The contribution of €335,315, in the form of an endowment, comes from Meta's XR Programs and Research Fund. Social XR is a collection of technologies that enable individuals to meet each other remotely in 3D. The research will be conducted independently by TNO and completed in 2024.

New collaborations:

NXTGEN HIGHTECH
NXTGEN HIGHTECH is a consortium consisting of 340 organisations, which aims to put the Dutch high-tech equipment ecosystem among the leading high-tech clusters in Europe by 2030. This programme is developing a new generation of high-tech equipment focused on sustainability, digitalisation, health, and technology sovereignty. This equipment will be manufactured, deployed, and maintained with digital technology to keep production in the Netherlands and the EU profitable. This will strengthen the earning power of the Netherlands and addresses societal challenges. NXTGEN HIGHTECH received €450 million from the National Growth Fund.

Future Network Services
The Ministry of Economic Affairs and Climate Policy and Top Sector ICT support the Growth Fund proposal by TNO and partners to create Future Networks Services (FNS). FNS will be submitted in the third application round of the National Growth Fund, which closes in early 2023. Industry partners were urged to join this consortium as soon as possible. Dozens of telecom companies, technical universities, and knowledge institutions joined in 2022.

Qu-Test
TNO has been at the forefront of developments in quantum technology for years. Our innovative QITT Lab is just one of the many ways we are contributing to advancing this revolutionary technology. Now, for the first time, TNO has been selected to lead a federated network of 11 European Research and Technology Organisations (RTOs) and National Metrology Institutes (NMIs) funded by the European Commission (EC), with the aim of stimulating developments in the quantum technology sector through testing and experimentation.

Game changer

Sunsmart smart windows

Windows make climate control in the home particularly difficult. In winter, we lose a lot of heat through windows, but in summer, windows sometimes actually allow too much heat into the home. To solve this problem, TNO is developing Sunsmart smart windows, which automatically switch between letting in and blocking solar heat. And this leads to additional energy and cost savings of up to 9% and €25 per m^2 of glass per year compared to state-of-the-art HR++ windows.

The effective use of sunlight and solar heat can have a major impact on the energy efficiency of buildings as it reduces heating demand in winter and cooling demand in summer. Bringing this technology to market within two to three years could make a major contribution to achieving the European energy and climate targets. In early 2022, the smart windows entered the pilot phase and initial results show good performance in realistic field conditions.

Partners: Hasselt University, imec, Catholic University of Leuven, Yparex, Everlam, Glass for Glass, Soltech

Unit: Circular Economy & Environment

Organisation of our research

Three things are essential to the organisation of TNO's research: how we programme our knowledge, the research facilities we invest in, and the researchers who conduct our research. All three are necessary for a well-functioning TNO.

Programming TNO's knowledge

TNO's agenda and programming are created by national and international (European) policy through close coordination with partners and clients or they are based on statutory tasks such as Defence Research and the Geological Survey of the Netherlands. This forms the basis of our knowledge development (intellectual capital).

Roadmaps

TNO manages strategic research programming through a portfolio of 'roadmaps'. Roadmaps capture the needs of the outside world in product/market combinations (PMCs) and link these to TNO's projects, thus differentiating the TNO strategy to specific domains. A roadmap sets out the social and economic impact of the intended product/market combinations, the required investments in technologies and methodologies, the mix of funding sources, and the research facilities needed.

External dynamics mean that TNO's roadmaps have to be adapted accordingly and the portfolio continued to be in constant development in 2022. Over the next few years, TNO will intensify its efforts on a number of topics by investing more of its government funding in those areas (within the existing possibilities). It concerns:

New Transitions & Transformations roadmap: supports public and private decision-making in complex transformations by working with multiple parties within the limits of the available resources (space, raw materials, labour, etc.) to increase overall prosperity. In 2022, TNO launched a multi-annual collaboration with AiNed and CBS to better measure the impact of innovation programmes. TNO also designed a Dutch support platform for 'NetZeroCities', linked to the EU Cities Mission '100 Climate-neutral and Smart Cities by 2030'. In addition, TNO defined the 'Green Chemistry, New Economy' action agenda for the raw materials transition.

Growth of Environment & Sustainability roadmap: focuses on solutions for creating a circular economy and support for the government and the business community in this transition. In 2022, TNO further strengthened its thought leadership on circularity and the systemic approach to it through participation in Circular Plastics NL and Syschemiq. In addition, great strides were made in scaling up recycling technologies, TNO contributed to the Work Programme for Monitoring and Guiding the Circular Economy (Netherlands Environmental Assessment Agency) and it did further work on 'Materials Strategic Independence' for the Dutch government.

Strengthening Smart Industry roadmap: digitalisation of the Dutch manufacturing industry (including SMEs). This is achieved through 1) the creation of autonomous production processes, 2) smart connected networks, and 3) the development of knowledge and skills in business and industry. The National Scaling-Up Agenda 2022-2026 was launched in 2022, with the goal of having 1,000 companies take a significant step in the area of factory digitalisation. TNO's development of '10xklaar' (10xready) and 'Smart Connected Supplier Network' enables companies with limited resources to take the first steps in the digitalisation transition in an easily accessible manner.

Early Research Programmes

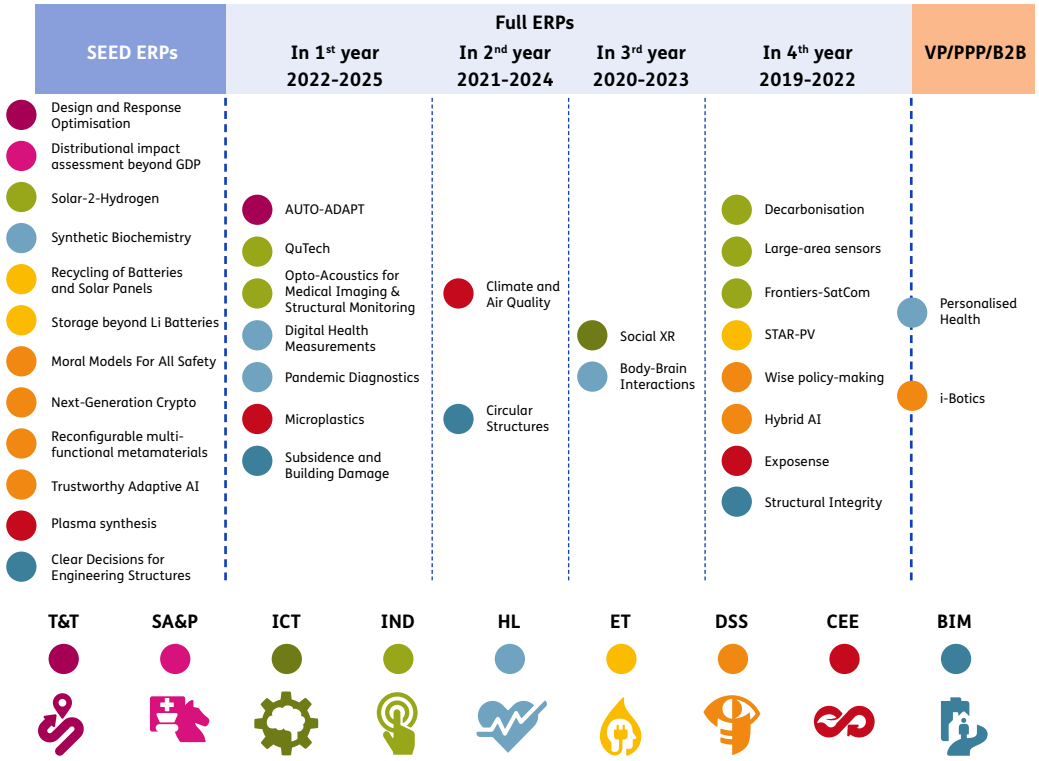
In the Early Research Programmes (ERPs), TNO develops new knowledge to strengthen our technology position, enabling us, together with knowledge partners and stakeholders, to make a major contribution to meeting societal challenges and strengthening the economy. The technology positions developed find their way into TNO roadmaps, where they are further developed and exploited in Demand-driven Programmes, Shared Research (public-private partnerships), Contract Research, licences, and spin-offs.

Six new 'Full ERPs' (four-year programmes) kicked off in 2022: Digital Health Measures, Pandemic Preparedness, Subsidence and Building Damage, Opto-Acoustics, Auto-Adapt, and MicroPlastics. These programmes involve fields with clear scientific challenges and high social relevance. The ERPs were selected from among 10 'Seed ERP' projects from 2021. In addition to the six new ERPs, 10 new 'Seed ERPs' were also selected.

Demand-driven programmes

The year 2022 was the third year of the Mission-Driven Top Sectors and Innovation Policy (MTSIP). Part of the Ministry of Economic Affairs and Climate Policy's innovation policy, this mission-driven approach sees the government, the 'top sectors' – industries in which Dutch companies and research centres excel worldwide – and knowledge institutions join forces on five topics: Energy and Sustainability, Agriculture, Food and Water, Health and Healthcare, Safety and Security, and Key Technologies. In 2022, TNO was closely involved in aligning the 'knowledge and innovation agendas' (KIAS) and translating these to research programmes for nearly all specific missions.

The mission-driven approach guides TNO's research programming, which focuses on creating both social and economic impact while also acting as a bridge between the public and the private sector. Over half of the state funding that TNO receives comes under the umbrella of the MTSIP. As in 2021, TNO's research programmes were geared specifically towards contributing to the integral topics of the MTSIP.



TNO's research programmes cover almost all mission-driven topics, with 'Energy and Sustainability' and 'Key Technologies' being the most prominent ones for TNO, followed by 'Health and Healthcare' and 'Safety and Security'. To tie in with the MTSIP even more closely and thus be better able to liaise with coordinators in the public and private sectors, TNO started to consolidate research programmes in 2021. This reduced the number from 42 in 2020 to 32 in 2022. Each research programme will then have the kind of focus and critical mass behind it that is needed to be able to contribute to the missions.

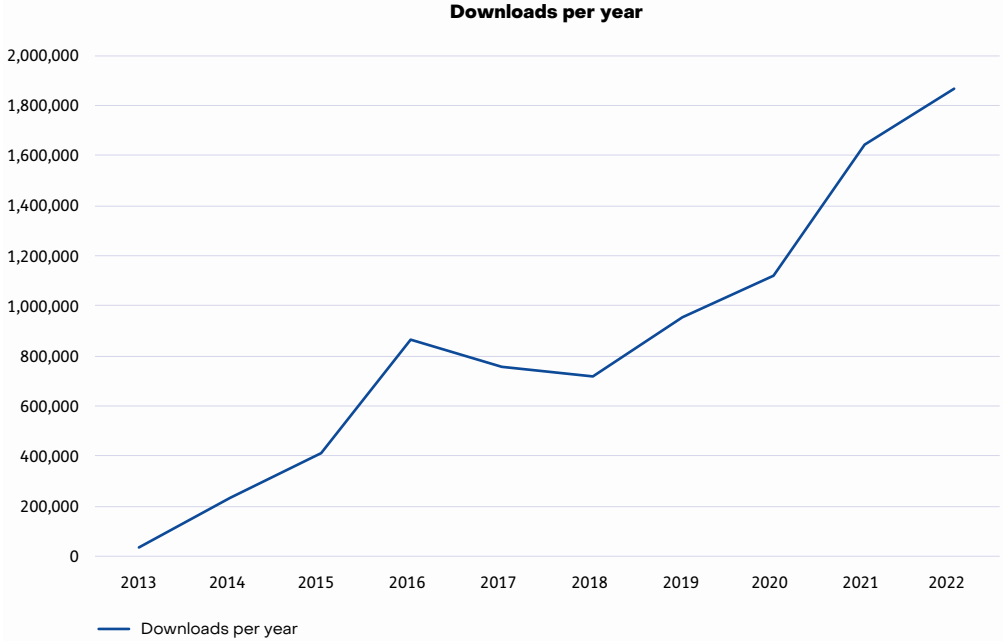
Quality of research

Research groups are reviewed every four years by an external audit committee. In addition to observations and recommendations, the committee makes a quantitative assessment of the group on three aspects: quality, impact, and viability. This Knowledge Position Audit (KPA) is carried out in each unit or, for the larger units, in each cluster of research groups. The outcome of the KPA is one of the Key Performance Indicators (KPIs). A good KPA result means the group is internationally recognised, competitive, has good focus, and shows potential for innovation. In 2022, KPAs were carried out at the DSS, Healthy Living, and ICT units. All three audits were completed successfully.

Open Access publications

The TNO Repository has been online since 2013. In line with Open Access guidelines, this is a free and freely accessible database, now with more than 56,000 TNO publications. The Research Information Support (RIS) department adds new publications almost daily. These are not only new publications but also old TNO publications that have recently been digitised. The full text of around half of the publications in the TNO Repository is available immediately, while for the other half, only the metadata are visible and the full text is accessible on request.

The impact of the TNO Repository is increasing, partly because TNO is making it increasingly easy to find and search. There were just under 2.5 million visitors in 2022, bringing the total number of visitors since its inception in 2013 to over 15 million. The number of publications downloaded rose by 200,000 in 2022 compared to 2021, reaching 1.8 million. In total, nearly 8.5 million documents have been downloaded since 2013.



World-class facilities (physical capital)

High-quality research facilities are crucial for knowledge development at TNO and are therefore necessary for the organisation to maintain a leading role. TNO prioritises the implementation of a long-term facilities agenda, with facilities that will be shared with partners in the relevant ecosystems where possible. A precondition for creating prestigious facilities is the availability of structural funding from the government. No structural funding was available for managing strategic research facilities until 2022. The fourth Rutte government's coalition agreement and the Government Vision Document on innovation from the Ministry of Economic Affairs and Climate Policy and the Ministry of Education, Culture and Science, published in November 2022, make funding available for investing in strengthening applied research facilities (€500 million), applied research (€100 million), and large-scale scientific infrastructure (€500 million). TNO is eligible for funding for applied research facilities. A large number of new, diverse research facilities became available in 2022.

New facilities

Quantum Application Lab, Delft

In March 2022, the Quantum Application Lab (QAL) was launched in Delft. The QAL is a public-private partnership aimed at making quantum computing applicable to users from various sectors. The lab provides parties with access to specific knowledge and technical infrastructure in order for them to start exploring the benefits of quantum technology in practice for their fields. The initiators of the Lab are the University of Amsterdam, the Dutch National Research Institute for Mathematics and Computer Science (CWI), TNO, SURF, Delft University of Technology, the Netherlands eScience Center, and IBM Quantum.

Smart Mobility Research Centre, Helmond

In March 2022, the Province of North Brabant provided a €2.5 million grant for the creation of a Smart Mobility Research Centre (SMRC) in Helmond. This is a widely accessible, state-of-the-art research facility linking the traditional automotive industry with the IT sector so that knowledge is developed and implemented in the area of systemic mobility challenges. This open research facility also lowers the threshold for SMEs to engage in innovation.

Solar energy, Eindhoven and Petten

In April 2022, research facilities for smartly designed semi-finished products were put into operation in Eindhoven and Petten. In Eindhoven, we develop processes for making flexible laminates with solar energy functionality in every conceivable variation of size, shape, and electrical power. The new solar energy integration lab in Petten is specially equipped to conduct research on all types, shapes, and sizes of silicon-based solar panels. These are complete solar panels and solar laminates that can be further integrated into various end products. At this location, it is also possible to determine the energy yields of various products and conduct research into service life, reliability, and safety.

