Fraunhofer

2024 annual report

Transfer for Our Future

Research with an impact — what our customers and partners are saying

"The Fraunhofer-Gesellschaft has always been the most important partner for the highly innovative mechanical engineering industry. The applied expertise of its institutes and staff is a cornerstone of our technological capacity. Together, we enhance our ability to transform ideas into practical solutions. We invite you to continue partnering with us as the best innovating partner for the thousands of small and medium-sized mechanical engineering enterprises that are so typical of Germany and central to its success as a hub for innovation. Fraunhofer's unique knowledge is more essential than ever. Let's work together to shape a positive future for Germany."

Bertram Kawlath

President of VDMA – Machinery and Equipment Manufacturers Association

"The collaboration between Fraunhofer and TRUMPF has been a fundamental building block of our work — and a guarantee of success — for many years. We will continue to invest in this close relationship between basic research and industrial practice in the future."

Berthold Schmidt

CTO of TRUMPF SE + Co. KG

"The Fraunhofer-Gesellschaft and the German Federal Ministry of Defence (BMVg) are connected by many years of very close partnership. As well as the opportunities offered by new technologies, Fraunhofer also helps to assess their potential threats. This provides a solid foundation for the transfer of knowledge and the integration of civil research findings into military applications. In its annual report for 2024, the Commission of Experts for Research and Innovation (EFI) also emphasizes that a close link between military and civil research is of great importance for innovative strength in technology as well as for national security. The collaboration between the German Armed Forces (Bundeswehr) and the Fraunhofer institutes, which is founded on an exceptional level of trust, remains essential to Germany's technological performance and the operational readiness of our armed forces."

Ministerial Councilor Alexander Schott

Director of Research and Innovation at the BMVg

"At BASF, the Fraunhofer-Gesellschaft is an important partner in our global knowledge network (Know-How Verbund). Together we can develop innovative solutions in chemistry and new technologies to overcome the challenges of our time. The collaboration between BASF and Fraunhofer enables us to pool the outstanding expertise of their creative researchers in order to implement forward-looking ideas as marketable and sustainable products. Our ten-year collaboration in the field of semiconductor technology is a striking illustration of how we can improve materials and processes by working together."

Stephan Kothrade

Member of the Board of Executive Directors and CTO of BASF SE

"As a bridge between research and industry, the Fraunhofer-Gesellschaft provides important momentum for innovation, and therefore for the future viability and competitiveness of our industry. We are involved in collaborative projects with Fraunhofer institutes or in consortia to develop our projects in the field of digital production. Fraunhofer is an indispensable pioneer and partner for us, and we are proud to be working together to build this dynamic landscape of innovation."

Kristina I. Schunk

CEO and Chair of the Management Board of SCHUNK SE + Co. KG

"For us as a logistics start-up, not only has the Fraunhofer-Gesellschaft opened the door to a strong network of logistics providers and industry partners, but it also continues to assist us with valuable expertise. This then enables us to hone our business model: the automation of multi-use asset management through a software as a service solution. The practical feedback and access to relevant markets mean we can align our solution to best meet the needs of our customer groups and launch it successfully on the market."

Philipp Hüning

Co-Founder and CEO of Logistikbude GmbH

Foreword

Holger Hanselka, President and Chair of the Executive Board of the Fraunhofer-Gesellschaft

Dear Reader,

In a world full of uncertainty, whether due to economic crises, geopolitical challenges, or technological upheaval, what we need most is an openness to opportunities and courage to remain capable of effective action and develop a positive outlook for the future.

There is every reason to be optimistic: Germany is the world's third-largest economy and its third-strongest export nation, despite having just one percent of the global population. When it comes to exports of research-intensive high-tech goods, Germany even ranks second worldwide. This success is built on first-class research and engineering expertise, a highly diverse scientific ecosystem, a close relationship between research, small and medium-sized enterprises (SMEs) and large-scale industry, as well as a strong, forward-looking SME sector. The diversity of companies and their close collaboration helps Germany remain a resilient, future-ready hub, as long as we put ourselves on the right path and push ahead with the necessary transformation processes.

A key step in preparing for the future is to comprehensively strengthen the transfer of research findings into practical application within Germany. The Fraunhofer-Gesellschaft's mission to translate ideas and new scientific findings into practice together with businesses means it has a central role to play as a key innovation partner. We know the strengths and weaknesses of our key transfer channels: contract research, licenses and patents, and spin-offs. And we are making every effort to build on strengths, overcome weaknesses, and improve conditions together with our partners in science, industry, and politics.

In 2024, we once again saw striking evidence of the solid foundation we have in this area, based on entrepreneurial thinking and action, market focus, and scientific excellence. For example, a team from ams Osram and the Fraunhofer Institute for Reliability and Microintegration IZM was awarded the German Future Prize for its Digital Light project. This was the sixth time the prize has been awarded to a team involving Fraunhofer since its inception in 1997. Equally remarkable is Teuken-7B, the first open-source large language model developed in Europe, launched by Fraunhofer together with its partners. Among other things, this model makes it possible to keep sensitive data inside an organization. This makes Teuken-7B particularly significant for the development of industrial applications in security-critical sectors, such as the automotive sector, robotics, medicine, or finance.

These are just two examples of the Fraunhofer-Gesellschaft's innovative achievements in 2024. I am convinced that, together with our partners, we will continue to contribute significantly to the performance and prosperity of Germany and Europe as a business hub. Let's embrace the challenge — the opportunities are there and we have every reason to be optimistic.

Holger Hanselka
President and Chair of the Executive Board of the Fraunhofer-Gesellschaft

Photo: Fraunhofer / Stefan Obermeier

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Executive board's report

The executive board

Holger Hanselka
President and Chair of the Executive Board, Corporate Strategy and Communications

Holger Hanselka has served as the 11th president of the Fraunhofer-Gesellschaft since 2023 and as chair of the executive board since April 2025. Before that, he was president of the Karlsruhe Institute of Technology (KIT) for ten years and vice president of the Helmholtz Association, responsible for the field of energy research. A mechanical engineer by training, Hanselka headed the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt from 2001 until 2013 and was, for a time, a member of the Fraunhofer presidium. He is active on various advisory committees that support the German chancellor on matters of science and research policy.

"For our future development, we are focusing on our core business and building on our mission-specific strengths within the innovation ecosystem. Fraunhofer holds a key position as an essential industry partner in Germany and Europe. The success of our innovations on the market is built on a foundation of scientific excellence."

Constantin Häfner
Executive Board Member for Research and Transfer

Constantin Häfner joined the executive board in February 2025. A laser physicist, he previously led the Fraunhofer Institute for Laser Technology ILT in Aachen. He took up that position after returning from the USA in 2019, where he had been in charge of developing the world's largest and most powerful laser systems at the Lawrence Livermore National Laboratory in California since 2006. These systems are used for research into laser-based inertial fusion, among other things. Häfner is the Fraunhofer officer for fusion research. In that capacity, he has also headed the expert group commissioned by the German Federal Ministry of Research, Technology and Space (BMFTR) since 2022.

"Fraunhofer has merged the executive units for research and transfer to more quickly and effectively shape the translation of innovative research findings to real-world applications for industry and society. The aim is to strengthen Germany's position as a hub for business as well as its international competitiveness and collaboration, particularly with Europe."

Photo of Häfner: Fraunhofer / Markus Jürgens, all others: Fraunhofer / Stefan Obermeier

Axel Müller-Groeling
Executive Board Member for Research Infrastructures and Digital Transformation

Axel Müller-Groeling is a professor at Kiel University. The physicist and executive has conducted research at several renowned institutes and research organizations in Germany, France and Canada. He worked as a management consultant and co-founded an international, publicly traded solar energy company, where he also served as an executive vice president. In 2016, he became the director of the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe. He then also became director of the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg. He has been on the executive board of the Fraunhofer-Gesellschaft since August 2022.

"The geopolitical landscape emphasizes the key role of the Fraunhofer-Gesellschaft as an applied-research organization in strengthening Germany and Europe as global competitors. This depends crucially on advancing digital transformation, expanding research infrastructures, and streamlining business processes."

Elisabeth Ewen
Executive Board Member for Human Resources, Corporate Culture and Legal Affairs

Elisabeth Ewen is a fully qualified lawyer with an additional specialization in administrative and labor law. After graduating, she worked as a lawyer in the HR department of the German Aerospace Center (DLR) before she became director of human resources at GMD – Forschungszentrum Informationstechnik GmbH. She joined the Fraunhofer-Gesellschaft in 2001 when GMD was integrated into the Fraunhofer-Gesellschaft. Since then, she has held several senior roles in human resources at the Fraunhofer-Gesellschaft, most recently as director of human resources. Ewen has served on the executive board of the Fraunhofer-Gesellschaft since August 2022.

"Fraunhofer's strategic HR management is driven by its mission of ensuring the transfer of talent. It commits us to dealing transparently with fixed-term contracts, providing binding career planning and training and creating an attractive work environment. Fraunhofer is deeply committed to a diverse workforce and an open corporate culture."

Sandra Krey
Executive Board Member for Finances and Controlling

Sandra Krey studied business administration and holds a doctorate from the University of Erlangen-Nuremberg. She worked for several years as an auditor at KPMG before joining the MAN Group, where she held various leadership roles in finance and accounting over a 20-year period. From 2013, she was a senior vice president for accounting & finance processes at MAN Truck & Bus SE and managing director of the MAN Shared Services Center in Poland. Krey has been on the executive board at the Fraunhofer-Gesellschaft since August 2022.

"Innovative research and its translation into practical applications and solutions require financial stability and reliability. One or our most important tasks right now is to ensure that the Fraunhofer budget is balanced — despite today's sluggish economy, rising costs and limited public funding."

2024 management report

2024 management report

Key data

Trend for the Fraunhofer-Gesellschaft for 2024 (in € million)

	2023	2024		Change
Total business volume	**3,404**	**3,563**	**+159**	**+5%**
Contract research	2,991	3,136	+145	+5%
Additional research funding	249	260	+11	+4%
Major infrastructure	164	167	+3	+2%
Business volume by budget	**3,404**	**3,563**	**+159**	**+5%**
Operating budget	2,823	2,978	+155	+5%
Capital expenditure [1]	581	585	+4	+1%
Project revenue	**2,327**	**2,302**	**-25**	**-1%**
Contract research	2,167	2,162	-5	-0%
of which industrial revenue	836	867	+31	+4%
of which public-sector revenue [2]	1,331	1,295	-36	-3%
Additional research funding	139	133	-6	-4%
Major infrastructure	21	7	-14	-67%

1 Current capital expenditure for contract research, additional research funding and major infrastructure capital expenditure.

2 Comprises German federal and state government, EU and other revenue.

Profile, strategy and operating environment

Profile of the Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is a leading applied research organization. Since its foundation in 1949, Fraunhofer institutes have been strengthening the competitiveness of business and innovation in Germany and Europe. Fraunhofer's comprehensive range of solutions for industry and policymakers has an impact across industries. The Fraunhofer-Gesellschaft is also a **significant location factor** for Germany as a country of innovation: its activities increase investment effects in the economy, afford innovation-based competitive advantages to businesses and create jobs, while skilled workers earn qualifications and modern technology becomes more socially acceptable.

In 2024, nearly 32,000 people, predominantly scientists and engineers, were employed across 76 institutes with an annual research budget of around €3.6 billion, €3.1 billion of which was allocated to the core business of contract research. Fraunhofer generated around a third of this from **industry contracts and license-fee revenue**, totaling €867 million. Around another third came from **publicly funded research projects**. The last portion of the contract research funding came from base funding from the German federal government and state governments. **Base funding** enables strategic research and the long-term development of technologies that are not yet directly funded by industry but have high innovative potential and will become economically and societally relevant in the near future. Contract research for industry is the most important business focus. Fraunhofer is an **important supplier of innovative know-how** for businesses of all sizes. The Fraunhofer-Gesellschaft also contributes to the success of key technology missions for society as a whole. For public-private partnerships, Fraunhofer is an attractive and established player. At an organization-wide level, Fraunhofer identifies trending technologies and innovative business units with major market potential and significant relevance to society and advances them, in part through in-house research programs.

Each individual Fraunhofer institute and research institution develops its own business units and core areas of expertise on the basis of its immediate market environment and its links with the wider scientific community. Although the institutes operate as separate profit centers, they are not autonomous legal entities. The institutes also collaborate in research fabs and alliances to capitalize jointly on certain business units or sectors.

Framework strategy process

In April 2024, the executive board of the Fraunhofer-Gesellschaft agreed on a collective process for an organization-wide **framework strategy** to realign our strategic direction. This needs to be developed and implemented against a background of external challenges, such as the increasingly turbulent economic environment with uncertainties around financing, political instability internationally and an increasing shortage of skilled workers. We also need to address a number of internal challenges, including streamlining business processes and developing our corporate culture. A further contribution to the modernization and transformation process is the implementation of a new governance structure, with the executive board enshrined as a collective body in the new statutes and the **senate strengthened** in its role as an advisory and supervisory body.

The Fraunhofer-Gesellschaft will intensify its focus on its **mission** and core function: to work together with business on driving the transfer of scientific findings to practical application. It will also enhance its profile in the long term and increase the prominence of its **unique selling points in the German research world**, such as its financing model and the resulting strong market focus of its R&D work. Fraunhofer stands for the **competitiveness of the German economy** and is a **symbol of Germany's capabilities as one of the world's leading research nations**. That is worth preserving. Fraunhofer must therefore increase its agility, swiftness, and capacity to act in positioning itself on the global stage. **Strengthening Germany as an industrial hub** is the Fraunhofer-Gesellschaft's most important contribution to the well-being of society. This is where the strategy process will focus.

Consequently, the executive board has formulated overarching goals for the framework strategy. These goals aim to ensure that Fraunhofer can make a significant contribution to the future viability of industry and society with excellent applied research.

A key partner for industry

Fraunhofer's ability to continue serving as a key partner to industry depends on solid financing and is based on the Fraunhofer model. It is designed to maintain a balanced mix between private- and public-sector revenue. To increase their market relevance, the institutes need to make the most of

all channels for technology transfer to the private sector. By expanding market and technology intelligence, and thereby gaining a deeper understanding of the current and future needs of customers and partners, Fraunhofer intends to strengthen Germany's position as an industrial hub.

Driving groundbreaking technological innovation
Excellent research is only possible with highly qualified and motivated employees. Through targeted programs specifically tailored to target groups, Fraunhofer attracts and develops top talent in research, technology and administration. To consolidate Fraunhofer's leading technological position, each institute focuses on its unique selling point and research excellence. The technology infrastructure in place at and across the Fraunhofer locations is optimized to contribute directly to technological breakthroughs. Fraunhofer also strengthens the country's technological sovereignty as an industrial hub.

Outstanding institution
As both an employer and partner to industry, the Fraunhofer-Gesellschaft continuously evolves its corporate culture and governance through a participative approach. Efficient internal processes are indispensable to meeting the needs of its customers. This requires employees at every level to take the initiative, be willing to take risks and assume responsibility.

Science policy framework and positioning

In 2024, research policy was dominated by the national budget situation. On the one hand, the 2024 German federal budget once again required **compliance with Germany's constitutional debt limit** (Schuldenbremse) for the first time since 2019. As a result, the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Federal Ministry of Health (BMG) saw **budget cuts**. In Fraunhofer's grant authorities, the German Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Defence (BMVg), however, budgets remained close to the previous year's level. On the other hand, the **Federal Constitutional Court's** ruling on funding for the **Climate and Transformation Fund** (KTF) had significant implications for the long-term financing of R&D projects in the field of energy technologies. Similar funding constraints are expected in the 2025 federal budget.

Beyond the financing situation, the **tense geopolitical climate** continued to shape the research policy debate in Germany. The ongoing war in Ukraine, escalating political tensions in the Middle East, as well as strained relations between China and the West have sparked important **debates on research security and dual-use regulations**. The Fraunhofer-Gesellschaft is very actively involved in this debate at both national and European levels, including submitting statements to the European Commission, participating in stakeholder meetings with parliamentary groups and contributing in the federal chancellor's Zukunftsrat (Future Council). In the Zukunftsrat, Holger Hanselka, together with Tanja Brühl, President of the Technical University of Darmstadt and Co-President of TU9, sponsored a policy brief on the implications of the *Zeitenwende* speech by Olaf Scholz for sovereignty, defense capability and innovation.

Fraunhofer continues to bring its applied research perspective to research policy discussions to help improve overall conditions and make them more conducive to innovation as well as to **accelerate** and streamline **knowledge and technology transfer**. This gave Hanselka the opportunity to address a public hearing of the German federal parliament's Committee on Education, Research and Technology Assessment in October 2024. There, he set out both the strategic development of the Fraunhofer-Gesellschaft and the Fraunhofer-Gesellschaft's research policy recommendations for innovation and technology transfer. In-depth talks were also held with the working groups for education and research of various parliamentary groups, as well as with individual members of parliament. In addition, Hanselka plays an active role in the **founding committee of the German Agency for Transfer and Innovation (DATI)** alongside 15 other experts. Fraunhofer's president has regularly brought an applied research perspective to this committee.

The previous federal government (composed of the SPD, The Greens and the FDP) pursued a research policy aimed at bolstering Germany's international competitiveness with its "Future Strategy for Research and Innovation." This strategy focused on strengthening the research and innovation system and promoting the transfer of innovative research findings to practical application. Fraunhofer has drawn up research policy recommendations for two of the six **missions of the Future Strategy for Research and Innovation**, and these are now being incorporated into the ongoing strategy development

process. They are related to the following missions:

[1] Enabling resource-efficient, competitive industry designed for a circular economy as well as sustainable mobility,

[4] Securing the digital and technological sovereignty of Germany and Europe and making use of the potential offered by the digital transformation.

Fraunhofer has also been active in discourse on important interdisciplinary digital policy topics that are crucial to Germany's and Europe's position as a hub of innovation. For example, Fraunhofer has published a **position paper** with a number of recommendations for bringing generative AI into widespread use in accordance with the **requirements of the EU AI Act**. The Fraunhofer-Gesellschaft has also brought its **expertise** to the parliamentary development of the German Health Data Use Act (Gesundheitsdatennutzungsgesetz, GDNG) and, at an early stage, the German Research Data Act (Forschungsdatengesetz, FDG). Fraunhofer has also provided research policy support for the **introduction of a field laboratory act**.

Under the **heading "Competitive Factor,"** Fraunhofer experts published a series of **position papers** for the **2025 federal elections** highlighting key areas of science and innovation policy for Germany's role as an industrial hub. The papers were commissioned by the Fraunhofer executive board and outline current political and economic challenges in key areas of technology policy, identify necessary actions and offer concrete political recommendations.

For the 75th anniversary of the Fraunhofer-Gesellschaft in November 2024, a celebration was held in Berlin where important ideas for furthering the development of Germany's innovation system were exchanged with external stakeholders from industry, science and politics.

In 2024, the **Alliance of Science Organizations in Germany** dealt with relevant issues in innovation and research policy, including the **German Research Data Act** , **research security** and the **amendment to the German Lobbying Register Act (Lobbyregistergesetz, LobbyRG)**. In addition, Fraunhofer has adopted shared stances with the alliance on the need for the **reconstruction in Ukraine** following the Russian war of aggression, **against boycotts of Israeli researchers and scientific institutions and for an open society and a strong democracy**. Fraunhofer has also prepared itself both in content and organization to take on the **leadership of the alliance**, which passed from the Max Planck Society (MPG) to the Fraunhofer-Gesellschaft in 2025. This role underscores Fraunhofer's commitment to scientific excellence and innovation for industry and society. As part of the alliance, Fraunhofer and its partner organizations advocate for strong and consistent research and innovation policy. The aim is to strengthen Germany as a hub for science, from higher education to basic and applied research, with a holistic and long-term perspective.

Because of the new requirements resulting from the amendment to the LobbyRG, the Fraunhofer-Gesellschaft has set out new compliance standards for its lobbying activities. The process of collecting the relevant data for the German federal parliament's lobby register has been optimized with the aim of increasing compliance effectiveness. Employees are receiving tailored, multi-stage compliance training. Ongoing evaluation of the procedural changes is helping to identify and implement control mechanisms in the area of lobbying.

International collaboration

The Fraunhofer-Gesellschaft's international activities aim to create scientific value within the organization and to generate value-added benefits for Germany and Europe as well as partner countries. In the majority of their international collaborations, the Fraunhofer institutes collaborate directly with industry and research partners in European and global research markets. The total project value of these collaborations on the part of the institutes amounted to €366 million (excluding license-fee revenue) in 2024.

Growing **geopolitical uncertainty** has made **collaborations with defense and security partners** more important. These are always conducted in compliance with foreign trade law and research security protocols. The Fraunhofer-Gesellschaft has long-established regulations in place to prevent an unwanted knowledge drain in international collaborations and security-related projects and ensure that the resulting information and technology transfers are handled securely. These apply high standards to both R&D projects and the recruitment of foreign nationals. Fraunhofer needs to ensure

confidentiality and **legal compliance** in its collaborations with business and public authorities. Collaborations with the German Federal Ministry of Defence (BMVg) and with the security and defense industry are also subject to highly stringent requirements. Fraunhofer has defined foreign trade law requirements in tried and tested **export control** processes and embedded them throughout the organization. These processes have been put forward in various national and international committees, and Fraunhofer considers them to be a model of best practices in export control at a research institution. A number of Fraunhofer experts are actively involved in the German federal government's 2024 **stakeholder process on research security**.

Fraunhofer has developed various formats to generate excellent scientific content in **collaboration with attractive partners worldwide**. The **9 legally independent Fraunhofer foreign affiliates** represent the most institutionalized form of such partnerships:

- Fraunhofer USA, Inc.
- Fraunhofer Austria Research GmbH
- Fraunhofer Italia Research Konsortial-GmbH
- Fraunhofer UK Research Ltd
- Fundación Fraunhofer Chile Research
- Associação Fraunhofer Portugal Research
- Stiftelsen Fraunhofer Chalmers Centrum för Industrimatematik (in Sweden)
- Fraunhofer Singapore Research Ltd.
- Fraunhofer Spain Research Foundation

The foreign affiliates act as legal entities for 11 research centers outside of Germany. These institutionalized Fraunhofer collaborations with local universities facilitate long-term research activities abroad. As their work is not profit-oriented, the foreign affiliates generally qualify for base funding from their country of domicile, and they are financed in a manner similar to the Fraunhofer funding model. The foreign affiliates currently have around 500 employees between them, working on Fraunhofer projects with a total volume of some €60 million.

International **Fraunhofer representative offices** in China, Brazil, India, Japan, and Korea function as hubs for networking and marketing. They provide local support for all Fraunhofer institutes in initiating and setting up collaborations with research partners from their respective countries. The representative offices provide the Fraunhofer research portfolio with crucial impetus thanks to their knowledge of the respective regional and local research landscape.

Other international collaboration formats include:

- **Fraunhofer innovation platforms (FIPs):**
  Long-term collaboration with international universities and research institutions; in 2024, there were 15 FIP collaborations in 11 countries

- **ICON program:**
  Funding for three-year research projects with excellent international partners; in 2024, there were Fraunhofer researchers working on 14 ICON projects with research institutions in 12 countries

- **Fraunhofer International Mobility Program (FIM):**
  Support for international networking through research visits lasting several months; in 2024, research visits for 23 Fraunhofer employees were funded, including placements at Harvard Medical School, the Massachusetts Institute of Technology MIT, Yale University (all USA), and the University of Cambridge (UK)

The objective of the **PACT (Program for Affiliate Cooperation and Knowledge Transfer)** program and the associated R&D projects, commercialization activities, and initiatives is to create added value for the entire Fraunhofer network by increasing collaboration between the Fraunhofer foreign affiliates and Fraunhofer institutes. A total of 16 PACT projects were approved in 2024, involving 2 foreign Fraunhofer affiliates, 5 centers and 20 Fraunhofer institutes.

In 2024, a PACT project with the Fraunhofer USA Center for Manufacturing Innovation CMI in Boston led to 1.4 million US dollars in research funding by the National Institutes of Health for the development of an HIV self-test. An ICON project with the Dutch institute AMOLF also set a new efficiency record of 36.1 percent for silicon multi-junction solar cells.

On January 1, 2025, the Fraunhofer-Gesellschaft assumed **leadership of the Ukraine coordination group in the Alliance of Science Organizations in Germany**, which is active in the reconstruction of Ukraine's scientific landscape. The

Fraunhofer-Gesellschaft is represented by the liaison officer for Ukraine, Welf Zöller.

The alliance's action plan, which was presented in 2024, sets out short-term, medium-term, and long-term measures to strengthen science and research in Ukraine. Fraunhofer's core activities are the transfer projects conducted under the banner **Rebuilding Ukraine — resilient and sustainable,** which the Fraunhofer Future Foundation has been funding since 2023. This gives Fraunhofer researchers the opportunity to develop their technological solutions together with partners in industry and society in ways that are specifically focused on their use in Ukraine. The Fraunhofer Future Foundation is supplying €3.1 million in funding for 2024/2025.

Business report

Total business volume

Following strong growth in the preceding years, Fraunhofer entered a **phase of consolidation** in 2024. The total business volume rose by 5 percent from the previous year to €3.6 billion. Contract research accounted for 88 percent of this sum (€3.1 billion) and represents the organization's core activity. Around one-third of contract research funding is provided by base funding from the German federal and state governments. Research with long-term funding that falls outside the scope of this regular base funding is allocated to a new item, additional research funding, which amounted to €260 million in the reporting period. Funding for major infrastructure amounted to €167 million. These three segments will be discussed in greater detail in the following sections.

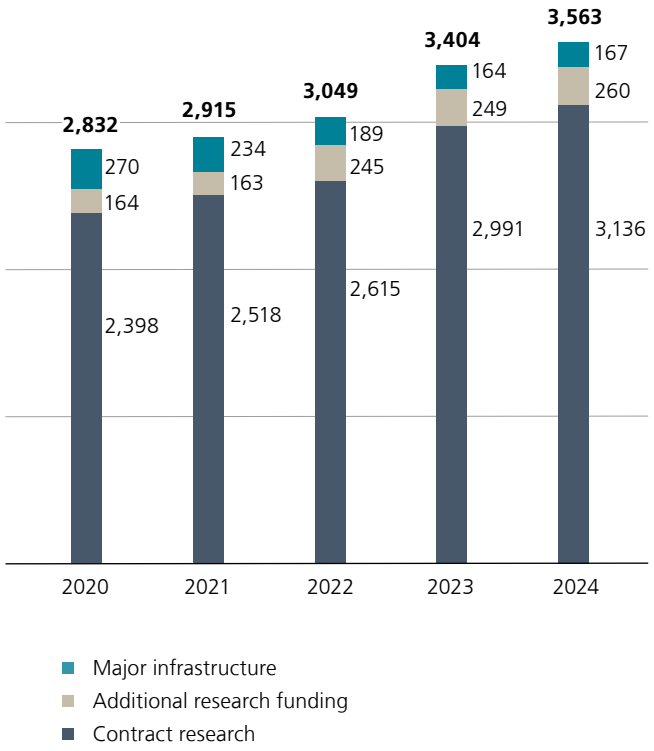
Business volume is based on the performance statement, which meets the requirements of the grant authorities. The operating budget includes personnel and non-personnel expenses in accordance with generally accepted accounting principles. As capital expenditure, on the other hand, is recognized at the amount incurred at the time of purchase, depreciation, amortization and impairment losses are not included in the performance statement. In 2024, Fraunhofer's capital expenditure amounted to €585 million overall, a 16-percent share of the total business volume. The rise in personnel expenses to €2,055 million was the result of a 3.8-percent increase in the number of permanent staff members at the reporting date and the pay rise under the German Collective Bargaining Agreement for the Public Service (Tarifvertrag für den öffentlichen Dienst, TVöD), which took effect on March 1, 2024. At €923 million, non-personnel expenses slightly exceeded the previous year.

Contract research

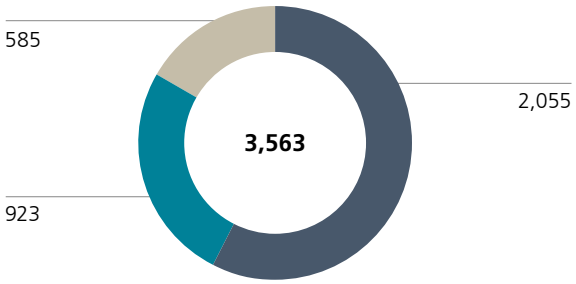
Contract research is the mainstay of Fraunhofer's business activities and, in line with the Fraunhofer model, consists of three core funding areas:

- Research directly contracted by industry
- Publicly funded research projects
- Pre-competitive research financed through base funding

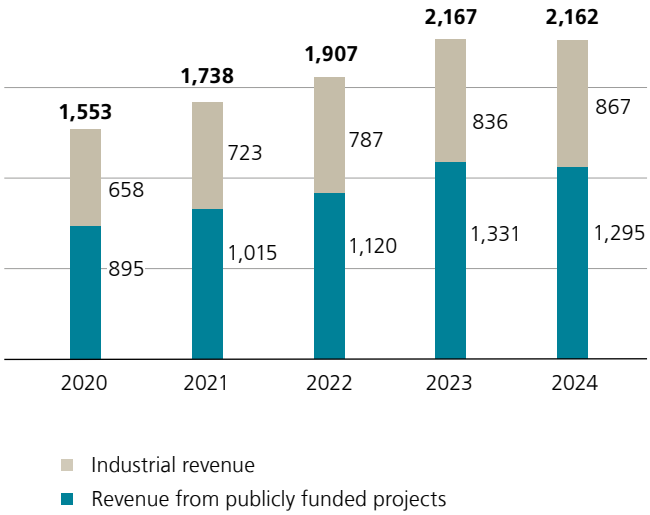
Fraunhofer total business volume in € million



2024: Total business volume by budget in € million



Project revenue from contract research in € million



Base funding is provided by the German Federal Ministry of Education and Research (BMBF) and the state governments at a ratio of 90:10. This forms the basis for groundbreaking pre-competitive research that will become important for the private sector and society in the years ahead.

Industrial revenue rose by 4 percent to a new high of €867 million. This increase was driven by a 4-percent rise in revenue from industry contracts, to €705 million, and a 3-percent rise in license-fee revenue from industry, to €162 million.

At 51.5 percent, **more than half of industrial revenue is attributable to customers from the manufacturing sector** in accordance with the European Community's system for classifying business sectors (NACE classification). Within this sector, the greatest total share of industrial revenue comes from projects with customers operating in the manufacture of computer, electronic and optical products, pharmaceutical

Industrial revenue in 2024 (including licenses) by industry

NACE code (statistical classification of economic activities in the European Community since 2008)*				**% of total**	**Cumulative**
C		Manufacturing		51.5%	51.5%
	of which: 26	Manufacture of computer, electronic and optical products	15.9%		
	28	Manufacture of machinery and equipment	6.6%		
	29	Manufacture of motor vehicles, trailers and semi-trailers	6.0%		
	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	4.1%		
	20	Manufacture of chemicals and chemical products	3.5%		
		Other manufacturing	15.4%		
M		Professional, scientific and technical activities		25.7%	77.2%
J		Information and communication		3.9%	81.1%
S		Other service activities		3.3%	84.4%
G		Wholesale and retail trade; repair of motor vehicles and motorcycles		3.2%	87.6%
O		Public administration and defense; compulsory social security		2.4%	90.0%
D		Electricity, gas, steam and air conditioning supply		2.1%	92.1%
K		Financial and insurance activities		2.0%	94.1%
		Other sectors or no sector		5.9%	100.0%

* European Commission, Eurostat, (2008). NACE Rev. 2: Statistical classification of economic activities in the European Community. Publications Office. *https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-ra-07-015*

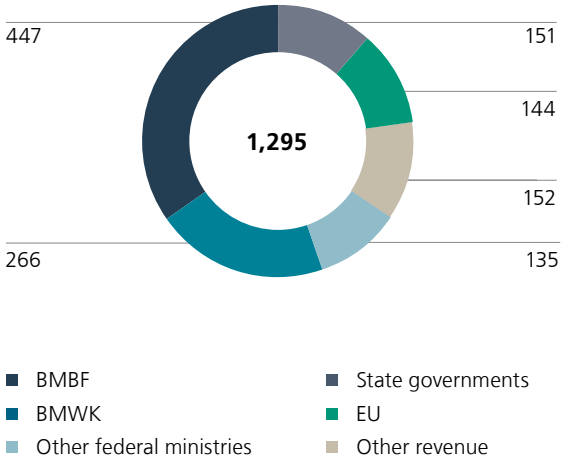
products, chemical products and vehicles, or of machinery and equipment. The second largest share of industrial revenue, 25.7 percent, comes from customers carrying out professional, scientific and technical activities. These include, for example, companies in research and development, engineering firms and business consultancy firms.

Revenue from publicly funded projects fell by 3 percent in 2024 to €1,295 million, having risen continuously in the preceding years. Project funding from the German federal government rose by 6 percent to €848 million. Revenue from the German Federal Ministry of Education and Research (BMBF) rose by 10 percent to €447 million, and funding from other federal ministries by 5 percent to €135 million. Funding from the German Federal Ministry for Economic Affairs and Climate Action (BMWK) remained at the previous year's level of €266 million. From the high starting point of the preceding years, project funding from the German state governments fell by 35 percent to €151 million in 2024. There was a rise in EU revenue, which was up 26 percent to stand at €144 million. As a result of one-off effects in the previous year, other revenue decreased by 17 percent to €152 million, including revenue from foundations, universities and other research funding institutions, and license-fee revenue of €2 million from customers outside of industry.

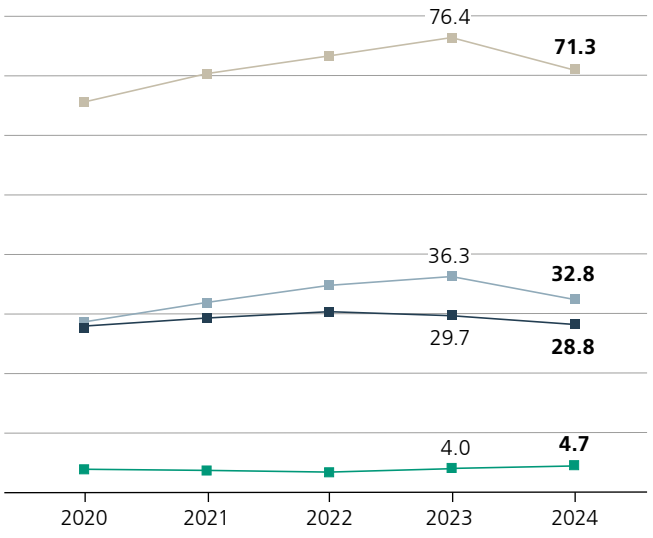
In addition to being one of the Fraunhofer institutes' criteria for success, the high **share of funding coming from external project revenue** is a **unique selling point** for the Fraunhofer-Gesellschaft. The project funding share therefore serves both as a key performance indicator and as a barometer for establishing an optimal funding mix in contract research. It is calculated as the share of project revenue in the operating budget, including imputed depreciation of capital assets (excluding project groups and special effects on the balance sheet). After peaking in the previous year, the share from external project revenue decreased to 71.3 percent. This decrease is largely due to the fall in the project funding ratio from German federal and state governments to 32.8 percent. The share stemming from industrial revenue was slightly reduced to 28.8 percent because of the disproportionately high rise in the operating budget.

International project volume rose by 10 percent in 2024 to €366 million (excluding license-fee revenue). Of this, €204 million was attributable to industrial revenue with

2024: Revenue from publicly funded projects in € million



Funding share in %



Total project revenue
(including other revenue, 2024: 5.0%)
German federal and state governments
Industry
EU

foreign customers and partners, €144 million to EU funding and €18 million to other revenue. Of the international project volume, 39 percent came from EU funding, 24 percent came from customers and partners inside the EU and 37 percent was generated with customers and partners outside the EU. The largest international markets were the USA with revenue of €46 million, Japan with €20 million and Switzerland with €17 million.

Additional research funding

Additional research funding covers research activities with long-term funding outside the scope of regular base funding.

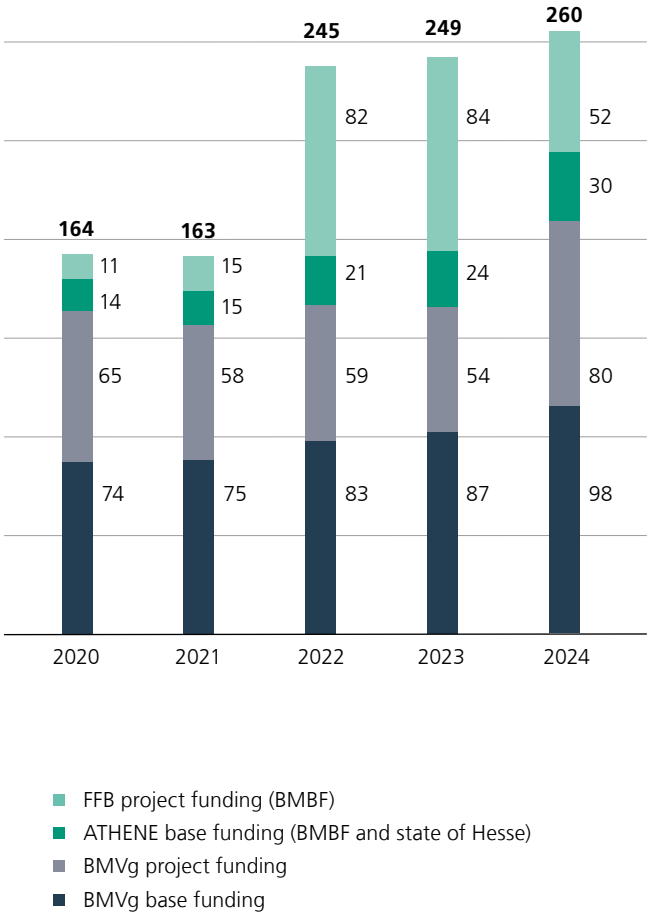
In addition to defense-related research, the National Research Center for Applied Cybersecurity ATHENE and the Fraunhofer Research Institution for Battery Cell Production FFB fall under additional research funding.

ATHENE is operated jointly by the Fraunhofer Institute for Secure Information Technology SIT and the Fraunhofer Institute for Computer Graphics Research IGD in collaboration with the Technical University of Darmstadt and the Darmstadt University of Applied Sciences. Its research focuses on the **protection of critical infrastructures** such as power and transportation and the safeguarding of IT systems. The center applies an interdisciplinary approach, combining IT and engineering with legal and economic issues, psychology and ethics. ATHENE is funded by the BMBF and the federal state of Hesse at a ratio of 70:30 and recorded a budget of €30 million in 2024.

The development and operation of the **Fraunhofer Research Fab Battery Cells FFB** gave rise to expenses of €52 million in 2024. The BMBF is providing a total of €500 million in funding for this large-scale initiative through project finance. Another €320 million is being provided by the federal state of North Rhine-Westphalia for land and the construction of new buildings. Fraunhofer FFB is to become the center for developing modern and scalable battery cell production for Germany and Europe.

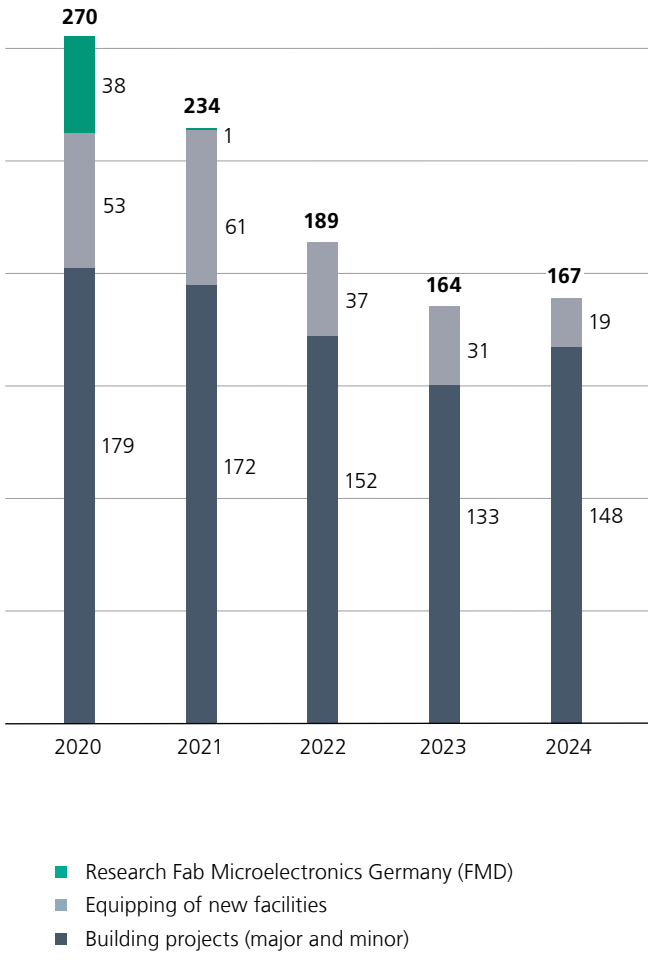
In the field of **defense research**, Fraunhofer has pooled the research and development activities of seven Fraunhofer institutes that receive base funding and ongoing project funding from the German Federal Ministry of Defence (BMVg).

Additional research funding in € million



The objective of these R&D activities is to provide people, infrastructures and the environment with the best possible protection against potential security threats resulting from natural disasters or military, technological, terrorist or criminal activity. Defense research expenses rose significantly compared to the previous year and stood at €178 million. In particular, project funding from the BMVg increased by €26 million to €80 million.

Major infrastructure in € million



Major infrastructure

Major infrastructure comprises building projects and the purchase of scientific instruments and furniture to equip new facilities. Expenditure for **construction and equipping of new facilities** was €167 million, slightly higher than the previous year. The amount spent on construction projects increased by €15 million to €148 million, of which €100 million related to major construction projects and €48 million to minor construction projects. Investments in the equipping of new facilities, on the other hand, decreased by €12 million to €19 million. External factors continue to delay progress in major construction projects. These include longer testing times on the part of public administrative bodies as well as stricter requirements for subsidized construction, such as mandatory certification under the Assessment System for Sustainable Building (BNB certification) and environmental impact testing for projects funded by the European Regional Development Fund (ERDF). Special funding for major building projects and the equipping of new facilities is provided by the federal and state governments at a ratio of 50:50. The state governments often provide additional funding from the ERDF, which reduces the funding required from federal and state governments by an equivalent amount. Minor building projects are financed from joint base funding at a ratio of 90:10. The funding required from the German federal and state governments totaled €160 million. Project revenue from ERDF funds from state governments and other revenue fell significantly to €7 million following the completion of construction work from the previous ERDF funding period.

Financial and net asset position

At December 31, 2024, the Fraunhofer-Gesellschaft had total assets of €4,836 million, down €19 million or 0.4 percent year on year. Assets presented in the ordinary accounts comprised 99.7 percent of total assets, with non-profit organization capital accounting for the remaining 0.3 percent.

Noncurrent assets accounted for 65 percent of assets and were €161 million higher at €3,158 million. This increase was chiefly attributable to the fact that capital expenditure on property, plant and equipment exceeded depreciation. Property, plant and equipment grew by €162 million to €3,080 million.

Current assets accounted for 34 percent of assets and were €180 million lower at €1,622 million. Receivables from the German federal and state governments relating to base funding increased by €23 million to €397 million, including receivables for funding approved during this financial year. Their over-year nature is ensured by the budgetary instrument of Selbstbewirtschaftungsmittel (SBM – resources managed independently), and they therefore include SBM to the amount of €385 million from the German Federal Ministry of Education and Research (BMBF). Receivables from the German federal and state governments from project billing (including contracts) decreased by €57 million to €298 million. Receivables

from affiliated companies remained at the same level as the previous at €0.4 million. Bank account balances (including cash and cash equivalents) are also at the same level as in the previous year at €18 million. The value of the securities portfolio was €136 million lower, at €324 million. Of this reserve fund, €314 million stemmed from license-fee revenue reserve and €10 million corresponded to the extraordinary item "Financing restructuring measures."

Equity — which comprises the non-profit organization capital that is not financed by government grants (€15.7 million) and the reserve for statutory purposes (€11,525) — increased by a marginal amount.

The extraordinary item "License-fee revenue reserve for statutory purposes" decreased by €43 million to €329 million in the reporting year. Of this, €26 million was used to pre-finance projects funded by third parties and allocated to the extraordinary item "Financing of current assets" to reduce the funding shortfall. The extraordinary item "Grants relating to noncurrent assets" was €161 million higher at €3,147 million. The extraordinary item "Financing of current assets" amounts to €175 million at the reporting date and is used to account for income not yet received, less expenses not yet paid, by the reporting date. The extraordinary item "Financing restructuring measures" for the cleanroom infrastructure is €10 million at the reporting date. Over the course of the reporting year, €7 million was spent. The extraordinary item "Payments from patent sales" is €26 million at the reporting date. It decreased by €77 million compared to the previous year, €53 million of which was due to reclassification as warranty provisions on the balance sheet.

Provisions increased by €117 million to €394 million, €69 million of which was accounted for by provisions with maturities of more than one year. In the case of pension and compensated leave provisions, a corresponding amount of receivables from the German federal and state governments totaling €121 million was entered on the assets side of the balance sheet.

Liabilities decreased by €23 million to €732 million. In addition to an increase of €63 million in grants from federal and state governments still to be used from base funding and project billing, the trade payables, accounts payable to affiliated companies and other liabilities fell by a total of €86 million.

As a beneficiary of public funds, the Fraunhofer-Gesellschaft is subject to budgetary constraints that prohibit it from making use of the capital markets or of lines of credit with banks. Nevertheless, the organization's liquidity is guaranteed at all times as it can regularly call on cash payments from its grant authorities under base funding arrangements and can use its reserves as needed. The Fraunhofer funding model has stood up to the test in times of crisis and is built on a solid foundation.

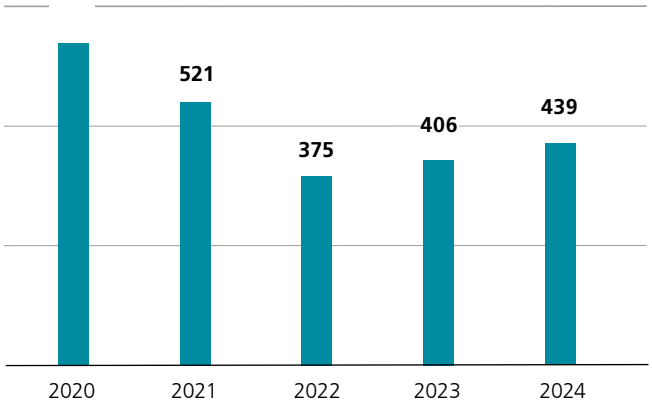
The Fraunhofer Future Foundation, which was established in 2008, is a legally independent institution created with the mission of supporting technology-oriented research projects at the Fraunhofer institutes as per the statutes. The foundation added €4.4 million in all to the spending capital in 2024. These additions result from proportionate returns from successful foundation projects, repayable grants, revenue from asset management and donation income. The Fraunhofer Future Foundation provided €9.4 million in funding for projects at Fraunhofer institutes in 2024. Consumable capital decreased from €88.4 million to €82.9 million.

Shareholdings and spin-offs

At the reporting date, the Fraunhofer-Gesellschaft held equity investments in a total of **80 companies** operating in a diverse range of sectors. The transfer of technology to industry formed the focus of activities at 53 of the companies in the investment portfolio, while a further 21 equity investments were of a strategic nature. Equity investments also include 6 affiliated companies. In 2024, the Fraunhofer-Gesellschaft invested a total of €5.7 million in the acquisition of equity interests in shareholdings. The Fraunhofer-Gesellschaft added one company to its investment portfolio and divested its shares in 4 companies. The total carrying amount of shareholdings (including shares in affiliated companies) increased to €36.0 million (previous year: €31.5 million). Income from the divestiture of shareholdings came to €2.0 million.

Spin-offs are an integral part of Fraunhofer's strategy for exploiting its industrial property rights. In individual cases, Fraunhofer takes a minority share in the spin-off under company law as part of its technology transfer activities. In **2024**, Fraunhofer Venture provided support to **68 new spin-off projects**. Across Fraunhofer as a whole, **21 new spin-offs** were established.

Patent applications claiming rights of priority



Fraunhofer has set itself the goal of increasing not only the number of spin-offs but also their proportional contribution to overall industrial revenue. Fraunhofer's innovation hub AHEAD offers a package of targeted entrepreneurship measures and programs to help achieve this. The Fraunhofer AHEAD program takes on and provides funding to around 60 new teams each year. Intensive workshops and coaching sessions are provided to teach entrepreneurship. Fraunhofer AHEAD offers a networking platform for early-phase spin-off and licensing projects with the national entrepreneurship ecosystem. As well as the general AHEAD program, there are also specialized tracks in the fields of Sustainable Development Goals and life sciences.

Exploitation of intellectual property rights

Fraunhofer has a focused and targeted IP strategy that concentrates on securing long-term patents for inventions with high potential for exploitation. This approach helps to ensure the optimum use of time and financial resources. In 2024, the Fraunhofer institutes registered **507 inventions**. To ensure the best possible support for the inventive step, the Patents department has developed an e-learning program to facilitate the transfer of knowledge related to inventions and patenting, which will soon be available to all researchers in the Fraunhofer-Gesellschaft. In 2024, **439 patent applications claiming rights of priority** were filed. The number of active patent families remains at the same level as the previous year at 7,081. The institutes are focusing still more on the cost aspect of intellectual property rights and are tailoring their decisions on the registration of patents to their IP strategy. As a result, the patent portfolios are being streamlined and optimized for efficiency. Fraunhofer is also continuing to actively pursue the exploitation of intellectual property rights by preparing patent portfolios and offering them to selected businesses for licensing or, in specific cases, for sale. This strategy ensures that valuable inventions are used effectively, while also providing new opportunities for collaboration and innovation.

In general, Fraunhofer generates revenue from the **commercial exploitation of intellectual property** rights by concluding licensing agreements. In addition, IP can also be contributed to patent pools or exploited through the sale of IP. The most successful of these pools consist of patents for audio and video encoding. In conjunction with other parties from different countries that hold patents that are relevant to standards, Fraunhofer uses various patent pools to issue licenses on a worldwide basis. The income from these pools is reinvested in pre-competitive research, thereby helping strengthen Germany's position as a research hub for the long term. **Revenue from the licensing and sale of IP** amounted to approximately **€164 million**.

Sustainability aspects

The Fraunhofer-Gesellschaft's responsibilities

Fraunhofer works with partners from industry and business to set new standards in sustainable technologies. Together, they develop innovative solutions to tackle societal challenges. Applying research findings **provides crucial support to business in achieving their sustainability targets** and designing environmentally friendly products and services.

Beyond research and transfer, the organization enshrines environmental, economic, and social sustainability within the framework of responsible corporate governance in every area. As a non-profit organization, the Fraunhofer-Gesellschaft is not directly required to implement the EU Corporate Sustainability Reporting Directive (CSRD). It does, however, work to align itself with the CSRD standards in terms of transparent and responsible reporting in order to progressively meet the expectations of its partners in science and industry and its own mission. In 2017, Fraunhofer became a member of the UN Global Compact, and since then has steadily worked to implement the initiative's sustainability principles through a compliance management system. Fraunhofer has also joined the **newly founded** *Netzwerk Deutschland* (Germany network), which provides a basis on which to pursue its commitment to the ten principles and Sustainable Development Goals (SDGs) in a more targeted and lasting manner.

As part of a **materiality analysis**, workshops were held with various Fraunhofer experts in January 2024. The most important external stakeholders were involved in reviewing findings and determining focus points to ensure a more sustainable future for Fraunhofer. Selected expert teams are currently looking into possibilities for future tracking of relevant parameters.

In addition, the risk management system has been expanded to include the examination of sustainability risks so that they can be managed proactively and comprehensively.

In May 2024, Fraunhofer created a new Corporate Sustainability Management department to coordinate sustainability initiatives across Fraunhofer and oversee related reporting. The department reports to the Corporate Strategy directorate and collaborates closely with the other departments at Fraunhofer headquarters and the Fraunhofer institutes. Its establishment underscores the growing strategic importance of sustainability for Fraunhofer at the corporate level.

Socially responsible research

The commitment to socially responsible research reflects the various responsibilities of Fraunhofer's researchers with respect to their overall scientific contribution to projects. This responsibility begins with the choice of topic (with questions such as "What should we research? What do we not want to research?") and ends with the application of research results with a focus on benefits. While **consideration of the benefits** for industry and society has long been established at Fraunhofer, it is becoming increasingly important to address the possibility of unintended effects. This could, for example, include **assessing the risks of potential abuse of research findings**. Carrying out projects according to good scientific practice and in compliance with other internal and external regulations is also standard practice at Fraunhofer. Here too, however, expectations are rising, for example regarding adherence to codes of ethics when conducting human subject research. Fraunhofer's ethics office supports its scientists in meeting these requirements at the corporate level by providing advice and guidance for projects.

To support compliance comprehensively, Fraunhofer provides project leaders and staff with appropriate tools and continuing education resources. Custom guidelines developed specifically for Fraunhofer help the project teams to raise awareness and facilitate discussion of all key ethical aspects within the team. In order to incorporate external views or stakeholder perspectives into their project as well, scientists at Fraunhofer receive additional training in the **continuing education module "Ethics in technology and ethical reflection in project management."** This module was developed specifically for Fraunhofer in 2023 and tested at several events in 2024. As of 2025, it is now available to all employees involved in Fraunhofer projects through the standardized Fraunhofer continuing education programs.

Together, the guidelines and the continuing education module, serve to strengthen the excellence of Fraunhofer's research and increase employees' satisfaction with their own work, as reflected in the acceptance of these resources.

Fraunhofer Future Foundation

The Fraunhofer Future Foundation runs a funding program aligned with the UN's Sustainable Development Goals (SDGs). With an annual funding volume of €5 million, it enables researchers from the Fraunhofer-Gesellschaft to develop products, services, and business models aimed at helping to make the world **more environmentally friendly, socially equitable and financially viable**.

Through its funding, the foundation aims to strengthen **technology transfer** in particular. It focuses on closing the gap between research and the real-world implementation of technological solutions. It encourages research teams to involve stakeholders early and systematically in real-world projects. The foundation explicitly promotes the **involvement of members of civil society**, such as NGOs or affected citizens. Collaborations in pilot applications are designed to incorporate the needs and feedback of future users at an early stage of project design. The aim is not just to accelerate the successful transfer of innovation to practical application but also to build trust in these collaboratively developed technologies.

One example of early involvement of stakeholders in research is the project "Müllberge ade!" (No more mountains of trash!) run by the Fraunhofer Institute for Machine Tools and Forming Technology IWU. The researchers have set themselves the task of developing recycling processes for single-use products in clinics (such as surgical textiles or dialysis machines). The project was chosen by an online vote in a public crowdfunding competition and then supported financially by the Fraunhofer Future Foundation. As the project continues, the researchers are now working together with parties across the entire process chain to develop suitable practical solutions. Participants include manufacturers of relevant products, users (clinic operators, medical professionals), recycling companies, and companies developing new products from the recycled material. The stakeholder dialogue conducted as part of the project has recently been incorporated into the diverse Circular Saxony innovation cluster, making it a significant force in the region and in civil society.

The researchers in the funded project CycloPlasma are also benefiting from direct dialogue with relevant target groups. The team from the Fraunhofer Institute for Building Physics IBP has developed a process for sustainably renovating **contaminated buildings**. This relates to timber structures treated in the 1970s and 1980s with wood preservatives containing the carcinogen lindane. Architects and owners, renovators or restorers of buildings have been facing this problem for decades. The foundation offered them and the researchers an easy and accessible way for direct communication: **the online event format Science Sofa.** Via a live feed from the laboratory environment, researchers presented their technology and its potential applications in an easily understandable way and invited feedback on users' specific requirements and expectations. They also responded to questions about the technology. The live chat from the event provided not only valuable comments on how to continue developing the technology in a needs-based way, but also contacts for pilot projects. Together with individual property owners and a company that wants to bring the technology onto the market, they are putting their research findings through one last practical test and making the final adjustments. Stakeholder dialogue has helped the foundation and researchers succeed in building a bridge for technology transfer.

The foundation is planning to give even greater prominence to societal aspects in research. It intends to do this through its funded projects by trialing further methods of successfully involving members of civil society in research and development and making research findings more broadly available.

Sustainability in scientific research

Climate-friendly research processes and infrastructures are a key sustainability target for the Fraunhofer-Gesellschaft. Since late 2020, Fraunhofer has been implementing concrete measures to reduce greenhouse gas emissions in its climate strategy.

Energy efficiency

Increasing energy efficiency is an important element. In 2022–2023, the first 3 pilot institutes successfully introduced their own energy management systems, paving the way to begin the global deployment of an ISO 50001-certified energy management system in 2024. This was possible thanks to a decision by the Fraunhofer executive board in 2024 to mandate its introduction at all locations, and the documents and tools created and the expertise built up during the pilot phase.

The Energy Efficiency and Climate Protection Networks launched in 2023 began their in-depth collaborative work in 2024. With support from an external energy consultant, the four networks of 44 institutes jointly defined measures to increase energy efficiency and drew up common savings targets. The implementation of these measures over the coming two years is expected to **reduce energy consumption with potential savings of approximately 20 gigawatt hours (GWh) per year.** The measures include optimizing heating, refrigeration and ventilation technology, energy efficiency measures for compressed air and modernizing existing lighting by switching to LEDs. The main focus in terms of reducing CO_2 is the continued building of photovoltaic systems.

Many of these measures are cost-effective and can be implemented directly using institute funds. For more significant investments or for institutes that are in a less strong financial position, there is a specially created **internal funding program** with €20 million in available funds. This program works on the principle of "intracting," whereby institutes receive funds to invest in energy efficiency measures and pay them back from their returns so that those funds can be reinvested in new measures. At the end of 2024, 15 applications totaling around €3.2 million had been submitted. More applications are currently being prepared.

Buildings and infrastructure

Following the entry into force of the **building energy guidelines** developed together with researchers and adopted in the summer of 2024, the executive board of the Fraunhofer-Gesellschaft is ensuring that all new or refurbished buildings comply with the climate strategy. The internal document, which is mandatory for all construction activity, contains technical and organizational specifications relating to energy consumption and planning methods, for example. The stipulations in the guidelines include a ban on fossil fuel combustion systems, the full utilization of photovoltaic potential and the inclusion of environmental auditing in the planning process.

The **site-specific renovation and sustainability plans** that were completed in March 2024 have been developed as a tool for retrofitting the building infrastructure and technical systems at the Fraunhofer locations. At their core, the concepts consist of concrete plans for supplying renewable energies and for the necessary renovation measures. These are intended to optimize Fraunhofer properties with respect to the Fraunhofer climate targets and the efficient use of resources. The 3 sets of guidelines that have been tested at pilot locations ensure that these institute-specific, implementable solutions for Fraunhofer properties are developed and quality-assured. In 2024, 3 institutes drew up their own renovation and sustainability plans to tackle this target.

In the area of **heating and cooling supply**, one of the methods being used to reduce CO_2 emissions is the operation of geothermal probe fields. In collaboration with researchers, plans to build near-surface geothermal systems are being carried out at five pilot locations. This will demonstrate the feasibility of a zero-emission alternative to heat generation by fossil fuels even in the public construction sector.

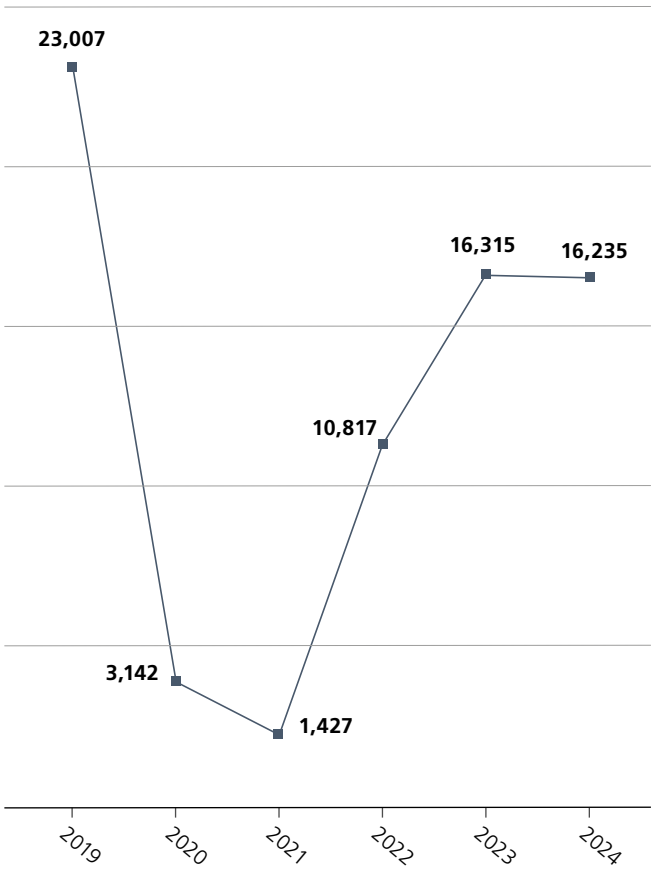
Transportation

With more than **500 charging points** in 2024, the Fraunhofer-Gesellschaft has an extensive charging infrastructure **for electric vehicles**. The system, which was developed through the joint research project LamA (Laden am Arbeitsplatz, charging at work) funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), provides charging for company, employee and customer vehicles at affordable prices and in compliance with all applicable legal requirements. More institutes have joined the LamA network since the official project funding stage ended in late 2023; over 40 institutes now have LamA charging infrastructure in place at around 50 locations, and there are plans to expand further.

A **large share of the Fraunhofer-Gesellschaft's greenhouse gas emissions** come from the **business trips** made by its nearly 32,000 employees. Air travel is the biggest emitter, although no bigger than it has been since the end of the COVID-19 pandemic: In 2024 emissions from air travel amounted to 16,235 metric tons of CO_2 equivalents (CO_2e)*, slightly less than in the previous year and significantly below their level in 2019. The number of passenger kilometers (pkm)

* Since the decision to offset air travel in 2019, flight-related emissions have been calculated using the VDR standard with a radiative forcing index (RFI) of 2.7 in order to take into account the total climate impact of flights taken by Fraunhofer employees. In the interests of transparency, these are reported accordingly.

CO_2 emissions from flights by Fraunhofer employees, in metric tons



- Flight emissions calculated according to the VDR standard + RFI 2.7 (recorded from 2019)

traveled by train, on the other hand, did increase slightly. They amounted to 28.2 million pkm in 2024, an increase of another 0.7 million pkm from the previous year. This shows that the internal efforts to cut air travel and switch to rail are having an effect. Through a national agreement between the German federal government and Deutsche Bahn, train journeys for Fraunhofer continue to be regarded as carbon-neutral. Emissions from flights in 2023 were voluntarily offset over the course of 2024 with two Gold Standard certified **climate action projects in Kenya**.

Material flows

Cleanroom technology in particular uses substances that, although they are not environmentally hazardous themselves, do contribute significantly to the greenhouse effect. One example is sulfur hexafluoride, which is used as an etching gas in semiconductor manufacturing. To determine the actual share of emissions from climate-relevant gases and substances, a pilot project with five institutes was launched in 2024 to record the actual consumption of those substances and measure how much of them escapes into the atmosphere. The aim of the project is to obtain precise data and find approaches to avoid and reduce those emissions.

Total waste figures are available with one year's delay, so they are currently only available for 2023. According to these figures, the Fraunhofer institutes generated 6,387 metric tons of non-hazardous waste and just under 761 metric tons of hazardous waste in 2023. A significant **increase in waste figures** was recorded compared to the previous year: 1,000 metric tons of non-hazardous waste and 80 metric tons of hazardous waste. The increase in non-hazardous waste is largely attributable to the **creation of a geothermal test field** as part of a research project that required enormous quantities of excavated earth to be declared as waste and removed. Most waste generated by projects cannot be controlled directly. Fraunhofer distinguishes between hazardous and non-hazardous waste in line with the German Waste Catalogue Ordinance (Abfallverzeichnisverordnung, AVV). Many institutes maintain leasing arrangements in which traditional non-hazardous municipal waste (paper, residual waste, plastics, etc.) is disposed of in part by the landlord or, in the case of collaborations, by higher education institution partners. In these cases, the amounts are estimated based on the container volume and a specific conversion factor for each type of waste. As a result, the available data do not cover all Fraunhofer research units and institutes.

Employees

At December 31, 2024, Fraunhofer had **31,877 employees**. This represents a slight staffing decrease of 0.2 percent (65 people) over the previous year. This was the result of a significant reduction in student numbers of 12.9 percent (-1,015 people). This figure includes a displacement effect from 255 student employees who are now covered by the collective wage agreement for research, technical and administrative employees (RTA) and had previously been reported under the student employee group. In 2024, RTA staff numbers rose by 3.8 percent (+887 people, 255 of which were student employees); excluding the student employees brings this figure down to 2.7 percent, a fall compared to the previous year (5.0 percent). In terms of trainee numbers, Fraunhofer achieved a significant increase of 12.3 percent (+63 people).

Recruitment during a shortage of skilled workers
For the Fraunhofer-Gesellschaft's HR marketing department, 2024 was a year of consistent development and implementation of its new employer brand. Building on the claim **Change starts with us**, key actions were designed and implemented to strengthen Fraunhofer's long-term attractiveness as an employer:

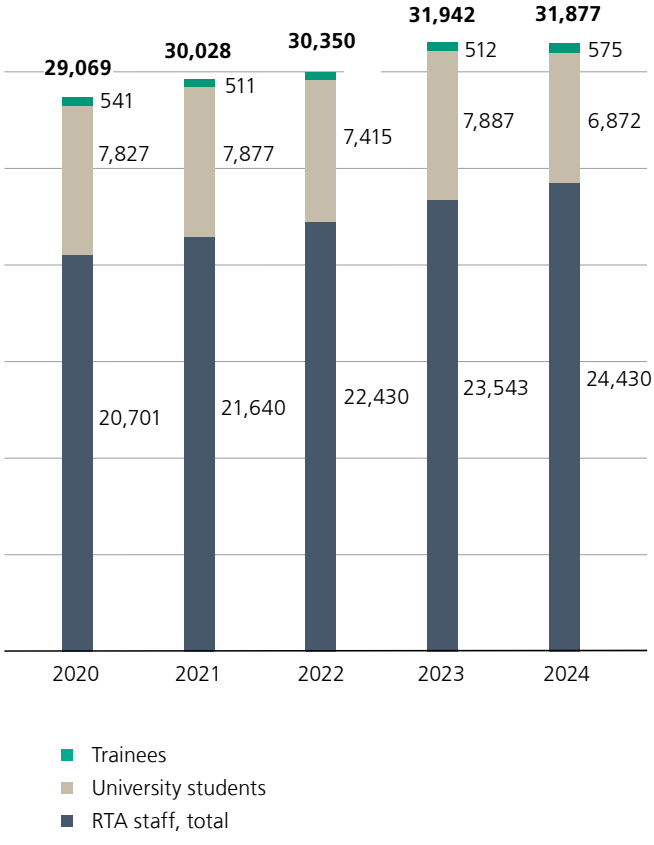
- An overhaul of the careers website to better address the needs of the various target groups.
- The launch of another social media campaign in late 2024 to increase coverage and bring more clicks to the Fraunhofer careers website.
- The design of an image film to be implemented and presented in 2025.
- The implementation of a toolbox for creating professional job listings.