Concurrent Design Facility, Soesterberg

The Dutch Defence Materiel Organisation and TNO intensified their collaboration by opening the Concurrent Design Facility (CDF) in Soesterberg in April 2022. Concurrent Design is an interactive, multi-disciplinary method of collaboration. For the Ministry of Defence, TNO will, over the next few years, deepen and broaden its knowledge and innovate in the field of design processes and strategic and managerial decision-making, with the CDF as a field lab.

Sylviusweg location, Leiden

In October 2022, almost all research groups of the Healthy Living unit moved to the new research facility at Leiden Bio Science Park.
This anchored TNO at the heart of innovation in Life Sciences & Health in the Netherlands, where high-quality education, research, healthcare, and business come together. In Leiden, TNO has high-quality research facilities, such as the Accelerator Mass Spectrometer (AMS) for faster drug development, unique microbiology facilities, and an advanced biomarker laboratory to identify and validate complex biomarker panels.

Home for talent indicators

Number of employees
as at 31 December

3,897
2021: **3,652**

Number of FTEs
as at 31 December

3,595
2021: **3,337**

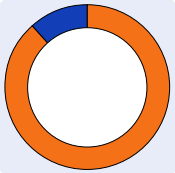
New staff

631
2021: **403**

Left employment

386
2021: **314**

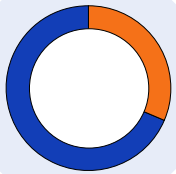
Nationality



86.5% Dutch
2021: **88.5%**

13.5% Non-Dutch
2021: **11.5%**

Gender ratio
All of TNO



32.7% Female
2021: **31.5%**

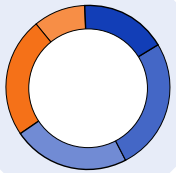
67.3% Male
2021: **68.5%**

Gender ratio
Top of TNO, SB, EB, 1st Echelon

40% Female
2021: **45.8%**

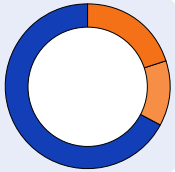
60% Male
2021: **54.2%**

Breakdown by age



669 < 30
1,013 31-40
900 41-50
922 51-60
393 >= 61

Full-time/Part-time



20.2%
Part-time 90%-100%

12.8%
Part-time < 90%

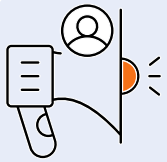
67%
Full-time

Contract

Fixed-term
587
15.1%

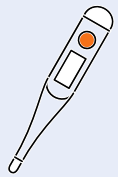
Permanent
3,310
84.9%

Employee engagement



7.2
2021: **7.3**

Sick leave



3.69%

1.05
Reporting frequency

Home for talent (human capital)

TNO wants to be a 'Home for Talent' for current and future employees. Being a good employer means investing in people. After all, the knowledge and employability of its staff are crucial to TNO's ability to achieve its strategic goals.

In 2022, the proportion of internationals (non-Dutch employees) at TNO increased and the number of women within the total TNO population rose slightly. In contrast, at the top of the organisation, the percentage of women decreased. This is partly due to the change in structure (from nine to six units), but is nevertheless considered undesirable. In the coming years, we will take action to restore the upward trend in the percentage of women at the top of the organisation, which was evident in recent years.

TNO supervised 401 students doing graduation and internship projects in 2022. Of these interns, 51 were recruited to a junior position at TNO.

A total of 12 new interns started on the TNO trainee programme in February and September 2022. The two-year programme had a total of 24 trainees at the end of 2022.

Intensifying recruitment

Due to the increase in task-related funding from the Ministry of Defence and the approval of a large number of National Growth Fund proposals in both 2021 and 2022, TNO expects a significant and steady increase in the number of research hours over the next few years. As a result, we stepped up recruitment activity and made preparations to absorb a large number of new employees into the organisation. The result was clearly visible in the second half of 2022 and net inflow increased significantly. A new brand and work campaign was developed at the end of 2022 and will be launched in early 2023. TNO expects this to deliver the anticipated growth.

Empower

When the Empower programme was launched in 2020, TNO formulated the ambition of achieving a more equal and mature relationship between the organisation and its employees with regard to performance management. Regularly giving and receiving feedback and feedforward is an essential part of this, together with identifying and developing talent. In this way, personal development, talent, and performance are aligned and there is room for customisation. Of course, Empower should also offer opportunities to grow and develop at a faster pace to employees whose performance is outstanding.

In early 2022, it was noted that the implementation of Empower was not going well in all parts of TNO. Several adjustments were therefore made to the programme during 2022, including annual Home for Talent Review sessions focusing on staff development.

Attractiveness as an employer

For the second year in a row, TNO won the Randstad Award for most attractive non-profit employer of the Netherlands. TNO also won this award in 2014 and 2016. TNO's good reputation and financial health, as well as the interesting work and job security at the organisation, achieved high scores in Randstad's survey. TNO also featured again on LinkedIn's list of the '25 Top Companies To Grow Your Career' in the Netherlands. It was in sixth place after coming third the previous year.

As an employer, TNO is very proud of such recognition and it encourages us to continue offering attractive employment opportunities. In this context, it is essential to know and focus on the needs of employees. In 2022, 'Pulse Surveys' were therefore launched alongside the comprehensive annual Employee Engagement Survey (EES) to additionally track key factors such as workload and job satisfaction throughout the year. Furthermore, TNO initiated projects such as optimising the experience of candidates and employees in the recruitment, pre-onboarding, and onboarding processes, and redesigning the HR-IT landscape.

Employee Engagement Survey
In 2022, 62% of TNO employees participated in the Employee Engagement Survey (EES). The survey found that, on average, TNO is perceived as a safe, inclusive, and instructive work environment. Employees experience great job satisfaction and challenges in their work. Employee engagement fell slightly in 2022, to 7.2 out of 10, compared to 7.3 in 2021. Psychological safety at TNO is high on average but differs greatly between departments and individuals.

Burnout-related complaints remained the same as in 2021 at TNO's overall level. Younger employees (25-34 years old) in particular experience these complaints and an increase compared to 2021 was identified specifically for this group. Reducing burnout-related complaints, as well as the perceived impediments to work that underlie them, remains a priority for TNO in the 'Vital Organisation' strategic programme. This is also included in the above-mentioned Pulse Surveys.

Strategic Programme: Vital Organisation
This programme aims to ensure that TNO and its employees are ready for the challenges of the coming years. Given our ambitions, the expected growth in various parts of TNO, and the tight labour market, it is now more important than ever that everyone at TNO enjoys their work and that demotivating factors are carefully eliminated. This is the only way to attract and retain motivated employees. It is also a prerequisite for implementing our strategy and achieving our ambitions. The programme brings together efforts in the areas of vitality, hybrid working, workload, cutting red tape, and leadership. The expected growth requires a coordinated approach to recruitment, onboarding, retention, organisational adaptation, accommodation, the working environment, and more. Coordination from the 'Vital Organisation' programme enables TNO to manage these efforts more effectively and efficiently.

TNO employees in the spotlight

Since 1932, TNO has been working successfully on applied research to increase the prosperity and well-being of the Netherlands. How have we managed to do that? By giving people the freedom to do their work and by giving them space to develop and deploy their talents. On this page, we present several TNO employees.

Kallol Das
Senior scientist
At TNO, we not only deal with today's challenges but also do a lot of research for tomorrow's world. This is different from academia, where research is usually not concerned with practical applicability. And different from industry, which is guided much more by product portfolios and the flavour of the month. TNO bridges these two worlds by giving scientists the opportunity to work on issues that matter.

Nadine Wennersbusch
Senior project manager
At TNO, I can help solve a societal problem. Why don't I put my knowledge of physics to direct use? I've always enjoyed contributing to a wide range of aspects.

Robert Muller
Junior scientist innovator
You won't learn the things we do here on any other study programme. And we need everyone: higher professional or university graduates, PhDs – everyone has a role. I never expected to end up at TNO, but everything just fell into place during the job interview. TNO has a wide variety of projects and expertise in-house; it's a place where I can be creative and express myself.

Shari Finner
Cyber Security project manager
Research is only worth something if it's applied somewhere in practice. Otherwise, you can't develop it further. I went in search of an employer that shared this view and would give me the opportunity to discover what I'm really passionate about.

Niek van Breederode
Infrastructure team leader
What I love about TNO is that you're given the freedom to shape your own career. We have so many disciplines here that it's easy to take the step from managing to developing, for instance. Even if after some time you want to be more involved in the substantive side of IT, closer to research, you can make this happen. Just try it out for a couple of months, is what I say. Personal experience has taught me that this brings out the best in people.

Stefanie Bus
Geohydrologist
If you see an opportunity, seize it. If you have a good idea, go for it. This is how I came to be responsible at TNO for making groundwater data accessible to decision-makers. And I'm not even a professor. Everyone's opinion is important at TNO, regardless of your position in the organisation. If you know what you can do and how you can contribute to TNO's success with it, there are lots of possibilities here.

Game changer

Poverty reduction using Multi-Party Computation

With historically high inflation and rising energy bills, poverty reduction is more relevant than ever. Elderly people who do not have enough income and assets to make ends meet often have the right to the Supplementary Provision of Income for the Elderly (Aanvullende Inkomensvoorziening Ouderen, AIO). It is estimated that around 30% of this group is not yet using the scheme, but the Social Insurance Bank (SVB) is not allowed to simply request the details of a person's family income.

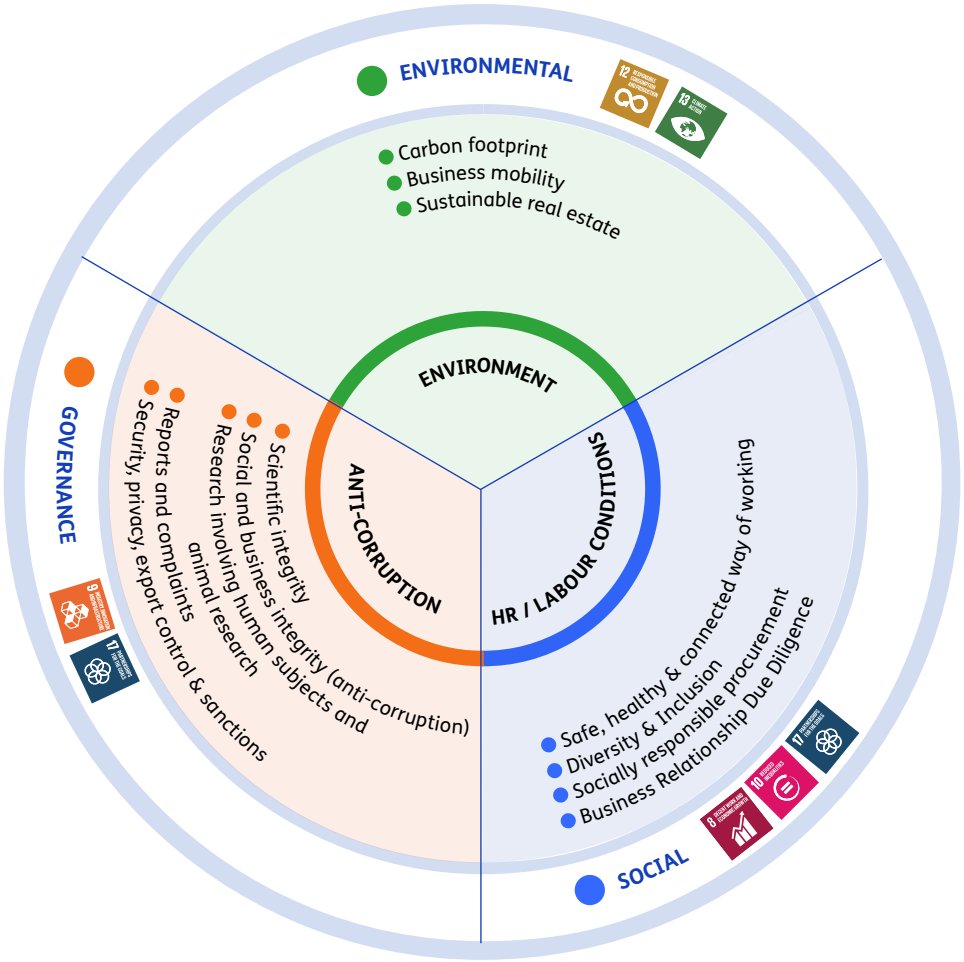
Effective poverty policy requires a better understanding of the many dimensions of poverty. Using Multi-Party Computation (MPC), a technique we use to process data securely without having to view them, we can see exactly who might be entitled to AIO. This TNO innovation not only enables the Dutch government to design its services to be more proactive but also makes a real difference to the lives of many individuals.

Partners: SVB and UWV

Unit: Information & Communication Technology

Sustainable and responsible operations

TNO is aware that its credibility and licence to operate depend on the way in which it shoulders its social responsibility and 'practises what it preaches'.



The key points of TNO's sustainability policy are:
- TNO aims to have made its operations climate-neutral by 2040.
- TNO is committed to the UN Global Compact and subscribes to the 10 principles of sustainable business practices.
- TNO recognises its supply-chain responsibility towards both suppliers and customers.
- TNO focuses in particular on themes related to its primary process: integrity, energy and sustainability, diversity and inclusion, and working conditions.
- TNO intends to include the priority areas in the annual plans of the relevant departments.

Progress on the themes will be tracked by means of two Key Performance Indicators (KPIs) established in 2022 and measured at a company level: the total carbon footprint and the score on the EcoVadis benchmark (see separate box).

The image opposite shows TNO's priorities for sustainable and responsible operations, clustered according to the Environment-Social-Governance (ESG) classification. These priorities have also been linked to the relevant UNGC principles. Finally, there is a link to the SDGs to which TNO contributes with its sustainable and responsible business operations.

Highlights of sustainable and responsible operations

- EcoVadis score increased by 10 points.

Environment:
- Carbon footprint: decreased per FTE and per euro of revenue.
- New sustainable mobility policy implemented.
- Interim targets for climate neutral by 2040 elaborated.

Social:
- Sustainability results in four tenders.
- Improvements made to method for Risk Inventory & Evaluation (RI&E).

Governance:
- Security Awareness programme rolled out across TNO.
- National Knowledge Security Guidelines implemented.

Environment

TNO reports on its carbon footprint every year. This concerns emissions caused by its employees' mobility as well as energy consumption in its buildings and in the procurement of products and services. In addition, TNO reports on steps taken over the past year in the areas of business mobility and sustainable real estate.

Carbon footprint

TNO takes responsibility for direct and indirect greenhouse gas emissions resulting from its business activities. TNO's goal is to ensure that its business activities are climate neutral by 2040. To measure and adjust progress, the carbon footprint is determined annually in accordance with our established calculation method.

In 2022, TNO worked out the intermediate emission targets leading up to 2040. TNO considers its emissions to be net neutral if its carbon emissions are reduced (avoided) or, for the part that cannot be avoided, offset by 'negative' emissions that remove CO_2 from the atmosphere. Furthermore, TNO's sustainability efforts first focus on the largest sources of emissions (fair share) and involve the entire organisation. In working out the emission targets, we chose the 'ideal' path with absolute intermediate targets, with a greater reduction in emissions to be achieved over the next few years.