Corporate culture — focus on dialogue
The project **Fraunhofer Corporate Culture: A Future Vision** (which ran from the fall of 2022 to the fall of 2024) worked on an analysis of current overall conditions and on levers to develop the Fraunhofer culture even further. An important part of the project was the design and implementation of two closely coordinated forms of participative dialogue:

- Meet the Executive Board
  This open discussion format centering on current overall conditions and future prospects is based on personal discussion between employees and at least two executive board members.
- Cultural Dialogue
  Fraunhofer employees met for 16 target group-specific workshops where they mapped out positive changes they would like to see in Fraunhofer's culture going forward.

In 2024, Meet the Executive Board was established as a permanent format and "Cultural Dialogue" was made available for the institutes to use.

Employees (number at year-end)



Development of the Fraunhofer-Check
The Fraunhofer-Check is a **Fraunhofer-wide survey of all employees**. Its guiding principle is the idea that systematic dialogue with employees is essential to Fraunhofer's further development and evolution. The executive board agreed on the framework of the Fraunhofer-Check questionnaire jointly with representatives of the central works council, the standing committee of the scientific and technical council (STC), the presidium, the administrative organization review committee (RAVO), the equal rights officers and the overall representative of employees with severe disabilities. This survey is scheduled to be held in May 2025. A repeat survey is set to take place in no more than two years.

Training for career development
The Careers with Fraunhofer approach is characterized by the mission "Transfer of Talent" to the Fraunhofer-Gesellschaft. This approach covers a comprehensive HR development policy to promote individual career development plans for employees. The mandatory **employee development meeting** is at the heart of these individual career plans, which are aligned with the Fraunhofer development and career paths and supported by a wide range of HR development programs.

Following the introduction of the **SAP Learning Management System (LMS)** as a unified learning platform, the full registration and approval process for continuing education programs is now conducted in the LMS as a further consolidation measure. This is another step toward the full digitalization of the Fraunhofer training program. A new, central portfolio of qualifications related to scientific work, Academic Essentials, has been developed to cover the entire research process through a variety of e-learning programs, advice and seminars.

In 2024, a new seminar and consulting program for individual career planning was set up. It encourages employees to **proactively take responsibility for designing their own career plans** and provides support for professional transitions to external careers. The program addresses topics such as career planning, profile analysis, self-marketing and job applications in science and industry for different target groups (scientific employees, science support staff and women).

In addition, target group-specific career programs continue to promote networking across the institutes. For top- and upper-level management, Fraunhofer offers the Vintage Class and Advanced Management Class. For managers, Leadership@Fraunhofer is a central program of seminars with two program tracks: START LEADING for those new to management and LEADING INTO THE FUTURE for experienced managers. TALENTA is available to women scientists and scientific managers, while a program for supervisors offers qualifications from doctoral studies to professionalization and ways to increase the quality of supervision.

Encouraging the next generation of scientists is a core element of the Fraunhofer-Gesellschaft's work. In concrete terms, this means providing a reliable framework for junior scientists and the best possible support for individual training and career development. Since the **"A Doctorate at Fraunhofer" Code of Conduct** was introduced in 2020, the headquarters has successively worked to consolidate the implementation of its quality standards in the institutes and enshrine them in the corporate culture. On the basis of the evaluation survey conducted in 2023 on the current level of implementation of the quality standards in the code of conduct, the resulting processes in the institutes have been supported intensively by the headquarters.

Diversity

At Fraunhofer, diversity, fair opportunities, and the creation of inclusive conditions are an indispensable cornerstone of the corporate culture. Fraunhofer considers it part of its job to promote individual differences and diversity among all its employees, promote gender equality and eliminate existing inequalities. The aim is to create inclusive and accessible conditions, so that every individual can contribute their own talents and potential and feel respected and welcomed as part of the team, regardless of gender, age, disability, or nationality. Since 2022, having a **Gender Equality Plan** has been a mandatory requirement for admittance into the Horizon Europe program. Promoting equal professional opportunities in research and innovation is an important concern for the EU Commission, and is eagerly welcomed and supported by the Fraunhofer-Gesellschaft. To promote **professional gender equality**, Fraunhofer has had an overall concept that identifies four areas of action in place since 2013. These include recruiting and promoting the career development of women scientists, communication, monitoring and cultural development. The gender ratio reached 50:50 women to men for the first time

when the new institute directors were welcomed in 2024. The achievement of a 50 percent share of women institute directors is an important step toward equality and fair professional opportunities at Fraunhofer.

A core part of the overall approach to promoting equal opportunities is the **equal opportunities support program**, which continued in 2024. The aim of the program is to support institutes in developing an equal opportunities strategy, provide information on designing processes and structures to offer fair opportunities, and enable participants to learn from each other through topic-specific workshops, best practices and peer-to-peer communication.

TALENTA is a targeted and holistic funding and development program that has formed another central pillar for the promotion of more equal opportunities in research and leadership at Fraunhofer since 2013. Since successfully becoming a long-term career development option in 2023, TALENTA has been positioned as a permanent HR development option in the long-term funding model. Since 2013, 887 women scientists have benefited from the comprehensive funding with career and research time and from training and networking formats to achieve their career goals. Examples of these goals include completing doctoral studies, developing leadership skills and strengthening scientific visibility at Fraunhofer.

To reduce the impact of unconscious bias, Fraunhofer has adopted a de-biasing approach to drive conscious action and reduce unconscious bias. This is intended to educate employees and managers on the effects of unconscious prejudices and to provide training in strategies for dealing with them. The approach covers a variety of measures and instruments, such as practical resources for implementation in institutes, support including informational material, checklists and tools, and awareness-raising training. The Unconscious Bias pilot initiative was launched to support institutes in planning individual measures to address unconscious bias and integrate e-learning. In 2024, the initiative gave 9 institutes the opportunity to make use of an analysis, training, and communication package. This package comprises a short virtual talk, a budget for an on-site analysis workshop and a budget for further measures and communication materials. The total funding for the pilot initiative was €90,000. The short talks enabled more than 1,000 employees at 9 institutes to engage with the topic of unconscious bias and reflect on its impacts for equal opportunities and diversity. Following the analysis workshop, 7 institutes have carried out plans to identify further changes to implement by highlighting possible entry points for unconscious bias in the processes and conditions on site and their effects on diversity.

For the past 13 years, the **diversity funding program** has been assisting institutes in implementing new measures to promote equal opportunities and diversity. Since the start of the program, a total of 270 applications from institutes have been funded at a total cost of €2.5 million. The institute-specific measures approved in 2024 include management training in dealing with sexual harassment in the workplace, a series of workshops on diversity and unconscious bias, innovative measures to make buildings accessible for people with disabilities, and the establishment of a buddy program for employees with migrant backgrounds.

In the fall of 2023, the Fraunhofer-wide framework contract with **pme Familienservice** was extended by another two years. The services offered by pme Familienservice include emergency childcare, home/elder care and even life coaching. The contract also includes the use of the pme Akademie, which includes webinars, e-learning programs and tips for living mindfully. Employees can engage with issues such as parenting, health, care, burden reduction and greater balance. In 2024, there were 14 requests for childcare and 77 for home and elder care, but employees also made use of a total of 170 life coaching sessions.

Work-life balance is very important to Fraunhofer. To reflect this, the **Family Logo** was developed as an internal seal of quality in 2018. The Family Logo is a Fraunhofer-specific certification process that helps the institutes to stand out as employers for people with families. The certification process looks at a range of aspects including information and communication, flexible working options, institute-specific care services or the conditions relating to parental leave and reintegration. Since 2019, the Family Logo has been awarded to a total of 24 institutes. In 2024, work began to develop the certification further. Specialist departments at the headquarters and the equal opportunities officers of four institutes revised the Family Logo questionnaire in the light of new proposals and needs expressed by employees with care responsibilities.

Accessibility is an important part of promoting **inclusion**. Because of this, the executive board adopted the **Fraunhofer accessibility policy** in 2023, which was then communicated throughout Fraunhofer in 2024. This introduced a comprehensive package of measures with two strategic emphases: the analysis project on accessibility and the inclusion support program. These measures are intended to raise awareness at the Fraunhofer headquarters and institutes and support them in creating inclusive conditions for employing people with disabilities. The first step, the analysis project on accessibility, was carried out at the headquarters and involved a structured survey and evaluation of the current situation in terms of the accessibility of spaces, digital technologies and verbal communication in various Fraunhofer-wide systems and programs. This survey has given rise to specific recommendations for further action to remove existing barriers and implement accessibility throughout Fraunhofer. The aims of the **inclusion support program** are to help institutes acquire expertise in designing inclusive processes and structures, develop strategies for promoting inclusion, and support the institutes along their individual journeys toward building an inclusive organization. The program provides the institutes with individual support from an external inclusion service provider. It provides resources such as workshops and consultation units on inclusive HR marketing and recruiting, careers and participation, accessibility and disability awareness. At the starter camp in September 2024, 10 institutes joined the first cohort of the inclusion support program.

Since 2023, organizations from the Alliance of Science Organizations in Germany, including Fraunhofer, Max Planck and other research institutions, have been collaborating on a joint initiative to promote inclusion. Through a strategy workshop, the initiative has produced a map of measures that has served as a guide for the individual scientific organizations since 2024. Each scientific organization is expected to identify one to two organization-specific measures and plan steps to implement them by 2025 at the latest. Fraunhofer is focusing on implementing accessibility as a condition of inclusion.

The above conditions are one of the reasons that Fraunhofer is ranked in the **top employers** list every year. In 2024, the Fraunhofer-Gesellschaft was also one of the most popular employers in the Trendence and Universum employer rankings. In the Trendence graduate and professional barometers, Fraunhofer took second place in the research sector.

Continuing to implement the German Supply Chain Act

The German Supply Chain Act (Lieferkettensorgfaltspflichtengesetz, LkSG) entered into force in January 2023. This piece of German federal legislation governs the duty of care of German-based companies of a certain size (initially 3,000 or more employees, down to 1,000 or more employees from the start of 2024) to minimize the risks in their supply chains for human rights and the environment. The Fraunhofer-Gesellschaft is cognizant of its social responsibility and implemented the requirements of the LkSG and measures to fulfill all the duties of care before the end of 2023.

The head of the Supply Chain Management Strategy department is the human rights officer of the Fraunhofer-Gesellschaft. The Fraunhofer-Gesellschaft human rights strategy was adopted in late 2022. It was set out in a declaration of principles by the executive board and can be accessed on the Fraunhofer website. An **LkSG channel** was also added to the existing **Fraunhofer whistleblowing system**. This ensures that incoming reports of possible violations can be processed systematically and anonymously. The existing risk management system of the Fraunhofer-Gesellschaft has also been expanded to include the LkSG and will continue to grow in order to permit the identification of risks related to human rights and the environment.

The first regular risk analysis aimed at identifying risks related to human rights and the environment in Fraunhofer's sphere of business and among direct suppliers was performed in 2023. An external specialist provider was brought in to provide support in carrying out the risk analysis. As the first step, the specifications of the LkSG and the guidelines from the German Federal Office for Economic Affairs and Export Control (BAFA) were used to perform an abstract risk analysis. The results were then subjected to a manual plausibility check. This process identified risks but no violations, and appropriate preventive measures were initiated. Corrective processes that will apply in the event that any violations are identified in the future were also defined. In relation to indirect suppliers, a **process of as-needed risk analysis** was defined to allow for immediate action if substantiated information on violations in the supply chain is received. Documentation is maintained on a continuous basis and stored for seven years as stipulated by the LkSG. Public reporting in line with the requirements of the

BAFA took place on time through the completion of the BAFA questionnaire and the publication of the LkSG report. It is available on the *Fraunhofer website* for further information.

The second regular risk analysis is being conducted at the time of writing this management report. Fraunhofer is also preparing for the future implementation of the EU Corporate Sustainability Due Diligence Directive (CSDDD), which has more stringent requirements in some areas. Whether the Fraunhofer-Gesellschaft will fall within the scope of the directive depends on its transposition into German law.

Corporate governance

The executive board of the Fraunhofer-Gesellschaft is composed of the president and up to four members, and is responsible for the general management and strategic alignment in the areas of research, transfer, major infrastructure, human resources, and finances. The conduct of the executive board shapes the corporate culture and ensures a coherent research portfolio that meets both legal and scientific standards. It creates the conditions for the lawful, proper and cost-effective management of the organization's activities and those of its institutes and research units, and implements them through guidelines and control systems such as the **Fraunhofer compliance management system**.

As part of this, Fraunhofer has implemented mechanisms for identifying and reporting unlawful conduct that consider both internal and external reports. The compliance management system also ensures that strategies to combat corruption and bribery are pursued and continuously developed. Internal reporting channels, training and measures to prevent retaliation are in place to protect whistleblowers in accordance with Directive (EU) 2019/1937. The central reporting office under the German Whistleblower Protection Act (Hinweisgeberschutzgesetz, HinSchG) is an integral part of the compliance department — this allows potential structural improvements to be identified as a result of reported violations.

The **senate**, which comprises up to 26 members from the fields of business, science and public life, is tasked with overseeing and advising the executive board and appointing its members, and with approving the financial plan and research strategy.

In 2024, there were 76 active institutes in the Fraunhofer-Gesellschaft, each acting independently and managing their activities in line with the organization's overall strategy. These institutes form **expertise-based groups** to promote coordination between specialists and a common market presence. The chairs of these groups work closely with the executive board on the presidium, which supports the executive board's decision-making process and has the right to make proposals and to be heard.

In general, the Fraunhofer-Gesellschaft strives to conduct its business transparently, responsibly and ethically through these measures.

Opportunities, risks and outlook

Opportunity management

A **unique selling point** of Fraunhofer in the German research landscape is the large proportion of contract research for industry, i.e., the **transfer of research to businesses of all sizes**. It is also a major opportunity for Fraunhofer to contribute to the transformation of the German economy with greater competitiveness, productivity and sustainability. For example, Fraunhofer is heavily engaged in the fields of **AI and robotics, materials and recycling science, as well as energy technologies.**It sees great potential for innovation and improvement in these areas through collaborations with industry. The Fraunhofer institutes, with the support of the Fraunhofer headquarters, conduct active opportunity management by independently focusing their portfolios on promising unique selling points in pioneering technologies. The framework strategy process, which was launched in 2024, is a key part of this.

A **foresight process** is underway to consider possible scenarios for Fraunhofer-Gesellschaft's future environment and develop suitable strategic options. This process is identifying important influencing factors that could shape the future environment of the Fraunhofer-Gesellschaft. These influencing factors include the principles of **science governance, the sources of funding for the German scientific system, and global scientific collaboration**. Issues such as socioecological transformation, demographic change and digitalization also play a crucial part.

These scenario analyses describe long-term developments (over 8–10 years) as well as transitional situations (3–5 years). By comparing different scenarios to each other, it is possible to anticipate current trends and future changes in the market environment at an early stage. This allows new business opportunities to be identified and pursued in a targeted way. Looking at the opportunities and risks inherent in different scenarios allows resources to be channeled to areas that have the greatest prospects for success. This increases the Fraunhofer-Gesellschaft's **ability to respond to unexpected developments**.

Based on the influencing factors identified in 2024, Fraunhofer is defining 3 to 5 key environmental scenarios for the future. These scenarios will help the institutes and executive board to evaluate strategic decisions in view of opportunities and risks.

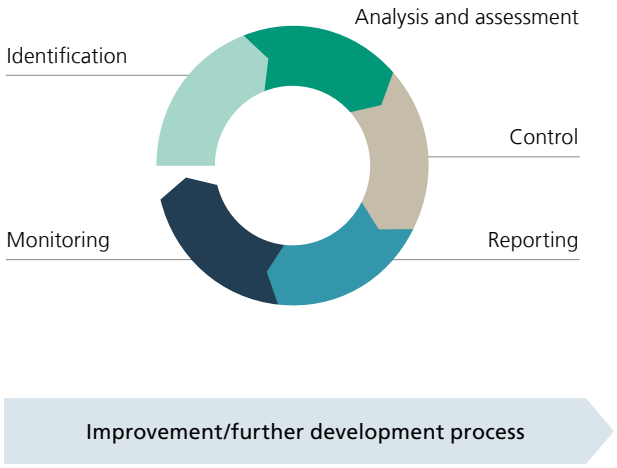
The decentralized structure and the entrepreneurial thinking and culture of learning from mistakes that are embedded throughout the Fraunhofer-Gesellschaft are the keys to opportunity management. Instruments like environmental scenarios further increase the prospects of success of strategic decisions.

Risk management and risks

The Fraunhofer-Gesellschaft continues to face a complex landscape of risks characterized by restrictive frameworks and multiple ongoing crises, including geopolitical and economic challenges and the progression of climate change. The consistent implementation of adaptation measures needs particular attention, including measures to increase the efficiency of business processes and make progress on digitalization so that **resilience can be further increased**. As things stand, however, no sustained risk to the Fraunhofer-Gesellschaft has been identified for 2025. Fraunhofer takes risk to mean all internal and external events and developments that might jeopardize the organization's success. These include both risks where the monetary value can be directly ascertained and qualitative risks. Fraunhofer's risk management system is designed to identify existing and potential risks at an early stage and to manage them by means of appropriate measures in such a way that they either do not materialize at all or do not have consequences that could endanger Fraunhofer's business success or jeopardize its ability to fulfill its mission in accordance with its statutes. To achieve this objective, the Fraunhofer-Gesellschaft has set up a risk management system that takes into account its requirements and structure and undergoes continuous improvement.

In the cyclic risk management process, risk experts in the specialist departments carry out **systematic, standardized risk assessments on a yearly basis**. Overarching high-level risk surveys of upper management are also conducted to supplement these efforts. In these surveys, managers identify what they believe to be the biggest risks to the Fraunhofer-Gesellschaft, regardless of the specific topics for which they are responsible, and propose actions to take to mitigate those risks. This information is used along with external risk assessments to review whether the information is complete and perform plausibility checks. The individual risks identified through the standardized risk inventory process and the associated countermeasures are then summarized and evaluated

Cyclic risk management process



collectively under the appropriate risk categories in an annual risk report that is presented to the executive board. Additionally, the specialist departments inform the executive board of relevant risk-related developments — both routinely and on an ad-hoc basis — via the established reporting channels.

The Fraunhofer-specific **risk classification model** provides a framework for the annual risk assessment, which in turn serves as a basis for the risk report presented to the executive board. The first layer of the model consists of four main areas of risk: business model, financing, resources, and business operations. The second layer of the model assigns individual Fraunhofer-specific risks (currently 19) to these four main areas.

This year, significant **developments** in the risk inventory/reporting process have been implemented. Alongside **efficiency measures**, supplementary **risk information for sustainability and compliance management** is now being incorporated. This allows sustainability risks to be managed proactively and comprehensively in order to minimize negative environmental and social impacts. The clear labeling of compliance risks assists the systematic analysis of compliance risks. The purpose is to provide a deeper understanding of compliance risks that could jeopardize the Fraunhofer-Gesellschaft's achievement of its compliance targets.

Business model risk encompasses types of risk that represent a threat to the continuation and further development of the Fraunhofer business model. This relates to both important external conditions and risks regarding the internal design of the business model. University collaborations are an essential structural pillar that is strategically crucial to the performance and competitiveness of the Fraunhofer institutes. Restrictions imposed by unfavorable legal frameworks could impair regional integration and the core structure and culture of the organization. Regardless, if a change of legal position on the part of the tax authorities significantly reduces the VAT input tax deduction, this could give rise to considerable financial risks. To ensure the continuity and stability of the tax situation, a working group of scientific organizations has been established with the cooperation of the German Federal Ministry of Education and Research (BMBF).

In the context of **financing risks**, the focus is on containing risks that might compromise Fraunhofer's access to research funding or its solvency.

The Fraunhofer funding model is based on three financing pillars: industrial revenue, public (project) revenue and base funding, each of which contributes around one-third of the total funding. Fraunhofer is facing major challenges to all three of these pillars, which it is combating with **diversified risk spreading** and strategic measures. Economic circumstances, such as the general economic climate, digital disruption, inflation, the energy crisis, and geopolitical conflicts, hamper the generation of industrial revenue. Budget consolidation and early federal elections make it more difficult to acquire public funding for projects. The order backlog for public projects is at a relatively high level, but incoming orders are showing a downward trend. Part of the project funding from the German state governments comes from the European structural funds (ERDF, ESF). Forthcoming changes to the funding conditions from cost-based to more flat-rate funding would lead to a significant funding gap in the projects that would need to be covered by base funding. The stability of the third pillar, base funding, is also at risk in spite of the long-term Pact for Research and Innovation, because the high inflation in recent

years has led to real-term cuts. This is making it more challenging to cover the funding deficit with base funding. The fact that a large share of funding comes from industrial revenue means that the Fraunhofer model is highly dependent on the economic situation and carries with it an **entrepreneurial risk**. As such, a **financial reserve** is crucial for ensuring a suitable level of stability to maintain capacity and skills. It is essential that the formulation of the revised financial statutes does not lead to restrictions on the financial flexibility of the organization. Fraunhofer is therefore facing a challenge when it comes to securing short-term liquidity while also meeting its long-term project obligations. The need for pre-financing in the projects needs to be handled through active receivables and liquidity management. It is becoming increasingly difficult in an environment of economic strain to bring in this pre-financing in a timely manner, and additional liquidity management measures therefore need to be taken. As part of the **European Chips Act**, the EU, the German federal government and the German state governments recently approved the large-scale **APECS** (Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems) project, which will make a decisive contribution to improving innovative strength and research and production capacity for semiconductor technologies in Europe. The project also carries risks for Fraunhofer, however, including a possible liquidity shortfall because of the need for pre-financing, as well as process and liability risks arising from the complex contractual and funding structures. Comprehensive risk management measures are in place to counter this.

Resources risk encompasses those types of risk that may affect the availability of tangible and intangible resources needed to successfully carry out research activities.

In an environment that is both competitive and driven by economic crises and structural transformation, it is crucially important to have competitive and efficient business processes in place. Fraunhofer is therefore working intensively on further accelerating the lead times of selected business processes. Climate change is leading to an increased frequency and intensity of damage from natural hazards. This could mean significant material damage to research infrastructure, which could in turn entail not only reconstruction costs and work stoppages but also environmental damage. Evaluating and adapting measures continuously is essential for increasing resilience.

Fraunhofer risk classification model

Main risk areas	Specific risk types
Business model	■ State aid law ■ Non-profit status, taxation ■ IP exploitation, spin-offs ■ Corporate strategy, portfolio management ■ International activities
Finances	■ Base funding ■ Public-sector revenue ■ Industrial revenue ■ Operating expenses/Capital expenditure/Construction ■ Liquidity, advance funding, other financial risks
Resources	■ Human resources ■ IP, know-how ■ Infrastructure ■ Reserve, non-profit organization capital ■ Reputation, brand
Business operations	■ Service performance, contractual risks ■ Legal risks ■ Information security ■ Governance, internal control systems

Business operations risk comprises those types of risk that may arise from research and administration processes or from conducting specific research projects.

Fraunhofer also focuses on continuously developing the compliance management system (*see "Corporate governance"*), particularly in relation to communication, culture, targets and monitoring. Important improvements to the governance structure were made in 2024. This has further raised awareness of compliance in the senate, executive board and institutes.

Secure handling of information and data is very important to an applied research organization. The threat of cyberattacks, including ransomware, cyberespionage and social engineering, is rising with global conflicts and new AI technologies. The legal security requirements are also increasing. This makes it all the more important to continue progressively implementing the countermeasures set out in Fraunhofer's cybersecurity action plan.

Outlook

Fraunhofer is confronting the current high levels of economic and political uncertainty by continuing to develop its internal financial and strategic management mechanisms, and is in a stable financial position from the current vantage point for the 2025 financial year.

Fraunhofer expects to see staff growth further dampened in 2025. The three percent linear wage increase in the new public sector wage settlement effective on April 1, 2025, will cause a slight increase in personnel expenses, the largest single block of costs. Non-personnel expenses are expected to rise only moderately on the basis of the current level of inflation. Because of the capital expenditure related to the **European Chips Act** in particular, **investment activity** will increase significantly in 2025, which will be reflected in another slight rise in the Fraunhofer-Gesellschaft's total business volume.

On the funding side, Fraunhofer's order books for 2025 are looking **similar to the previous year**. With regard to publicly funded projects, the planned level of revenue is largely secured through projects already acquired in previous years. For the coming years, however, a slight downward trend in public funding for projects can be seen from today's vantage point, further reinforced by the uncertain political situation at the federal level with snap elections and a new government. For 2025, growth in industrial revenue is expected that is slightly above than the previous year's level. As regards the impending changes in global trade policies and their interaction with a persistent economic recession in Germany, for the time being it remains difficult to determine what effect they will have on Fraunhofer's business performance, particularly in terms of contracts from industry and business.

In times of profound political, economic and technological upheaval, the Fraunhofer-Gesellschaft is especially serious about its responsibility as a systemically critical **engine of innovation for the economy**, especially for SMEs, in Germany and Europe. When it comes to transfer activity in Germany and Europe, Fraunhofer's unique selling point among scientific organizations is its direct contract research for industry. **Industrial revenue** reached a **new high** of €867 million in 2024. Experience from a wide range of associated projects turns ideas into innovations that are then put into practice and open up new possibilities for value creation.

Among the strategically important key technologies, the central ones at present are microelectronics, **AI research**, the development of **sustainable energy supply and storage technologies**, and research into nuclear fusion. They are fundamental building blocks for the **digital transformation, competitiveness and sovereignty in Germany and Europe**. An important milestone in this field is the development of the **Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems (APECS)** pilot line under the EU Chips Act, initiated in 2024. This pilot line aims to scale up chiplet technology innovations and transfer these into industrial processes, expanding Europe's research and production capacities for semiconductors. The pioneering project is being implemented with a total of €730 million in funding over 4.5 years from the Research Fab Microelectronics Germany (FMD). The platform was initiated by Fraunhofer in 2017 as a national platform for microelectronics research, and is now growing into a European lighthouse with the help of partners from research and industry, SMEs and start-ups. The **Teuken-7B** large language model has been available since late 2024 under an **open-source license** as a basis for European value creation in generative AI. This large language model, which was primarily developed with the participation of Fraunhofer institutes, contains seven billion parameters and has been trained on all 24 official EU languages.

With funding from the non-profit Dieter Schwarz Foundation, the existing Bildungscampus in Heilbronn has been converted into the **Fraunhofer Heilbronn Research and Innovation Centers — Fraunhofer HNFIZ**. Since early 2025, 8 Fraunhofer research and innovation centers have been working on cognitive service systems, future skills, innovation

and foresight, hybrid AI, transformation and governance, AI-based robotics, cybersecurity and applied quantum AI.

The issue of **sustainability** continues to be a focal point and a core priority. Reducing greenhouse gas emissions by 2030, as agreed in the EU Effort Sharing Regulation, remains a challenge for Germany. There are numerous Fraunhofer projects to support the efforts to reach a low-carbon circular economy based on sustainable materials. Examples include the low-carbon processes for creating steel (Carbon2Chem®) or decarbonizing the cement industry, ways of increasing the efficiency of renewable energies such as technologies for determining locations for offshore wind farms, innovative assembly technologies with modified materials for photovoltaic cells, or new material developments for the circular economy such as carbon-cutting battery casings for the next generation of electric vehicles. Since the latest breakthroughs in the USA, nuclear fusion is almost within reach as a sustainable, carbon-neutral and safe energy source. Germany is taking on a leading research and development role in basic research and the development of key technologies. The Fraunhofer-Gesellschaft, in close collaboration with industry, is working actively to drive the development of power plant technologies that also promise to have significant spill-over effects into new markets. To this end, the Fraunhofer-Gesellschaft is leading joint research projects to develop technologies for laser inertial confinement fusion and magnetic confinement fusion in Germany and with international partners.

A decline in economic performance not only weakens R&D expenditure by companies but also has a negative impact on patent registrations, tax receipts and financial resources for public budgets. Countering these challenges requires focused and reliable innovation and technology policy that is pursued across legislative periods. In its **innovation hub position paper** for the 2025 German federal parliamentary election, Fraunhofer proposes a series of efficient measures, such as innovation-focused public procurement and the adoption of the prepared Field Laboratory Act (Reallabore-Gesetz) to simplify testing of new technologies in legally regulated testing environments. It also recommends a review of the laws governing non-profit status to allow more freedom for research findings to be transferred to industry in a timely manner. Among the affected areas are the small-scale manufacture of products from R&D contract research that are not available on the commercial market, licensing of software and databases, intensive collaboration on standardization committees and the simplification of conditions for founding start-ups.

The executive board would like to thank the members, supporters, friends and, most of all, the employees of the Fraunhofer-Gesellschaft for their support, dedication and hard work in 2024.

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.

The executive board
Holger Hanselka
Elisabeth Ewen
Constantin Häfner (from February 2025)
Sandra Krey
Axel Müller-Groeling

The senate's report

- The senate s report on the financial year 2024
- New senate member

The senate's report on the financial year 2024

Hildegard Müller,
Chair of the Senate of the Fraunhofer-Gesellschaft

The capacity for innovation is and will continue to be a substantial foundation for growth, prosperity and jobs in Germany and Europe. The big global challenges, from the energy, mobility and raw materials transitions to the digital transformation to the strengthening of security and technological sovereignty, will give rise to the markets of the future. Those markets should be served by a shared innovative spirit, commitment and opportunity-based investment from the business and political sectors. This context makes the Fraunhofer-Gesellschaft's mission and purpose, with its research focus on the key technologies of the future and the transfer of research findings to industry, more relevant than ever — particularly in times of increasing international competition. Fraunhofer researchers are developing practical solutions to market readiness in almost every area of technology that is relevant to our future, and are helping to create lasting strength for businesses and for Germany and Europe's position as a hub for business.

One example of the successes of the 2024 financial year is the AI language model Teuken-7B, which was trained on all 24 of the EU's official languages through the research project OpenGPT-X and contains seven billion parameters. It has been developed in accordance with the relevant European data storage and processing standards. It is an applied AI model made in Germany and offered by Fraunhofer. This powerful, trustworthy and open-source alternative to the large, common AI language models will strengthen digital sovereignty for Germany's companies and authorities. Deutsche Telekom is the first company to offer a commercial service based on Teuken-7B. Another impressive demonstration of innovative capability was the launch of the ERNST nanosatellite in August 2024. Several Fraunhofer institutes, together with the Fraunhofer spin-off constellr, pooled their interdisciplinary expertise to work on the project, which has taken innovative solutions to global challenges — such as aerial defense and environmental monitoring — into space. These examples are a striking example of Fraunhofer's contribution to boosting Germany's and Europe's future capacity for innovation and technological sovereignty.

This is possible thanks to Fraunhofer's strong financial performance in 2024. Of the total volume of €3.6 billion, contract research accounted for 88 percent (€3.1 billion) and represents the organization's core activity. Around one-third of contract research funding is provided by base funding from the German federal and state governments. Industrial revenue rose by four percent to a new high of €867 million. Fraunhofer is an important engine of innovation for Germany and Europe as a business hub.

In 2024, the senate fulfilled the duties entrusted to it under the statutes. It met four times in 2024. The Fraunhofer annual assembly was held on June 12, and the second regular meeting on November 20. The senate also convened on February 19 and April 16 for two extraordinary meetings on the subject of governance reform.

Photo: Dominik Butzmann

The senate made key decisions relating to the structure and executive board matters of the Fraunhofer-Gesellschaft, including:

- **Governance reform**
  In the context of governance reform, the annual general meeting adopted the revised version of the statutes of the Fraunhofer-Gesellschaft on June 13, 2024, on the recommendation of the senate. On the basis of those, the rules of procedure of the senate and its newly constituted standing committees, the rules of procedure of the executive board and the election regulations were also revised. The new statutes, which took effect on January 9, 2025, are in line with the German Public Corporate Governance Code and modern corporate governance principles. They give Fraunhofer an effective governance structure that is ready for the future.

- **Executive board elections**
  On the recommendation of an appointed senate committee for the election and re-election of executive board members, in its meeting on June 12, 2024, the senate elected Constantin Häfner, previously institute director of the Fraunhofer Institute for Laser Technology ILT in Aachen, Executive Board Member for Research and Transfer. Until Häfner took up the office on February 17, 2025, the executive unit was headed in an acting capacity by President Holger Hanselka.

- **Structural adaptations**
  In view of an in-depth analysis of the portfolio as well as business and research strategy factors, and following extensive consultation in its spring meeting, the senate adopted the executive board's resolution to dissolve the Fraunhofer Center for International Management and Knowledge Economy IMW in Leipzig effective March 31, 2025, and to integrate two remaining departments into the Fraunhofer Institute for Systems and Innovation Research ISI with effect from January 1, 2025. The senate also approved another board resolution to integrate the Fraunhofer Institute for Technological Trend Analysis INT into the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE with effect from January 1, 2026, with the aim of creating a synergistic research unit ideally positioned to benefit from the opportunities for joint strategic development.

- **APECS pilot line**
  At its meeting in the fall of 2024, the senate adopted the research strategy measure Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems (APECS), a pilot line under the EU Chips Act. The pilot line aims to integrate highly disparate technologies into one microsystem and transfer them to industrial processes on a scalable basis, including through the use of chiplet technology, and to build semiconductor research and manufacturing capacity in Europe. The ultimate goal is to increase the technological resilience and competitiveness of the semiconductor industry in Europe.

In addition, the annual financial statements and the management report of the Fraunhofer-Gesellschaft again received an unqualified audit opinion from the appointed auditing company.

The senate would like to thank the executive board and all Fraunhofer-Gesellschaft employees specifically for their great commitment and successful work in 2024. I am certain that this commitment and the high level of expertise, excellence and creativity of our employees will allow us to continue making a crucial contribution to maintaining Germany's position as a hub for business.

Hildegard Müller
Chair of the Senate of the Fraunhofer-Gesellschaft

New senate member

"Digital technologies, data analytics and artificial intelligence are rapidly changing existing infrastructures and business models."