EcoVadis score

EcoVadis provides sustainability assessments of companies based on four themes (the environment, labour and human rights, ethics, and sustainable procurement), each with a maximum score of 100. The overall assessment consists of the average on the four themes, based on policy and other documentation supplied. This documentation is reviewed by international experts. Last year, TNO turned its progress on sustainable and responsible operations into a substantial increase from 38 points (2020) to 48 points in 2022. With this result, TNO has scored above average in the 'Scientific Research and Development' sector and reached the 'Bronze level'. In particular, much has been improved on the theme of sustainable procurement, but there was also progress on the themes of the environment and labour and human rights. With further significant steps, TNO aims to reach the 'Silver level' (56 points) by 2025.

CO_2 emissions in three scopes

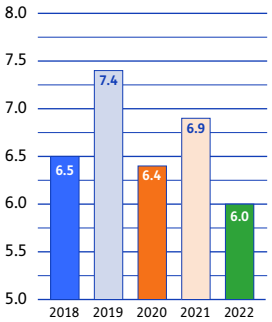
Emissions can be broken down into three scopes, with various targets:

- Scope 1: direct emissions from TNO's own operations (fuel for lease cars and gas consumption in buildings). TNO wants these emissions to be at net zero by 2040.
- Scope 2: indirect emissions from TNO's own operations (business travel, electricity and heat consumption in buildings). TNO wants these emissions to be at net zero by 2040.
- Scope 3: indirect emissions from other activities in the supply chain (commuting and the procurement of goods and services, such as materials and transport). In order to prevent an undesired shift of CO_2 emissions from our own activities (Scopes 1 and 2) to the supply chain (Scope 3), the total carbon footprint per euro of revenue, expressed as a five-year average, must also be reduced.

In 2022, TNO's total carbon footprint was 176 kilotonnes of CO_2 equivalents, roughly equal to its footprint in the pre-COVID year of 2019. If we look at the individual scopes, it is noticeable that Scopes 1 and 2 have fallen sharply (both -20%) compared to 2019. The impact of sustainability measures on real estate and mobility is most evident here. Scope 3 emissions have increased by 5 kilotonnes from 2019. This was probably caused by the effects of the 2022 price increases on the calculation method used (based on spend). By 2023, TNO wants to make a switch to a calculation method for Scope 3 that makes the effects of sustainability more measurable.

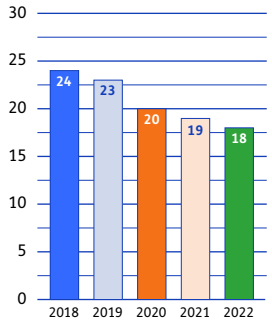
Carbon footprint (in kilotonnes CO_2-eq)

Scope 1: direct emissions



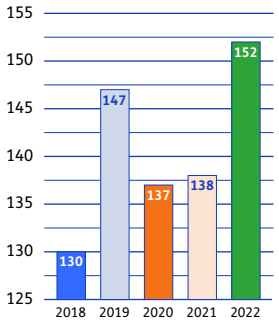
2022 vs. 2019
6.0 ▼ -19%
-1.4 CO_2

Scope 2: indirect emissions



2022 vs. 2019
18 ▼ -20%
-5 CO_2

Scope 3: emissions in the chain



2022 vs. 2019
152 ▲ +4%
+5 CO_2

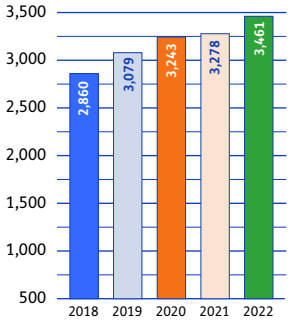
Emissions in Scope 3 (in tonnes CO_2-eq)

Emissions category	2019	2020	2021	2022
Labs	39,173	39,834	42,359	43,464
Contracting research and staff	47,588	42,926	41,695	39,903
Buildings	28,196	31,304	31,290	36,452
Offices	9,728	9,465	8,937	13,600
Mobility	13,348	7,892	7,494	8,637
Printed matter and client relations	4,861	3,939	4,178	5,702
Facilities, waste, and water	6,006	3,016	7,174	3,657
Total	**148,900**	**138,375**	**143,127**	**151,415**

Emissions in Scope 3 cover several categories, with labs, the hiring of research and staff, and the renting of buildings accounting for around 80% of emissions. The rise in office spending also stands out here. Scope 3 emissions increased in 2022, presumably due to major purchases of IT resources, refurbishments, renovations, and price increases. Emissions due to waste, water, and facility services actually halved, probably due to sustainability measures. To reduce Scope 3 emissions further, TNO is working on policy for circular operations.

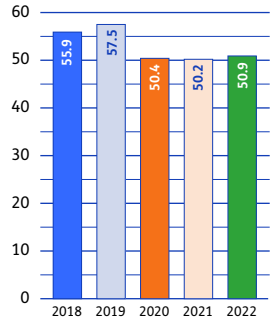
Carbon footprint in relation to employees and revenue

Number of employees
(FTE)



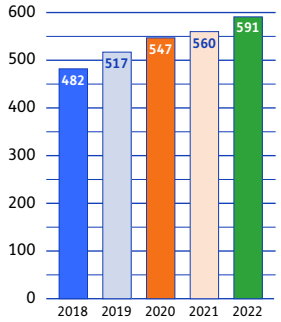
2022 vs. 2021
3,461 ▲ +6%
+183 FTE

Relative emissions
(tonnes co_2-eq/FTE)



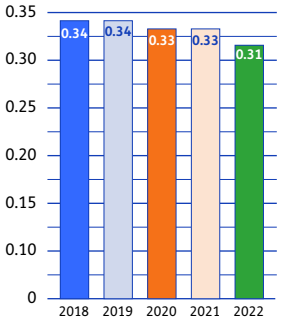
2022 vs. 2021
50.9 ▲ +1%
+0.7 CO_2

Revenue
(millions of €)



2022 vs. 2021
591 ▲ +5%
+31 mln

Five-year average emissions
(kg CO_2-eq/eur)



2022 vs. 2021
0.31 ▼ -6%
-0.2 CO_2

TNO also considers its total carbon footprint (Scopes 1, 2 and 3) relative to its size in number of employees (FTEs) and revenue generated (in euros). The bar diagrams on this page present this relative carbon footprint over the last five years. They show that relative CO_2 emissions increased slightly from 50.2 to 50.9 tonnes per FTE. The five-year average per euro of revenue fell to 0.31 kg per euro. This shows that despite an increase in revenue, TNO is able to make its operational processes more sustainable. For TNO, the priority for 2023 is to update the method for measuring emissions so that the effects of measures in Scope 3 (circularity) can be clearly measured.

Business mobility

In 2022, much work went into implementing TNO's new mobility policy, which takes effect from 2023. One of the cornerstones of the new policy is the sustainability of travel movements, both for business mobility and commuting. The main new sustainability measures are accelerated electrification of the lease car fleet, full public transport reimbursement, subsidies for the purchase of sustainable transport, no short-haul air travel, and carbon pricing for emissions from air travel. These measures are expected to result in TNO achieving the planned 25% reduction in CO_2 emissions per FTE by 2025 and a 50% drop by 2030 (compared to benchmark year 2016; see table on emissions by mobility type). This is in line with the ambitions of the 'Coalitie Anders Reizen' (Alternative Travel Coalition), a collective of 75 companies that want to make business mobility more sustainable, which TNO joined in 2020.

The year 2022 was used as a run-up period to prepare, implement, and tender for mobility policy tools, invest in facilities, and develop the national and international travel policy. From 2022, employees could only opt for electric lease cars, making the lease car fleet increasingly sustainable. More than half of the lease car fleet (272 vehicles in total) now consists of fully electric vehicles or hybrids.

Externally, TNO actively contributed to the Alternative Travel Coalition through participation in various workshops and events, such as the CEO event, the HR event, and the 'New Horizons' hackathon. In line with agreements with the Coalition, TNO mobility figures were also provided.

Emissions per type of mobility (in tonnes of CO_2-eq)

	Scope	2016	2019	2020	2021	2022
Lease cars	Scope 1	1,493	1,438	913	786	883
Business travel (by air)	Scope 2	2,387	2,085	357	211	1,213
Business travel (car/train)	Scope 2	1,028	1,080	505	434	1,013
Commuting (estimate)	Scope 3	4,188	7,896	3,061	2,254	2,570
Transport	Scope 3	5,100	5,452	4,831	5,240	6,067
Total emissions ktonnes		**14,195**	**17,950**	**9,667**	**8,925**	**11,746**
CO_2 mobility kg per FTE		*5.4*	*5.8*	*3.0*	*2.7*	*3.4*

In 2022, business mobility increased by a third compared to the previous year due to relaxations in measures to combat COVID. In particular, there was an increase in emissions from air travel and business travel. Emissions from commuting increased only slightly. Despite this increase, emissions per FTE declined by 37% compared to the benchmark year 2016. This is in line with the objectives of the Alternative Travel Coalition. The COVID-19 pandemic is expected to lead to a lasting reduction of about 25% in business mobility in the coming years. At the same time, the impact of measures within the new mobility policy will manifest itself more strongly from 2023 onwards.

Sustainable real estate

At the end of 2022, TNO was on track to achieve the objective of making TNO climate-neutral in regard to real estate by 2040. Seven projects were carried out in the Energy and Sustainability Property (E&S Real Estate) programme. Totalling €1.7 million, TNO invested heavily in the sustainability of its accommodation portfolio in 2022. Where possible, TNO will bring forward €10 million of investments in 2023 or accelerate projects for saving energy, such as more energy-efficient heating and air treatment installations and the installation of solar panels.

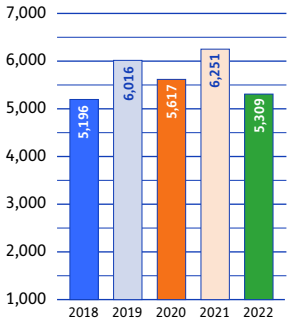
In 2022, TNO took leave of the Zeist location and relocated to Leiden and Groningen. This brought savings of 23,000 square metres, and the space in the new buildings is much more sustainable. Solar panels have been installed at three sites, leading to a reduction in overall energy consumption. Other investments included façade insulation and replacing or upgrading heating and air treatment systems in various buildings.

The energy consumption of the TNO real estate portfolio shows the following picture: in 2022, 500 cubic metres less gas was consumed, mainly due to a relatively mild winter, savings (such as a government campaign to turn down the heating) and economical use. This led to a 15% saving in emissions compared to the previous year. Energy emissions showed a slight decrease of 2%, which is a good result in view of the fact that more employees returned to the office. Finally, energy consumption for heating fell by 11%, partly due to the disposal of old buildings. Energy generation by TNO's own solar panels increased to 410 MWh in 2022. The programme therefore more than met its target of 3.5% savings per year, achieving a reduction of around 6%. A further decline is expected in 2023 due to the further disposal of old office buildings.

However, actual TNO emissions from gas and electricity are lower because electricity has been purchased from Dutch wind and biomass sources since 2010. So far, this concerns the larger locations owned by TNO or for which TNO purchases its own gas and electricity. Since 2022, TNO has offset 100% of CO_2 emissions from gas and electricity for all locations through Gold Standard Verified Emission Rights (VERs) and Guarantees of Origin (GOs). CO_2 compensation of purchased gas and electricity did not take place in 2022, as the tender necessary for this was delayed. TNO switched to a much more expensive gas contract in 2022 due to uncertainty over the supply of gas from Russia.

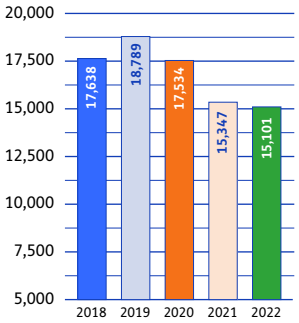
Building-related energy consumption (Scopes 1 and 2) (in tonnes of CO_2)

Scope 1: natural gas combustion



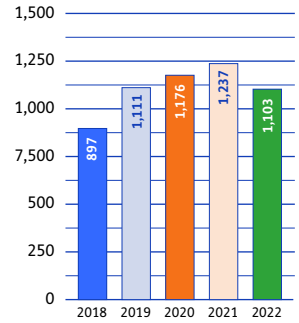
2022 vs. 2019
5,309 ▼ -12%
-707

Scope 2: energy, electricity



2022 vs. 2019
15,101 ▼ -20%
-3,688

Scope 2: energy, heat



2022 vs. 2019
1,103 ▼ -1%
-8

'Practise what you preach' in the field
TNO advises companies and public authorities to practise circular construction and wants to lead by example according to the motto 'practise what you preach'. When the old TNO laboratory for energy and materials technology in Delft had to go, we used as many materials as possible for the new TNO Building Innovation Lab. The old lab provided such a substantial amount of materials that it could not all be used for the new TNO Building Innovation Lab. The remaining material was sold to BAM, which will reuse it in the construction of a circular hub in Rotterdam. In this way, materials from the old TNO lab have been given a second life.

Social

TNO is committed to an equal relationship with its employees based on mutual added value. It wants to facilitate a safe, healthy, and connected way of working, aimed at the sustainable employability of its staff. As an employer, TNO is also committed to diversity and inclusiveness, ensuring a workplace where everyone feels at home and is given equal opportunities to develop. Finally, TNO recognises its responsibility in the supply chain, imposing ESG requirements on suppliers of products and services (upstream chain responsibility) and its clients (downstream chain responsibility).

Safe, Healthy & Connected Way of Working

TNO thinks it is important that employees work in a 'safely, healthy, and connected' manner and it undertook several initiatives in 2022 that contributed to this. For instance, the Hybrid Way of Working policy introduced during the pandemic, which gives employees more scope to choose where and when to work, became a permanent part of TNO's terms and conditions of employment. The same applies to the reimbursement that allows employees to claim for workplace facilities. Furthermore, the mobility policy introduced in 2022 supports both the hybrid way of working and sustainable mobility: an optimal combination that increases TNO's attractiveness as an employer.

In the area of 'safe working', TNO had the mandatory Risk Inventory and Evaluation (RIE) assessed in 2022. This assessment led to an improvement plan to further enhance the expertise of prevention officers in evaluating and advising on departmental and project RIEs. The RIE was also expanded to include the topics 'social safety and undesirable behaviour', 'risks for specific groups' such as pregnant employees, and a greater focus on 'periodic occupational health examinations', which TNO offers to employees who may be exposed to hazards such as laser radiation, noise, or hazardous substances.

TNO wants employees to report dangerous situations and incidents, also because these are learning opportunities. The number of reports increased by 36% in 2022 compared to 2021. In 2022, reports were followed up promptly and accurately in 97% of cases. The increased number of reports is the result of a new KPI formulated by TNO in 2022 to encourage employees to report more dangerous situations and incidents. In addition, we set up two research unit programmes to improve the culture and behaviour of employees with regard to safety.

TNO conducts structured accident investigations into the causes of serious incidents and dangerous situations. In 2022, investigations were launched into seven incidents. For example, in two situations, a hose came loose and made uncontrolled movements due to high pressure. The investigation found that there were ambiguities in the design and the procedure. The conclusions from these investigations led to improvements in preventive maintenance, clearer procedures, and increased employee expertise.

Diversity & Inclusion

TNO wants to be a place where all employees feel at home and dare to be themselves. An organisation where everyone is given equal possibilities to participate and develop. By bringing together diverse talents and perspectives, TNO strengthens its innovation power. In January 2022, the TNO Diversity & Inclusion (D&I) Strategy 2022-2025 was launched, with themes, goals and actions contained in a roadmap. TNO's D&I goals are based on an earlier inclusiveness survey at TNO and multiple roundtable sessions with employees. The survey found that employees perceived inclusion at TNO to be sufficient. However, TNO aims to be better than sufficient, with a particular focus on employees who consider themselves to be minorities.

The focus for 2022 was on the theme of inclusive leadership, and training on this theme was therefore included in existing development processes. Structural D&I representation was also set up in all units to facilitate and promote D&I initiatives. All units were also facilitated in setting their own diversity goals, tailored to their staffing situation, challenges, and ambitions. This year, there are four TNO D&I networks that employees lead themselves: Women@TNO, International and Cultural Diversity@TNO, Rainbow@TNO, and Neurodiversity@TNO. Furthermore, a week-long celebration of diversity and inclusion was held for the second time in October 2022, with workshops and events at various locations. The year 2023 will be dedicated to the theme of 'equal opportunities', with the aim of structurally analysing and, where necessary, improving processes to strengthen equal career opportunities.

Socially Responsible Procurement

In 2022, the Procurement department began implementing the Ambition Web methodology to include sustainability in a structured way, particularly in the larger procurement processes. This methodology is used to determine the ambition for each process in relation to energy and climate, circularity, integrity, working conditions, and diversity. This helps in translating the ambition into requirements, wishes, and selection and award criteria in the tender. In 2023, this methodology will also be used to monitor performance on Socially Responsible Procurement.

In addition, a new category analysis was conducted, which showed which procurement categories contribute most to sustainable and responsible operations. This is taken into account in procurement planning and procurement processes.

Sustainability results were achieved in the following four procurement processes in 2022:

- Tender for natural gas: natural gas is procured with a 'climate neutral' label (CO_2 emissions are offset by purchasing Verified Emission Rights).
- Tender for mobility tooling and card to encourage sustainable travel behaviour.
- Tender for removal services in which a 'social return' pilot project was created for people who have greater difficulty entering the labour market.
- Tender for parcel services that maximise positive social impact and sustainability (logistics movements).

Business Relationship Due Diligence

In 2022, the Business Relationship Due Diligence (BRDD) process was developed in more detail. External influences affected the approach that year. First, due to the geopolitical situation, TNO tightened and implemented its Russia/Belarus policy. This policy is part of the BRDD process. Second, the European Commission published a proposal for a 'corporate sustainability due diligence' directive, which gives direction to a BRDD process to be introduced.

In 2022, TNO explicitly considered the question of what risks we want to know about regarding our downstream business relationships (clients/partners) before making a well-founded decision on collaboration. For each risk, we looked at risk indicators based on available data and a possible assessment framework, including standard mitigation measures. This allows the process to be automated as much as possible. Implementation is continuing in 2023.

Governance

TNO pursues the highest standards of integrity in its operations; this is the basis for our 'licence to operate'. Integrity is in our employees' DNA and is enshrined in the TNO code. The manner in which TNO's innovations are achieved falls within the domain of research integrity and TNO policy on research involving human subjects and animal testing. Securing our knowledge is central to TNO's export control and security policy. Finally, TNO handles requests, reports, and complaints with integrity.

Integrity and anti-corruption

Research integrity is very important for independent, high-quality applied scientific research. TNO has committed itself to the Netherlands Code of Conduct for Research Integrity (NCCRI). The implementation of this code in the organisation, processes, and way of working was completed in 2022. A research integrity audit designed last year will be conducted in 2023 to evaluate this implementation. There is a constant focus on research integrity in internal communication, training, and monitoring.

The TNO code is the basis for our social and business integrity. It is an integral part of TNO's terms and conditions of employment, and all TNO employees must be familiar with the code and act in accordance with it. Furthermore, all TNO employees must report their ancillary positions that are relevant to TNO each year. The 2022 Employee Engagement Survey shows that the majority of employees know the TNO code well (average score of 5.7 on a seven-point scale) and also consider, based on their experience, employees at TNO to act with integrity (average score of 5.9 on a seven-point scale).

In addition, there is an ongoing dialogue with management on issues such as conflicts of interest and corruption risks. Employees are involved through the 'Dilemma Bank' on the TNO intranet and linked dilemma dialogues. Here, dilemmas facing employees and management that require additional attention are discussed, such as an employee's desire to engage in political activities or support third-party lobbying statements. The guiding principle is that TNO's independence must never be compromised.

Research involving human subjects and animal testing

TNO's work also covers research involving human subjects and research for which personal data are collected. Some of this research is subject to the Medical Research Involving Human Subjects Act ('Wet Medisch-wetenschappelijk Onderzoek met mensen') and is reviewed by an external medical ethics review committee. All research that is not subject to this legislation is assessed by a TNO-wide internal-review committee, which assessed around 100 proposals in 2022. The internal review is itself evaluated annually and the results are reported to the Executive Board.

TNO conducts biomedical research with a view to improving human health. Its ambition is to keep animal testing to an absolute minimum. Where such testing is unavoidable, TNO will do its utmost to carry out the research involved in a meaningful way, using as few animals and causing as little distress as possible. TNO's policy in this respect is that of the three Rs (replacement, reduction, and refinement). The organisation has a number of project permits available for conducting its animal experiments. All these projects are authorised by the Central Authority for Scientific Procedures on Animals, following an external review by an independent Animal Experiments Committee. TNO also has its own Animal Welfare Body, which is responsible for internal oversight, reviews, advice, and policy in the area of animal welfare in animal testing and laboratory animals.

Some of the genetic material used by TNO for research qualifies as 'genetic resources' under the Nagoya Protocol. This protocol lays down rules for the use of genetic resources, aimed at the fair and equitable sharing of the benefits arising from use of the resources. The year 2022 was dominated by further training of 'local points of contact' (contact persons for the Nagoya Protocol in the relevant units). In turn, the local points of contact increased awareness within the relevant research groups, such as by holding information sessions.

Confidential Organisation
Since 2012, TNO has had a group of confidential counsellors who are representative of the organisation in terms of location, diversity, and affinity, for example having an international or scientific background or identifying as LGBTQI+. The Confidential Organisation team has 15 members, 10 of whom were TNO colleagues at the end of 2022. In addition, two external confidential counsellors are available from the occupational health and safety service Beter. In 2022, the position of Central Confidential Counsellor was established, responsible for coordinating the group of confidential counsellors and – in cooperation with HR – advising in complex cases. During 2022, three confidential counsellors stopped due to career moves within or outside TNO. In 2022, the confidential counsellors were approached 71 times. Around 40% of the meetings were more in the nature of conversations between colleagues and, in around 60%, the person was approached as a confidential counsellor. In 18 situations, colleagues received more long-term guidance from a confidential counsellor or a confidential counsellor was approached jointly by several colleagues.

Reports and complaints
TNO has adapted its work processes to the new Open Government Act ('Wet open overheid', WOO) and is preparing for the entry into force of the active disclosure requirement. TNO aims to deal effectively and efficiently with all requests under the Open Government Act. There were 50 requests received under the Government Information (Public Access) Act/Open Government Act in 2022, of which 11 were directly addressed to TNO. Of that total, 39 requests were for the opinion of another administrative body. All requests were dealt with in accordance with the statutory requirements.
On two occasions in 2022, an objection was raised against a primary decision by TNO. In two cases, an objection was lodged against a TNO decision on a complaint. In 2022, two appeal cases were pending in relation to an appeal that had been lodged previously against a TNO decision on a complaint.

TNO has an Internal Complaints Procedure, an External Complaints Procedure, and a system for addressing cases in which wrongdoing is suspected. One complaint was submitted based on TNO's External Complaints Procedure in 2022. This complaint was handled in an informal manner. Under TNO's Internal Complaints Procedure, one complaint was also submitted and taken up in 2022. This case is still ongoing. In addition, the handling of the complaint filed in 2021 was completed in 2022. Two reports were received through the integrity hotline. These were taken in hand internally and are still being processed. In a case regarding a whistleblower statement made in 2016 under the whistleblower regulation valid at the time, a court ruled in favour of TNO on all essential points in 2020. A recommendation from the Dutch Whistleblowers Authority has meanwhile also been published. This decision is essentially in line with a previous decision handed down by the court, concluding that TNO did not wrong the complainant in relation to his report. The complainant has appealed the court's decision. TNO is also confident regarding these proceedings.

Security, privacy, export controls, and sanctions
Security Awareness was a major focus at TNO in 2022. Through a digital programme, TNO employees were challenged several times during the year regarding security issues based on TNO policy and current affairs. This has increased the security awareness of employees and TNO's resilience.

In the area of data protection, TNO began digitising the privacy compliance process for research involving human subjects in 2022. Work was also done on new policy related to the application of the GDPR rules to data processing with personnel data and the transfer of personal data to third countries. Privacy and data protection were also an integral part of the Security Awareness programme.

In addition, an internal audit was carried out on Privacy Compliance at TNO. The findings from this audit will be addressed in 2023. 14 data breaches were reported in 2022, four of which resulted in reports to the Dutch Data Protection Authority. One of these was later withdrawn. Stakeholders submitted four requests under the GDPR in 2022 and these were dealt with by the deadline set.

TNO wants to comply strictly with international and national legislation and regulations on the export of knowledge. TNO has had an Internal Export Compliance programme (IECP) in place since December 2019, which embeds safeguards for export control and sanctions assurance in our organisation. In addition to the continued development of supporting automation, there was special attention in 2022 to monitoring and safeguarding new sanctions legislation due to the volatile geopolitical situation. As a result, TNO is continuing to invest in proper safeguards for internal processes relating to export control and sanctions.

There was a strong focus on knowledge security in 2022. Any outstanding parts of the National Knowledge Safety Guidelines published in early 2022 have now been implemented. For example, a knowledge security risk analysis has been carried out, from which no significant new risks have emerged as yet. Further implementation of the guidelines, together with export control, will be integrated into the previously mentioned BRDD process.

Game changer

TOmCAT

Technological developments such as self-driving cars, social media with more videos, and the Internet of Things are creating a growing demand for more data. The existing radio frequency spectrum can no longer cope with that demand. It is too limited in terms of data throughput and a great many people are already using it, causing scarcity and disruptions. Laser-satellite communication, using satellites that send information to Earth in the form of invisible light signals, could be the answer.

During a field trial with several partners, TNO succeeded in establishing an optical laser communication link over 10 kilometres in the Province of Utrecht between the KNMI test site near Lopik and the Gerbrandy Tower in IJsselstein. The test, conducted as part of the Terabit Optical Communication Adaptive Terminal (TOmCAT) project, looked at the entire optical communication chain. Sending bits is one thing, but transmitting them without errors is a huge challenge. This breakthrough will enable faster, safer, and cheaper laser satellite connections in the near future.

Unit: Industry

Healthy financial management

Financial indicators (consolidated result)

(in millions of €)

TNO consolidated result	2022	2021	2020
Operating income	608.0	572.5	553.5
revenue	590.7	559.9	541.0
other operating income	17.3	12.6	12.5
Revenue breakdown			
Market revenue	292.0	291.2	282.2
State funding	298.7	268.7	258.8
Costs			
Operating expenses	610.3	546.9	540.7
personnel costs	392.6	362.4	356.5
impairments	1.1	–	4.7
Net result	**0.5**	**45.4**	**65.6**
Result from participating interests	1.3	26.7	52.0
Cash flow for the financial year	-21.5	38.8	105.3
Capital			
Operating capital invested[1]	435.8	418.3	361.3
Equity	374.8	374.3	328.9
Solvency ratio[2]	48%	49%	47%
Assets			
Tangible fixed assets	233.4	219.9	204.7
Investments in tangible fixed assets	56.5	44.1	46.3

Employees	2022	2021	2020
Number of employees (average FTEs)	3,461	3,278	3,243
Number of employees (FTEs at year end)	3,595	3,337	3,263
Number of group company employees (average FTEs)	2	2	3
Number of group company employees (FTEs at year end)	2	2	3
Number of FTEs (at year end)	3,597	3,339	3,266
Average number of FTEs	3,463	3,280	3,246

[1] Invested operating capital = total balance sheet – current liabilities
[2] Solvency ratio = equity divided by total assets

Sound financial foundation

TNO's legal remit is to ensure the maintenance of an appropriate knowledge base infrastructure. This is only possible with a structurally sound financial foundation and through effective operational management. Additional funding from the national government has played an important role in this since 2017. For the next strategy period, our ambition to boost investments and ensure sound operational management will be as strong as ever, with the aim of accelerating the progress of societal transitions. **Revenue** is an indicator of our contribution to a specific important societal issue. An **operating profit** is a requirement for sound financial management, to provide a buffer for setbacks and also to create scope for investment in innovation. Our **equity** enables us to accelerate our investments in knowledge and facilities. Proper **risk management** enables TNO's management to weigh up risks in order to achieve its strategic objectives.

Revenue

For the purpose of developing, applying, and disseminating knowledge, TNO obtains its funding from a number of sources. Performing research in projects generates (net) revenue. These sources of funding are:

- **Institutional funding:** funds made available by the Dutch government (through the Ministry of Economic Affairs and Climate Policy as intermediating ministry) for developing, applying and disseminating knowledge for the purpose of resolving societal issues, giving support regarding government tasks and policy, and enhancing the innovative strength and competitive position of the Netherlands. The Early Research Programmes (fundamental knowledge development to strengthen TNO's own knowledge base) and Demand-Driven Programmes, among others, are funded in this way. In 2022, €190 million of acquired institutional funding was spent on research (2021: €183 million).
- **Programme funding:** earmarked funds from various ministries. Each ministry involved indicates the topic or subject for which these funds should be used. An important and special part of this is the task-related funding for carrying out delegated knowledge-intensive, statutory public tasks for the Ministry of Defence and the Geological Survey of the Netherlands. In 2022, €109 million of programme funding provided by ministries was converted into research by TNO (2021: €86 million).
- **Competitive funding:** contributions from partners in collaborative projects that TNO acquires on a competitive basis, such as EU projects and large-scale public-private partnerships (Shared Research). Partner contributions to collaborative projects totalled €97 million in 2022 (2021: €100 million). In these projects, TNO matches these contributions with institutional funding or programme funding.
- **Contract funding:** fully external public or private funding for Contract Research, which TNO obtains by making offers and winning contracts. The content of the contract is tailored to the client's needs, but with TNO remaining alert to the uniqueness of the contribution. In 2022, contract research worth €194 million was carried out (2021: €191 million).

All funding, much of which is long-term, is used to implement projects and is therefore accounted for as revenue. TNO has the duty to use the state funding it receives as effectively as possible and to achieve the right balance between this income (programme and institutional funding) and third-party contributions (competitive and contract funding). The relationship between these two sources of income is expressed by what is called the 'multiplier': total revenue divided by the amount of state funding.
In 2022, the average ratio of public funding to market revenue was €1.00 to €0.98 (2021: €1.00 to €1.08).