Annette Beller

Photo: Marco Moog

Annette Beller

Qualified tax advisor and auditor | Graduate in business administration

The who's who of German family-owned businesses listed Annette Beller as one of the German business world's most important leaders in early 2024. She holds a doctorate in business administration and spent almost three decades at the medical engineering firm B. Braun SE in Melsungen. Her last position there, starting in 2011, was as board member (CFO) responsible for finance/tax and controlling, IT, logistics and purchasing, before she retired in April 2024.

Annette Beller was born in Paderborn in 1960. She studied business administration in Göttingen. After completing her degree, she initially worked as a research scientist at the Institute for Accounting and Auditing of Public and Private Enterprises at the University of Göttingen. She earned her doctorate there alongside her professional work, and then began working as an auditor at the auditing and tax consulting firm Dr. Wollert — Dr. Elmendorff KG (now Deloitte GmbH Germany) in Düsseldorf. She also completed her tax consultancy and auditing examinations through part-time study. In 1995, she joined B. Braun Melsungen AG in Melsungen as senior vice president of finance, tax and accounting. In 2011, Annette Beller became a member of its executive board.

As an experienced financial expert, she made a strong mark on the company. For example, in 2002, she lent her support to the establishment of an in-house bank, where a payment factory was established for the B. Braun group in 2012. Later on, in addition to syndicated financing and bonded loans, she also concluded several funding deals for R&D projects with the European Investment Bank (EIB) and the International Finance Corporation (IFC).

In addition, Beller was also a member of the University of Kassel's university council from 2016 to 2024 and has been a member of the administrative board and audit committee of Landesbank Hessen-Thüringen (Helaba) since 2015, its chair since 2018 and a member of administrative board of GFT Technologies SE in Stuttgart since 2013. At GFT, which is a service provider specializing in the digital transformation of businesses, she is chair of the audit committee. GFT SE collaborates with Fraunhofer, including on the development of technologies for energy-adaptive factories. Since early 2025, Annette Beller has been a member of the Fraunhofer senate and chair of the Fraunhofer audit committee.

Review of Fraunhofer research

- Pioneering achievements
- Initiatives, structures, funding programs
- Projects and results
- Awards
- People in research
- Selected transfer activities

Pioneering achievements

Next-generation charger for electric vehicles

The chargers built into today's electric vehicles, on-board chargers (OBCs), are mostly limited to 11 kilowatts for charging by alternating current. A team at the Fraunhofer Institute for Reliability and Microintegration IZM has been able to make a significant breakthrough. The inductive components are laid out in a completely different way because of the high clock speeds, allowing them to be produced cost-effectively in an automated process using circuit-board technology. For example, the gallium nitride-based wide bandgap semiconductors in the sine amplitude converter enable clock speeds of 1.3 megahertz — switching rates of 1.3 million per second — which reduces the size of the transformer. The much smaller throttle for the power factor correction converter is designed to lie flat on a circuit board with four magnetically coupled coils on a shared ferrite core. The result is an OBC with a volume of three liters, half the volume of chargers commonly in use today, and double the charging capacity, 22 kilowatts compared to today's 11. The module is also bidirectional and compatible with 400 and 800 volt batteries, and has an efficiency rate of over 97 percent. The project is supported by funding from the EU's Horizon 2020 program.

Aluminum yttrium nitride, an energy-efficient semiconductor material

Researchers at the Fraunhofer Institute for Applied Solid State Physics IAF have successfully produced and characterized

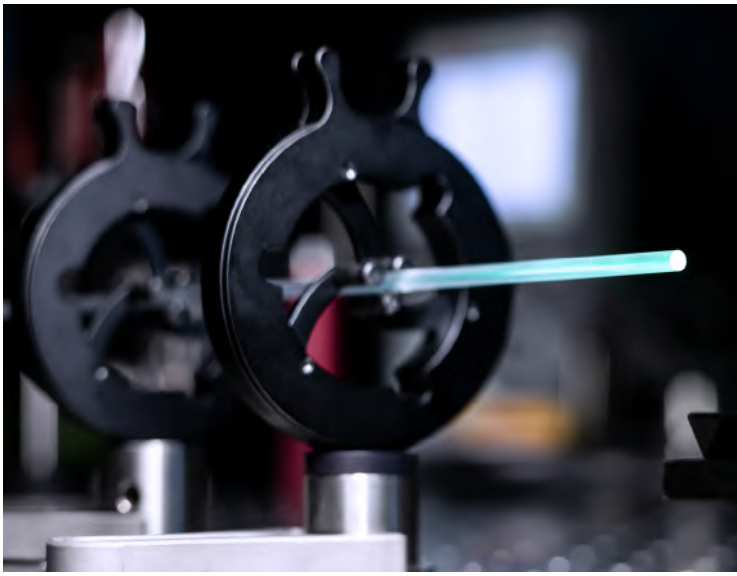
The new developments give the charger twice the charging power of chargers commonly in use today

the promising innovative semiconductor material aluminum yttrium nitride (AlYN) by metalorganic chemical vapor deposition (MOCVD) for the first time. Until now, it has only been possible to deposit AlYN using the magnetron sputtering process. The MOCVD method of manufacturing can be scaled up to industrial-sized substrates. The use of AlYN, particularly in heterostructures with gallium nitride (GaN), enables performance increases while minimizing energy consumption for semiconductors. In their development of the new compound semiconductor, the researchers at Fraunhofer IAF are focusing mainly on its compatibility with gallium nitride (GaN). Its ferroelectric properties and unlimited layer thickness make AlYN particularly well suited to the development of non-volatile storage applications. This is especially relevant for data centers that are being used to cope with the exponential increase in computing capacity for artificial intelligence, and as a result are consuming significantly more energy.

New cooling limit achieved with laser light

A research team from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF and the University of New Mexico has been working since 2019 on anti-Stokes fluorescence cooling, which uses laser light to cool specially doped materials. In the spring, researchers set a new record cooling limit thanks to a number of optimizations: By irradiating an ytterbium-doped quartz glass rod using an excitation laser with 97 watts of power and a wavelength of 1,032 nanometers, they were able to demonstrate a temperature decrease of 67 kelvins below room temperature within two minutes. The breaking of the previous cooling limit record opens up a number of possible developments: For example, extremely stable lasers could mean improvements in precision measurement technology or quantum experiments, and low-noise amplifiers with vibration-free cooling are needed in the fields of materials analysis and medical diagnostics. These measurements also provided the opportunity to collect laser spectroscopy data, which is now available to the global research community for the design of fiber lasers.

The production of AlYN/GaN wafers using the MOCVD process, which can be seen here in various yttrium concentrations, is a breakthrough in the field of semiconductor materials



A laser-excited ytterbium-doped quartz glass rod was used to achieve a temperature reduction of 67 kelvins below room temperature within two minutes

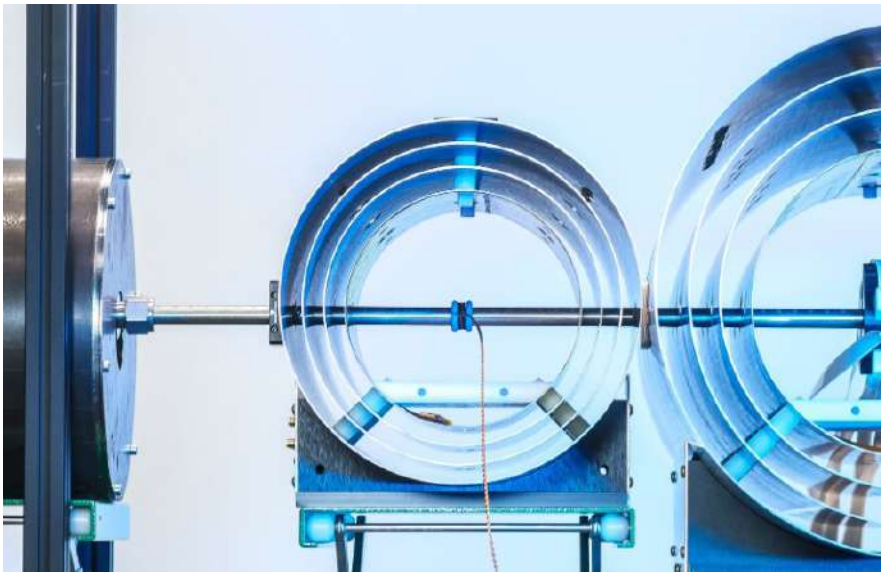
Photos: Fraunhofer IZM / Volker Mai, Fraunhofer IAF, Fraunhofer IOF

Quantum sensors for flow measurement

At the Fraunhofer Institute for Physical Measurement Techniques IPM, a contactless flow measurement method has been developed based on magnetic fields: For the first time, a research team has been able to show the quantitative impact of the flow profile on the magnetic signal. The flow measurement process developed by the team is based on magnetic fields and can provide the flow rate of magnetizable fluids very precisely without requiring contact with the fluid: First, the fluid medium is magnetically polarized with a permanent magnet and its alignment is turned using high-frequency pulses. This creates local magnetic markings in the fluid, which are ultimately logged from the outside of the pipe using highly sensitive quantum sensors after a certain distance has been passed. The process opens up new possibilities for controlling and automating manufacturing processes with flowing fluids. A process like this, with reliable data on the flow rates of fluids, could be significant for sectors such as the chemical or pharmaceutical industry. The results have been published in the Journal of Applied Physics.

Scalable tandem solar cell with perovskite

Researchers at the Fraunhofer Institute for Solar Energy Systems ISE have successfully produced a perovskite silicon tandem solar cell with a 31.6 percent efficiency rate. What is special about the square-centimeter solar cell is that the perovskite layer in the top cell was



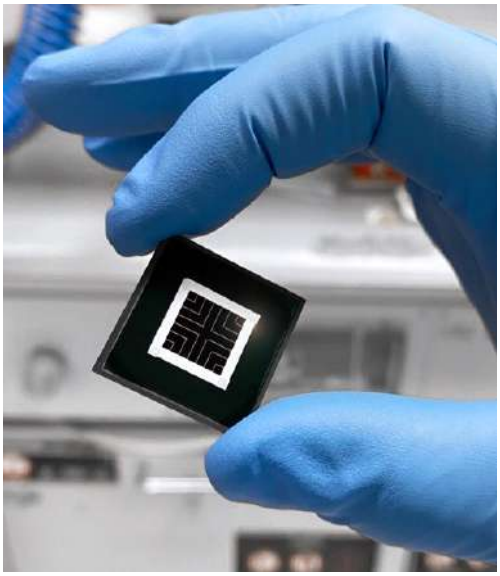
In the magnetic flow measurement process, a strong magnet polarizes the fluid, which flows from left to right through the structure in a steel pipe. The central screen contains the HF coil, which implants the marker in the fluid. A quantum sensor in the right screen detects the marker.

Photos: Fraunhofer IPM, Fraunhofer ISE, Fraunhofer IGB

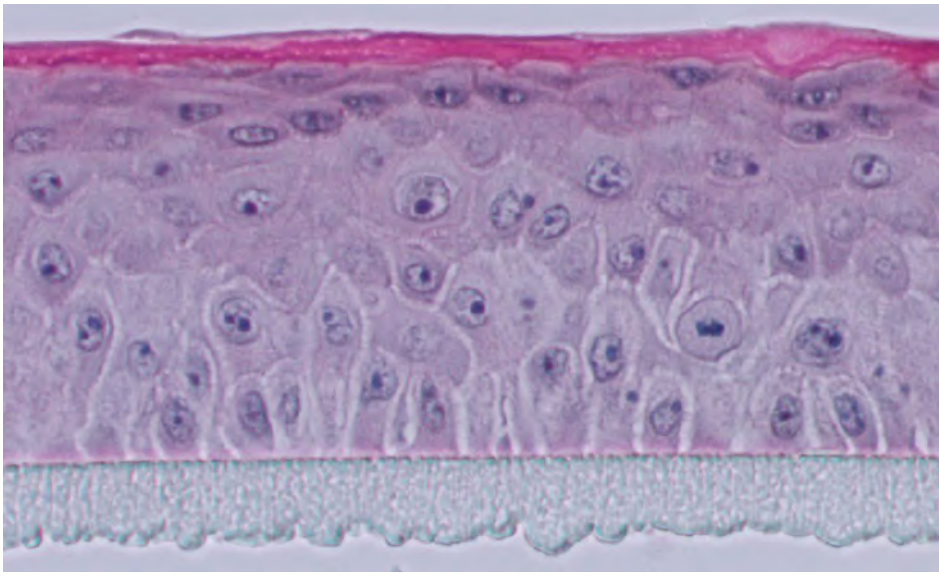
designed on top of a standard silicon solar cell like those currently used in the industry. Using this industry standard as a basis for perovskite silicon tandem solar cells produces high energy yields and makes the new cell type easier to integrate into established manufacturing processes. One of the requirements for the industrial production of tandem solar cells based on standard silicon solar cells is that their structure must be evenly coated with the perovskite top cell. However, there is a challenge here: Standard silicon solar cells have a pyramid-shaped surface to increase light incidence. To allow the perovskite layer to be applied evenly to this surface, the Fraunhofer consortium developed a process consisting of evaporation and wet chemical deposition. The project received considerable funding from the Fraunhofer flagship project MaNiTU, the national funding project PrEsto and a collaboration with the King Abdullah University of Science and Technology in Saudi Arabia.

Reporter skin to replace animal testing

The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB has developed a skin model, called reporter skin, that significantly simplifies the work of pharmaceutical and chemical companies in responding to the EU REACH Regulation. While risk assessments of chemicals or cosmetics often used to be conducted on animals, this is now largely prohibited. At Fraunhofer IGB, a 3D skin model made of human cells has been created. The model replicates the complex physiology of the skin very well, including an intact skin barrier, and therefore produces much more meaningful results than single-layer cell cultures. The patented skin model also makes it possible to test chemicals containing oil or solids such as polymers, textiles or foods for the first time. The main innovation is the integrated reporter genes. These make cell reactions, such as the activation of different cellular stress signal paths, rapidly and specifically visible through the use of a test substance. This allows undesirable effects such as skin sensitization to be analyzed specifically on the living model, while also providing information about the toxicological potential of the substance in the same model. It also makes it possible for the first time to take multiple samples or conduct multiple test combinations.



Applying a perovskite coating to an industrially textured silicon heterojunction solar cell opens the door to the industrial manufacture of tandem solar cells with improved efficiency.



Cross-section of a three-dimensional in-vitro reporter skin model under the microscope: The epidermis (middle, pink) is cultivated on a carrier membrane (bottom, gray) and creates a functional horny layer (top, pink) that acts as a barrier to protect the skin.

Initiatives, structures, funding programs

Initiatives

Strengthening Europe's microelectronic sovereignty

Late 2024 saw the start of development on a pilot line to strengthen technological resilience in Europe and increase global competitiveness in the semiconductor industry. The Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems (APECS) pilot line is becoming a cornerstone of the EU Chips Act, driving chiplet innovation and enhancing semiconductor R&D production capabilities in Europe. The APECS pilot line is expected to drive new innovations in heterointegrated assembly technologies, especially new chiplet technologies. Semiconductor research is at the heart of today's technological (r)evolutions, such as AI and quantum technologies or supercomputers. Individual chips will no longer be enough to manage the many functions that these future electrical systems will need to have. APECS developments therefore go beyond conventional system-in-package (SiP) methods to address CMOS nodes containing multiple microelectromechanical systems (MEMS). This also relates to chiplets, which can combine function blocks (IP cores) of different chip parts.

The APECS pilot line will make it possible to expand the R&D infrastructure for semiconductor technologies and applications further in the coming years

Photo: Ioewn / Bernhard Wolf

Developing an innovative assembly and connection technology from an early stage is therefore crucial to allow European businesses and organizations to work with robust, reliable heterogeneous systems and so increase Europe's technological resilience.

In the APECS pilot line, the Fraunhofer and Leibniz institutes are collaborating closely with other European partners under the Research Fab Microelectronics Germany (FMD) umbrella. The pilot line will provide industry, including SMEs and start-ups, with low-threshold access to cutting-edge technologies. APECS is co-financed by the Chips Joint Undertaking and national grants from Austria, Belgium, Finland, France, Germany, Greece, Portugal and Spain as part of the Chips for Europe initiative. The total funding for the APECS pilot line amounts to €730 million over 4.5 years.

Collaboration with Helmholtz

In a time of increasingly scarce resources, there is a growing need in Germany's diverse scientific and innovation system to pool expertise, infrastructure and knowledge across the boundaries of individual research institutions.

Examples of such synergies include Fraunhofer's collaboration with Deutsches Elektronen-Synchrotron (DESY) in Hamburg and Forschungszentrum Jülich (FZJ). These partnerships combine mission-specific strengths and open up new paths to industrial and societal commercialization. Fraunhofer and DESY began their collaboration in 2023, and since then have been working together to solve real-world issues in a range of technological fields. A custom access model makes it easier to use the research infrastructure and the associated X-ray-based analytical methods. In the pilot phase, 23 projects have so far been implemented, totaling over 1,500 hours of beam time in the PETRA III accelerator. There are plans to solidify the successful collaboration with a collaboration agreement.

Forschungszentrum Jülich (FZJ) and Fraunhofer are also pursuing a strategic collaboration based on ten years of working together successfully. Their aim is to secure a competitive position for Germany and Europe in the research and application of generative AI (GenAI). When it comes to foundation models, Fraunhofer and the FZJ have a development head start of several years. Both organizations intend to bring the Teuken models developed on Germany's most powerful computer to date, JUWELS, to the commercial sector. This will ensure that its industrial application is widespread and sovereign. For the training of large foundation models, in addition to JUWELS the collaboration will also benefit primarily from the use of JUPITER, the future exascale computer.

Fraunhofer Heilbronn Research and Innovation Centers — Fraunhofer HNFIZ

Fraunhofer research activities on the Bildungscampus in Heilbronn have been funded by the non-profit Dieter Schwarz Foundation since 2019. The catalyst for this was the collaboration with the Fraunhofer Institute for Industrial Engineering IAO, which was later also joined by the Fraunhofer Institute for Systems and Innovation Research ISI and the Fraunhofer Information Center for Planning and Building IRB. Since early 2025, there have been 8 Fraunhofer research and innovation centers working in Heilbronn on cognitive service systems, future skills, innovation and foresight, hybrid AI, transformation and governance, AI-based robotics, cybersecurity and applied quantum AI. Through their close collaboration with businesses, organizations, innovators and public bodies, the Fraunhofer Heilbronn Research and Innovation Centers HNFIZ aim to generate intensive transfer and commercial utilization far beyond Heilbronn's limits. As well as Fraunhofer IAO, Fraunhofer ISI and Fraunhofer IRB, the collaboration will soon also include the Fraunhofer Institutes for Intelligent Analysis and Information Systems IAIS, Secure Information Technology SIT and Manufacturing Engineering and Automation IPA. There are plans to increase the number of employees in Heilbronn to around 180 in the next 10 years.

Stakeholder dialogue with government on research security

With its position paper on research security in the light of the *Zeitenwende*, the German Federal Ministry of Education and Research (BMBF) began a participative process with the state governments and with the scientific and research community in March 2024. The objective of this is to define a guiding framework that is adapted to the new geopolitical challenges. Together with members of the scientific community, the process is aimed at developing a strategic approach to bring the valuable asset of scientific freedom into line with security policy interests in international collaboration. The stakeholder process includes members of the scientific community, trade associations, security agencies and the German Federal Ministry of Defence (BMVg).

Funding from the Dieter Schwarz Foundation is enabling a significant expansion of Fraunhofer activities in Heilbronn. From left to right: Holger Hanselka (President of the Fraunhofer-Gesellschaft), Reinhold Geilsdörfer (Managing Director of the Dieter Schwarz Foundation) and Wilhelm Bauer (Institute Director of Fraunhofer IAO)

It is also aimed at strengthening Germany's technological sovereignty in key technologies. With a view to the international collaborations, which are essential for leading-edge research, the BMBF intends to take research security measures that are proportionate to the risks. Existing research security instruments, structures and processes are being reviewed to determine whether they correspond to current national security interests. The strict separation between civil and military research that exists in some areas is also being reconsidered as joint infrastructure has long been in use in the Dresden North institute center, and the suitability of existing civil clauses is being examined with respect to possible efficiencies from closer links between civil and military research funding. Together with the German federal cyber agency, the Fraunhofer-Gesellschaft has been tasked with leading a working group to draw up proposals for protecting sensitive technologies and redefine the concept of dual use.

Photo: Dieter Schwarz Foundation / Nico Kurth

Structures

Innovation research in Leipzig

The Fraunhofer senate and executive board adopted various measures in 2023 to maintain and strengthen the Leipzig location over the long term. Specially developing the Fraunhofer portfolio for innovation research in the best possible way, both professionally and economically, was a fundamental part of the decision-making processes. Another package of measures related to the Fraunhofer Center for International Management and Knowledge Economy IMW, which was dissolved as an independent entity with effect from January 1, 2025. To strengthen the key topics of structural transformation and regional policy advice, the knowledge and technology transfer department and the regional transformation and innovation policy department of Fraunhofer IMW had already been integrated into the Fraunhofer Institute for Systems and Innovation Research ISI in July 2024. The former Fraunhofer IMW is now a new Leipzig location for the Karlsruhe-based Fraunhofer ISI and can continue to make use of the local expertise and networks.

Following detailed analyses and deliberations, by the spring of 2024 it was clear that business and research strategy factors had made it impossible to avoid closing further departments. The dissolution and partial closure of Fraunhofer IMW as an independent entity was completed on March 31, 2025.

Chemical and process industry in Halle

The Center for Economics and Management of Technologies (CEM) in Halle is becoming another branch office of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden, specializing in technology and process innovation. This integration is the result of a strategic decision by Fraunhofer to pool technology transfer for partners and customers in the chemical and process industry and expand research capacity.

Enhancing security research in Wachtberg

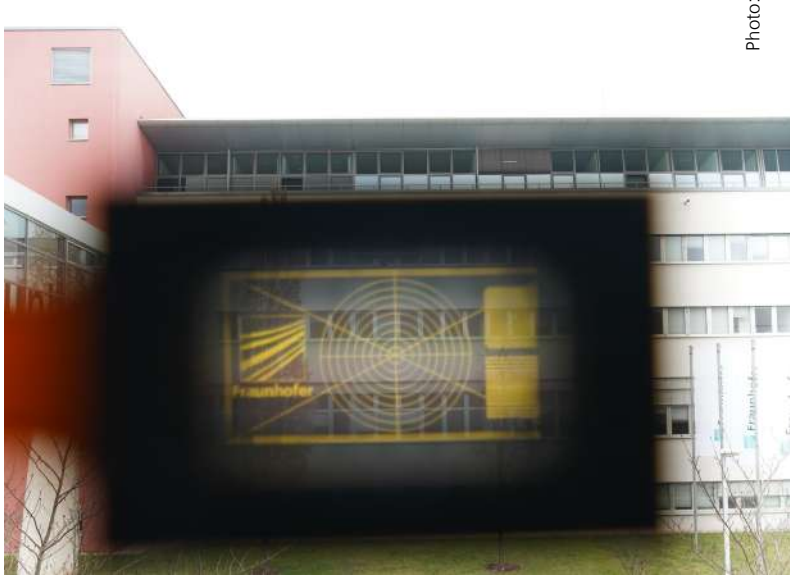
Fraunhofer will be enhancing the security research portfolio in North Rhine-Westphalia: Starting in 2026, the Fraunhofer Institute for Technological Trend Analysis INT will be integrated into the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE. Since Fraunhofer INT was impacted by the flooding in the Ahr valley in 2021, Fraunhofer FKIE has been providing support, including by taking on the data center in Wachtberg. The Fraunhofer senate approved this change back in June 2024.

For 50 years, Fraunhofer INT has been a reliable partner to the German Federal Ministry of Defence (BMVg), and this will continue under the new umbrella. Its scientists conduct research into areas such as technological analysis and strategic planning, as well as the effects of nuclear and electromagnetic radiation. The merger with Fraunhofer FKIE is expected to build on the synergies in these areas in particular as well as boosting civil contract research.

Microdisplays and sensors in Dresden

The Microdisplays and Sensors business unit at the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP has been integrated into the Fraunhofer Institute for Photonic Microsystems IPMS with retroactive effect from January 1, 2024. The organizational merging of expertise and structures is producing synergies that are strengthening the research field. At a 2024 conference in South Korea, this research group presented the first OLED microdisplays with never-before-achieved transparency levels of 45 percent, which could be used in products such as energy-saving augmented reality glasses.

Photo: Fraunhofer IPMS



The Microdisplays and Sensors business unit at Fraunhofer IPMS develops microdisplays using a number of different technologies. Semitransparent solutions offer opportunities for thin, near-eye lenses

Funding programs

High-performance centers

In 2022, the funding instrument for high-performance centers was changed to the omnibus model: For new high-performance centers to be initiated in any competition round, the same number of existing centers must be withdrawn from the funding scheme in the same round. In the third and final appraisal of 21 high-performance centers in the summer of 2024, the first round of the competition and a small reduction in the medium-term financial plan led to 16 high-performance centers qualifying for the second round in 2025–2027, while funding ended for 5 centers in 2024 and 4 new consortia were launched.

The overall result of the first round of the competition reflects the tremendous success of the top 3 high-performance centers: Simulation- and Software-Based Innovation in Kaiserslautern, Photonics in Jena and Electronic Systems in Erlangen. These consortia repeatedly impressed the committee with their significant impact in industry and society, their active collaboration in the regional innovation ecosystem — with the strategic involvement of scientific partner institutions — and with their outstanding transfer highlights. These include spin-offs: In the context of the Kaiserslautern high-performance center, 11 spin-offs were formed in the ecosystem, including 9 Fraunhofer spin-offs. Strategic partnerships were formed, such as the partnership with BioNTech on production planning and documentation for mRNA vaccines and medicines. Additionally, in 2023, 27 collaborative doctoral dissertations were completed by specialist employees. With the regional partner institutes in the high-performance centers, Fraunhofer is setting concrete examples for what needs to be achieved by organizations such as DATI on a large scale: key drivers for the development of the German innovation system.

Across the program, the diverse transfer success of the high-performance centers in 2023 translated into industrial revenue of €65 million. This significantly exceeded the requirement stipulating that, based on annual funding of €1 million per high-performance center, at least double this amount should be leveraged as industrial revenue, i.e., €42 million for all 21 high-performance centers.

Because of the one-year offset of the appraisal — next set to take place in the summer of 2025 — there are no figures available yet for industrial revenue in 2024.

Clusters of excellence

The Fraunhofer cluster of excellence format was established in 2018 to increase the (inter)national visibility of selected research areas. To this end, the clusters support long-term and sustainable collaboration between multiple Fraunhofer institutes with core areas of expertise that complement each other. The cross-group initiative represents extraordinary scientific quality. The clusters of excellence support the dynamic pursuit and development of strategic roadmaps for systemically important and potentially disruptive innovations.

The funding format addresses topics in keeping with the strategic alignment of national and international research and development (R&D). The research areas include high-power laser systems, key technologies for the cognitive internet, programmable materials, research into immunological diseases and solutions for the circular economy and the energy transition.

After a five-year development phase, the clusters of excellence presented their accomplishments in the form of KPIs in a number of categories, such as research, acquisition, transfer, spin-offs and industrial and scientific collaborations. Following a successful evaluation, 6 clusters moved into the current 4-year funding phase:

- Advanced Photon Sources CAPS
- Circular Plastics Economy CCPE
- Cognitive Internet Technologies CCIT
- Immune-Mediated Diseases CIMD
- Integrated Energy Systems CINES
- Programmable Materials CPM

The current funding phase for 4 clusters is set to run until the end of 2026, and for 2 until the end of 2027. During 2024, the clusters submitted milestone reports focused on IP management, as set out in the funding decisions. The clusters of excellence are integrated into existing (infra)structures and are usually spread across several locations. Shared access to distributed resources and scientific infrastructure, along with the pooling of expertise and synergistic strategic developments, has allowed the participating Fraunhofer institutes to respond to markets and customer queries in a flexible and agile way. The long-term and sustainable collaborations between the participating institutes, both within and across clusters, are helping to strengthen the role of the Fraunhofer-Gesellschaft as an innovative partner for politics and industry.

Fraunhofer innovation platform: FIP-H2ENERGY@KENTECH

A Fraunhofer innovation platform (FIP) is a temporary research unit at a foreign public institution, established in close collaboration with one or more Fraunhofer institutes in Germany. The aim of these platforms is to generate positive economic and societal effects in both of the collaborating countries by combining complementary expertise and a collaborative approach to the transfer and commercialization of scientific research findings. The participating Fraunhofer institutes receive funding in proportion to their work from the internal CONNECT Science Innovation People funding portfolio.

In 2022, the project Fraunhofer Innovation Platform for Hydrogen Energy at Korea Institute of Energy Technology H2ENERGY@KENTECH was launched in view of the similar technical challenges facing Germany and South Korea in establishing a green hydrogen economy: In both countries, the demand for hydrogen is greater than the production capacity. Together with the South Korean research institute KENTECH, which was founded in 2021, 6 Fraunhofer institutes are conducting research into aspects of the production, conversion or liquefaction, transportation and use of green hydrogen or its derivatives. The collaboration is currently working on four joint projects throughout the hydrogen value chain, including a project to develop international standards (Project H2Korea), a project to use and convert ammonia and a project for the risk assessment of power plants.

In 2024, KENTECH received development funding of over €22 million to develop research infrastructure for liquid hydrogen in Boryeong City. An EU-funded project (M-ERA.NET HYPHAD) to design metal hydride alloys for hydrogen applications was also acquired.

Flagship project: ALBACOPTER®

The flagship projects are designed to make full use of Fraunhofer's potential for synergies. They combine expertise from multiple institutes to deliver solutions to some of the challenges facing German industry. The ALBACOPTER® consortium is developing unmanned aerial systems to store some of the traffic volume in the lower airspace. Aviation safety, sustainability and economic efficiency requirements are extremely high in the aviation sector, however, and flights beyond the visual line of sight are currently only permitted in a few countries. In this early phase of development, the ALBACOPTER® consortium has developed numerous technologies for an autonomous transport drone that can glide across great distances like an albatross, and take off and land vertically like a multirotor. The German Federal Aviation Office (Luftfahrt-Bundesamt, LBA) has already approved the flight testing of the first prototype on the drone testing field in Cochstedt.

The frame of the aircraft is made from recyclable, extruded, fiber-reinforced plastic profiles that guide the flow of forces into patented node elements. With a wingspan of 7 meters and a take-off weight of 150 kilograms, the aircraft can carry a maximum payload of 25 kilograms in a transport box made from recyclable material. Thanks to its swiveling rotors and a battery system designed for avionics applications, the ALBACOPTER® flies entirely on electricity. Robust autopilots ensure a reliable transition between the hovering and gliding phases while the rotors are swiveling. The AI-based environment recognition and trajectory planning systems are overlaid on the flight altitude control system. Camera, lidar and radar sensors supply the initial data for obstacle and landing site recognition. Before its first actual take-off, the ALBACOPTER® can be thoroughly tested in digital twin form on an open-source simulation platform.

Measurement on a test bench for water electrolysis with a polymer electrolyte membrane at the partner institute in South Korea

ALBACOPTER®: Fraunhofer's answer to shifting transportation to low-level airspace

Photos: Fraunhofer IMWS, Fraunhofer IEM / Janosch Gruschczyk

PREPARE project: BIOSYNTH

Since the creation of the internal funding program PREPARE in 2019, it has resulted in nearly 60 projects that have brought interdisciplinary pre-competitive research to commercial applications. One of the 47 ongoing projects is BIOSYNTH. The project brings together 3 Fraunhofer institutes from life sciences and microelectronics to develop a mass data storage technology based on nucleotide sequences (DNA, RNA) or peptides. If successful, it would be capable of storing 9 terabytes of data on one cubic millimeter of DNA. The aim is to develop a microchip platform on which software-defined DNA, RNA or peptides can be written. This is expected to enhance mass production processes for storage in the microelectronics industry in the future as compatible manufacturing methods for high-throughput biological mass data storage are found. To this end, binary code is being translated into an artificial DNA string. The research team is working to produce error-free sequences of up to 250 nucleotides. Synthesizing and sequencing the DNA requires microchip platforms. The synthesis equipment, which currently takes up a lot of room, is to be replaced by portable, low-cost systems that do not use a lot of energy, therefore enabling commercial biological data storage. The consortium has three objectives: to drastically increase storage density, to increase the speed at which bits and bytes are transferred to DNA, and to eliminate or identify and correct errors in the transfer to organic molecules. Such a platform could also open up applications for ecotoxicology and food toxicology, personalized therapies, biocomputing or logistics.

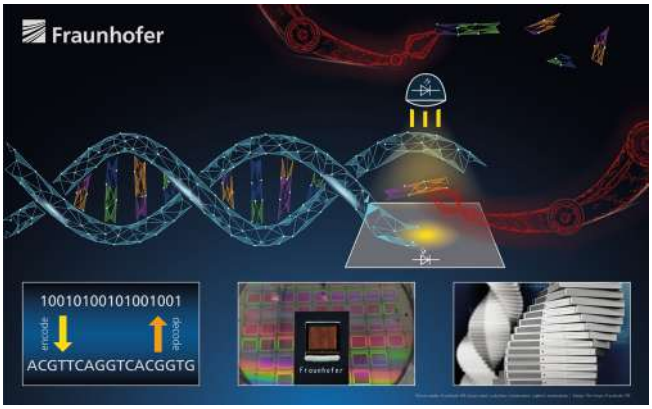
Like all PREPARE projects, BIOSYNTH ensures its practical relevance with a specific group of advisors. The members of this group include the University of Marburg, the German Federal Archives and X-FAB Semiconductor or Infineon Technologies.

Program on rapid mittelstand-oriented in-house research Acoustic intelligence

One particular focus of the Fraunhofer mission is the funding of innovation in European small and medium-sized enterprises. From as early as 1976, Fraunhofer has had an internal funding format for those customer groups. Each year, the funding line Schnelle Mittelstandsorientierte Eigenforschung – SME (Rapid mittelstand-oriented in-house research) provides funding to around 40 projects developing promising research approaches in ways that make them accessible and interesting to SMEs.