TNO seeks contributions from third parties to maintain and renew its knowledge base, in addition to the funding it receives from the government. The ratio in relation to state funding varies by research area, but should result in a multiplier of between 2 and 3 on average. Too low a multiplier would mean that public and private partners, as well as clients, do not find TNO research relevant enough to invest in it. However, too high a multiplier implies that the portfolio activities might be 'mature' by now and could be left wholly or partly to other parties (such as commercial parties). Continuing to achieve a multiplier of between 2 and 3 will prove challenging in the next few years, as private investment in the Netherlands is not growing strongly and companies are using 'corporate venturing' as an alternative to in-house R&D. Moreover, the National Growth Fund allows companies, with government grants and their own 'in-kind' contribution, to collaborate with knowledge institutions. This ensures that instead of innovating directly in collaboration with TNO, companies can participate in the National Growth Fund and thus collaborate and innovate indirectly. To assess the effective use of state funding, TNO therefore not only wants to look at expenditure by third parties at TNO, but also at the expenditure by third parties in projects such as the National Growth Fund, in which TNO participates, and at the value creation of its spin-offs.

Since 2017, the Technology Transfer programme has focused on transferring technology developed by TNO to the market by granting licences and/or setting up new companies (spin-offs and carve-outs). This programme is funded by TNO itself and aims to become 'revolving' over time, with proceeds from the sale of the equity interest in TNO spin-offs at least covering the costs of the Technology Transfer programme. Five new spin-offs were set up in 2022 (2021: 5). As at 31 December 2022, 38 TNO spin-offs had been created from the Tech Transfer programme. The total value of these companies is €243 million and the spin-offs have provided 506 jobs. In 2022, €93 million in funding was raised by these spin-offs.

Operating result

Revenue was up €30.8 million, rising to €590.7 million in 2022 (2021: €559.9 million). Other operating income in 2022 was €17.3 million, which was €4.7 million higher than in 2021 (€12.6 million) due to the sale of real estate. Total operating expenses increased by €63.4 million to €610.3 million in 2022 (2021: €546.9 million). This produced an operating loss before interest and taxes of €2.3 million (2021: operating profit of €25.5 million).

Operating expenses consist of direct project costs, personnel expenses, depreciation, impairments, and other operating expenses. Direct project costs increased by €6.5 million to €72.5 million as a result of growth in revenue. Personnel costs increased by €30.2 million in 2022, with €28.0 million attributable to higher wages and salaries, including for pension and social insurance contributions, as well as for changes in personnel provisions. This rise can be attributed to the increase in staffing in 2022, as well as the organic growth in salaries of 2.7% implemented on 1 January 2022. Other personnel costs rose by €3.7 million, partly offset by lower costs for temporary employees of €1.5 million. Depreciation declined by €0.9 million in 2022 to €23.8 million. Impairments in 2022 were recorded mainly on fixed technical installations, amounting to €1.1 million due to relocations.

Other operating expenses increased by €26.4 million to €120.3 million, mainly due to higher energy and rental costs. Accommodation and energy costs, materials, general management costs, use of technical equipment, and outsourced work showed a net rise of €13.2 million. Other expenses of €16.4 million consist of strategic investments, the write-off of assets under construction at three projects, and other non-recurring items. This increase is offset by a decline of €1.9 million, which is due to movements in provisions and lower contributions provided.

Net financial income increased by €1.5 million in 2022 to a positive €0.4 million (2021: €1.1 million negative) due to the rise in interest rates. For 2022, we expect a corporate tax gain of €1.1 million because the tax book value of the real estate sold was already equal to the market value and therefore no gain was recognised on the transaction for tax purposes (2021: €5.7 million negative). The corporate income tax returns to the end of 2021 have been finalised by the Dutch Tax and Customs Administration. In 2022, there were no significant value changes in our participating interests, leaving a result of €1.3 million (2021: €26.7 million). As a result of the above, a net result of €0.5 million (2021: €45.4 million) remains.

Equity

Of TNO's equity totalling €374.8 million at the end of 2022, €140.1 million relates to TNO's research for the Dutch Ministry of Defence. The allocated reserve for the renewal of housing for defense research fell by €2.7 million in 2022 and amounted to €30.0 million at the end of the year. This reduction is due to additions to this allocated reserve of €6.9 million and withdrawals based on investments of €9.6 million. The statutory reserve, containing non-distributable profits of group companies' participating interests, increased by €0.9 million.

Taken together, the above movements and the positive result of €0.5 million led to a €2.4 million increase in the general reserve. The general reserve has grown sharply over the past few years as a result of the sale of participating interests. In coordination with the Ministry of Economic Affairs and Climate Policy, it will be used for strategic investments in research and innovation.

Liquid assets

At the end of 2022, the balance of liquid assets stood at €352.2 million (against €373.6 million at the end of 2021). The reduction in liquid assets of €21.4 million in 2022 has several causes, which are explained in more detail below:

- On balance, tangible fixed assets were up by €13.5 million. At €52.0 million (including investments financed from the 'climate envelope' and €25.2 million obtained through state funding), the investment level is above the depreciation charges of €24.4 million. Divestments totalled €2.0 million in 2022.

- Working capital fell by €23.5 million. Around €13.1 million of this is attributable to the transfer of investment resources from the working capital to the investment resources equalisation account for long-term liabilities. Prepayments and accrued income increased by €4.2 million due to rising prepaid items such as rent and service contracts, and other items in current liabilities caused a further working capital deterioration of €6.2 million.
- Long-term liabilities show a net increase of €16.7 million. This increase is largely due to the aforementioned transfer of investment funds from working capital to long-term liabilities.
- The positive net result, including the result of participating interests of €0.5 million and other balance sheet movements of €1.6 million, made a positive contribution of €2.1 million to net liquid assets at the end of 2022.

Of the liquid assets, an amount of €52.6 million (2021: €64.2 million) was reserved for public funding yet to be provided on the one hand and for the settlement of funds received in advance in the context of coordinated partnerships on the other. An amount of €30.0 million in liquid assets was also set aside for future investments in housing for defense research.

Shortly after the start of the COVID-19 crisis, TNO reduced the payment term on procurement invoices from '30 days' to 'immediate payment upon procurement invoice approval'. This arrangement still applies. The 2023 investment budget totals around €44.0 million, which is €19.6 million more than the depreciation charges.

Solvency

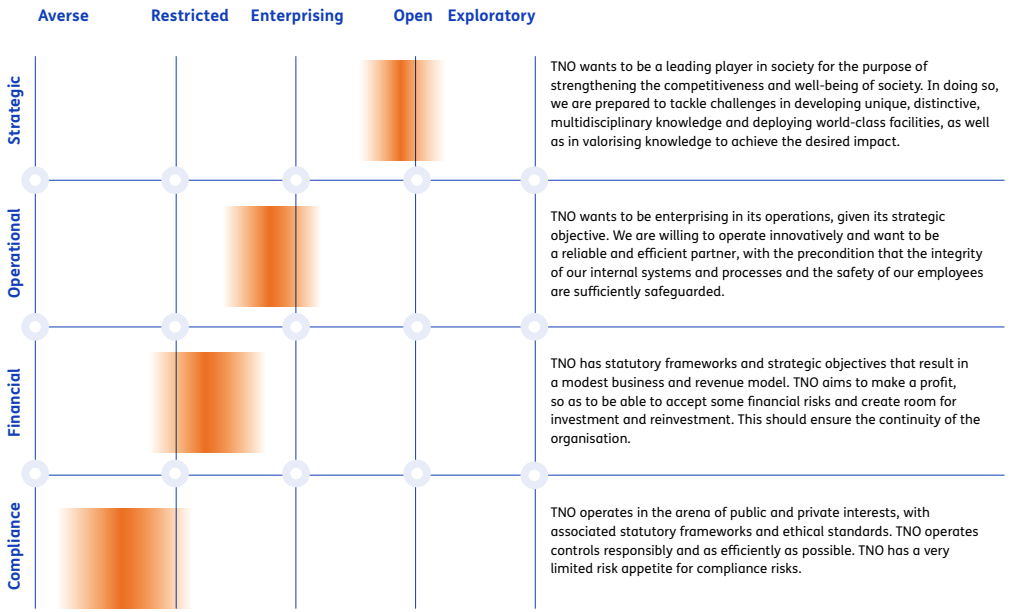
The solvency ratio was 48% in 2021, almost equal to the level of 49% at the end of 2022.

Risk management

TNO wants to protect its legitimacy and continuity, to be able to achieve its strategic goals. To this end, we carry out risk management in which we weigh up the opportunities and risks. The Executive Board is responsible for developing, implementing, and monitoring TNO's comprehensive risk management and control system.

Risk appetite in 2022

TNO's risk appetite is related to its objectives and to the unique nature of TNO as a Research and Technology Organisation (RTO). Risk management is about creating the right assessment frameworks and addressing the question of whether risks can be mitigated, consciously accepted, or avoided. TNO's risk appetite can be represented and described as follows:



TNO-wide risk analysis for 2022

The TNO Executive Board identified the following five risks as strategic risks for 2022. These risks emerged in an iterative process between the Executive Board and the managing directors. This process is part of the 2022 budget process.

	Risk description	Owner
1	Risk of TNO's distinctive position in the field of universities, knowledge institutions, government, and industry coming under pressure, or further pressure	CEO
2	Risk that the desired impact will not be achieved due to insufficient scientific quality or an inadequate process of portfolio and account management	CSO
3	Risk of insufficient balance between public and private funding	CFO
4	Risk that due to insufficient funding or financially unsound business cases, TNO has insufficient facilities to contribute to the organisation's knowledge development	COO
5	Risk that talented employees cannot be recruited in sufficient numbers, are not motivated or cannot sufficiently be retained by the organisation	CEO

Throughout 2022, these risks were assessed by the Executive Board during business reviews, partly based on input from the units and the service organisation. It was concluded that in 2022, there were no notable developments in relation to the risks that had been identified. The risks and the implementation of measures remain a constant priority.

No major shortcomings were identified in the way the current risk management and control system functions. This is confirmed in internal and external audit reports received in 2022. In 2022, work was done to embed the compliance framework within TNO.

In control statement

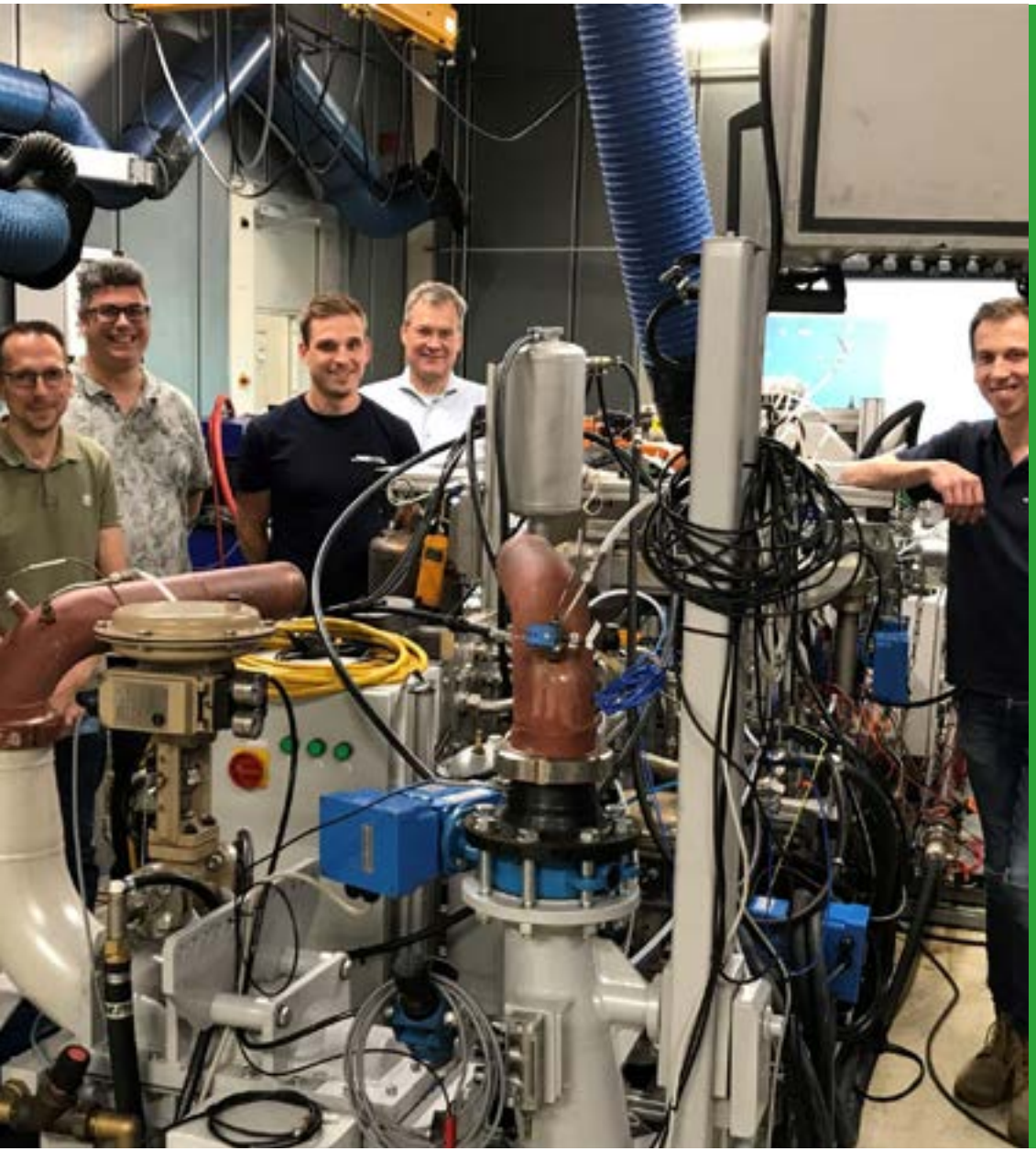
The Executive Board considers that internal controls and risk management with regard to finance, privacy, and export control and sanctions are properly designed and proved to be sufficiently effective during 2022. There were no indications to the contrary. As far as the other aspects of operations are concerned, no evidence has emerged that these do not comply with current requirements. It should, however, be noted that risks may also occur that cannot be anticipated, and that not all inaccuracies, losses, fraud, or non-compliance with legislation and regulations can be ruled out.

Finances

Objective	Risks	Controls
Reliable and sound financial management	Control information unreliable	1. Planning and control cycle: framework letter, bottom-up budget process, adoption of budget, adoption of annual plan, monthly reporting, monthly reviews, and forecasting. 2. Description of the financial model, definition of target values, translation of target values for the various units, follow-up on improvement plans, and inclusion of these in the budget.
	Incorrect financial accounting	Process and data-oriented checks to guarantee accuracy, timeliness, and completeness of the financial data reported.
	Unlawful use of public funds	1. Predefined process within the Knowledge Procedure. 2. Formulating Knowledge Plans for projects paid for entirely through state funding. 3. The use of state funding in Mixed Funding is assessed by the Internal Assessment Committee. 4. Monitoring of projects with regard to time, content, and money. 5. End-of-year review by Corporate Control of the use of state funding in Mixed Funding.
	Non-compliance with tax legislation	Tax Control Framework.
	Insufficient insurance coverage	Risks are identified and insured in consultation with the insurer.
	Non-compliance with European tendering rules	1. Capacity planning for the procurement department. 2. Spend analysis. 3. Tender reporting.

Compliance

Objective	Risks	Controls
Compliance with legislation and regulations, and ethical standards	Non-compliance with sanctions and legislation and regulations regarding export controls	1. Risk-based checks on all opportunities and/or projects for risks with respect to i) international sanctions, ii) permit requirements when exporting controlled technology. 2. Applying for the required permits.
	Failure to demonstrate GDPR compliance	1. TNO has a detailed GDPR step-by-step plan in which personal data are handled with the utmost care. 2. Data breach protocol: TNO has a protocol for reporting data breaches and learning from incidents. 3. Rights under the GDPR: TNO gives information about data processing on the website and provides the possibility of exercising rights. 4. TNO has records of data processing operations. 5. TNO has a privacy policy and related regulations. IT measures are described in the TNO security policy. 6. TNO concludes GDPR contracts with partners and suppliers with which personal data are exchanged, using Standard Contractual Clauses of the European Commission.



Game changer

TNO's hydrogen combustion engine wins prizes

Heavy-duty engines are very expensive but have a long economic life, potentially lasting 20 to 30 years. Moreover, they are less suitable for electrification, which means that much of the existing equipment causes substantial CO_2 emissions. TNO is working on a promising alternative: the hydrogen combustion engine. With green hydrogen from renewable sources, CO_2 emissions are reduced to zero.

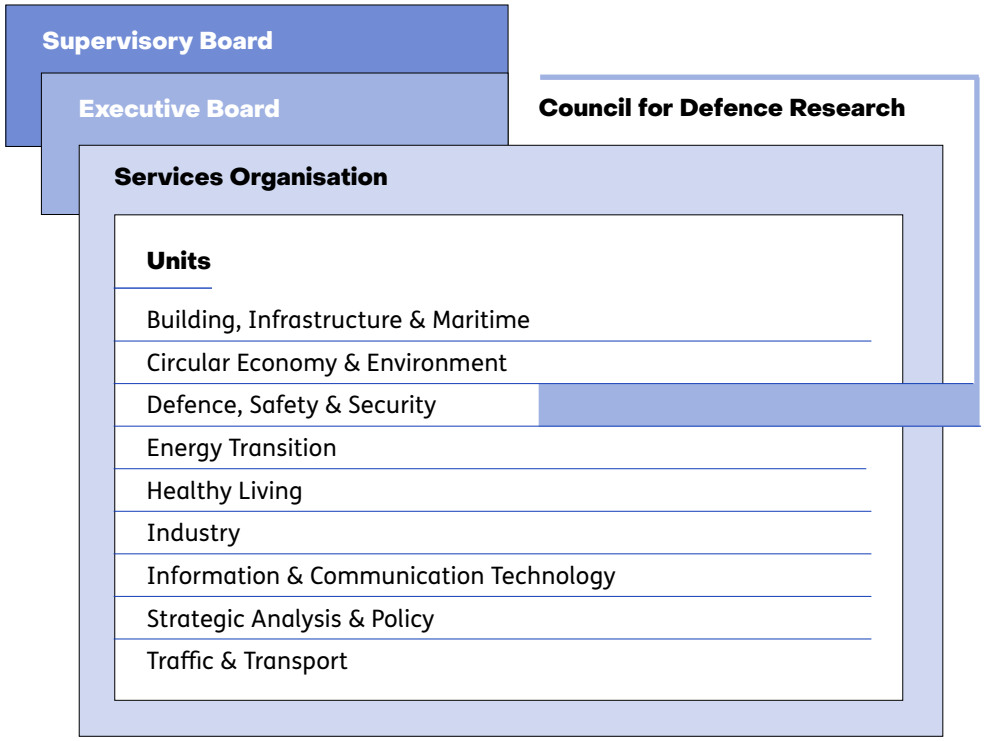
Unlike many other sustainable alternatives, this innovation uses reliable, proven technology and an existing value chain. This will ensure rapid market acceptance in the near future. The greatest advantage of TNO's technology is that you can also modify existing engines. For example, a diesel-powered marine engine can be partially or fully converted to hydrogen. In this way, we can accelerate the energy transition in sectors where few sustainable alternatives are as yet available. Together with DAF, TNO worked on a prototype that won the International Truck of the Year Innovation Award in 2022. TNO also took second prize at the EARTO Innovation Awards.

Partners: DAF

Unit: Traffic & Transport

Organisation chart

From 1 January to 15 November, TNO was organised as follows.



To facilitate collaboration within TNO and improve the manageability of the organisation as a whole, the number of TNO units was reduced from nine to six as of 15 November 2022. This decision led to the following organisational changes:

- The Buildings, Infrastructure & Maritime (BI&M) and Traffic & Transport (T&T) units were merged into one Mobility & Built Environment (MBE) unit. This merged unit focuses primarily on the theme of a sustainable living environment, including buildings, infrastructure, and mobility.
- The Energy Transition (ET) and Circular Economy & Environment (CEE) units were merged into one Energy & Materials Transition (EMT) unit. This merged unit focuses primarily on the themes of a sustainable energy system and sustainable industry, including circularity.
- The Information & Communication Technology (ICT) and Strategic Analysis & Policy (SA&P) units were merged into one ICT, Strategy & Policy (ISP) unit. This merged unit focuses primarily on digital technologies and transition methodologies.

The remaining TNO units, Defence, Safety & Security; Healthy Living; and Industry, remained unchanged, with Healthy Living being renamed Healthy Living & Work, and Industry being renamed High-Tech Industry. There were also no changes to the structure of the Services Organisation (staff departments).

Game changer

Tresspass

It is essential for Europe, the Netherlands, and the Netherlands' military police (Royal Netherlands Marechaussee, KMar) to organise safer and smarter bordertraffic in order to better monitor our borders, but also because it is proving increasingly difficult to find and retain suitable staff. As part of the EU project 'robusT Risk basEd Screening and alert System for PASSengers and luggage' (TRESSPASS), the KMar is investigating the possibilities of risk-based border control. This project uses information that is already available before a passenger is actually at the border.

Analysing this information is called 'screening' and it provides an indication of the risk posed by the passenger crossing the border. On that basis, checks are adjusted at the border control itself. This makes it possible to have strict border checks if necessary, but also lighter checks if possible. This enhances safety and improves the flow of people and goods. Pilot projects have already been carried out at Poland's border with Belarus and sea borders at the port of Athens, Greece, and there has been a pilot project for air borders in the Netherlands.

Partners: Royal Netherlands Marechaussee

Unit: Defence, Safety & Security

The Supervisory Board

At the end of 2022, The Supervisory Board consisted of (from left to right) Baptiest Coopmans, Hester Bijl, Gijs de Vries, Louise Verheij van Wijk, Marko Hekkert, Peter van Laarhoven, and Jolanda Lamse-Minderhoud

Report of the Supervisory Board

Comprising seven members, the Supervisory Board is tasked with overseeing the policy pursued by the Executive Board and offering it advice. The Supervisory Board was fortunately able to meet again regularly in person and at various TNO locations in 2022 after COVID restrictions were relaxed.

Topics

In a general sense, the Supervisory Board oversaw the policy pursed by TNO in 2022. A number of significant issues are examined in more detail below.

Composition of the Executive Board

There was a smooth change on the Executive Board in 2022. After more than seven years at TNO (since 2015), CEO Paul de Krom stepped down on 1 February. The Supervisory Board is very grateful to Paul de Krom for all he has meant to TNO. He leaves behind a financially sound organisation that has made its mark with the various ministries, public authorities, industry, and politicians and is embedded in society as the primary institute for applied research in the Netherlands. After a thorough search and selection process in coordination with the Ministry of Economic Affairs and Climate Policy, an excellent successor was found in Tjark Tjin-A-Tsoi, who became TNO's new CEO and Chair of the Executive Board on 1 June 2022.
At the end of 2022, CSO Peter Werkhoven, in close consultation with the Supervisory Board, decided to step down as CSO from 1 January 2023 for personal reasons. He will continue to work at TNO as Chief Scientist. The Supervisory Board expresses its thanks to Peter Werkhoven and is pleased that he is continuing to carry out some of his activities at TNO.

Strategy implementation

TNO drew up a new strategic plan in 2021, as prescribed by the TNO Act, so that 2022 was the first year of the new strategy period 2022-2025. The Supervisory Board regularly discussed the implementation of the Strategic Plan and urged TNO to intensify its focus. In late 2022, some elements of the strategy were firmed up, including TNO's core tasks, the demonstrable impact of innovations, valorisation, and implementation in society. The Supervisory Board endorses this tightening of the strategy, as well as the launch of the strategic change programmes 'Systems Innovation', 'Customer Excellence', and 'Vital Organisation'. These are designed to increase innovation across disciplines, improve collaboration, and achieve impact based on client-focused thinking and working.

The focus on SMEs and on positioning TNO through a number of targeted 'moonshots' on recognisable and topical innovative issues is also welcomed by the Supervisory Board. TNO's visibility increased in 2022 on relevant societal issues.

Knowledge position

Once every four years, the technology portfolio of each unit undergoes a Knowledge Position Audit (KPA), conducted by an external committee. The Quality Committee discussed the results of two KPAs that had been conducted and considered the recommendations these contained and what the next steps should be. Partly as a result of the response from a recent KPA committee, it was discussed what changes to the KPA system would be desirable in order to better reflect the character and objectives of TNO.

NGF, personnel planning, and labour market developments

The Supervisory Board was pleased to learn that TNO was involved in a large number of proposals for the National Growth Fund (NGF) in 2022. In addition, in 2022, the Dutch government decided on significant investments in Defence in response to the war in Ukraine. These two developments prompted TNO to prepare to expand its research capacity in the coming years. Partly in view of the tight labour market, the Supervisory Board emphasises the importance and urgency of making additional efforts to recruit and retain employees in order to continue achieving TNO's objective. It is impressive that TNO was able to recruit 631 new employees in 2022, but retention remains a key concern.

Change to unit structure and formation of the Executive Committee

In 2022, the Supervisory Board agreed to reduce the number of TNO units from nine to six. The objective is to facilitate collaboration within TNO and improve the manageability of TNO as a whole. The 'Organisation Chart' section of this annual report discusses this topic in more detail. At the same time as the change to the unit structure, an Executive Committee was established, comprising the members of the Executive Board, the Managing Directors of the units, and the Managing Director Strategy. This structure enables them to discuss issues that affect TNO as a whole in order to strengthen collaboration across the organisation. It also provides a solid basis for the first echelon of management to be involved in strategic thinking in terms of how to execute the course set by TNO.

Compliance and risk management
The Supervisory Board regularly talks with the Executive Board about TNO's compliance with current legislation and regulations. The further structuring of Business Relationship Due Diligence within TNO was discussed several times in 2022. There was also an explicit focus on cybercrime and the topic of knowledge security received additional attention at the instigation of the Minister of Education, Culture and Science. Knowledge security is also being coordinated in the TO2 Federation. Targeted programmes aimed at improving the internal IT landscape were also discussed. The Supervisory Board continues to stress that internal operations and policymaking would benefit if procedures, the number of forms of consultation, and reporting requirements were simplified. Various external developments, such as the war in Ukraine, high inflation, and a number of societal challenges, are ramping up uncertainty, which also affects TNO's operations. Risk management, including exploring various scenarios, has therefore received extra attention this year.

Finances
On 15 March 2022, the Supervisory Board approved the 2021 financial statements and, on 19 December 2022, the budget for 2023. EY has audited TNO's financial statements since 2018. A tender for audit services took place in 2022 and EY again emerged as the best candidate. EY will therefore continue to audit the financial statements over the next few years.

Performance of the Supervisory Board and evaluation of the Executive Board
The Supervisory Board keeps track of developments in relevant areas through the Audit Committee, the Quality Committee, as well as the Selection and Renumeration Committee. The Supervisory Board also obtains information during meetings, for example with the Executive Board, by inviting experts from the organisation. Furthermore, as indicated earlier, it carries out periodic working visits. The Executive Board informs the Supervisory Board periodically by means of an appropriate overview that includes relevant management information. The same applies to progress information on the Technology Transfer programme. The members of the Supervisory Board briefly discuss the meetings in advance and also regularly reflect on their own performance and evaluation aspects between meetings.

The Supervisory Board's performance was evaluated by the supervisory directors training firm Hemingway in 2021. The results of this evaluation were discussed jointly. The Supervisory Board professes a shared interest in the implementation of the strategic plan and the supervision of this implementation. One of the wishes arising from this interest is that the Supervisory Board should fulfil its advisory role more often through dialogue based on dilemmas. A supervision agenda has been drawn up, formulating priorities for supervision. To evaluate the Executive Board and its individual members, the Supervisory Board conducted the annual round of performance reviews with both the Chair and members of the Executive Board. The Supervisory Board highly appreciates the way in which TNO employees and management were able to achieve a good result again in 2022. With the input of all people within TNO, the organisation has developed a future-proof strategy and is visible on numerous innovative fronts in society; it is in a healthy position and stands out as an attractive employer.

Composition of the Supervisory Board and its committees

In 2022, Prof. Peter-Paul Verbeek left the Supervisory Board after the expiry of his second term. The Supervisory Board is very grateful to Mr Verbeek for the manner in which he has fulfilled his role as a member of the Board over the past 10 years. He was succeeded by Prof. Marko Hekkert.

The three permanent Supervisory Board committees were composed as follows in 2022:

	Audit Committee	Quality Committee	Selection and Remuneration Committee
Gijs de Vries			Member
Peter van Laarhoven			Chair
Hester Bijl		Member, Chair (from 1 May)	
Baptiest Coopmans	Member		
Marko Hekkert		Member (from 1 May)	
Jolanda Lamse-Minderhoud	Chair		
Peter-Paul Verbeek		Chair (until 1 May)	
Louise Verheij van Wijk	Member		Member

Independence

In the opinion of the Supervisory Board, the requirements related to independence of action, as specified in provisions 2.1.7 to 2.1.9 of the Dutch Corporate Governance Code, were satisfied.

Meetings

The Supervisory Board met six times in 2022. The Audit Committee met five times and the Selection and Remuneration Committee and the Quality Committee both met twice in 2022. Outside the meetings, there was contact between the committees as necessary. Representatives from the Supervisory Board attended two Works Council meetings. Furthermore, the Supervisory Board liaised regularly with the Ministry of Economic Affairs and Climate Policy.

Attendance

The attendance record of the individual members of the Supervisory Board at its own meetings and those of its permanent committees in 2022 was as follows:

	SB meetings	Committee meetings
Gijs de Vries	6 (of 6)	2 (of 2)
Peter van Laarhoven	6 (of 6)	2 (of 2)
Hester Bijl	5 (of 6)	2 (of 2)
Baptiest Coopmans	6 (of 6)	4 (of 5)
Marko Hekkert	4 (of 4)	1 (of 1)
Jolanda Lamse-Minderhoud	6 (of 6)	5 (of 5)
Peter-Paul Verbeek	2 (of 2)	1 (of 1)
Louise Verheij van Wijk	6 (of 6)	7 (of 7)

Council for Defence Research

At the end of 2022, the Council for Defence Research was composed of (from left to right) Harold Bousché (Secretary), Auke Venema, Marja Eijkman, André Steur, Marc Gazenbeek, and Maarten Tossings (Chair).