One of these is the funded project Acoustic Intelligence. In two and a half years, researchers from the Fraunhofer Institutes for Machine Tools and Forming Technology IWU and for Industrial Mathematics ITWM have managed to develop an AI-based noise monitoring system for the objective quality assurance of production processes. The aim was to reduce costs from production waste by diagnosing machine failures early. The developers achieved particular success in AI-based psychoacoustic signal capture by using a deep drawing process. This is needed in automobile and aircraft manufacturing as well as in the packaging industry. Cracks arising from process-related component faults were detected with 100-percent accuracy in the project by using psychoacoustic characteristics of the production process. Material, plate thickness and lubrication were also successfully classified with greater than 85-percent accuracy. This makes it possible to identify process faults at an early stage.

There is a high level of interest in this approach to process monitoring. Once the use of psychoacoustic characteristics has been transferred to other processes and systems, it will be possible to transfer the results to related industry projects starting in 2025. A progressive spread into industry is also planned by means of an Industrial Collective Research project with ten participating companies.



DNA, RNA and peptides as the media of the future for storing mass data

AI-based noise monitoring for objective quality assurance in production processes such as sheet metal forming

Images: Fraunhofer IPMS, Getty Images, photo: Fraunhofer IWU

Projects and results

As an applied research organization, Fraunhofer fulfills its responsibility to society to develop solutions for the challenges of our time. As part of this, Fraunhofer works with partners from industry and science to translate research findings into sustainable products and services. This work is guided by the UN's 17 Sustainable Development Goals (SDGs). These ambitious goals address all social stakeholders in the fields of politics, industry, civil society and science. Fraunhofer is no exception and has taken the SDGs as an important guiding framework. Accordingly, the model research projects are allocated to selected SDGs.

Working with and for industry to develop marketable, sustainable innovations is a core task for the Fraunhofer-Gesellschaft. As such, Sustainable Development Goal 9 (Industry, innovation and infrastructure) is of particular importance to Fraunhofer. Above and beyond this, its research addresses Sustainable Development Goals in all areas.

The Fraunhofer group structure also forms a basis for the choice of projects and findings to put forward. One publicly funded project and one project (co-)funded by industrial partners is presented from each group. This also applies to the Segment for Defense and Security VVS.

Energy technologies and climate protection

WITH INDUSTRY

Survey to build an offshore wind farm

Baltic Power is a project by the companies ORLEN and Northland Power to build an offshore wind farm in the Baltic Sea, with 76 wind turbines, two transformer platforms and a cumulative total output of up to 1.2 gigawatts. The locations need to be chosen carefully and the subsoil must be thoroughly examined. A possible construction risk is that of previously undetected boulders. The cable corridors also need to be surveyed to optimize the laying of the submarine cables.

The Fraunhofer Institute for Wind Energy Systems IWES has conducted a boulder detection campaign, commissioned by Baltic Power, for the foundations of the planned wind turbines. This has detected boulders on the seabed and up to 100 meters below it. The survey technology has also been used for the first time along the planned submarine cable routes. To enable this, an innovative measuring system has been developed at Fraunhofer IWES involving a towed array equipped with special seismic sensors (hydrophones) and positioning systems. During data acquisition, the hydrophones capture sound waves that are emitted by a signal source and reflected or scattered by the subsoil. This makes it possible not only to map out sediment layers but also to locate rocks in the subsoil under the seabed. With this unique method of diffraction imaging, the acoustic energy scattered by the boulders can be traced back to its point of origin. The risks for cable route laying have also been investigated for the first time.

This boulder detection technology, which was developed and patented by Fraunhofer IWES, makes it possible to minimize risks when building wind turbines and transformer platforms (OSS), and laying cables.

WITH FUNDING

Infrastructure for the hydrogen economy

The System Analysis group is drawing up forecasts and recommendations for a European hydrogen economy from 2050 through the flagship hydrogen project TransHyDE commissioned by the German Federal Ministry of Education and Research (BMBF). Under the leadership of the Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG and DECHEMA e. V., the consortium is forecasting demand for at least 700 terawatt-hours of hydrogen (H_2) in Europe and the United Kingdom in 2050.

Producing H_2 within Europe depends on the development of its wind and solar power facilities. The researchers looked at the demand from industry, households and the transport sector. Despite expected cost reductions for green energy sources after 2030, they have found that there will only be enough H_2 available for high-temperature applications like steel production, centralized power and district heating generation or use as an industrial raw material in the production of chemicals, for example. It remains unclear whether it will be possible to cover the entire European value chain, from green energy to H_2 production to chemical production.

The reuse of old natural gas pipelines is one deciding factor in the transformation of the European energy system. Various models indicate that these pipelines do meet the supply requirements. Pipelines seem particularly well suited to imports of H_2, for example from the MENA region. Importing H_2 derivatives such as ammonia or direct reduced iron appears to be more cost-effective than producing them in Europe. Security of supply was also modeled. This can be achieved with minimal total system costs by a suitably designed core H_2 network. This core network could connect potential generators of renewable energies, particularly in the north and south, to the underground storage facilities and industrial centers of central Europe.

An innovative measuring system helps to build offshore wind farms on solid foundations

The reuse of old natural gas pipelines is a deciding factor in the transformation of the European energy system

Photos: Fraunhofer IWS / Frank S. Bauer, Getty Images

Health

WITH INDUSTRY

Pilot project for Europe's plan to beat cancer

Europe has one-tenth of the global population but a quarter of all cancer cases. In view of this, the EU Commission created Europe's Beating Cancer Plan in 2021. For one of the first projects to receive consortium funding, IDERHA (Integration of Heterogeneous Data and Evidence Towards Regulatory and HTA Acceptance), participants from the fields of health data, imaging and oncology came together to build a Europe-wide digital research infrastructure in the healthcare sector. Using lung cancer cases as an example, the experts investigated how the collection and exchange of data and AI could help to improve and personalize treatments and get findings from health data into clinical practice more rapidly.

To this end, the partners in the project have developed a Europe-wide health data space. Thanks to this data ecosystem, a wide range of healthcare data can be accessed, (re)used and integrated, and federated learning methods can be applied. The Fraunhofer Institute for Software and Systems Engineering ISST will create the technical building blocks for this new platform, which will comply with data protection standards, be able to interact with other data environments and provide secure access to data for research purposes. The researchers at the Fraunhofer Institute for Algorithms and Scientific Computing SCAI are also working on AI/ML algorithms to analyze large datasets that could be useful for diagnosis and treatment.

The initiative is headed by the Fraunhofer Institute for Translational Medicine and Pharmacology ITMP and Johnson & Johnson Medical GmbH. The consortium comprises 33 academic, clinical, medical engineering, pharmaceutical and IT partners, as well as patient organizations and public bodies.

Europe's plan to beat cancer includes a Europe-wide digital research infrastructure

From left: Dorothee Stamm, Thorsten Buzug, Frank Schwartze, Philipp Rostalski and Anna Lena Paape at the Lübeck Innovation Hub for Robotic Surgery (LIROS)

WITH FUNDING

Healthy and resilient aging — thanks to medical engineering

The North German Hansa Innovation Community was awarded funding by the DATIpilot initiative of the German Agency for Transfer and Innovation (DATI) for its project for healthy and resilient aging through sustainable medical engineering (GRANNI). With social and technical innovations, the consortium partners are combating the dual demographic shift in the healthcare system: the influx of aging baby boomers with an increasing need for healthcare services combined with the shortage of skilled workers in the healthcare system, which is worsening as the baby boomer generation retires.

Examples of the planned support from medical engineering include fall prevention from AI-based movement analyses or the monitoring of risk factors with digital healthcare applications tailored to the relevant age group. Researchers from the Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE are particularly involved in developments for a new treatment approach for removing brain tumors (TINUSA) and preventing the diabetic foot condition (GLUCOSole). Additively manufactured shoe inlays with sensors are designed to prevent the development of diabetic foot in (age-related) diabetes because the disease can ultimately require amputation. AI-supported monitoring of the blood sugar level and pressure ratios in the foot act as preventive measures. The TINUSA project deals with the increase in age-related brain tumors and the rising demand for neurosurgical care. The plan behind the project is to use ultrasonic pulses to identify the brain tissue to which the tumor has spread, and to fragment and aspirate it.

The GRANNI consortium is composed of clinics in Lübeck under the leadership of Universität zu Lübeck, Fraunhofer IMTE and TH Lübeck.

Photos: Getty Images, Sandy Bever / Fraunhofer IMTE

Innovation research

WITH INDUSTRY

For a future-proof supply of drinking water

Each person uses just under 130 liters of water per day according to the Federal Statistical Office of Germany. However, the supply and disposal of water from residential areas needs to be more climate-resilient and resource-efficient as water and energy become more scarce and problems with water cleanliness and hygiene increase. Commissioned by 12 industry partners, the Fraunhofer Institutes for Systems and Innovation Research ISI, Industrial Engineering IAO and for Interfacial Engineering and Biotechnology IGB are working within the InDigWa (Integrated Digitalization of Drinking Water Supply) innovation network to research how to design a smart, future-proof water management system for the supply of drinking water.

The innovation network deals with the resilience of water infrastructure, climate change and the opportunities of digitalization. Some technical innovations made by the business partners are being combined and integrated into a new system to produce data-based efficiency improvements. The approach covers the full breadth of the drinking water cycle: from supplier to consumption in neighborhoods to disposal and recycling. The business partners operate in areas relating to water supply and disposal, the housing industry and building management — such as fittings, water treatment, pumps, measuring technology, sensors and digitalization.

A think tank is developing various future scenarios for data-based efficiency and quality improvements to the supply of drinking water. Participants range from start-ups to technology suppliers, service providers and property managers. The results of the project will be developed and integrated into a residential area managed by GEWOBA, a real estate company in Bremen, and pilot tests will be conducted.

WITH FUNDING

Enabling a tailored transformation

The phasing out of lignite poses significant challenges, including for the mining regions in Lusatia and central Germany. The structural transformation needs to provide new jobs, value creation and quality of life. To identify the most effective and promising measures in the areas themselves, researchers from the Fraunhofer Institute for Systems and Innovation Research ISI in Leipzig (until March 2025 the Fraunhofer Center for International Management and Knowledge Economy IMW) are supporting regional politicians with data-based advisory instruments. Saxony's State Ministry for Regional Development, for example, has commissioned digital twins of the mining regions to develop evidence-based solutions with which to approach the phase-out of coal and create transparency about the development of the mining regions.

The digital twins include the latest information from data science about economic geography and AI-based methods. To ensure this, the regional statistical information is being collected and linked with data on economic, innovative and social activities in the mining regions from different, often unstructured, data sources using AI. This qualitatively improved data will be made available to decision-makers through an online platform. Analytical models will be used to identify new development paths, network partners together and allow the effects of structural transformation funding in Saxony to be measured. The researchers at Fraunhofer ISI in Leipzig are providing the public, business and politicians with scientific support on a large number of issues relating to the transformation process.

The GENESIS project on designing new development paths for the structural transformation in Saxony is funded by the German federal government funding program STARK.

Future-proof water management includes drinking water supply

The phasing out of lignite affects regions like Lusatia and central Germany. They need action for structural transformation

Photos: Getty Images

ICT Group

WITH INDUSTRY

3D planning for high-speed fiber-optic expansion

To supply Germany with high-speed internet, Deutsche Telekom is taking huge steps to drive forward fiber-optic expansion. By the time the thin fiber-optic cables are laid, there will have been extensive preparatory work to overcome, including planning, applications to public bodies and municipalities, and on-site appointments. In planning distributor locations and cable laying paths in particular, Deutsche Telekom relies on digitalization and automation.

Researchers at the Fraunhofer Institute for Computer Graphics Research IGD are assisting with the placement of the network distribution boxes that connect the individual fiber-optic cables from the trunk cable to households. The software that has been developed, which is called Fibre3D, makes it possible to efficiently process and visualize very large sets of geodata. This provides the planners at Deutsche Telekom with an interactive 3D visualization of the rollout areas based on panoramic images and point clouds. They position the boxes virtually at suitable locations in a 3D world, which is much less time-consuming than the previous method of visiting and surveying the actual sites.

Additional support is provided by Fraunhofer IGD's open-source workflow management system Steep: Rollout areas are scanned with laser scanners and panoramic cameras developed in part by the Fraunhofer Institute for Physical Measurement Techniques IPM, producing around 1.5 terabytes of raw data per day of scanning. These quantities of data and their AI-based analysis algorithms for automatic object recognition place high demands on the IT infrastructure. With developments like this, Fraunhofer researchers have helped to increase the rollout speed by 75 percent in recent years, according to estimates made by the planners at Deutsche Telekom.

Planning processes for fiber-optic expansion are being accelerated with an interactive visualization tool

European AI language models are being developed at the Barcelona Supercomputing Center

WITH FUNDING

High-performance computing for generative AI made in Europe

Computing capacity of 8.8 million GPU hours on H100 chips has been granted to the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS and AI Sweden's NLU group on the new MareNostrum 5 at the Barcelona Supercomputing Center under the EuroLingua-GPT project. This is one of the largest blocks of capacity granted by the European High Performance Computing Joint Undertaking (EuroHPC JU) on its infrastructure to develop European large language models (LLMs). In early summer 2024, the partners began running the first multilingual open-source large language models; the project is set to last one year.

The EuroLingua models are based on a training dataset of 45 European languages, dialects and codes, including the 24 official European languages. This means that a significant emphasis is on European languages. The trained models made in Europe are intended to provide a boost to business as well as science.

Fraunhofer IAIS and AI Sweden's NLU group are two of Europe's leading laboratories for LLMs. Fraunhofer heads the consortium project OpenGPT-X funded by the German Federal Ministry of Research, Technology and Space (BMFTR), which has also developed large European multilingual open-source models. AI Sweden's NLU group has developed the large language model GPT-SW3 for the Scandinavian languages. The two teams are also working together on other open-source projects, including TrustLLM, which is also developing European large language models. EuroLingua-GPT is another one of three large ongoing EU large language model projects in which Fraunhofer IAIS and AI Sweden are taking part.

Photos: Deutsche Telekom / Fraunhofer IGD, Barcelona Supercomputing Center

Light & Surfaces

WITH INDUSTRY

Detecting contamination in production

At the Fraunhofer Institute for Physical Measurement Techniques IPM, an entire family of fluorescence measurement systems has just been developed. These F-Scanners are already used in production lines to inspect whether surfaces are clean and free from unwanted dirt. The measurement systems direct the light from a UV laser into points on the surfaces, making even small quantities of organic matter such as fats, oils and adhesives visible through fluorescence.

The F-Scanners are specially designed for use in production lines and enable 100-percent real-time inspections. They are easy to integrate into existing production processes through various communication interfaces. A key component of the F-Scanners is automatic image processing, which scans the fluorescent image in real time. This technology makes it possible to optimize production processes by identifying defects or deviations and initiating appropriate measures, such as rejecting or cleaning components.

Different designs of F-Scanner system have been developed, for example systems for flat component surfaces in conveyor systems, systems for very harsh industrial environments with a watertight and oil-tight housing, or miniature systems for cooperating with industry robots. A crucial factor is the high scanning speed, typically 200 to 800 projected lines per second, which enables millimeter-fine resolutions even with rapid movement. One of these fluorescence measurement systems is developed by researchers at Fraunhofer IPM together with custom machine builder Plasmatreat GmbH. The project was funded using SME-oriented technology funding put in place by the German federal government via AiF Projekt GmbH, a subsidiary of AiF Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" e. V. (a working group of industrial research associations).

WITH FUNDING

Innovation community for spectral detection

Making spectral sensors available to the general public, users and technological innovators — that is the objective of the SpeeD (Spectral Detection for Socially Relevant Applications) project, which includes the Fraunhofer Institute for Applied Optics and Precision Engineering IOF, the University of Applied Sciences Jena and the SpectroNet innovation cluster. Spectral sensors can help to fill many of the needs of a resource-efficient economy, for example in environmental analytics, medical diagnostics or quality assurance up to and including the detection of leaks. Spectral sensors are also being used in Germany's first satellite mission, EnMAP: The satellite was co-developed by Fraunhofer IOF and, since 2022, has been analyzing the state of the earth and bodies of water from space to make the consequences of climate change visible.

One of SpeeD's self-declared objectives is to build a cross-industry platform for testing new technologies and exchanging experience. There are plans to provide OpenLabs in the future to bring technological innovators and users together, identify future application-specific transfer opportunities and implement suitable solutions. Users, such as farmers in Thuringia, will have the opportunity to discover new technologies and the potential of those technologies for their everyday work.

In this way, SpeeD intends to lower the transition threshold for bringing advanced technology into widespread practical use and therefore take full advantage of the potential offered by spectral sensors for the resource-efficient economy of the future. The first community project has been planned and is set to enable the transfer of a high-resolution spectral measuring and mapping sensor system to assist in the diagnosis of skin conditions.

The F-Scanner devices enable rapid and large-scale purity and coating checks, even in production lines

Making spectral sensors available for widespread use is SpeeD's objective. Processes are also being developed for agriculture

Photo: Fraunhofer IPM, visualization: Fraunhofer IOF

Microelectronics

WITH INDUSTRY

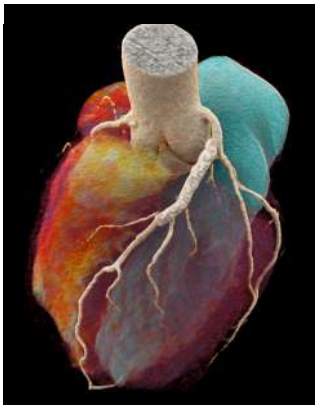
Quantum-counting computed tomography scanner

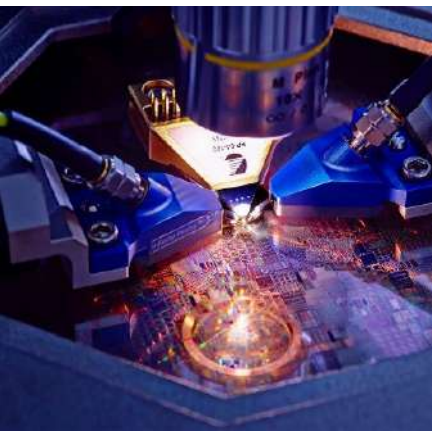
Over a decade of research and development has gone into the quantum-counting computed tomography (CT) scanner NAEOTOM Alpha by Siemens Healthineers. Fraunhofer has also made its own important contributions. With a minimum dose of radiation and reduced image noise, NAEOTOM Alpha enables a much higher imaging resolution of body structures than previously and provides spectral information to discern materials in the body. This makes examinations using the CT scanner even more reliable and opens up new areas of application.

The core of the CT scanner is the QuantaMax® detector, with a resolution of over a million pixels. It converts X-rays directly into electrical signals and takes several thousand images per revolution, which are then used to produce cross-sectional images. The crucial microelectronic innovations include the through silicon vias (TSVs) developed by ASSID, the Dresden branch of the Fraunhofer Institute for Reliability and Microintegration IZM. The TSVs make it possible to install the radiation detector and signal processing unit very close to each other. Another innovation was developed with the involvement of the Fraunhofer Institute for Integrated Systems and Device Technology IISB: NAEOTOM is the first scanner to use crystalline cadmium telluride as a detector material for the X-ray light. The Erlangen-based Fraunhofer institute assisted in optimizing the crystal growing process and the metal contacts of the cadmium telluride detectors.

The computed tomography scanner NAEOTOM Alpha is an excellent example of advanced technology, research and production made in Germany. The US Food and Drug Administration (FDA) has called the device the first major step for imaging devices in CT technology in nearly a decade.

Calcification of cardiac vessels, detected using the computed tomography scanner NAEOTOM Alpha





On-wafer testing of ultra-high-frequency chips for RADAR and terahertz sensors

WITH FUNDING

Terahertz: a future between electronics and photonics

A previously almost unused frequency range is expected to open doors to new areas of application: Terahertz waves are a part of the electromagnetic spectrum between microwaves and the photonic range of infrared radiation. This is where electronics and photonics meet. The wavelengths are shorter than one millimeter and the frequencies are higher than 300 gigahertz (GHz). This makes terahertz waves suitable for many possible uses related to highly pressing future issues.

The terahertz.NRW network is focusing on the usage areas of communication, material characterization, medical engineering, positioning and environmental monitoring. The enormous quantities of data used in communication, for example in augmented reality on mobile devices, require a new mobile communication standard: 6G. At present, members of the International Telecommunication Union (ITU) are discussing the global use of frequencies for ranges up to 280 GHz; the next step will be to negotiate use up to 800 GHz. With its ability to pass non-destructively through matter — whether bodies or materials — without ionizing radiation, terahertz radiation opens up new diagnostic methods in medicine and material sciences, new security applications and more. It could also be used in disaster operations to provide positioning services for autonomous rescue robots or monitor the life signs of survivors. Terahertz radiation will also be indispensable for environmental monitoring in modern agriculture.

The Fraunhofer Institutes for Microelectronic Circuits and Systems IMS in Duisburg and High Frequency Physics and Radar Techniques FHR in Wachtberg are both participating in terahertz.NRW, as are the Universities of Bochum, Duisburg-Essen and Wuppertal. The network is funded by the Ministry of Culture and Science of North Rhine-Westphalia.

Photos: Courtesy of Erasmus Medical Center, Rotterdam, The Netherlands, Fraunhofer FHR / Uwe Bellhäuser

Production

WITH INDUSTRY

Production technologies for mRNA therapeutics

Therapeutics based on messenger ribonucleic acid (mRNA) open up innovative possibilities for preventing and treating various infectious diseases, cancers, autoimmune disorders or genetic disorders in many cases. The mRNA is encapsulated by nanoparticles that ensure it is taken up into the target cells. The composition and production of the nanoparticles, with the associated formulation technologies, are key factors in the process of manufacturing mRNA therapeutics.

A collaboration between the drug manufacturer Lonza Group AG, FDX Fluid Dynamix GmbH and the Fraunhofer Institute for Production Systems and Design Technology IPK is breaking new ground on these formulation technologies. A major challenge is the scaling of preclinical development for commercial use. So far, it has only been possible to implement different production scales using different formulation systems, requiring extensive adjustments to processes. The basis of the collaboration is the FDmiX platform, which is already fully developed and has mixers that enable the ribonucleic acid to be formulated in nanoparticle-based drug delivery systems. An oscillating current is generated in the mixer, making intermixing six to eight times faster and more uniform and therefore leading to more precise particles and higher yields. The FDmiX platform was developed by Fraunhofer IPK and FDX Fluid Dynamix. It has the advantages of providing better product stability and requiring less effort to prepare the particles for the finished medicine. The scalability and design, which are in line with good manufacturing practice, have significantly reduced the cost of producing promising drug candidates at all scales of production. The FDmiX encapsulation technology is protected as IP and has been licensed to Lonza for all development scales.

WITH FUNDING

Digitalization of air freight for powerful transport chains

Air freight is taking on a central role in the global trade in goods. The challenges in Germany and beyond are a severe shortage of workers, limited infrastructure and rising costs. In the Digital Testbed Air Cargo (DTAC) project, nine air freight operators, under the leadership of the Fraunhofer Institute for Material Flow and Logistics IML, are actively working on stable, powerful transport chains. The aim is to help boost the performance of the air freight industry and similar sectors by allowing the reliable, rapid and efficient transport of goods to continue in the future.

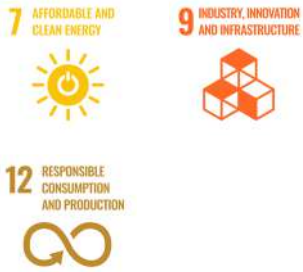
Automation and digitalization are indispensable factors in increasing the efficiency of the (air) freight industry. For this reason, the German air freight hubs of Frankfurt, Cologne, Leipzig and Munich are working with other stakeholders on transferable digital solutions that will be made available to the international community on an open-source basis. Examples of connected processes include the use of the international ONE.record data standard and AI methods. This allows AI-based forecasts to determine when passenger baggage levels are expected to leave cargo space for goods transport.

Automated and autonomous loading robots for loading and unloading freight at airports are also being tested. Collaboration with international partners is a central element of the project. Global best practices are being integrated to strengthen technological progress and Germany's position as a hub for industry. The expected results are expected not only to revolutionize the air freight industry but also to serve as a blueprint for other sectors facing similar challenges. DTAC is a project funded by the German Federal Ministry for Digital and Transport (BMDV), and in 2024 it secured continued funding up to August 2026.

The FDmiX mixer: simple and precise production of nanoparticle shells for mRNA therapeutics

Cargo area at Munich Airport: The evoBOT transports cargo to the testbed

Photos: B. Bobusch / FDX Fluid Dynamix GmbH, Flughafen München GmbH



Resource technologies and bioeconomy

WITH INDUSTRY

Brand-new cars with recycled plastic

The automotive industry is facing significant challenges from tightening sustainability requirements even beyond electrification. Starting in 2030, EU requirements stipulate that 25 percent of the plastic in a brand-new vehicle will need to come from recycled plastic, and one-quarter of this will need to be from end-of-life vehicles. Experts at the Fraunhofer Institute for Process Engineering and Packaging IVV have therefore been working together with AUDI AG and others to develop a new plastic recycling process. The technology makes it possible to recycle purified plastics from shredded cars and reuse it in the automotive industry.

In collaboration with the Remondis Group and the device manufacturer Unisensor, a sorting process has been developed to filter out technical plastics from shredded cars that are currently sent to the incinerator unprocessed. The pre-sorted plastics are then fed into a solvent-based recycling process. The excellent value of the process is due to the selective dissolution and purification of target plastics to recover highly pure and defined polymers from complex plastic mixtures so that existing polymer chains are retained and therefore do not lose their production energy.

The recycled material recovered in this way meets the highest quality standards. The supplier ECKERLE has successfully used it to produce injection-molded components. The technology, which was developed at Fraunhofer IVV, offers significant energy savings over producing virgin materials and allows the industry to use more than five times the EU-stipulated amount of recycled plastic from old cars in the production of new ones. These developments are underpinned by Fraunhofer IVV by means of strategic collaborations in the Fraunhofer flagship project Waste4Future and the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE.

An innovative recycling process enables the reprocessing of complex plastic mixtures into high-purity recycled materials

The Carbon2Chem® pilot plant in Duisburg

WITH FUNDING

Carbon cycle for the basic chemical industry

Climate-friendly production and a circular economy even for the energy- and raw material-intensive basic chemical industry — that is the objective of the project Carbon2Chem® at the thyssenkrupp Steel Europe steelworks in Duisburg. A pilot facility was commissioned back in 2023 and has so far produced over 2000 liters of methanol. Researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT are developing a process to recover the smelting gases arising from steel production and make use of them. This would prevent the large quantities of harmful CO_2 emissions that currently result from burning those gases.

Since 2016, Fraunhofer UMSICHT, together with other partners in industry and science, has been conducting research into a solution that allows this CO_2 to be recovered and fed into the cycle. One of the target products is the basic chemical methanol, which is currently still obtained from fossil raw materials. By recovering the CO_2, the researchers are solving two problems at once: The climate gas stays out of the atmosphere and also forms the basis for more sustainable methanol production.

In the second phase of funding, which ran until 2024, the researchers demonstrated the robustness of their concepts for purifying industry gases and synthesizing various chemicals for the lime and cement industry and waste incineration plants. At a conference in the spring of 2024, a number of methods and tools were presented for developing and evaluating carbon capture and utilization (CCU) process concepts in a way that is tailored to specific industries and locations. The Carbon2Chem® project funded by the German Federal Ministry of Education and Research (BMBF) is coordinated jointly by Fraunhofer UMSICHT, thyssenkrupp AG and the Max Planck Institute for Chemical Energy Conversion.

Photos: Fraunhofer IVV, thyssenkrupp

Materials and Components

WITH INDUSTRY

Digitalization of wheel set testing for rail vehicles

Regular material tests are essential for safe rail transport. An important focus is rail vehicle wheel sets. Until now, such tests have largely been carried out by hand in small workshops, and the test results have not always been traceable. The Fraunhofer Institute for Nondestructive Testing IZFP has been working with Evident GmbH and RailMaint GmbH to develop PASAWIS (Phased Array Semi-Automated Wheelset Inspection System), a system of digital testing procedures for testing wheel set shafts, flanges and treads.

With three handheld scanners, PASAWIS makes it possible to carry out complete wheel set tests on shaft, flange and tread based on defined testing programs. The mobile system can be used in production, can be operated by just one person and comprises a phased array with custom software.

PASAWIS complies with the Europe-wide guideline issued by VPI European Rail Service GmbH for maintaining freight cars with non-destructive testing. The testing system also offers data storage, and is therefore traceable and transparent. Locally stored data can be transferred to central storage locations via interfaces. Parameters such as tester, test date, signal amplification or test ranges are documented in DICONDE (Digital Imaging and Communication for Non-Destructive Evaluation) format in line with the open ASTM E2633 14 US standard. The test results are saved automatically as custom test reports in PDF format and contain the graphic results for the individual wheel set as well as metadata such as the calibration date, device serial number, tester's name or workshop. The test report receives a secure digital signature, guaranteeing a high level of security.

WITH FUNDING

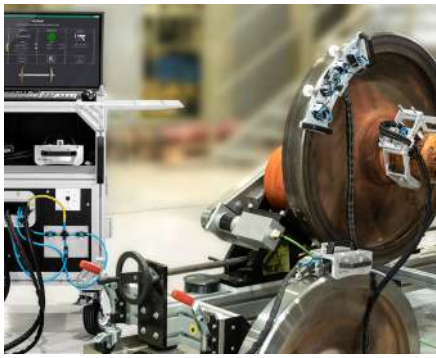
Material solutions — plant-based, not oil-based

The European Union has set itself the target of achieving a smart, digital and sustainable industrial economy. The European Green Deal contains an ambitious package of measures to create a sustainable green European economy with net zero emissions by 2050. This includes a transformation to bio-based raw materials. At present, the EU economy is heavily dependent on fossil fuels, but the prevalence of fossil raw materials in Europe is low.

The INN-PRESSME project (funded by HORIZON 2020) involves 27 partners from 9 EU countries and aims to find plant-based material solutions to replace oil-based ones. INN-PRESSME has a dual approach to supporting European businesses, particularly SMEs, in achieving the ambitious climate targets. Firstly, it is developing plant-based raw materials for new marketable, recyclable products. Secondly, it is creating digitalization instruments for businesses to model life cycle value chains. This data is the key to getting the maximum benefit from starting materials in the circular economy. It is also the key to ensuring that the higher production costs of producing bio-based raw materials pay off.

Within 4 years, the consortium of INN-PRESSME completed 9 test cases for pilot production in various sectors. Demonstrators made from bio-based materials for environmentally friendly packaging, energy, transport and consumer goods were manufactured on a pilot scale. In addition, an open innovation test bed (OITB) is supporting European businesses in manufacturing new marketable products and goods from bio-based materials. The project includes the Fraunhofer Institutes for Chemical Technology ICT and for Silicate Research ISC and is coordinated by the Finnish research organization VTT.

Wheel set testing is essential for safe rail transport. The PASAWIS system, with its handheld scanners, helps to achieve this



Bio-based particle foam, e.g., for environmentally friendly packaging

Photos: Fraunhofer ICT, EVIDENT / Roland Sander

Defense and Security

WITH PUBLIC-SECTOR CLIENTS

More security for major events in insecure times

Major events like the 2024 UEFA EURO are unfortunately no longer just a string of exciting matches but also a potential target of terrorist activity. Large gatherings of people are obviously at especially high risk of attack. In times of escalating wars and religious fanaticism, fears of terrorist violence ahead of the EURO were entirely reasonable. The fact that none of these fears were realized and that the tournament inspired millions is due in no small part to the committed cooperation of emergency personnel working to ensure security at the highest level. An important contribution came from developments by the Fraunhofer Institute for Transportation and Infrastructure Systems IVI in Dresden.

The operations management and communication technologies MobiKat®, MePol and the SE-Netz have been used in the everyday operations of authorities and organizations charged with security tasks for many years. They are developed continuously in close cooperation with users, and are also used by numerous authorities outside of Germany. Now for the first time, the SE-Netz has also successfully been used as a national standard for special police forces.

During the 2024 UEFA EURO, the Fraunhofer technology was used to secure matches and related events and in parallel everyday and major deployments. For example, the management of the fire department used MobiKat® to coordinate 1,000 fire department responders and 1,000 ambulance service responders on match days in Leipzig. Meanwhile, Saxony's police force coordinated the deployments of all inspection, patrol and protection services and of closed units using MePol, while the operations management of special units was done through the SE-Netz.

Various Fraunhofer technologies support emergency personnel at the 2024 UEFA EURO

A common mission: A total of 116 satellites financed the total cost of the rocket launch. ERNST is in one of the black satellite launchers in the middle of the image

WITH FUNDING

Small Fraunhofer satellite for detecting rocket launches

ERNST is a small satellite built at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI in Freiburg and funded by the German Armed Forces (Bundeswehr). Its mission is to test the performance of this class of satellites and demonstrate how rocket detection can be done from orbit.

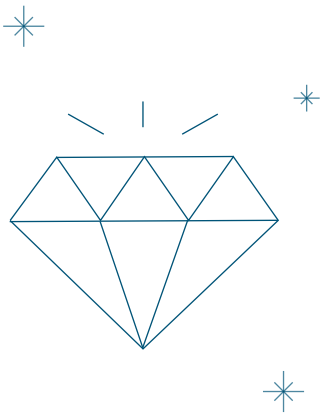
Launch and start-up are critical moments where the system needs to prove itself in space for the first time. Since its launch in August 2024, all its systems have been started up and tested. ERNST has passed these tests successfully. The X-band downlink for large data packets from the infrared camera to Earth also works correctly. With its high-resolution infrared camera, it records the surface of the Earth and follows objects it identifies by means of camera panning. As an experimental satellite, it trials early rocket warning methods and technologies that could be used in future operational European satellite constellations.