Report of the Council for Defence Research

In 2022, Russia invaded neighbouring Ukraine – an event that marked a turning point in European security thinking. For those who still had any doubts, this made it clear that peace and security can never be taken for granted. The year 2022 also saw the publication of the new Defence white paper 'A Stronger Netherlands, a Safer Europe', which also reflects this turning point. The fourth Rutte government is investing an extra €5 billion a year in Defence, the largest investment since the Cold War. With the Defence white paper, the Ministry of Defence is building agile and future-proof armed forces by investing in people, support, equipment, and collaboration.

Technology and innovation are increasingly making a difference to our ability to win the wars of today and tomorrow. The Ministry of Defence will therefore greatly strengthen its innovative capacity in the coming years. This will be done in close collaboration with industry and knowledge institutions, as well as with allies and other partners. The Ministry of Defence's 'Implementation Agenda for Innovation and Research' of November 2022 describes how this move to enhance innovative capacity will be carried out. At the same time, the 'Defence Industry Strategy in a New Geopolitical Context' was published, which defines the active national and international industrial policy demanded by these times of major changes.

In light of the above developments, the outlook for defence research is favourable. After all, knowledge and innovation are indispensable. Growing investment by the Ministry of Defence is having a positive impact on the scope and innovative nature of defence research and opportunities for national and international collaboration. For this reason, 2022 was another good year for defence research. Order books are well filled and the associated increase in recruitment has begun.

TNO has the role of 'home laboratory' for the Ministry of Defence and therefore practises science and innovation at the frontline. We work together on a daily basis to create a society that is and feels safe. Since 1947, TNO has ensured that the military and security professionals of the Netherlands and its allies have access to state-of-the-art equipment and the best possible information position, guidance, and preparation. In the words of a previous Minister of Defence: 'TNO helps the Ministry of Defence compete in the Champions League.' In 2022, TNO and the Ministry of Defence, together with partners, proudly celebrated 75 years of defence research at TNO and their close collaboration.

The Council for Defence Research (CDR) determines the policy to be pursued with regard to TNO's Defence Division, with due regard for the provisions set with respect to the Executive Board. TNO's Defence Division includes the Defence & Security unit. The CDR met six times in 2022. There were no changes to the composition of the CDR in 2022. At the last meeting, the members said goodbye to Ministry of Defence member André Steur, who will become Commander of the Royal Netherlands Air Force from mid-April 2023. The composition of the Defence & Security unit's Strategic Advisory Council (SAC) for the 2022-2025 strategy period was finalised in early 2022. Chaired by Prof. Beatrice de Graaf, the composition has been revised and is now more balanced. In 2022, the subject of ethics – especially in relation to developments around artificial intelligence – and the need for national research facilities for defence research were explored in more detail.

In September 2022, TNO CEO and Chair of the Executive Board Tjark Tjin-A-Tsoi, who took up his duties on 1 June 2022, participated in the CDR meeting. Participants at the meeting exchanged views on a variety of issues, including the various roles of TNO, the need to consider 'the question behind the question', the nature of innovation, and TNO's function as a think tank.

The radically changed geopolitical situation, new modes of warfare, and technological developments are forcing the Ministry of Defence – and thus the TNO Defence & Security unit – to change. The substantial additional investment in knowledge and innovation that the Dutch government has earmarked for the coming years will give impetus to defence research, but will inevitably also bring challenges. The three main challenges are:

- strong growth in times of staff shortages;
- organisational restructuring to increase decisiveness and agility, create a better balance in the organisation, and reduce the span of control where it is too large;
- adapting the research portfolio to the new policy and the new and rapidly growing needs of the Ministry of Defence in particular.

Appropriate steps were taken to address all three challenges in 2022. Staff numbers rose by around 10% compared to the beginning of 2022. Around 10 employees join the Defence & Security unit each month. Everyone in the unit is committed to achieving growth and steering it in the right direction. Initial plans for organisational restructuring were developed in 2022, to be further elaborated and put into effect in 2023. Work was done in the research portfolio to strengthen short-cycle innovation. In addition, the unit's Knowledge Plan was implemented, partly based on the Ministry of Defence's 'Strategic Knowledge and Innovation Agenda', and a start was made on updating the content of the three defence-focused TNO roadmaps.

The Ministry of Defence and TNO joined forces again in 2022 to take part in national and international innovation and R&D programmes, such as the National Growth Fund, the Mission-Driven Top Sectors and Innovation Policy, and the European Defence Fund (EDF). Together, we constantly seek opportunities to better leverage the Ministry of Defence's research investments through the use of new tools. The Ministry of Defence has provided additional funding in order for TNO to participate cost-effectively in the EDF. In the first round of the EDF, TNO collaborated on 12 proposals, of which nine projects eventually qualified for an EU grant. This success rate is 67% higher than the European average. The EU contribution in the nine projects totals €4.3 million. 17 proposals were submitted for the 2022 EDF round and the results will be announced in the first half of 2023.

In the first half of 2022, the Knowledge Position Audit (KPA) for the research groups in the Human and Operational Modelling Cluster resulted in a final report. All departments collectively scored a four on the five-point scale. A management letter sets out the unit management's response to the KPA committee's recommendations.

There were a number of developments in the area of real estate and research facilities in 2022. The Hybrid Way of Working has eased the pressure on available real estate. The partial vacancy at the Oude Waalsdorperweg location in the Hague will be filled by the Military Intelligence and Security Service due to the departure of the NATO Communications and Information Agency. For the new construction of the CBRN department at the Ypenburg location in The Hague, a 'bouwteam' ('construction team') tender was chosen. A 'construction team' is a partnership between the client and a number of advisers and implementing parties. The new building is expected to be completed in 2025 and, after the relocation of the CBRN (chemical, biological, radiological, and nuclear protection) department, the Rijswijk Lange Kleiweg location can be divested.

The CDR agreed to sell the 'dormant' Heimolen location in 2022 and this has now been completed. In Soesterberg, a Concurrent Design Facility for the Ministry of Defence was created in collaboration with DMO and ownership of the Desdemona simulation facility was fully transferred to TNO.

In 2022, the annual 'Innovation in Defence' event was held twice. The first event, in April, was actually the December 2021 event, which had been postponed due to COVID-19 restrictions. At the second event in December, a record number of knowledge programmes, technology projects, and innovation experiments were presented in a new format, classified according to the Research & Technology areas from the Ministry of Defence's Strategic Knowledge and Innovation Agenda.

In conclusion: the reporting year was a good year for TNO's Defence Division. The COVID-19 pandemic definitely seems to be behind us. At the same time, geopolitical developments are boosting defence research, so we are entering a period of growth. In the good relationship between the Ministry of Defence and TNO, which is based on trust that constantly needs to be maintained, predictability is important to each side. After 75 years, collaboration between the Ministry of Defence and TNO is still as vigorous as ever. With the plans announced nationally and in the European context for Defence and for innovation in general, the Defence Division of TNO is in an excellent position to further deepen this collaboration in the coming years.

On behalf of the Council for Defence Research,
Maarten Tossings, Chair

Composition of the Executive Board, Supervisory Board & CDR and Strategic Advisory Councils

Composition of the Executive Board

There was a change in the Executive Board in 2022. After more than seven years at TNO (since 2015), CEO Paul de Krom stepped down on 1 February. He was succeeded by Tjark Tjin-A-Tsoi on 1 June 2022. At the end of 2022, Peter Werkhoven decided, in close consultation with the Supervisory Board, to step down as CSO for personal reasons.

Distribution of portfolios on the Executive Board

CEO:
- External positioning and profiling of TNO, strategy, corporate governance, point of contact for the Supervisory Board and Works Council, marketing, communication and public affairs, human resources, internal audit, integrity
- Chair of Executive Board, Chair of Integrity Advisory Board and Diversity & Inclusion Board

COO:
- Operations of units, real estate & facilities, information services, operational excellence & auditing, security, investment in research facilities, Corporate Social Responsibility
- Chair of CDR, Chair of Investment Board, member of CSR Board

CSO:
- External positioning and profiling of TNO, strategy, knowledge strategy, IP development, scientific quality and research integrity, Strategic Advisory Councils, point of contact for Supervisory Board Quality Committee
- Vice-chair of Executive Board, Chair of Science Board, member of Integrity Advisory Board

CFO:
- Planning & control, financial policy & reporting, risk management, procurement, business intelligence, legal & compliance, valorisation, tech transfer & IP, market strategy, point of contact for TNO Pension Fund Foundation and Supervisory Board Audit Committee
- Chair of Governance, Risk & Compliance Advisory Board, Tech Transfer Board

Dr T.B.P.M. (Tjark) Tjin-A-Tsoi, Chair/CEO (1966)
Since 01-06-2022.
Executive and supervisory positions:
- Executive Board member, Federatie van Samenwerkende Organisaties in het Toegepast Onderzoek (Federation of Applied Research Institutes, TO2)
- Member, Zuid-Holland Economic Board
- Supervisory Board member, Vrije Universiteit Amsterdam (VU)
- Supervisory Board member, PreWonen
- Supervisory Board member, Dutch National Opera & Ballet
- Member, 'Raad van Nesteliers' (Advisory Council), Royal Netherlands Marechaussee
- Member, Royal Holland Society of Sciences and Humanities
- Member, Netherlands Academy for Technology and Innovation (ACTI)

Mr P. (Paul) de Krom, Chair/CEO (1963)
From 01-03-2015 to 01-02-2022.
Executive and supervisory positions:
- Executive Board member, Federatie van Samenwerkende Organisaties in het Toegepast Onderzoek (Federation of Applied Research Institutes, TO2)
- Supervisory Board member, HTM Personenvervoer (public transport provider in the City of The Hague)
- Director, Koninklijke Hollandse Maatschappij der Wetenschappen (Royal Holland Society of Sciences and Humanities)
- Supervisory Board Vice-Chair, Utrecht University of Applied Sciences
- Member, Zuid-Holland Economic Board
- Chair, Holland International Distribution Council (HIDC)

Mr M.G.L.H. (Maarten) Tossings, COO, Rear Admiral (1962)
Since 15-03-2019.
Executive and supervisory positions:
- Board member, The Netherlands Industries for Defence & Security (NIDV)
- Member of the Executive Committee, NIDV Naval Construction Cluster (NMC)
- Board member, Stichting Maritiem Kenniscentrum (MKC) (Centre for Maritime Expertise)
- Board member, Dcypher
- Chair, Digital Task Force, Zuid-Holland Economic Board
- Supervisory Board member, Holland Metrology
- Supervisory Board member, Stichting Bibiliotheek Krimpenerwaard (Krimpenerwaard Library Foundation)

Ms S.M. (Susan) Swarte RC, CFO (1968)
Since 01-05-2021.
Executive and supervisory positions:
- Non-executive director, Toxys BV
- Supervisory Board member, Audit Committee chair and Remuneration Committee member, Acta Marine Holding BV

Prof. P.J. (Peter) Werkhoven, CSO (1959)
From 01-05-2019 to 31-12-2022.
Executive and supervisory positions:
- Professor, Utrecht University
- Board member, Top Consortium for Knowledge and Innovation, High Tech Systems and Materials
- Member, Technology and Innovation Committee, VNO-NCW (employers' organisation)
- Supervisory Board member, PhotonDelta
- Board member, Stichting Toekomstbeeld der Techniek (Foundation for the Future of Technology)
- Social Advisory Council member, Royal Netherlands Meteorological Institute
- Member, Netherlands Academy for Technology and Innovation (ACTI)

Dr W.C.A. (Aloys) Maas, Secretary (1967)
Since 01-01-2018.

Composition of the Supervisory Board

Mr P.G. (Gijs) de Vries, Chair (1958)
Since 01-07-2019; first term runs until 01-07-2024.
Professional activities outside TNO:
- Chair of the Supervisory Board, Erasmus University Medical Center Rotterdam
- Chair of the Supervisory Board, Arbo Unie (occupational health service)
- Chair of the Supervisory Board, Netherlands Comprehensive Cancer Organisation (IKNL)
- Chair of the Board, Stichting Achmea Slachtoffer en Samenleving (Achmea Victim and Society Foundation)
- Chair of the Board, Foundation National Monument Camp Amersfoort
- Coach, Executive Sherpa Coaching/Mind&Health

Dr P.J.M. (Peter) van Laarhoven, Vice-Chair (1959)
Since 01-10-2016; second term runs until 01-10-2026.
Professional activities outside TNO:
- Chair of the Supervisory Board, CQM
- Chair of the Supervisory Board, Port of Moerdijk
- Chair of the Supervisory Board, Arnhem and Nijmegen University of Applied Sciences Foundation
- Vice-Chair of the Supervisory Board, CB Logistics
- Member of the Supervisory Board, H&S Group
- Vice-Chair, the Netherlands National Commission for UNESCO
- Chair of the Supervisory Board, Dutch Touring Opera
- Member of the Board, Association of University Supervisors (since 1-7-2022)

Prof. H. (Hester) Bijl (1970)
Since 01-09-2018; first term runs until 01-09-2023.
Professional activities outside TNO:
- Rector Magnificus, Executive Board, Leiden University
- Professor of Numerical Mathematics, Mathematical Institute, Leiden University
- Board member, Leiden Bio Science Park Foundation
- Supervisory Board member, Impuls Zeeland

Mr J.B.P. (Baptiest) Coopmans (1965)
Since 01-02-2021; first term runs until 01-02-2026.
Professional activities outside TNO:
- Senior Vice-President, Executive Leadership Team member, Liberty Global
- Supervisory Board member, Burg Group
- Supervisory Board member, VodafoneZiggo
- Supervisory Board member, Royal FrieslandCampina (since 13-12-2022)

Prof. M.P. (Marko) Hekkert (1971)
Since: 01-05-2022, first term runs until 01-05-2027.
Professional activities outside TNO:
- Director, Netherlands Environmental Assessment Agency (since 1-1-2023)
- Professor of Dynamics of Innovation Systems at the Copernicus Institute of Sustainable Development at Utrecht University
- Academic Partner, Netherlands Environmental Assessment Agency (until 1-1-2023)
- Member of the Committee on Sustainable Development of the Social and Economic Council (SER)

Ms J.D. (Jolanda) Lamse-Minderhoud RA (1969)
Since 01-11-2014; second term runs until 01-11-2024.
Professional activities outside TNO:
- Partner, PricewaterhouseCoopers (PwC)
- Executive Board Member, PricewaterhouseCoopers Netherlands (until 1-7-2022)
- Supervisory Board member, Wildlife Justice Commission
- Member of the Board of Management, PwC Digital Technology Services B.V.

Prof. P.P.C.C. (Peter-Paul) Verbeek (1970)
Since: 01-05-2012; second term runs until 01-05-2022.
Professional activities outside TNO:
- Professor of Philosophy of Human-Technology Relations, University of Twente
- Co-Director, DesignLab, University of Twente
- Honorary Adjunct Professor, Aalborg University
- Chair, UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST)
- Vice-Chair of the Board, Rathenau Institute
- Chair of the Committee on Freedom of Science and Technology of the Royal Netherlands Academy of Arts and Sciences
- Board member, Social Sciences and Humanities Domain, Netherlands Organization for Scientific Research (NWO)
- Commission member, Social Sciences and Humanities Sector Plans OCW
- Programme Board member, Maatschappelijk Verantwoord Innoveren (MVI) (Socially Responsible Innovation), Netherlands Organization for Scientific Research (NWO)
- Member, the Netherlands National Commission for UNESCO
- Member, Royal Netherlands Academy of Arts and Sciences

Ms L. (Louise) Verheij van Wijk (1964)
Since 01-10-2019; first term runs until 01-10-2024.
Professional activities outside TNO:
- Chair, Supervisory Board, Star-shl
- Managing Director, MRI Centre (until summer 2022)
- Member, IT & Innovation Think Tank of the Netherlands Comprehensive Cancer Organisation (IKNL)

Dr W.C.A. (Aloys) Maas, Secretary (1967)
Since 01-01-2018.