ERNST was set to identify its first rocket in January 2025. SpaceX's Transporter-12 mission was in ERNST's flyover window. However, the launch of the civilian rocket on January 14 was delayed by a few minutes, so ERNST ended up above the Vandenberg launch site in California too soon and just missed it. It would have been a real win: The rocket was carrying Sky Bee-1, the first satellite made by the Fraunhofer EMI spin-off constellr, which also contained components developed by ERNST workers.

For now, ERNST is training its detection systems by observing gas flares from crude oil extraction. The heat from these is similar to that of rocket exhaust jets. In the process, the team is testing the target tracking system and the infrared signal in different wavelength ranges against the background of the Earth. The team of scientists at Fraunhofer EMI is ready and waiting to take on the real objective: rocket detection.

Photos: alamy/Powerpics, SpaceX

Awards



Fraunhofer science prizes 2024

Stifterverband Science Prize
Stifterverband is made up of around 3,000 companies, business associations, foundations and private individuals that have come together to drive progress in science and education.For more than 15 years, Stifterverband and Fraunhofer have been awarding this prize, which is worth €50,000, on a biennial basis. This recognizes joint applied research projects of particular scientific excellence that have been developed by Fraunhofer institutes in collaboration with industry and/or other research organizations.

Joseph von Fraunhofer Prize
Since 1978, the Fraunhofer-Gesellschaft has awarded the Joseph von Fraunhofer Prize annually to its employees for outstanding scientific achievements that solve practical problems. Criteria for awarding the prize include how new and innovative the scientific-methodical approach is, the advancement of knowledge, and the implementation of the scientific results in applications. Three Joseph von Fraunhofer Prizes were awarded in 2024, each one with €50,000 in prize money.

Hugo Geiger Prize
The Bavarian Ministry of Economic Affairs, Regional Development and Energy awards the Hugo Geiger Prize for outstanding doctoral theses written in collaboration with Fraunhofer institutes. The award is named after the Bavarian secretary of state Hugo Geiger, who sponsored the inaugural assembly of the Fraunhofer-Gesellschaft on March 26, 1949.

Fraunhofer Founder Award
The High-Tech Gründerfonds and the Fraunhofer-Gesellschaft have awarded the Fraunhofer Founder Award, worth €50,000, every year since 2016. The award goes to a successful spin-off that generates direct benefits for society through its products and services. The High-Tech Gründerfonds was started in 2005 by representatives of the German Federal Ministry for Economic Affairs, the industrial sector and industry experts.

Fraunhofer Alumni Award
Since 2020, Fraunhofer-Alumni e. V. has supported research projects addressing social issues. The prize of €10,000 is awarded every two years. The prize money is funded by Fraunhofer-Alumni e. V. members' dues.

Stifterverband Science Prize 2024

DNA evidence for sepsis diagnosis

Pathogen identification — optimized diagnostics thanks to next-generation sequencing
In the fight against sepsis, one of the most common causes of death in Germany, the sepsis-triggering pathogen needs to be identified as quickly as possible. Kai Sohn, Department Head for In-Vitro Diagnostics at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, and his partners, Thorsten Brenner from University Hospital Essen and Silke Grumaz and Philip Stevens from Noscendo GmbH, have developed an entirely new detection process to detect, with a high degree of sensitivity, tiny traces of DNA left by the pathogen in the blood.

This approach can establish the pathogen causing the infection in the blood of up to 70 percent of patients examined. Conventional sepsis diagnosis with blood cultures gives a positive result in less than 30 percent of cases. Now approved for use by Germany's statutory health insurers, it is already making it significantly easier to deliver targeted care to these patients. The jury's rationale for the award emphasizes the "significance of forming an alliance encompassing Fraunhofer research, the university hospital, and commercial implementation."

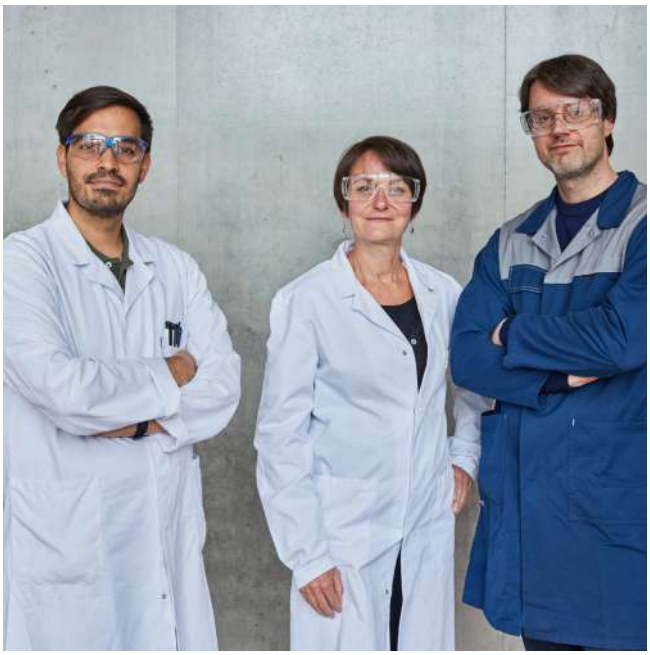
Kai Sohn, In-Vitro Diagnostics at Fraunhofer IGB, and Silke Grumaz, Noscendo GmbH

Joseph von Fraunhofer Prize 2024

Polylactide for single-use plastic film packaging

Bio-based plastics — sustainable plastic film material made from PLA bioplastic
André Gomoll, Benjamín Rodríguez and Antje Lieske from the Fraunhofer Institute for Applied Polymer Research IAP have succeeded in developing a bio-based, flexible and recyclable material for film applications that also permits commercialization by medium-sized companies. The biopolyester, called polylactide (PLA), is bio-based and biodegradable and can be chemically recycled into new products with relatively little use of energy. Because PLA is very brittle in its conventional form, it was not previously suitable for the production of flexible disposable packaging items such as shopping bags or garbage bags, which are among the main sources of single-use plastic waste. It was also not profitable to produce it outside of large-scale plants in continuous operation.

Aspects praised by the jury include the fact that the research team "has achieved the same properties as the polyethylene used so far through the development of the material via block copolymers and demonstrated the feasibility of implementation in a pilot plant together with an industrial partner, which shows great commercial potential."



Benjamín Rodríguez (left), Antje Lieske and André Gomoll from the Polymer Synthesis department at Fraunhofer IAP

Joseph von Fraunhofer Prize 2024

Self-adapting numerical point clouds

Simulation methods — saving time in mapping complex processes

From the automotive sector to production, simulations and digital twins are a must for many companies. However, highly dynamic processes such as those involved in hydroplaning, Pelton turbines, or machining of metal are often not reproduced satisfactorily by conventional software. The team headed by Jörg Kuhnert and his colleague Isabel Michel at the Fraunhofer Institute for Industrial Mathematics ITWM has devised a solution that closes these gaps: the mesh-free simulation tool MESHFREE. The software combines the generalized finite difference method (GFDM), which it uses to solve the conservation equations of mass, momentum and energy, with efficient algorithms for solving linear systems of equations — a feature found nowhere else in the world. The cloud of numerical points that is used can adapt flexibly to moving geometries. This eliminates the need for laborious subsequent corrections in the computational mesh. The jury highlights "the continuous development of the technology and adaptation to various industrially relevant issues" as "exemplary."

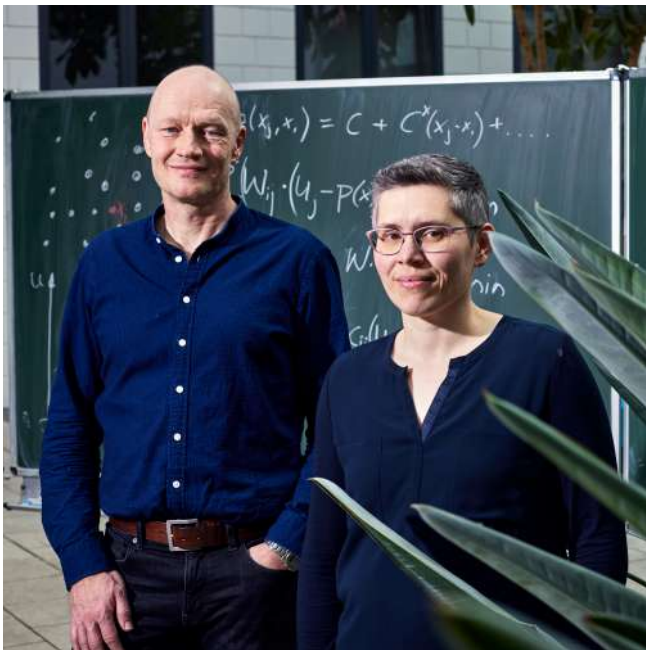
Joseph von Fraunhofer Prize 2024

PV modules with 3D photonic structures

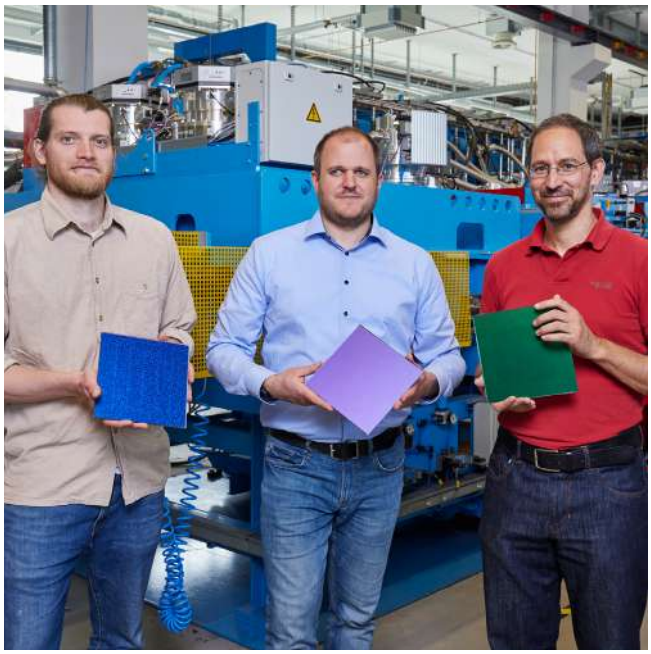
Solar energy — highly efficient colored photovoltaic modules for buildings

The energy transition is creating a high global demand for photovoltaic modules. Integrating them into buildings in an aesthetically pleasing way without decreasing their power output has, however, been a major challenge for researchers. Taking inspiration from the 3D photonic structures on a morpho butterfly's shimmering blue wings, Oliver Höhn, Thomas Kroyer and Andreas Wessels at the Fraunhofer Institute for Solar Energy Systems ISE have developed colored solar panels that can be incorporated into a building's exterior practically invisibly while maintaining very high efficiency.

Featuring high transparency and color saturation, the MorphoColor® technology they have developed is far superior to all comparable technologies available on the market and can also be manufactured industrially at low cost. The jury found this technology impressive for various reasons, including "the scientific achievement, the expanded range of possibilities, even extending to protected historical spaces, and the high efficiency of these solar modules."



Jörg Kuhnert and Isabel Michel from the Transport Processes department, Fraunhofer ITWM



From left: Andreas Wessels, Dr. Oliver Höhn and Thomas Kroyer, Fraunhofer ISE, creators of the MorphoColor®

Photos: Piotr Banczerowski

Hugo Geiger Prize 2024 | First place

Thermoformable plastic alternative made from cellulose

A plastic made from plant cellulose that is both biodegradable and thermoformable — as part of her doctoral studies, Kerstin Müller from the Fraunhofer Institute for Process Engineering and Packaging IVV developed a physical approach to develop just such a plastic, and optimized that approach into an industrial process. She used compatible polylactic acid molecules as spacers to create more space and flexibility between the narrow, long-chain cellulose molecules derived from wood, cotton or other plants. The completely bio-based material is highly versatile.

Hugo Geiger Prize 2024 | Second place

Slurry-based 3D-printing of ceramic casting cores

As part of her doctoral work, Patricia Erhard from the Fraunhofer Institute for Casting, Composite and Processing Technology IGCV has developed a process for 3D-printing casting cores. Instead of dry sand, she used a liquid ceramic suspension that is applied in layers, dried and printed with binders. This process produces intricate, high-strength casting cores with precisely engineered cooling channels that direct waste heat from high-performance cast components directly to the point of origin. This property can be used to make more efficient electric motors, for example.

Hugo Geiger Prize 2024 | Third place

More efficient high-performance fiber lasers and laser diodes

With her doctorate, Sarah Klein from the Fraunhofer Institute for Laser Technology ILT has paved the way for the further development of industrially relevant high-performance fiber lasers and laser diodes. She used fiber Bragg gratings to incorporate resonator mirrors for the fiber lasers, which amplify the radiation, directly into the fibers. This simplifies the assembly of the lasers and increases their robustness and brilliance, opening a path for more efficient fiber and diode lasers that can be used in a greater range of industrial applications and could contribute to laser-based inertial fusion, for example.

Kerstin Müller, Fraunhofer IVV

Patricia Erhard, Fraunhofer IGCV

Sarah Klein, Fraunhofer ILT

Fraunhofer Founder Award 2024

The award for the best Fraunhofer spin-off in 2024 went to Fusion Bionic. Its bio-inspired laser textures are well suited to many sectors, including the automotive, aeronautical engineering and medical engineering sectors. The spin-off from the Fraunhofer Institute for Material and Beam Technology IWS and TUD Dresden University of Technology is inspired by natural surfaces like lotus leaves, shark skin or the morpho butterfly, giving it properties such as self-cleaning, anti-icing, antibacterial and drag reduction features. The Founder Award is awarded by Fraunhofer Venture and the High-Tech Gründerfonds to fund outstanding Fraunhofer spin-offs.

Fraunhofer Alumni Award 2024

The winner of the Fraunhofer Alumni Award in 2024 was a process for digitalizing health data for innovative billing systems in sub-Saharan Africa. Its objective is to use AI, image processing and letter recognition to digitize handwritten medical documents. This optimizes billing for healthcare services, which is a prerequisite for insurance services. A team from the Fraunhofer Institute for Industrial Mathematics ITWM is collaborating on this process with the social enterprise mTOMADY GmbH in Madagascar. The project is set to be brought to other regions and is receiving funding from the Fraunhofer Future Foundation.

An outstanding solution to strengthen the healthcare system in the sub-Saharan region. From left: Henrike Stephani, Florian Trefz and Jörg Wenzel, Fraunhofer ITWM

Photos: Fraunhofer IVV, Fraunhofer IGCV, Fraunhofer ILT / Ralf Baumgarten, Fraunhofer-Alumni e. V. / Martin Schindler

From left: German Federal President Frank-Walter Steinmeier, Minister of State Markus Blume, Norwin von Malm and Stefan Grötsch (ams OSRAM), Hermann Oppermann (Fraunhofer IZM) and Holger Hanselka, President of the Fraunhofer-Gesellschaft

Eric Bodden, Fraunhofer IEM

Research awards — national and international

GERMAN FUTURE PRIZE — FEDERAL PRESIDENT'S AWARD FOR TECHNOLOGY AND INNOVATION

Digital light concept

The German Future Prize was awarded to a team from ams OSRAM and the Fraunhofer Institute for Reliability and Microintegration IZM for their digital light concept based on the example of a smart car headlight. Norwin von Malm and Stefan Grötsch of ams OSRAM and Hermann Oppermann of Fraunhofer IZM have technologically implemented the idea of an LED matrix that can turn a car headlight into a projector. More than just car headlights, the technology also lends itself to many new smart applications.

The new headlight source combines 25,600 light sources in an LED light matrix composed of 320 × 80 points of light. Each LED can be individually controlled digitally. To achieve this, a matrix containing the necessary electronic circuitry is positioned precisely below the LED matrix and then connected right down to the pixel level. In combination with a special lens, this creates a headlight that works much like a video projector. Areas requiring brighter light are targeted precisely; others, such as oncoming vehicles, are left dark. In addition to its lighting function, the innovative headlight can also project warning pictograms onto the road. The innovation of creating digital light using smart LED technology could also enable optical data communication between computer chips, for example in data centers for AI applications or in augmented reality (AR): Here, the light matrix could be used as a virtual monitor for AR glasses, where digital information is displayed in the user's field of vision in addition to the real-world environment. Highly innovative jobs have already been created at ams OSRAM and in companies throughout the value chain.

ERC ADVANCED GRANT

Self-optimizing, secure software systems

For his research into secure software systems, Eric Bodden, Director of the Fraunhofer Institute for Mechatronic Systems Design IEM, is receiving an ERC Advanced Grant of €2.5 million from the European Research Council (ERC). The ERC grants are some of the most significant awards in European research funding. Bodden has long been conducting research into software tools to detect security vulnerabilities in software automatically. From the point of view of software developers, these need to be improved in terms of the reliability of warnings or duration.

With his Self-Optimizing Static Program Analysis project, he intends to bring the research to a new level: Future analytics tools will not only analyze the affected programs but also their own execution, and will continuously optimize it on their own. By doing this, they will optimize themselves for the needs of their particular usage context. This will avoid false alarms and other problems. The high degree of automation means that software engineers will no longer need to make the necessary adjustments themselves, which will save critical

Photos: Deutscher Zukunftspreis, Fraunhofer IEM

Marion A. Weissenberger-Eibl received the Rudolf Diesel Medal

Alexander Schott (left), German Federal Ministry of Defence, Karin Stein and Bryan Wells, NATO

In the presence of Minister-President Hendrik Wüst (left) and Minister for Economic Affairs, Industry, Climate Action and Energy Mona Neubaur, Manfred Renner received the Innovation Award NRW

personnel resources. Bodden wants to help secure the millions of software systems that society has learned to depend on. The project also offers a more cost-effective way for companies to implement the requirements of the Cyber Resilience Act (CRA) adopted by the EU in 2024 in response to increasing cyberattacks.

RUDOLF DIESEL MEDAL 2024

Best innovation promotion

Marion A. Weissenberger-Eibl, Director of the Fraunhofer Institute for Systems and Innovation Research ISI and holder of the Chair for Innovation and Technology Management (iTM) at the Karlsruhe Institute of Technology, was presented with the Rudolf Diesel Medal in the best innovation promotion category. The Rudolf Diesel Medal has been awarded since 1953 and is Europe's oldest innovation award. Weissenberger-Eibl's research work covers the full spectrum of innovation management, technology and knowledge management. Her memberships of the supervisory boards of Heidelberg Materials AG, MTU Aero Engines AG and Semperit AG Holding are also part of her role as a bridge-builder between science and industry. The Diesel Medal celebrates people and businesses that have made a significant contribution to increasing quality of life and prosperity and maintaining the culture of innovation in Germany.

NATO VON KÁRMÁN MEDAL

Between defense research and technology

Karin Stein, Department Head for Signatorics at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB, is the first woman to be presented with the Von Kármán Medal by NATO. This is the most prestigious honor bestowed by the defense alliance's Science and Technology Organization (STO). It is a recognition of Karin Stein's more than 30 years of research and leadership in the field of defense research, her extraordinary scientific contributions to NATO and her life's work. Stein has held positions including that of panel chair for system concepts and integration at the STO, and she has been the panel speaker for camouflage, concealment and deception (CCD) since 2013. The award certificate also highlights Stein's contributions as a mentor, an innovative researcher and a bridge-builder between military end users and technical professionals.

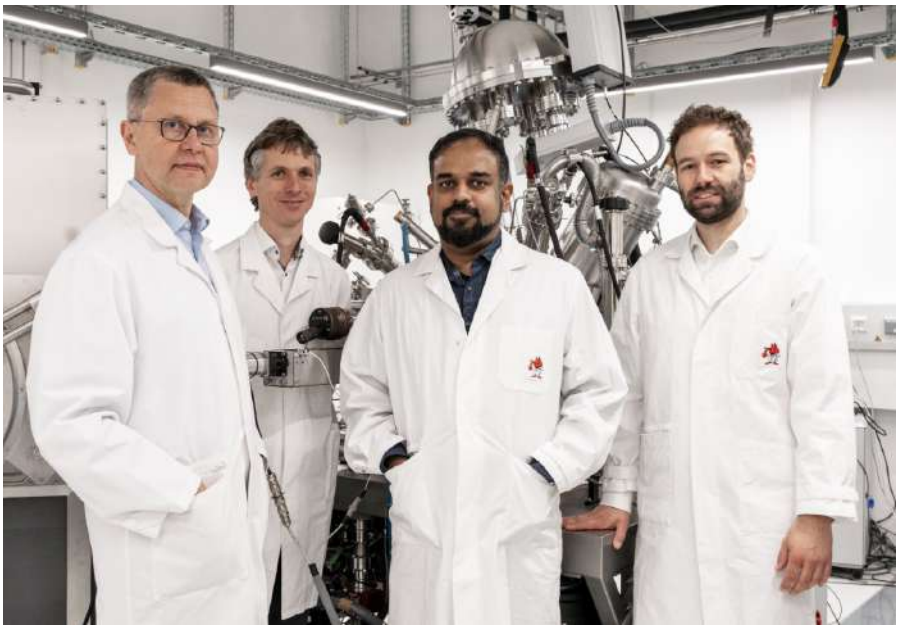
The Von Kármán Medal celebrates individuals who have dedicated their lives to international cooperation on science and technology (S&T) in NATO. The award is generally presented every year.

INNOVATION AWARD NRW

Sustainable aerogels for the mass market

Manfred Renner, Director of the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT, received the Innovation Award NRW in the innovation category. The award, which is worth €100,000, was in recognition of an innovative and mass-marketable production process for aerogels. Aerogels can be used as high-performance insulators. Until now, however, they have been very cost-intensive to produce and have therefore mainly been limited to niche applications.

Photos: Eichmeister-Kreativagentur, Fraunhofer IOSB, MWIKE NRW / S. Kurz



From left: Andrey Turchanin, Falk Eilenberger, Antony George and Christof Neumann

Andreas Körtge (left) and Reinhard Meyer, Minister of Economics, Infrastructure, Tourism and Labour of Mecklenburg-Western Pomerania

In just six years, the researchers at Fraunhofer UMSICHT have developed an innovative production process for aerogels that uses compressed CO_2 to combine several production steps and significantly reduce production costs: Manufacturing costs were reduced by 70 percent, and production time dropped from over ten hours down to four. Because the process is completely free from environmentally hazardous chemicals, it is also sustainable. The research team is now preparing to scale it up to an industrial level.

THURINGIAN RESEARCH PRIZE

Customized 2D materials for semiconductors

For their research into and scaling of an industrial manufacturing process for customized 2D materials, Andrey Turchanin, Antony George, Christof Neumann (University of Jena) and Falk Eilenberger (Fraunhofer Institute for Applied Optics and Precision Engineering IOF) were awarded the Thuringian Research Prize in the applied research category. The prize is worth €25,000.

The team investigated, characterized and produced nanomaterials with a particular focus on transition-metal dichalcogenides (TMDs). As a 2D material, these become direct semiconductors that can efficiently convert electricity into light and vice versa. This makes it possible to manufacture extremely small and powerful electronic, photonic and optoelectronic components. These 2D TMDs can be combined seamlessly with existing semiconductors, for example to perform some of the tasks of conventional computer chips photonically, thereby saving energy. As well as this, 2D materials are also well suited to applications in data transfer, camera technology and lighting systems. The research team performed the first industry-compatible manufacturing of customized 2D materials by vapor deposition, which grows the crystal as a nanometer-thin layer on a silicon or glass plate.

The 2D materials they studied represent a new class consisting of anywhere from just one to a few atomic layers that are hundreds of thousands of times thinner than a single hair, stronger than steel and efficient converters between light and electricity. The behavior of customized 2D materials is drastically different from that of the three-dimensional starting materials.

IDEAS COMPETITION FOR THE HEALTHCARE SECTOR

Testing laboratory for medical dialysis technology

At the ideas competition Innovative Ideas for the Healthcare Sector in Mecklenburg-Vorpommern, a Fraunhofer project succeeded in becoming one of the seven winning teams. The Rostock-based Extracorporeal Therapy Systems department of the Fraunhofer Institute for Cell Therapy and Immunology IZI applied to the competition with a marketing and innovation strategy for its testing laboratory for medical devices. The ASSESS-MED testing laboratory set up in Rostock assesses equipment, particularly dialysis equipment, hemofilters and adsorbers, regardless of their manufacturer and in accordance with standards such as DIN EN ISO 8637-1 to support a more rapid transfer of new technologies to market. The researchers' win will allow them to develop their marketing and innovation strategy so that it too can be used to support a more rapid transfer of new technologies to market.

Photos: Nicole Nerger / University of Jena, BioCon Valley® GmbH / Danny Gohlke

Left: Juliane Borchert

Right: Anton Windfelder with a tobacco hawk moth

Presentation of the CELTIC-NEXT Innovation Award 2024 at the 6G Conference in Berlin

HERTHA SPONER PRIZE

Silicon solar cells with perovskite

The German Physical Society (DPG) awards the Hertha Sponer Prize every year to one female scientist for excellent scientific work in the field of physics. The prize is named after the German physicist Hertha Sponer (1895–1968), who made important contributions to molecular physics and spectroscopy. The public award is aimed at attracting more women to physics, especially younger women scientists.

In 2024, it was awarded to Juliane Borchert in recognition of her excellent work on an innovative type of solar cell. Her research is on perovskites and their use in solar cells, especially as a tandem material in perovskite silicon solar cells. Her innovative approach of combining vapor deposition and photoluminescence allows the perovskite layers in innovative tandem solar cells to be precisely optimized. Since July 2022, she has headed a research group at the Institute for Sustainable Systems Engineering — INATECH at the University of Freiburg and the Fraunhofer Institute for Solar Energy Systems ISE.

INNOVATION AWARD FROM CELTIC-NEXT

Software for highly automated vehicles

The industry-led funded project AI-NET (Accelerating Digital Transformation in Europe by Intelligent NETwork Automation) encompasses communication networks and technologies for 5G and, in the future, 6G, near-user data centers and artificial intelligence (AI). Researchers from seven European countries are working on innovative solutions to automate optical communication networks. AI-NET has been presented with the CELTIC-NEXT Innovation Award 2024 for its outstanding developments and performance indicators in the past four years.

The Smart Mobility department of the Fraunhofer Institute for Open Communication Systems FOKUS has developed the software solution COOL-Fusor in a subproject for automated driving. It improves the AI-based environmental perception of automated and, in particular, remotely operated vehicles by integrating LIDAR data from surrounding vehicles into the highly automated vehicle using 5G and, in the future, 6G. The main challenges were latency, jitter, data volume and scalability. The software was evaluated using the open simulation environment Eclipse MOSAIC developed by Fraunhofer FOKUS. The AI-NET consortium was made up of over 30 partners in industry and research from Germany, Finland and France. It was funded by the German federal ministry of research, Business Finland and bpi France. AI-NET is a project within CELTIC-NEXT, an ICT cluster in the eureka network.

YOUNG INVESTIGATOR AWARD 2024

New approaches to bowel diseases

Anton Windfelder from the Fraunhofer Institute for Molecular Biology and Applied Ecology IME and Justus Liebig University Giessen received the Young Investigator Award 2024 from the German X-Ray Society (DRG) for his innovations in experimental medical imaging. As a junior research group leader for multimodal preclinical imaging, he works on, among other

Photos: Fraunhofer ISE, Pia Winfelder, Projekt AI-NET

Jochen Friedrich (left) and Andreas Erb

Michael ten Hompel with the City of Dortmund Dialogue Prize

things, high-resolution micro-CT imaging to visualize the complex anatomical structures inside insects like the tobacco hawk moth (Manduca sexta). This research has led to the discovery of new anatomical structures in the insect's intestinal tract and offers valuable insights into its digestive system, some aspects of which are comparable to human intestines. These findings are helping to develop new approaches for the treatment and diagnosis of chronic inflammatory bowel diseases. His research is a unique combination of disciplines such as radiology, gastroenterology and immunology with conventional zoology, entomology and evolutionary biology. The award speech praised Windfelder's work for opening up a new model for testing new contrast agents and tracers.

GERMAN ASSOCIATION FOR CRYSTAL GROWTH PRIZE

Crystal growth for semiconductors

The Deutsche Gesellschaft für Kristallwachstum und Kristallzüchtung e. V. (DGKK, German association for crystal growth) rewarded Jochen Friedrich, Department Head for Materials at the Fraunhofer Institute for Integrated Systems and Device Technology IISB, for his outstanding scientific and technical work on crystal growth and epitaxy and his public engagement in these areas. It highlighted Friedrich's scientific achievements in applied research and development for the semiconductor industry, such as the transfer of the vertical gradient freeze process for the industrial manufacture of the optical material calcium fluoride (CaF_2) or the numerical modeling of Czochralski growth for the mass production of silicon, which were advanced by Friedrich. The CrysMAS software package for simulating crystal growth processes and equipment, which was developed in his department at Fraunhofer IISB, is licensed worldwide. Jochen Friedrich also has a strong personal motivation to make crystal growth accessible to the general public. With regular initiatives such as crystal growth competitions, project weeks in schools, exhibitions and posters, he inspires schoolchildren, young adults and others besides to take an interest in materials research.

CITY OF DORTMUND DIALOGUE PRIZE

Useful application of AI in science and industry

For their contribution to the structural transformation and innovative strength of the City of Dortmund, the Fraunhofer Institute for Material Flow and Logistics IML and its former institute director Michael ten Hompel received the Dortmund Dialogue Prize in early 2024. The Gesellschaft zur Förderung des Strukturwandels in der Arbeitsgesellschaft e. V. (GFS, association for the promotion of structural transformation in working society) celebrated ten Hompel's active and communicative contribution to Dortmund's urban society in particular. It highlighted the role of Fraunhofer IML, one of the first and most important research institutions in the Dortmund Technology Park and, as such, a significant shaper of the city's science and business landscape, especially thanks to its many years of experience in the useful application of artificial intelligence (AI). This has made it possible to deal responsibly with this technology in science, business and society, the jury said.

Photos: Fraunhofer IISB / Elisabeth Iglhaut, Fraunhofer IML / Sebastian Beierle

People in research

With their outstanding research, the Fraunhofer institutes make an important contribution to securing Germany's future as a hub of economic activity. This is thanks to their employees, who are characterized in particular by their enthusiasm and expertise. To represent them, six researchers are presented here.






Top: Prof. Dr.-Ing. Manfred Renner (left), Prof. Dr. Julia Arlinghaus, Dr. Medhi Ali

Below: Amelie Reigl (left), Dr. Michael Richter, Prof. Dr. Iryna Gurevych

“The reshaping of our economy requires the cooperation of all participants.”

Prof. Dr. Ing. Manfred Renner

Photo: Fraunhofer UMSICHT / Mike Henning, background: Getty Images

Prof. Dr.-Ing. Manfred Renner

Director of the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen | Chair for Responsible Process Engineering at Ruhr University Bochum | Spokesperson for the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE

Pioneering the way in a sustainable world — that is how the researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT see themselves. "We want an Earth worth living on. An Earth where nature and civilization are not mutually exclusive. That is why the sustainable energy and raw materials transition is at the center of our work," says the Oberhausen-based institute on its website. That is where Manfred Renner, doctor of mechanical and process engineering, has worked since 2007.

From plastics expert to circular economy advisor

Renner, who is a specialist in material development and process engineering, went from being a plastics expert to circular economy advisor to the German federal government. This was helped by a number of factors: Renner's interest in how businesses and the economy work, his participation in the European Circular Plastics Alliance and, above all, his leadership of the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE with the pooled expertise of 6 Fraunhofer institutes. "If a spokesperson for several institutes recommends one technology from a wide portfolio, their credibility is much greater than if all I can do is offer solutions from my own organization." Expertise and credibility led Renner to the position of advisor to the German federal minister for the environment on the National Circular Economy Strategy (NKWS). In 2023, he represented the Fraunhofer-Gesellschaft in the German chancellor's transformation alliance on the circular economy for the battery and construction sector. Renner describes his mission like this: "This planet's resources are finite. There can only be one reasonable solution to the resource question: meaningfully reusing all the raw materials that have already been extracted and the materials that have already been produced as much as we possibly can." If the throwaway society had continued the way it was going, 400 billion metric tons would have needed to be extracted in 50 years to meet an economic growth target of 3 percent.

New business models to replace the throwaway society

What could it look like to transform to a circular economic system while also transforming the energy system? The engineer illustrates this using a drill as an example: "In most households, it sits in the basement for 364 days, 23 hours and 57 minutes a year without being used." The transformation is about integrating new competitive business models into the economy. Possible solutions could involve participation rather than ownership, or added value promises that rely on high product quality rather than on obsolescence. For example, a washing machine could be linked to a value promise — without the risk of having to buy a new machine in four years and throwing the whole thing away. The key concept here is that of product service systems. Also, as Renner knows: "We've never made it through such a sweeping change to the economic system before without having brutal events like wars. To achieve this transformation, all those involved need to work together; above all, society needs to be and remain convinced."

The engineer would have loved to do a second degree in economics, but instead he learned on the job. After completing the Fraunhofer training program in business management, Renner became strongly committed to developing the program further. As a result, its participants can now develop transfer initiatives for research projects at their own institutes. At Ruhr University Bochum, Renner's lecture on business development has been well established for 8 years, and in that time he has also enshrined those principles systematically at Fraunhofer UMSICHT. Renner plans to use the University Alliance Ruhr to incorporate more knowledge of economics into his professorship and the Fraunhofer institute. As a holder of several patents, including ones for environmentally friendly leather tanning and for low-cost aerogel production for use in building insulation, Manfred Renner is convinced: "In today's troubled times, when we have a lot of work ahead of us and Germany's economic situation is under strain, license-fee revenue is the best option to give a Fraunhofer institute the necessary financial space for innovation."