All members are Dutch nationals.

Composition of the Council for Defence Research

Mr M.G.L.H. (Maarten) Tossings
Chair, TNO, Executive Board member/COO

Mr M. (Marc) Gazenbeek
Vice-Chair, Ministry of Defence, Deputy Secretary-General

Mr M.J. (Marja) Eijkman
Member, TNO, Managing Director, Defence & Security unit

Major General A. (André) Steur
Member, Ministry of Defence, Director of Operational Policy and Plans

Mr A.P. (Auke) Venema
Member, Ministry of Defence, Strategic Knowledge & Innovation Advisor

Mr H.F. (Harold) Bousché
Secretary, TNO

Composition of the Strategic Advisory Councils

List of SAC members as at 1 November 2022

Unit	Mr/Ms	Name	Company	Department
Defence, Safety & Security	Ms	Prof. B.A. de Graaf	Utrecht University	Humanities Faculty Professor, Dept. History and Art History and History of International Relations
	Ms	Lieutenant General E.F. Boekholt-O'Sullivan	Ministry of Defence	DG Policy, Deputy Director-General
	Ms	I.C. Bryan	Fox-IT	Managing Director for NCC Group activities on the European mainland/Group Executive Committee member, NCC Group
	Mr	J.C. Dicke	Ministry of Economic Affairs and Climate Policy	Commissioner of Military Production
	Mr	Brigadier General J.P.L. Duckers	Ministry of Defence	Army Command, Knowledge and Development Director
	Mr	H.G. Geveke		National Police Board
	Ms	Prof. E. Giebels	University of Twente	Professor of Social Psychology of Conflict and Safety
	Mr	G.A. Kuiper	Ministry of Defence	DG Policy, Strategy Director, Policy Development and Innovation
	Mr	H.J.J. Lenferink	Municipality of Leiden	Mayor of Leiden
	Mr	Prof. E.R. Muller	Leiden University	Dean, Faculty of Governance and Global Affairs/Professor of Safety, Security and Law, Leiden University/Director Campus The Hague
	Mr	Air Commodore Prof. F.P.B. Osinga	Ministry of Defence	NLDA, Professor of Military Operational Sciences, Faculty of Military Sciences/Endowed Professor of War Studies, Leiden University
	Mr	L. Roffel	Thales Nederland	Chief Technical Officer
	Ms	H.M.J. Somsen	Ministry of Justice and Security, NCTV	Deputy Director, Cyber Security and Nation-State Actor Threats, NCTV
Buildings, Infrastructure & Maritime	Mr	J.H. Dronkers	Ministry of Infrastructure and Water Management	Secretary-General
	Mr	C.F. Eggink	HeartWork	Co-Founder
	Ms	C. Kremer	Vereniging Eigen Huis	Director
	Ms	T. Muusse, MSc		
	Ms	C. Reiner	Cooperation Organisation for Vocational Education, Training and the Labour Market SBB	Co-Chair
	Mr	M.R. Schurink	Ministry of the Interior and Kingdom Relations	Secretary-General
	Mr	B.P. Smolders	Heijmans Infra B.V.	Chair of the Board
	Mr	F. Vermeulen BA	Municipality of Wageningen	Mayor
	Ms	Prof. L. Volker	University of Twente	Faculty of Engineering Technology, Professor of Integrated Project Delivery
	Mr	R.P. van Wingerden MBA	National Coordinator for Groningen (NCG)	Executive Adviser

Unit	Mr/Ms	Name	Company	Department
Circular Economy & Environment	Mr	T.J.A. Wagenaar		Supervisor/manager
	Mr	B. Baker	Rabobank	Managing Director, Sector Head Banking4Energy Europe
	Mr	O. de Bont	Renewi	CEO
	Mr	Prof. L. Hordijk	Wageningen University & Research	Emeritus Professor
	Ms	J.C.M. Sap		Supervisor/manager
	Mr	W.N. Schouten	Impact Economy Foundation	Director
	Ms	J.C.V. Vaessen	Chemicals Top Sector	Chair of Chemicals Top Sector NL
	Mr	M. Waas	Nobian	Director/VP R&D, Technology and Sustainability
	Mr	Prof. B.M. Weckhuysen	Utrecht University	Distinguished Professor
	Mr	Dr M. Wubbolts	Corbion	Chief Science & Sustainability Officer
Energy Transition	Mr	G.J. Lankhorst	VEMW	
	Mr	J. Atema	NAM	Managing Director
	Mr	H. Fennema	Gasunie	CEO
	Mr	A.F. Gaastra	Ministry of Economic Affairs and Climate Policy	Director-General
	Mr	M.E. Galjee	Nouryon	Energy Director
	Ms	Prof. P.M. Herder	Delft University of Technology	Professor
	Mr	J.W. van Hoogstraten	EBN	CEO
	Mr	Prof. N.J. Lopes Cardozo	Eindhoven University of Technology/NWO, Exact and Natural Sciences	Professor
	Mr	R. Miesen	NWE Generation SE	CEO
	Ms	M. Minnesma	Urgenda	Managing Director
	Mr	Prof. A. Polman	Amolf/University of Amsterdam	Scientific Group Leader/Professor
	Mr	Y. Sebregts	Shell Global Solutions International B.V.	EVP Technology and CTO
Healthy Living	Mr	Dr E. Bruins		
	Mr	J.P. Daems	CNV trade union federation	Board member
	Mr	Prof. A.J. van Gool	Radboud UMC	Professor, Personalized Healthcare
	Ms	Dr M.E.Y. Koster	Janssen-Cilag B.V.	Lead Strategic Alliances Netherlands
	Mr	T.A.J. Oostrom	Nierstichting	Director
	Ms	Dr V.C.M. Timmerhuis	ZonMw	Director
Information & Communication Technology	Ms	S. van Heukelom-Verhage	Pels Rijcken	Chair of the Board
	Mr	S.B. Luitjens		
	Mr	Dr T.D. Poelhekken	Koninklijke KPN B.V.	Chief Technology Officer
	Mr	Prof. M.R. van Steen	University of Twente	Scientific Director

Unit	Mr/Ms	Name	Company	Department
Industry	Mr	M.H. Hendrikse	Holland High Tech	Figurehead of the High-Tech Systems & Materials Top Sector (HTSM)
	Mr	Prof. F.P.T. Baaijens	Eindhoven University of Technology	Rector Magnificus
	Ms	B. van Dijk-van de Reijt	The Brabant Development Agency (BOM)	Managing Director
	Mr	S. Hamminga	Robin Radar Systems B.V.	CEO
	Mr	Dr H. van Houten	Royal Philips N.V.	CTO
	Mr	Dr P.J. Nieuwenhuizen	Enerkem	Vice President Strategy & Development
	Mr	R. Postma	Airbus Defence and Space Netherlands B.V.	CEO
	Ms	Prof. B. Redlich	Felix Laboratory Nijmegen/Radboud University	Director
	Mr	Prof. G. van der Steenhoven	KNMI	Managing Director & CSO
	Mr	P.M. Sweers	Ministry of Economic Affairs and Climate Policy (DG B&I)	Director for Innovation and Knowledge
	Mr	H. Tappel	Bronkhorst High-Tech B.V.	Managing Director
Strategic Analysis & Policy	Mr	Prof. K.M. Becking	Nyenrode Business University	Chair of the Executive Board and Rector Magnificus
	Ms	Prof. N.M.P. Bocken	Maastricht University	Maastricht Sustainability Institute (MSI)
	Ms	M. Demmers MBA	Nature & Environment	Managing Director
	Mr	Prof. M.L.P. Groenleer	Tilburg University	Scientific director of Tilburg Center for Regional Law and Governance (TiREG)
	Mr	Prof. R. de Jong	Royal Philips N.V. and Tilburg University	Retired Member, Executive Committee Philips
Traffic & Transport	Mr	M.B. Unck	RET NV	CEO
	Ms	M. M. de Jager	Royal Dutch Touring Club	CEO
	Mr	B. Janssen	Deltalinqs	Managing Director
	Mr	P. van Nunen	Brainport Development N.V.	Director
	Ms	N. van 't Riet	DB Cargo Nederland N.V.	CEO/COO
	Ms	A. Rietstra	ProRail	COO
	Mr	J. Roodenburg	Huisman	President
	Mr	A. Toet		
	Mr	G. Veenstra	Keolis Nederland	Head of Corporate Affairs
	Mr	Prof. E. Verhoef	Vrije Universiteit Amsterdam	Professor, School of Business and Economics, Spatial Economics
	Mr	Prof. R. Zuidwijk	Rotterdam School of Management, Erasmus University	Professor of Global Supply Chains and Ports

Game changer

Reviewing key technologies

The Ministry of Economic Affairs and Climate Policy is developing a National Technology Strategy (NTS). The aim of the NTS is to create a vision as a basis for deploying resources on key technologies in order to contribute to more efficient, targeted investment choices. As a first step in the process of developing a NTS, the Ministry of Economic Affairs and Climate Policy asked TNO and NWO to review the existing list of 50 key technologies. The list plays an important role in the Knowledge and Innovation Agendas (KIAs) of Top Sectors, in particular through the KIA Key Technologies.

The aim of reviewing the list of key technologies is to update the existing list and to deepen and enrich its content so that it accurately represents the Dutch key technology landscape and provides a good framework for the formation of the NTS. This framework will be helpful in making policy choices in the next phase of the NTS. In this way, TNO is contributing to a strategy for the Dutch government and industry so that they can continue helping to achieve the transitions and boost the earning power of the Netherlands in the future.

Partners: NWO

Unit: Strategic Analysis & Policy

GRI table (GRI4, core)

GRI Indicator	Description	Explanation or Reference	Page number	Explanation
Organisational profile				
102-1	Name of organisation	TNO	cover and 1-34	
102-2	Brands, products and/or services	Our organisation	8	
102-3	Location of headquarters	Anna van Buerenplein 1 2595 DA The Hague, The Netherlands	80	
102-4	The number of countries in which the organisation operates	Internationally active	14	Within EU research programmes, TNO works across borders with partners from different European countries. Further information on TNO's international activities and locations can be found at: TNO as an international partner.
102-5	Ownership structure and legal form	Our organisation	8	The Netherlands Organisation for Applied Scientific Research was established by law in 1932: TNO. TNO's goal is to make knowledge usable for companies and public authorities. As a public organisation, we have an independent position.
102-6	Sales markets	Our organisation	8	
102-7	Size of the organisation	Home for talent indicators	38-39	
102-8	Composition of the workforce	Home for talent indicators	38-39	
102-9	Supply chain information	Stakeholders Sustainable and responsible operations Supply chain	3 43 50	
102-10	Significant organisational changes during reporting period	Organisation chart	61	To facilitate collaboration within TNO and improve the manageability of the organisation as a whole, the number of TNO units was reduced from nine to six as of 15 November 2022.
102-11	Explanation of the use of the precautionary principle	Innovating responsibly	20-24, 57-58	
102-12	External initiatives that the organisation endorses	External developments	14-18	
102-13	Membership of associations and interest groups	Stakeholders UN Global Compact EcoVadis	3 12 43-44	

GRI Indicator	Description	Explanation or Reference	Page number	Explanation
Strategy				
102-14	Statement from the most senior decision-maker about the relevance of sustainable development to the organisation	Value creation through sustainable and responsible operations	8-9 43	
102-15	Key impacts, risks, and opportunities	Value creation Strategy	9 20-33	
Ethics and integrity				
102-18	Operational structure of the organisation	Organisational structure Organisation chart	8 61	
Governance				
102-18	The governance structure of the organisation, including committees under the highest governance body, as well as the committee responsible for decision-making on economic, environmental, and social issues	Our organisation Sustainable and responsible operations Organisation chart Composition of the EB, SB, CDR, and SACs	8 43 61 70-75	
Stakeholder engagement				
102-40	List of stakeholder groups with which the organisation engages	Stakeholders SDGs	3, 11 12	
102-42	Principles for the identification and selection of stakeholders	Stakeholders SDGs	2, 11 12	
102-43	Method of stakeholder engagement	Stakeholders SDGs	2, 11 12	
102-44	Key topics and issues that have arisen from stakeholder consultations and how the organisation has responded to them	Stakeholders SDGs	2, 11 12	
Reporting principles				
102-46	Process for determining the content and specific boundaries of the report and principles used in doing so	Stakeholders SDGs Strategy 2022-2025	11 12 20-24	
102-47	Material issues identified during the process of determining the content of the report	Stakeholders SDGs Strategy 2022-2025	11 12 20-24	
102-48	Consequences of any rephrasing of information that was included in a previous report and the reason for the rephrasing	Not applicable		No changes in terms of scope and boundaries.
102-49	Significant changes with respect to previous reporting periods in terms of scope and boundaries	Not applicable		No changes in terms of scope and boundaries.
102-50	Reporting period	1 January 2022 – 31 December 2022		
102-51	Publication date of the most recent previous report	June 2022		TNO Sustainability Report 2021 TNO Annual Report 2021
102-51	Organisation response to issues that arose during stakeholder engagement	SDGs External developments	12 14-18	
102-52	Reporting cycle	Annual		
102-53	Contact point for questions regarding the report or its contents	info@tno.nl		This is TNO's first integrated annual report.
102-54	GRI application level	GRI 4 Core (2016 guidelines)	77	
102-55	GRI content index		77-79	

GRI Indicator	Description	Explanation or Reference	Page number	Explanation
Material topics				
203-1	Impact of procurement	Socially responsible procurement	50	
205-1	Anti-corruption	Integrity and anti-corruption	50	
206-1	Anti-competitive behaviour	Business Relationships	50	
302-1	Energy consumption within the organisation	Sustainable and responsible operations	44-48	
302-3	Energy intensity	Sustainable and responsible operations	44-48	
302-4	Reduction of energy consumption	Sustainable and responsible operations	44-48	
305-1	Direct (scope 1) emissions	Sustainable and responsible operations	44-45	
305-2	Indirect (scope 2) emissions	Sustainable and responsible operations	44-45	
305-3	Other indirect (scope 3) emissions	Sustainable and responsible operations	44-45	
305-4	Emission intensity	Sustainable and responsible operations	43-52	
305-5	Reduction of greenhouse gas emissions	Sustainable and responsible operations	43-52	
401-1	Employee inflow and turnover	Home for talent	38-40	
403-2	Health and safety at work	Home for talent	38-40	
404-1	Training and education	Home for talent	38-40	
404-2	Skills enhancement programmes for employees	Home for talent	38-40	
405-1	Diversity of executive bodies and employees	Home for talent	38-40	

Publication details

Would you like to know more about TNO?
Do you have any questions after reading
this report or do you have any ideas?
Please contact us at
info@tno.nl

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The Netherlands

Editing and text
TNO, Marketing & Communications

Design and production
CF Report, Amsterdam

TNO innovation for life