Prof. Dr. oec. Julia Arlinghaus

Industrial engineer | Director of the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg | Chair for Production Systems and Automation at the Otto von Guericke University Magdeburg | Chair of the Scientific Commission of the German Science and Humanities Council

What drives Julia Arlinghaus? "Securing prosperity in Germany," she says. That requires good industrial jobs, and she is laying the foundations for those at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg. Five years ago, she arrived there as institute director with her mission to boost value creation in Germany and Saxony-Anhalt. Her focus today is on maintaining this standard: "Because of the recent crises and the current global trade situation, some industries are fighting significantly harder than expected. That's why we as an industrialized society need to change much more quickly."

Arlinghaus is one of the leading experts in the digital transformation of industry and has been a member of the German Science and Humanities Council since 2021. With the evaluation committee, she heads a panel on the council that audits the government research institutions of the German federal ministries. The German Science and Humanities Council advises the federal and state governments on matters relating to the substantial and structural development of science, research and the university sector. In February 2024, she was appointed chair of the council's scientific commission: "Even I was surprised to find I could get excited about science policy. But it's fun to see how well everything fits together: In my professorship, I do basic research; at the institute, I think in economic terms and work on transfer; and in science policy, we create the framework for all that."

Success with transparency

She is responsible for around 200 employees at Fraunhofer IFF and deals with making new work, resilience and transparency more than just buzzwords: "My focus is on modern and employee-oriented leadership. That involves personal coaching and individual career support." When putting together her project teams, she pays attention to interdisciplinarity, bringing in scientists with backgrounds in teaching, social science or psychology. Their multiple perspectives produce solutions that work not just technically, but for all participants in the project. This is well received by customers.

The human factor plays an important role in her scientific work too: For example, she is conducting research into how cooperation between humans and machines in production processes can be improved, or how the human perspective can be taken into account when designing production planning and control systems. "We need to work to provide people with targeted support through technology," the scientist says. "The aim is to work better together across businesses, create transparency and share resources." Sharing data is an indispensable part of this, she says.

Microchips from Europe

That is exactly what the Semiconductor-X project is about: With Fraunhofer IFF and Intel Germany leading the consortium, more than 20 partners from the semiconductor and component supply industry have come together to make the complex supply chains in this area more sustainable and resilient. Achieving this will require a decentralized and sovereign exchange of data, made possible by an interdisciplinary ecosystem. At present, around 80 percent of chips are currently produced in Asia. The European Chips Act aims to change this: €43 billion is being made available to promote domestic microchip production and make the European market more resilient.

The announcement that Intel is having to postpone the planned construction of a chip plant in Magdeburg for the time being has significantly dampened the spirit of optimism in the region. Arlinghaus, however, remains positive: "I don't think the east is being left behind. On the contrary, there is potential here for transformation and an openness to host large companies. We at Fraunhofer IFF want to help keep this dynamic atmosphere going." Many of the Industry 4.0 projects demonstrated how much potential exists throughout Germany as a business location, whether in productivity growth or in digital twins of supply chains. "Now it's about turning these beacon projects into a sea of light," says Arlinghaus.

“We need to work to provide people with targeted support through technology.”

Prof. Dr. oec. Julia Arlinghaus

Photo: Fraunhofer IFF / Viktoria Kühne, background: Getty Images

“We need big investments and computing power in AI. That’s the only way Germany can take the next step and continue to be an important player.”

Dr. Mehdi Ali

Photo: Fraunhofer IAIS / Sven Döring, background: Getty Images

Dr. Mehdi Ali

Computer Science M.Sc. | Research & Tech Lead at the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Sankt Augustin | Innovation Group Leader on Foundation Model Research at the Lamarr Institute for Machine Learning and Artificial Intelligence

Anyone who meets Mehdi Ali quickly notices two things: He takes joy in his work and he radiates the optimism of someone who knows he can make a difference. Ali is one of very few AI experts in Germany who have made a name for themselves internationally. His work is published in international journals and he is in demand as a speaker at conferences, such as the Falling Walls Science Summit. As head of the Foundation Model Research innovation group at Fraunhofer IAIS, he works on training large language models. He and his team have worked on international projects such as OpenGPT-X. Creative collaboration on the team is a must here because progress in AI research today can only be achieved together — Mehdi is convinced of it.

AI promotes fairness and education

The researcher is first and foremost interested in making production and business processes faster or more efficient. In this area, even the economic experts are putting their hopes in AI. Mehdi Ali, though, sees potential applications in other areas too. AI could also help with the shortage of skilled workers, for example by relieving the administrative burden on workers with its potential for automation and opening up new capacity. In the area of education too, Ali sees great potential. "Children from financially disadvantaged households could get easier access to educational content through AI. That would be an important contribution to fairness and equal opportunities in our society."

Fairness, equal opportunities, teamwork — those are words that Mehdi Ali uses often. There is one project that is particularly close to his heart at the moment, and it deals with multilingualism. The objective of EuroLingua-GPT is to develop large language models for 37 European languages to address Europe's linguistic diversity, thereby supporting connected applications.

What Germany needs

What's next for AI in Germany? "We need big investments and computing power. That's the only way Germany can take the next step and continue to be an important player," Ali emphasizes. He sees Fraunhofer as bearing part of the responsibility for this too. He is working with the best experts in Europe. "Through projects like OpenGPT-X and TrustLLM, we are participating in national and international initiatives that are having a big effect. By getting involved in those kinds of key projects, we at Fraunhofer are helping Germany to stay in the game when it comes to this disruptive technology." Germany's chances look good as there is no shortage of know-how, motivation or experts.

Mehdi Ali has been at Fraunhofer for nearly ten years. He started as an intern while studying computer science. His fascination with AI in all its forms and facets has been a running theme since the start. He is fascinated by the subject of intelligence itself: "Anyone who works with AI also works with themselves. We try to understand intelligence better and find out how it works." That is perhaps also the reason why Mehdi Ali's joy is not dampened by the unavoidable stress of so many projects, a calendar full of online meetings, or all the business trips and conferences. Quite the opposite: "Challenging work is what drives me. I get to work with the best people in Europe every day to advance AI research and create the conditions for transferring it to business and society. That's an amazing job to have; it gives me positive energy and does me good."

Amelie Reigl

Biologist | Project manager at the Translational Center for Regenerative Therapies TLC-RT of the Fraunhofer Institute for Silicate Research ISC in Würzburg | Co-founder of TigerShark Science | @dieWissenschaftlerin

Amelie Reigl's research is focused on tissue engineering. In her doctoral thesis, she developed an in-vitro skin model with blood vessels to investigate one of the pathogens (T. brucei) that can trigger narcolepsy. In 2023, she completed her thesis in Bali, a process that was followed by the majority of her 400,000 or so followers on TikTok, Instagram and LinkedIn. Her posts from the world of science sometimes also provide a good starting point for her customer meetings in the pharmaceutical and cosmetics industry. "It's important to me to make my work fun," says Reigl. This is not her only job — in 2024, she is on three career paths at once: her doctorate in biology, her position at the Fraunhofer Institute for Silicate Research ISC and its Translational Center for Regenerative Therapies TLC-RT, and her role as project manager in the planned spin-off TigerShark Science. She also works as an influencer who wants to bring research and science closer to the general public — especially girls and women.

On three career paths at once

Science communications became an important cause for Reigl in 2020, when the COVID-19 pandemic forced her to work from home. "What does a biologist do without a lab?" she asked herself — her answer was to start a scientific consultancy as @dieWissenschaftlerin. Since then, she has built up a social media team that enables her to carry on her careers as both a researcher and a start-up founder at the same time. Her project, TigerShark, received EXIST funding of €1.3 million in 2024. This is helping Reigl and her funders and future co-founders, Dieter Groneberg and Florian Groeber-Becker of the TLC-RT, to build a spin-off that aims to bring human skin models with a never-before-seen level of complexity to the market. Why did the team choose the name TigerShark Science? "The tiger represents strength and precision, while the shark embodies adaptability and efficiency — characteristics that symbolize our mission to develop groundbreaking scientific solutions," explains Reigl. She has essentially made her passion into a career. She was interested in science even as a child, and she often used to build and make things with her father, Riegl says.

Since 2015, she has been growing innovative skin models from human cells to serve as test systems. These skin models could help to improve the effectiveness of pharmaceuticals such as cosmetics, and are also helping to reduce the amount of animal testing that is required in the pharmaceutical industry: "What particularly fascinates me is the potential to develop ethical and effective solutions that can replicate realistic human skin models in the laboratory." She spent her intern days with the Chair of Tissue Engineering at the University of Würzburg. Even then, she was taking part in customer meetings thanks to the chair's collaboration with Fraunhofer ISC. "That's what makes research and development at Fraunhofer so interesting: You always have your finger on the pulse and you know what's important for society and for the organization," she says. Of course, she continues, the other great thing about Fraunhofer is the ability to get so much interdisciplinary support from the network thanks to the collaboration between the institutes.

Skin models to replace animal testing

The key ingredients in her career, says Amelie Reigl, are networks and role models. Her awards and grants have been and continue to be helpful in forming contacts with role models and mentors. In 2022, she won first place in the Young Scientist Award, which is run by Fast Forward Science in collaboration with the German Future Prize. In 2023, she was selected for the program "Zia — Visible Women in Science" by the ZEIT publishing group. In 2024, she is a fellow of the Female Science Talents intensive track run by the Falling Walls Foundation. Thanks to the funding from EXIST Women, she looks forward in the foundation phase to working as a mentee with human biologist and start-up founding legend Christine Schuberth-Wagner. She is continuously building an ever stronger network where she receives support from inspiring women like Prof. Sina Bartfelt, who is her mentor in research matters. Of that, @dieWissenschaftlerin can be at least a little bit proud.

“With my TigerShark Science team, I’m working on developing ethical skin models to enable progress in skin research.”

Amelie Reigl

Photo: @dieWissenschaftlerin, background: Getty Images

“There is no alternative to developing bio-based products for the chemical industry.”

Dr. rer. nat. Michael Richter

Photo: Fraunhofer IGB / Marc Müller, background: Getty Images

Dr. rer. nat. Michael Richter

Chemist | Department Head for Chemistry at the Straubing Bio-, Electro- and Chemocatalysis (BioCat) branch of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

In gridlocked discussions, Michael Richter might sometimes make a literary allusion. For example, the Fraunhofer research scientist might reference the poem "lichtung" by Ernst Jandl to open up a new perspective on the situation. Topics such as consciousness, limits to being driven by a digital world, space for creativity — they are all significant to the chemist. Richter emphasizes that he is grateful for the ample freedom given to him by Fraunhofer in his research work. On the other hand, he continues that it goes without saying that he demonstrates strong commitment when dealing with customers. "That means speed, flexibility and a high level of confidentiality toward the customer!"

Bio-based plastics made from chicken feathers

With his team from the innovative field of bio-inspired chemistry, Richter has often demonstrated the importance of creativity and interdisciplinary approaches, for example in the development of components for bio-based adhesives based on chicken feathers for the Henkel group in the KERAbond project. To take another example, together with a Max Planck group in Marburg, Richter and his team have produced a proof of concept for the manufacture of special chemicals using bioelectrocatalytic synthesis by CO_2 fixation (*e*BioCO_2n project). At the moment, Richter is initiating a customer project aimed at manufacturing a bio-based fertilizer. Richter encourages his department to participate regularly in the New Products for the Bioeconomy ideas competition. Manuela Kaiser, a technical assistant in Richter's department, was one of the winners in 2021. Her topic was a completely bio-based and biodegradable adhesive tape for use in fruit tree grafting. Richter was of the opinion that, in the science world, a technician with her own idea could represent a project too. The project promoter running the competition took the same view. Tape2Grape became a project, and the team of scientists provided support for their technician. How flexible are hierarchies in the scientific community? Ernst Jandl, with his poem about "light and reft," might have had something to say here.

Making time for inspiration

Where does Michael Richter get his scientific ideas from? He developed the core idea for a biological fertilizer solution while on a train journey — an unfurling stretch of time and an opportunity for reflection. Exchanging ideas with colleagues is equally important to him. "That's how you really get to know yourself and each other as scientists. Those are the best moments!" He consciously breaks up the everyday stress with breaks, which he spends painting 10-minute pictures in watercolors or acrylics. He also takes longer periods of time for regular walks or hikes. Richter likes views that stretch into the distance, so the fact that his chosen home in Straubing is so close to the Bavarian Forest suits him very well.

On one of his hikes, the solution to a technical problem came together in front of his eyes like pieces of a puzzle, Richter says. One of those pieces was the findings of Professor Tobias Erb, who is now director of the Max Planck Institute for Terrestrial Microbiology. Richter knew that his former colleague at the University of Freiburg was familiar with the technology necessary to produce the special carboxylases. In 2019, the enzymes were among the most efficient CO_2-converting biocatalysts that had been described at that time. "I remember topics and people," says Richter as he describes his network. He has benefited from the ability to form contacts since his studies in Freiburg and Mainz and from his first leadership position at the Swiss Federal Laboratories for Materials Science and Technology (Empa), part of the ETH Domain, which Richter remembers as a "very competitive environment."

For the "modern mindset in chemistry," he also thanks his professor from his time in Freiburg, Michael Müller. In a world moving toward defossilization, organic chemistry is focused on manufacturing chemicals and materials using bio-based raw materials: "We're taking our example from nature."

Prof. Dr. Iryna Gurevych

(Computational) linguist | Head of Ubiquitous Knowledge Processing in the computer science department at the Technical University of Darmstadt | Principal Investigator at the National Research Center for Applied Cybersecurity ATHENE | Computer science department, Ubiquitous Knowledge Processing (UKP) Lab | Member of the German National Academy of Science Leopoldina

This page on Iryna Gurevych could easily have been filled with just her academic achievements and awards. Lichtenberg professorship at the Volkswagen Foundation, first LOEWE top professorship in Hesse, fellowship of the Association for Computational Linguistics, membership of the German National Academy of Science Leopoldina, the Milner Award from the British Royal Society — with her outstanding activities in the field of artificial intelligence, the computer scientist has built herself a prestigious global reputation. "I'm glad my work is being noticed," she says modestly. "That's always a little more difficult for women in science." There is something more important to Iryna Gurevych than recognition, though: "The money that comes with the awards I've won gives me a lot of research freedom. I can pursue topics that are very relevant today."

Her work focuses on machine learning and large language models like those used in ChatGPT. She heads the Ubiquitous Knowledge Processing Lab in the computer science department of the Technical University of Darmstadt, and is principal investigator at the National Research Center for Applied Cybersecurity ATHENE in Darmstadt. ATHENE is a research unit of the Fraunhofer-Gesellschaft involving its Institutes for Secure Information Technology SIT and Computer Graphics Research IGD, with the participation of the Technical University of Darmstadt, Goethe University Frankfurt and the Darmstadt University of Applied Sciences. The center is funded by the German Federal Ministry of Education and Research (BMBF) and the Hessian Ministry of Higher Education, Research, Science and the Arts (HMWK).

Freedom to research one's own interests

The AI expert has not always had the freedom to pursue her own interests. In her home country of Ukraine, she initially studied English and German linguistics. "I was always very good at science and I was interested in computers," she says. "But in Ukraine thirty years ago, it was rare to have access to those technologies. That's why I decided to study humanities."

Her doctoral studies in computational linguistics at the University of Duisburg-Essen ultimately led her to the field she specializes in today. "I'm very good at picking up knowledge myself," she says. "In my field, computer science, you need to work very closely with other fields. To do that, it helps to know how other disciplines work."

This interdisciplinary understanding is important in her work at ATHENE. In one project, Gurevych is working on filtering out false information online, of the kind that emerged during the COVID-19 pandemic. "At that time, a lot of false claims were being spread with supposed evidence from scientific work," she says. "Our aim is to use AI to check the relevant statements." Another area of research is the protection of privacy, especially in medicine. To train AI systems for use in this area, they need a lot of confidential patient data. Iryna Gurevych is working on using large language models to generate high-quality synthetic data, which can then be used in this training. Gurevych is convinced that even science per se can no longer manage without AI. "Anyone who doesn't use it will be too slow," she says. "AI is the new colleague that increases the team's capabilities."

Support for Ukraine

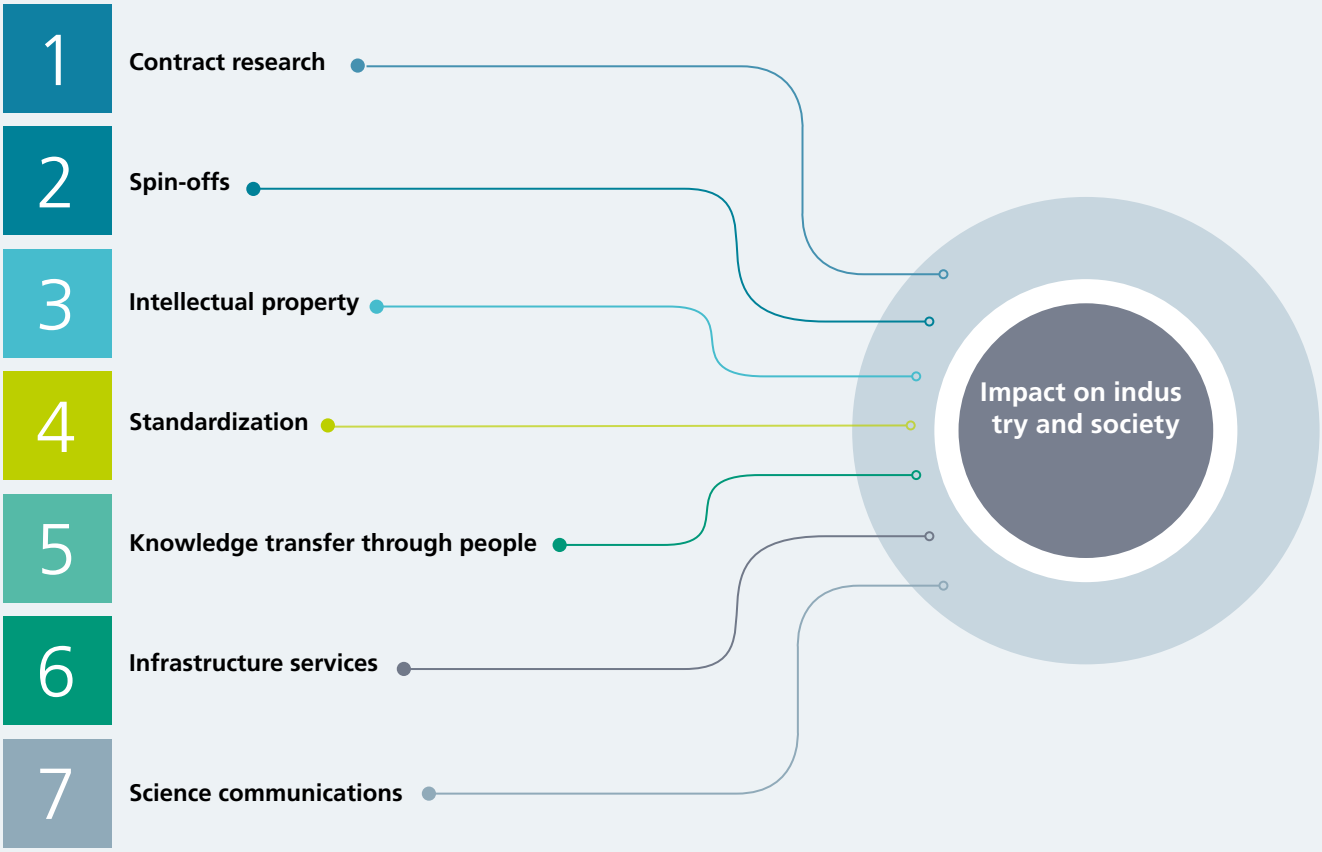
Alongside her scientific work, Irina Gurevych is also strongly committed to aid projects for Ukraine. "The war was a big shock for me," she says. "I didn't expect it to happen." Since it started, she has been intensively supporting Ukrainian refugees. In a German–Ukrainian association in Darmstadt, she has used her network to mobilize resources to provide aid. In Weiterstadt, where she lives, she has organized language courses and is giving young people from Ukraine a new home. She currently has the son of a long-time friend from Ukraine staying with her. "Many parents wanted to get their children to safety before the war," she says. In spite of the challenges and conflicts that this commitment sometimes brings, she likes to look after young people: "I'm just a family person."

“Anyone who doesn’t use artificial intelligence will be too slow. AI is the new colleague that increases the team’s capabilities.”

Prof. Dr. Iryna Gurevych

Photo: Rüdiger Dunker, background: Getty Images

Selected transfer activities



Putting research into practice: Results find their place in industry and society

The success of Germany's non-university research institutions in strengthening the country's industry and society is measured based on seven key pathways of knowledge and technology transfer.

As the Fraunhofer-Gesellschaft's mission is centered on applied research, the deciding factors it uses in measuring its own success are whether research results are being put into practice, and what impact they are making financially, environmentally and socially.

Fraunhofer customers commercialize more innovations and increase their sales and returns. Fraunhofer activities have been shown to create jobs in Germany, generate investment impact in the industry sphere and increase government revenue.

Impact of Fraunhofer research

Contract research

€705 million in contracts from industry (national and international, excluding license fee revenue)

1

Spin offs

21 Spin offs
80 Shareholdings

2

Scaling up hydrogen production
As a market leader in the manufacturer of green hydrogen, thyssenkrupp nucera is expanding its portfolio with technologies developed by the Fraunhofer Institute for Ceramic Technologies and Systems IKTS. Production of solid oxide electrolyzer cells (SOECs) is set to begin at a pilot plant in Arnstadt, the location of Fraunhofer IKTS, in early 2025. Over 20 years of research and development on SOECs have been brought together under the strategic partnership, in which thyssenkrupp nucera and Fraunhofer IKTS are taking the final steps toward the industrial manufacture and use of solid oxide electrolysis (SOE).

The SOEC stack technology is based on a gas-tight oxygen-ion-conducting ceramic electrolyte with screen-printed electrodes and pressed interconnectors made from a chromium-based alloy (CFY). The electrolyte-supported cells, the selection of the materials used, and the design all ensure high efficiency, long-term stability, robustness, and cost-effective mass production. As well as the greater efficiency of the power-to-hydrogen conversion, solid oxide electrolysis also offers the major advantage of being able to actively remove CO_2 from the environment and convert it, together with green hydrogen, into green synthesis gas and derivative products such as e-fuels.

The high energy efficiency of SOEC technology will mainly benefit industries that produce industrial waste heat from production operations, such as ammonia, methanol, fertilizers or green steel production. The partners signed the collaboration agreement, which also includes a license to produce and use CFY stacks, in March 2024.

Elastin producer goes from grant proposal to company
Just two years after its foundation, matrihealth secured a seven-figure seed funding round in June 2024. The funds were provided by two renowned private investors and the Fraunhofer-Gesellschaft to enable matrihealth to build capacity for the industrial production of elastin in Halle and open up additional market segments.

The protein elastin ensures the flexibility of organs and tissues, such as blood vessels, lungs and elastic ligaments. It is also essential for the functioning of the skin and can promote wound healing as part of a dressing. It also has significant potential for use in transplant medicine. However, the human body cannot regenerate elastin after an injury, and, until recently, the high cost of production made it unfeasible to manufacture it on an industrial scale. That changed in 2017, when Christian Schmelzer joined the Fraunhofer Institute for Microstructure of Materials and Systems IMWS through the Attract funding program.

His research application SkinNext contained not only research concepts for the industrial production of elastin but also a business concept for a spin-off. The Fraunhofer expert panel decided to fund the R&D and the business concept in parallel. In the years until matrihealth was founded in 2022, numerous processes for isolating and producing elastin were developed, tested and continuously optimized. As a successful example of a symbiotic combination of research and practical application, matrihealth demonstrates how enthusiastic research and an entrepreneurial spirit can drive each other forward at Fraunhofer.

Intellectual property

€162 million in license fee revenue from industry
507 invention disclosures
7081 active patent families
439 patent applications

3

Standardization

1415 standardization activities

4

Recycling road debris

Road repairs generate more than 3 million metric tons of tar-contaminated road debris every year in Germany. Since 2018, reincorporating this waste into federal highways has not been permitted. It is costly and space-intensive to store them in landfill, and there are only two facilities in Europe where they can be thermally processed.

Since 2022, 4 Fraunhofer institutes have been conducting research into improving the recyclability of tar-containing road debris as part of the internally funded project Inno-Teer. The Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT has recently presented a processing technology that works at low temperatures. The patented process can operate continuously at temperatures of around 400 °C. It combines vacuum pyrolysis with oxidative cracking of low-volatility contaminants. The content of polycyclic aromatic hydrocarbons (PACs), which are hazardous to health, was lowered to below detectable limits. The low-temperature process decontaminates the mineral content without damaging it so that it retains its material properties such as compressive strength, resistance to disintegration and particle size. This means that the recovered material can be used as a secondary raw material, for example in binder and cover layers in road construction.

The first industrial plant has been in the planning phase together with Grenzebach BSH at the EUROVIA asphalt mixing and recycling plant in Oberhausen, North Rhine-Westphalia since 2024. Fraunhofer has patented the technology and licensed it to Grenzebach BSH. There are also plans to explore more potential applications of the process, such as for tar-containing roof sheeting made from old stock, railway sleepers or oil sands.

Open-source standard for shipment tracking

Shipment tracking, or track and trace, is part of ordering goods. Many businesses have developed their own solutions using barcodes, blockchain, RFID or RTLS, but these systems do not speak the same language. This makes working together along the supply chain more difficult and often leads to very vague expected delivery times for customers, and processing for performance analyses is far from ideal. For example, status-related terms such as "in transit" are not clearly defined, and special event codes are not standardized.

For this reason, in early 2024, a working group of companies from the Open Logistics Foundation took on the task of standardizing these many track and trace solutions with a single open-source solution. To this end, it is developing an open-source event, reporting and data model. Its objective is the de facto standardization of process and interface descriptions. It expressly does not intend to produce a functional platform. Instead, its aim is to create a standardized understanding of events and messages that will make it clear where a shipment is. At the same time, standardized descriptions of shipping events will pave the way to easier automation of all communication processes.

The work is being carried out in the non-profit Open Logistics Foundation, founded in 2021 by Rhenus, Dachser, DB Schenker and duisport on the initiative of the Fraunhofer Institute for Material Flow and Logistics IML. In November 2024, the participants in the Track & Trace working group were Aventeon, Bohnen Logistik / duisport, Dachser, DB Schenker (Working Group Lead), logistics cloud, Rhenus and TradeLink, as well as Fraunhofer IML.

Knowledge transfer through people

Over **€9.1 million** in income from continuing education courses from the Fraunhofer Academy. **Around 7,000** participants in **475** courses

5

5.1 Continuing education for external specialist and managerial staff

Contract research and continuing education go hand in hand

In their search for efficient and sustainable materials, research and industry often take their lead from nature. As an example, the particular structural properties of wood and bone have made them a model for lightweight building and working materials made from metal foam. These are developed in facilities such as the metal foam center at the Fraunhofer Institute for Machine Tools and Forming Technology IWU and are transformed into products. This enables applications in many areas where rigidity and crashes need to be considered. At the end of their service life, the foams and foam composites can easily be fed into existing material cycles. Manufacturing companies are also building up capacity and resources in this area, and are placing their trust in Fraunhofer's expertise. The knowledge and experience of the employees at Fraunhofer IWU formed the basis for a major project worth just under €1 million to build a metal foam factory for a material manufacturing company.

The transfer of know-how in highly innovation-driven subject areas needs to go hand-in-hand with building the capabilities of future users — in this case, by training them in how to handle the innovative metal foam in the new center. For this reason, a comprehensive continuing education course was the second pillar of the major contract. Around a quarter (€260,000) of the contract volume was used to provide practical qualifications. The training was tailored to the individual areas of use and the work carried out by the employees in the metal foam center, and for the most part offered in English. This practical knowledge enables a transfer to day-to-day work and means that the center can be put into operation by the company quickly.

5.2 Individuals and careers

Training for positions of responsibility

In 2024, around 2,100 people left Fraunhofer to pursue their careers further — in business, science or their own independent endeavors. One key aspect of Fraunhofer's mission is the training phase that scientific staff in particular complete during their period of employment with Fraunhofer. Fraunhofer had a 9.9 percent turnover rate in its scientific section.

As part of the exit interviews, departing employees were asked where they were planning to go next in their careers. Approximately 70 percent of these departing employees said they were moving on to roles in industry.

Jobs and Career

Infrastructure services

There are no available figures yet for this area. These can be seen in other transfer paths.

6

Science communications

According to a media engagement analysis, Fraunhofer appeared in **10,991** articles, of which **62** percent were initiated by Fraunhofer.
Reach: **6,050** million

7

Location system for digital production

In digital production, it is essential to be able to locate materials, tools and machine parts. That is why omlox, an interoperable and open real-time locating standard, was installed at SmartFactoryOWL at the Lemgo location of the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in late 2023. A test laboratory authorized by PROFIBUS Nutzerorganisation e. V. has also been set up. The findings from the omlox test laboratory will be used by Fraunhofer to develop the technology behind the standard in order to durably strengthen Germany's position as a technological powerhouse. Manufacturers of location technologies can have their products independently tested to the omlox standard at SmartFactoryOWL to obtain certificates for their products.

The open real-time locating standard omlox enables interoperability between different manufacturers' location technologies and services. A range of location technologies, such as ultra-wideband radio, 5G, Bluetooth low energy, RFID or GPS, can be used in the omlox system via common interfaces. This interoperability can help to optimize industrial processes in many areas and make them more efficient, for example through tracking, automatic process documentation and location-based control. Another advantage is its increased relevance to security, particularly for the protection of individual workers, through precise locating.

The direct integration of omlox features into products such as professional power tools or autonomous transport systems significantly improves maintenance and fleet management by allowing devices to be located as soon as they become operational. This improves the administration and use of available resources in production.

Science, Art and Design network

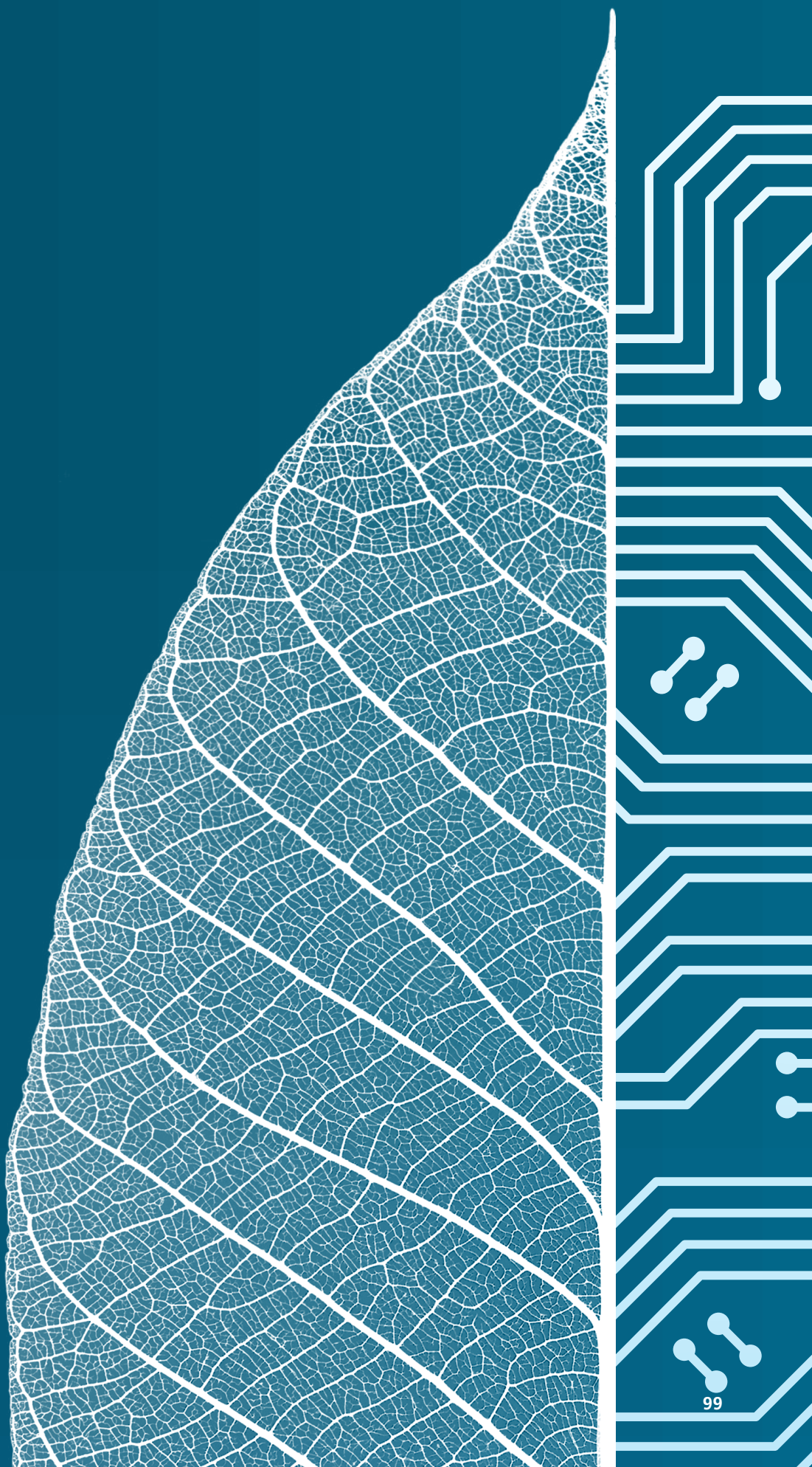
In 2018, Fraunhofer founded the Science, Art and Design (WKD) network. With 28 member institutes in 2024, the WKD network brings together different areas of knowledge to create new ways for the public to look at complex societal challenges. The funded initiatives include interdisciplinary research programs, exhibitions and residential programs for creators in art and design at Fraunhofer institutes, as well as an annual innovation camp with students.

The exhibition FUTURES. Material and Design of Tomorrow" (still running until August 24, 2025) at the GRASSI Museum of Applied Art in Leipzig includes research projects from the WKD network that offer the public a considered and optimistic outlook on possible future scenarios in material research. They highlight the role of design as an instigator of networking between research, industry and society. The special exhibition presents bio-based value chains for the circular economy, such as how natural rubber can be obtained from Russian dandelions for use as an alternative, sustainable raw material for bicycle and car tires, or how apple pomace and lignin can be used as promising plant-based alternatives to conventional materials based on crude oil.

For the duration of the exhibition, the Speculative Futures exhibit is investigating areas of application for biogenic materials and products. At a closing symposium in August 2025, members of the science, design and art worlds will discuss the project's progress and the potential of speculative design for future research.

Finances

- Balance sheet at December 31, 2024
- Income statement for the financial year 2024
- Excerpts from the notes to the 2024 financial statements
- Convenience translation of the German independent auditor s report



Balance sheet at December 31, 2024

ASSETS			2024	Previous year
	€	€	€	2023 in € (1,000)
A. Noncurrent assets				
I. Intangible assets				
1. Concessions, intellectual property rights and similar rights and assets	25,061,685.55			34,408
2. Advance payments	6,600,565.03			3,438
		31,662,250.58		37,846
II. Property, plant and equipment				
1. Land, land rights and buildings, including buildings on third-party land	1,628,030,614.40			1,597,244
2. Technical plant and machinery	638,851,048.59			603,033
3. Other plant, operating and business equipment	154,798,895.04			123,189
4. Advance payments and assets under construction	658,741,052.90			595,415
		3,080,421,610.93		2,918,881
III. Financial assets				
1. Shares in affiliated companies	92,782.82			93
2. Shareholdings	35,867,478.92			31,456
3. Securities held as noncurrent assets	8,247,024.61			8,238
4. Other loans	1,643,406.32			890
		45,850,692.67		40,677
			3,157,934,554.18	2,997,404
B. Current assets				
I. Inventories				
1. Raw, auxiliary and operating materials	–			41
2. Work in progress —	596,900,608.69			529,331
advance payments received	-497,066,539.37			-476,053
	99,834,069.32			53,278
3. Advance payments	–			131
		99,834,069.32		53,450
II. Accounts receivable and other current assets				
1. Trade receivables	255,128,603.93			326,725
2. Receivables from the federal and state governments				
a) relating to base funding	397,034,752.81			374,261
b) relating to project billing, including contract research	297,772,567.50			354,809
c) relating to pension and compensated leave provisions	120,540,400.00			109,263
	815,347,720.31			838,333
3. Accounts receivable from affiliated companies	372,539.60			402
4. Other current assets	109,280,533.86			105,385
		1,180,129,397.70		1,270,845
III. Other securities		323,565,898.33		459,185
IV. Cash and cash equivalents		18,225,461.94		18,232
			1,621,754,827.29	1,801,712
C. Prepaid expenses and deferred charges			56,739,179.86	56,368
			4,836,428,561.33	4,855,484
Trust assets			77,477,496.49	83,372

EQUITY AND LIABILITIES		2024	Previous year
	€	€	2023 in € (1,000)
A. Equity			
I. Non-profit organization capital			
Carried forward	15,638,746.78		15,526
Annual result	50,586.67		113
	15,689,333.45		15,639
II. Reserves for statutory purposes	11,525.00		11
		15,700,858.45	15,650
B. Extraordinary items			
1. License-fee revenue reserve for statutory purposes	328,766,325.44		372,238
2. Grants relating to noncurrent assets	3,146,845,591.55		2,986,184
3. Financing of current assets	175,473,377.79		320,428
4. Payments from patent sales	26,023,405.73		103,227
5. Financing restructuring measures	9,986,500.00		16,846
		3,687,095,200.51	3,798,923
C. Provisions			
1. Provisions for pensions and similar obligations	9,490,400.00		9,133
2. Other provisions	384,863,491.02		267,852
		394,353,891.02	276,985
D. Liabilities			
1. Trade payables	80,294,929.91		134,789
2. Grants from the federal and state governments that are still to be used			
a) relating to base funding	399,995,110.09		392,113
b) relating to project billing	224,309,088.13		169,370
	624,304,198.22		561,483
3. Accounts payable to affiliated companies	991,899.00		1,071
4. Other current liabilities	26,886,389.42		58,606
		732,477,416.55	755,949
E. Accrued expenses and deferred income		6,801,194.80	7,977
		4,836,428,561.33	4,855,484
Trust liabilities		77,477,496.49	83,372

Income statement for the financial year 2024

				2024	Previous year
		€	€	€	2023 in € (1,000)
1.	**Revenue from base funding**				
1.1	Federal government		930,859,361.54		848,171
1.2	State governments		185,423,308.32		169,048
				1,116,282,669.86	1,017,219
2.	**Revenue from own activities**				
2.1	Revenue from research and development activities				
2.1.1	Federal government: Project funding	954,727,959.15			906,318
	Contracts	23,993,533.24			23,867
2.1.2	State governments: Project funding	154,873,588.19			240,106
	Contracts	3,851,354.69			4,928
2.1.3	Industry, business and trade associations	859,952,912.35			821,256
2.1.4	Research funding organizations and other sources	171,217,738.17			213,289
			2,168,617,085.79		2,209,764
2.2	Other revenue		7,233,560.68		7,194
	Total revenue			2,175,850,646.47	2,216,958
2.3	Increase/decrease (-) in work in progress		67,570,052.09		6,292
2.4	Other internally constructed and capitalized assets		7,998,718.59		8,344
2.5	Other operating income		45,162,747.50		75,397
2.6	Income from shareholdings		2,779,011.72		8,100
2.7	Other interest and similar income		2,793,395.37		12,478
				126,303,925.27	110,611
	Total of base funding and revenue from own activities			3,418,437,241.60	3,344,788
3.	**Change in extraordinary items**				
3.1	License-fee revenue reserve for statutory purposes				
	Use of reserves		43,471,501.39		17,638
3.2	Grants relating to noncurrent assets				
	Allocation (capital expenditure)		-584,230,447.65		-579,968
	Reversals (depreciation and amortization)		420,586,709.69		378,835
3.3	Financing of current assets				
	Change from grant		171,301,412.86		59,298
	Change from reserve		-26,347,127.79		–
3.4	For financing restructuring measures				
	Reversals		6,859,300.00		4,299
				31,641,348.50	-119,898
4.	**Total of base funding and revenue from own activities available to cover expenditure**			3,450,078,590.10	3,224,890

			2024		Previous year
			€	€	2023 in € (1,000)
		Carryover:		3,450,078,590.10	3,224,890
5.	**Cost of materials**				
	5.1	Expenditure on raw, auxiliary and operating materials	243,309,954.19		256,736
	5.2	Expenditure on purchased research and development services	252,627,503.91		270,404
			495,937,458.10		527,140
6.	**Personnel expenses**				
	6.1	Salaries	1,675,814,295.47		1,565,593
	6.2	Social contributions and expenses for pension schemes and other benefits of which for pension schemes: €73,738,211.88 (previous year: €64,343 thousand)	379,464,053.25		354,021
			2,055,278,348.72		1,919,614
7.	**Amortization of intangible assets and depreciation of noncurrent assets**		418,958,028.67		378,507
8.	**Other operating expenses**		477,677,093.42		398,741
9.	**Amortization of financial assets and securities classified as current assets**		1,792,845.32		497
10.	**Interest and similar expenses**		383,929.20		282
	Total expenditure			3,450,027,703.43	3,224,781
11.	**Net income for the year**			50,886.67	109
12.	**Reserves for statutory purposes**				
	Withdrawal		–		5
	Allocation		-300.00		-1
				-300.00	4
13.	**Annual result**			50,586.67	113
14.	**Allocation to non-profit organization capital**			-50,586.67	-113
				–	–

Excerpts from the notes to the 2024 financial statements

1. General disclosures

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., headquartered in Munich, is a non-profit organization registered with the local court of Munich under the reference code VR 4461.

The annual financial statements for the year ending December 31, 2024, are prepared voluntarily, taking into account the principles of German commercial law and in accordance with the organization's constitution as a non-profit organization and grant recipient. The regulations for large corporations under German commercial law are applied. The income statement is prepared in accordance with the total cost method.

The basis of the Fraunhofer-Gesellschaft's accounting method is the performance statement, from which the annual financial statements are derived.

The performance statement is adapted to the requirements of the public funding authorities in terms of format and reconciliation. It provides a breakdown of operating expenses and capital expenditure at three different levels: individual institutes, headquarters and the organization as a whole. The components of the operating budget are presented as income or expenses in accordance with generally accepted accounting principles. Capital expenditure on property, plant and equipment and on financial assets, on the other hand, is recognized at cost on acquisition of the assets. Therefore, the operating budget does not include any depreciation/amortization expenses on these items.

In order to account for grants received from grant authorities, the performance statement for the organization as a whole is reconciled to the revenue and expense statement format used in single-entry bookkeeping by eliminating the effect of cash-neutral income and expense items. The income statement includes these changes in payables and receivables over the previous year as well as depreciation/amortization charges. In the balance sheet, these reconciliation items are included under the extraordinary items "Financing of current assets" and "Grants relating to noncurrent assets." In the management report, the figures are explained separately according to the three areas of contract research, additional research funding and major infrastructure.

Annual financial statements of the Fraunhofer-Gesellschaft			Reconciliation to the **income and expense statement format** used in single-entry bookkeeping
Balance sheet	Income statement		
Management report	Reconciliation between income statement and performance statement		
Notes to the financial statements	**Performance statement**		
	Operating budget and capital expenditure at Fraunhofer-Gesellschaft "Total business volume" level		
	Separate financial statements of the institutes/headquarters		
	Operating budget	Capital expenditure	
	Costs (excluding depreciation and amortization)	Expenses	
	Income	Income	

2. Recognition and measurement methods

Intangible assets and property, plant and equipment are measured at amortized cost, i.e., the cost of acquisition or production less depreciation/amortization calculated on a straight-line basis.

Intangible assets are amortized over a useful life of 3 years.

Institute buildings on Fraunhofer and third-party land are depreciated as follows:

- Added before April 1985 at 2 percent
- Added between April 1, 1985, and December 31, 2000, at 4 percent
- Added after January 1, 2001, at 3 percent

A useful life of 5 years is applied to movable items of property, plant and equipment. However, a useful life of 4 years is assumed for communication, video and audio systems, and 3 years for IT hardware. Motor vehicles are depreciated over a useful life of 4 years.

Financial assets are recognized at cost. Where the reduction in value is expected to be permanent, depreciation is recognized at the lower fair value.

Since the noncurrent assets presented in the ordinary accounts are financed by government grants, the extraordinary item "Grants relating to noncurrent assets" is reduced by an amount corresponding to the depreciation/amortization of these assets. Therefore, these adjustments have no impact on the income statement.

Work in progress is measured at the cost of production or fair value, whichever is lower. Production costs include applicable personnel expenses, cost of materials, general administrative expenses and depreciation/amortization charges. Advance payments received (including VAT) are openly deducted under inventories.

Trade receivables and other assets are recognized at their nominal value. Irrecoverable debts are remeasured at the reporting date. The overall non-payment risk is limited by creating a provision for doubtful debts corresponding to 2 percent of the total amount of accounts receivable.

Securities classified as current assets are measured at cost or, on the reporting date, at lower fair value.

Cash and cash equivalents are recognized at their nominal value.

Payments made before the reporting date for which the associated benefits will be received in a future period are recognized as prepaid expenses in the balance sheet.

The Fraunhofer-Gesellschaft makes use of the instrument provided for in its financial statutes of recognizing a balance sheet reserve in particular for liquidity and risk safeguards.

Funding used to finance noncurrent assets is allocated to the extraordinary item "Grants relating to noncurrent assets." A separate extraordinary item is used to account for grants used to finance current assets.

Provisions for pensions and similar obligations for which the Fraunhofer-Gesellschaft has a reinsurance policy in place are measured on the basis of the capitalized amount calculated by the insurance company at the reporting date. The capitalized amounts are calculated in accordance with the information provided by the insurance company and on the basis of the DAV 2004 R guideline tables. Adjustments to current pensions and to applicable income are not taken into account. If there is no reinsurance policy in place, or if the settlement cost of the pension obligations exceeds the capitalized amount calculated by the reinsurer, the amount recognized as a provision is calculated in accordance with an expert opinion based on actuarial evidence. The settlement amount of the pension obligation is calculated using the present value method (method for calculating current single premiums). A 10-year-average actuarial interest rate of 1.90 percent was used in the calculation in accordance with section 253 (2) of the German Commercial Code (Handelsgesetzbuch, HGB), along with the 2018 G Heubeck guideline tables.

Other provisions comprise amounts set aside to cover all identifiable risks and contingent liabilities. These provisions are measured in accordance with section 253 (1) HGB on the basis of a reasonable estimate of the most probable outcome. Other provisions for liabilities due in more than one year are discounted at the average market interest rate for loans of a similar maturity as calculated by the Deutsche Bundesbank in

December 2024, pursuant to section 253 (2) HGB. Provisions for partial retirement are calculated on the basis of the policies already concluded.

Liabilities are measured at the settlement amount.

Payments received before the reporting date for benefits to be delivered in a future period are recognized in the balance sheet as deferred income.

Amounts recognized for transactions in foreign currencies are translated at the applicable hedging rates of the respective currencies. In the annual financial statements, foreign currency holdings are translated at the average spot exchange rate prevailing on the reporting date.

Items in transit are noted as trust assets and trust liabilities in a separate line at the foot of the Fraunhofer-Gesellschaft balance sheet.

Convenience translation of the German independent auditor's report

This is a convenience translation of the German independent auditor's report. Solely the original text in the German language is authoritative. The independent auditor's report is based on the balance sheet at December 31, 2024, the income statement for the financial year 2024 and the full notes to the 2024 financial statements and the 2024 management report.

"To Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich

Audit opinion

We have audited the annual financial statements prepared by Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, comprising the balance sheet at December 31, 2024, the income statement for the financial year from January 1 to December 31, 2024, and the notes to the financial statements, including the presentation of the applied recognition and measurement methods. In addition, we have audited the management report of Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, for the financial year from January 1, 2024, to December 31, 2024.

According to our opinion, as based on the results of the audit:

- The attached annual financial statements comply in all material respects with the provisions of the German Commercial Code (Handelsgesetzbuch, HGB) as applicable to large corporate entities, the organization's statute, and those of German generally accepted accounting principles (GAAP). Together, this information presents a true and fair view of the organization's net assets and financial position as at December 31, 2024, and of its operating results for the financial year commencing January 1, 2024, and ending December 31, 2024.

- The attached management report provides a true and fair view of the organization's current operating situation. In all material respects, the management report is consistent with the annual financial statements, complies with German statutory requirements and provides an appropriate picture of the organization's future opportunities and risks.

In accordance with section 322 (3) item 1 HGB, we declare that our audit of the annual financial statements and management report did not lead to any reservation/observations.

Basis for opinion

We conducted our audit of the annual financial statements and the management report in accordance with section 317 HGB and the German generally accepted standards for the audit of financial statements set by the Institute of Public Auditors in Germany (IDW). Our responsibilities under those standards are further described below under the heading "Auditors' responsibility for the audit of the annual financial statements and management report." We declare that we are independent auditors as defined by German commercial law and that we exercise our other duties in Germany in compliance with the relevant professional code of conduct, with no other connection to or interests in the Fraunhofer-Gesellschaft. It is our considered opinion that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion on the annual financial statements and the management report.

Responsibility of the legal representatives and the senate for the annual financial statements and management report

The legal representatives are responsible for preparing the annual financial statements in accordance with the provisions of the HGB as applicable to large corporate entities, and for ensuring that they comply with German generally accepted accounting principles (GAAP) and present a true and fair view of the organization's net assets, financial position and operating results. Furthermore, the legal representatives are responsible for carrying out internal audits to the extent that these are considered necessary to comply with German GAAP, as a basis for preparing annual financial statements in such a way that they are free of material misstatements, whether due to fraud (i.e., fraudulent accounting manipulations and financial losses) or error.

In preparing the annual financial statements, the legal representatives are also responsible for determining the organization's ability to continue operating as a going concern, which includes disclosing any relevant information concerning this matter. Moreover, they are responsible for applying methods of accounting that allow assessment of the organization's continuing existence as a going concern, insofar as there are no material or legal circumstances that might contradict this assessment.

Another of the legal representatives' responsibilities is the preparation of a management report, which must be consistent with all material aspects of the annual financial statements, comply with German statutory requirements, provide a true reflection of the organization's financial position and provide a realistic assessment of the organization's future opportunities and risks. In addition, the legal representatives are responsible for such arrangements and measures (systems) as they have considered necessary to enable the preparation of a management report that is in accordance with the applicable German legal requirements, and provision of sufficient appropriate evidence for the statements made in the management report.

The senate is responsible for monitoring the organization's accounting process for the preparation of the annual financial statements and management report.

Auditor's responsibility for the audit of the annual financial statements and management report

Our objectives are to obtain reasonable assurance about whether the annual financial statements as a whole are free from material misstatement due to fraudulent activities or errors and whether the management report as a whole provides an appropriate view of the organization's position and, in all material respects, is consistent with the annual financial statements and the knowledge obtained in the audit, complies with German legal requirements and appropriately presents the opportunities and risks of the organization's future development as well as to issue an auditor's report comprising our audit opinion on the annual financial statements and on the management report.

Reasonable assurance implies a high level of confidence but does not guarantee that an audit conducted in full compliance with the provisions of section 317 HGB and of the generally accepted accounting principles set by the Institute of Public Auditors in Germany (IDW) will always detect a material misstatement when it exists. Misstatements may result from fraudulent activities or errors and are deemed to be material if it can be reasonably expected that they might individually or severally influence business decisions made by the reader on the basis of the annual financial statements or management report.

Throughout the audit process, we exercise professional judgment and maintain a neutral but critical attitude. We also:

- Identify and assess the risks associated with material misstatements in the annual financial statements and management report due to fraudulent activities or errors, plan and carry out our auditing activities in response to these risks and collect sufficient, appropriate documentary evidence to substantiate our audit opinion. The risk that a material misstatement resulting from fraudulent activities is not detected is higher than the risk that a material misstatement resulting from errors is not detected since fraudulent activities may involve collusion, forgery, intentional omissions, misleading representations, or the override of internal controls.

- Familiarize ourselves with the internal controls and other instruments and measures insofar as they affect the auditing of the annual financial statements and management report, in order to design audit procedures that are appropriate in the circumstances. However, it is not the purpose of the audit to judge the effectiveness of the organization's internal controls or of these instruments and measures.

- Assess the appropriateness of the accounting principles applied by the legal representatives and the extent to which their estimated values and the associated information they specify are backed up by documented evidence.

- Draw conclusions as to the appropriateness of the accounting principles applied by the legal representatives to determine the organization's ability to continue as a going concern and, on the basis of the audit evidence, to determine whether material uncertainties exist about

events or conditions that may cast significant doubt on the organization's ability to continue as a going concern. If our investigations lead to the conclusion that material uncertainties do exist, it is our duty to comment on this fact in our independent auditor's report, providing references to the relevant disclosures in the annual financial statements and/or management report. Alternatively, if such comments are inappropriate, it is our duty to modify our audit opinion accordingly. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the organization to cease to continue as a going concern.

- Verify that the overall presentation, structure and content of the entire annual financial statements, including the disclosures and the presentation of underlying business transactions and events, comply with German generally accepted accounting principles (GAAP) and present a true and fair view of the organization's net assets, financial position and operating results.

- Confirm that the management report complies with the annual financial statements, meets legal requirements and conveys a true image of the organization's situation.

- Perform audit procedures on the prospective information presented by the legal representatives in the management report. On the basis of sufficient appropriate audit evidence we evaluate, in particular, the significant assumptions used by management as a basis for the prospective information and evaluate the proper derivation of the prospective information from these assumptions. We have not provided an independent audit opinion on the prospective information or the data on which it is based. There is a substantial unavoidable risk that future events will differ materially from the prospective information.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal controls that we identify during our audit.

Nuremberg, April 17, 2025
Rödl & Partner GmbH
Wirtschaftsprüfungsgesellschaft

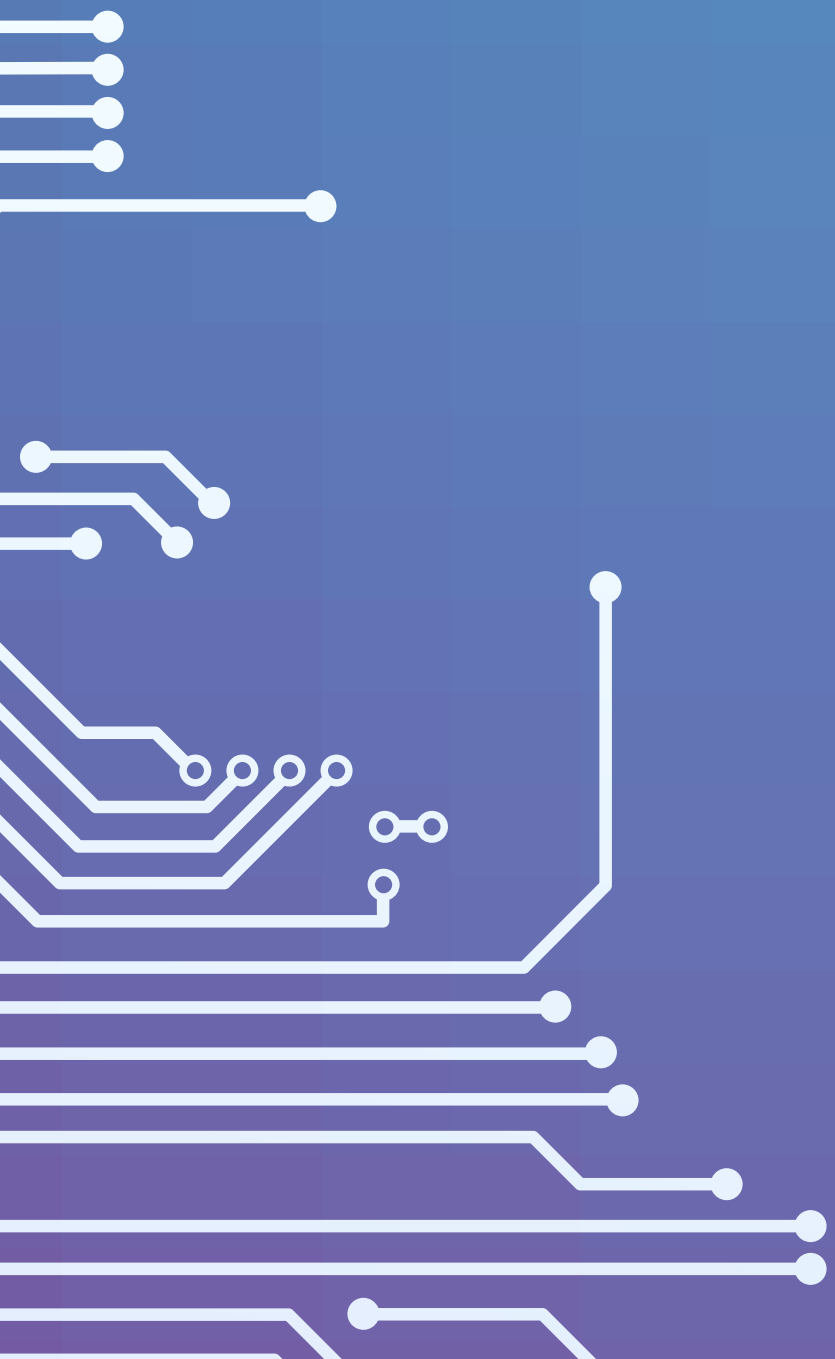
Signature: Grässle
Auditor

Signature: Hahn
Auditor

(End of convenience translation of the German independent auditor's report.)"

About Fraunhofer

- Structure of the Fraunhofer Gesellschaft
- Members, governing and advisory bodies
- Locations



Structure of the Fraunhofer-Gesellschaft

Governance: governing and advisory bodies

The **executive board** of the Fraunhofer-Gesellschaft consists of the president and up to four other full-time members. Its duties include managing the Fraunhofer-Gesellschaft and establishing the essential elements of its strategy, particularly in the areas of research, transfer, major infrastructure, human resources and finances. The executive board ensures, within the scope of its responsibilities under the statutes, that these are observed, and shapes the Fraunhofer corporate culture with its values and positions on issues. It ensures that the research portfolio of the institutes is coherent from the standpoint of the Fraunhofer-Gesellschaft as a whole, and creates the conditions for the lawful, proper and cost-effective management of the organization's activities and those of its institutes and other research units. The executive board ensures that these are observed through actions including but not limited to enacting guidelines and establishing the relevant control systems. The executive board acts as a **collective body**. The president represents the organization both internally and externally and coordinates the work of the executive board.

The **senate** comprises up to 26 voting members from the worlds of industry, science and public life, representatives of the federal and state governments, and members of the scientific and technical council (STC). The senate functions as a supervisory and advisory body to the executive board of the Fraunhofer-Gesellschaft. Its responsibilities include appointing the president and other members of the executive board. The adoption of the financial plan, including the financial planning, the establishment of the central elements of the science and research strategy, and the research and expansion planning are subject to the approval of the senate. It also handles the establishment, transformation or dissolution of research units belonging to the Fraunhofer-Gesellschaft.

The **annual general meeting** is made up of the members of the Fraunhofer-Gesellschaft. Ex officio membership is open to members of the senate and the executive board, institute directors and senior managers, and members of the boards of trustees. Applications for ordinary membership may be submitted by individuals and legal entities who wish to support the work of the Fraunhofer-Gesellschaft. Honorary members may be elected from among the research staff and patrons of the Fraunhofer-Gesellschaft in recognition of outstanding services to the organization.

The annual general meeting elects the members of the senate, discharges the executive board and senate of their functions and formulates decisions concerning amendments to the statutes.

The **scientific and technical council** (STC) is the organization's internal advisory committee. It consists of the directors and senior managers of the institutes and an elected representative of the scientific and technical staff of each institute. The STC advises the governing and advisory bodies on scientific and technical matters of essential importance. It makes recommendations concerning the central elements of the Fraunhofer-Gesellschaft's science and research strategy and strategic HR development, expresses its opinions regarding the establishment of new institutes or the closure of existing institutes, and participates in the appointment of new institute directors.

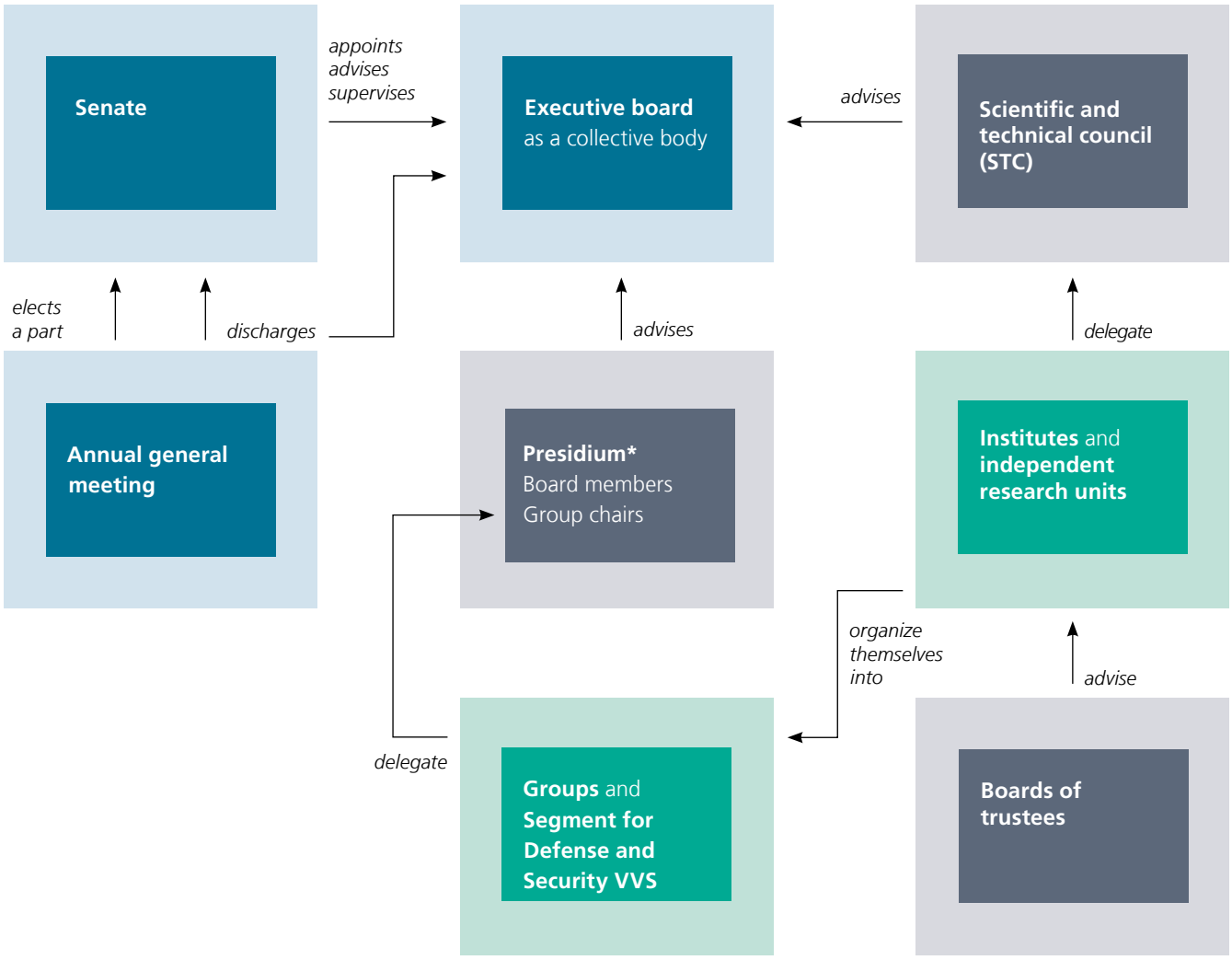
There are currently 76 **institutes** and **independent research units** working under the umbrella of the Fraunhofer-Gesellschaft at locations throughout Germany. They are the entities responsible for carrying out the Fraunhofer-Gesellschaft's research work, and each one cultivates its own market presence and manages its own budget. They do not generally have their own legal capacity, so they manage their activities in line with the overall Fraunhofer strategy and the planning and management processes established by the executive board. They can form **groups based on specific areas of expertise** and be tasked with coordinating their research within the Fraunhofer-Gesellschaft and harmonizing the market presence of the respective group members.

The chairs of these groups, together with the executive board and the chair of the Segment for Defense and Security VVS, form the **presidium** of the Fraunhofer-Gesellschaft. The presidium participates in executive board decision-making processes, supports the implementation of the executive board's decisions, and is entitled to make proposals and recommendations to and has the right to be heard by the board.

The **boards of trustees** are external advisory bodies of the institutes. They include representatives from the science, business and public sectors, who are appointed by the executive board. The boards of trustees advise the institute management, the executive board and, if necessary, the other governing and advisory bodies of the organization on matters including the institute's scientific and entrepreneurial alignment and any structural changes at the institute.

Report valid as of January 2025

Structure as per the statutes



- The Fraunhofer-Gesellschaft is organized as **one** legal entity; all institutes are therefore legally dependent.
- Legal form: association registered under German law (e. V.)
- Tax status: non-profit

- Governing bodies
- Advisory bodies
- Research structures

* Advisory committee, not an extended executive board

Members, governing and advisory bodies

Members

The Fraunhofer-Gesellschaft has 1,186 members, comprising 50 legal entity members, 63 natural person members, 89 former executive board members and institute directors, 989 ex officio members and 6 honorary members. Some members have multiple functions.

Honorary members

Dr.-Ing. Peter Draheim

Dr.-Ing. Horst Nasko

Dr. Dr. jur. Dirk-Meints Polter

Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h. c. Ekkehard D. Schulz

Dr. rer. pol. Hans-Ulrich Wiese

Dr. jur. Markus Söder

Senate

Members from the science and business communities, and from public life

Hildegard Müller
Chair of the Senate of the Fraunhofer-Gesellschaft, President of Verband der Automobilindustrie e. V. (German Association of the Automotive Industry)

Kerstin Grosse
Deputy Chair of the Senate of the Fraunhofer-Gesellschaft, Managing Director of DEROSSI Invest GmbH

Prof. Dipl.-Ing. Oliver Zipse
Deputy Chair of the Senate of the Fraunhofer-Gesellschaft, Chairman of the Board of Management of BMW AG

Dr.-Ing. Oliver Blume
Chairman of the Board of Management of Volkswagen AG, Chairman of the Executive Board of Dr. Ing. h.c. F. Porsche AG

Dr. rer. nat. Roland Busch
President and Chief Executive Officer of Siemens AG

Anja-Isabel Dotzenrath

Otto Fricke
Member of the German Federal Parliament (Bundestag) and the Free Democratic Party (FDP) Federal Executive Board, Budget Policy Spokesperson of the FDP Bundestag Parliamentary Group

Sabine Herold
Managing Partner of DELO Industrie Klebstoffe GmbH & Co. KGaA

Pär Malmhagen
Senior Advisor

Bernard Meyer
Managing Director of MEYER WERFT GmbH & Co. KG

Prof. Dr. phil. Anja Reinalter
Member of the German Federal Parliament (Bundestag) and Parliamentary Business Manager of the Alliance 90/The Greens Parliamentary Group, Professor of Social Work at Kempten University of Applied Sciences

Sönke Rix
Member of the German Federal Parliament (Bundestag) and Deputy Chair of the Social Democratic Party (SPD) Bundestag Parliamentary Group

Prof. Dr. rer. nat. Dr. h. c. mult. Ulrich Rüdiger
Rector of RWTH Aachen University

Dr.-Ing. Katrin Sternberg

Dr.-Ing. Karl Tragl
Chairman of the Executive Board and Chief Executive Officer of Wacker Neuson SE

Grazia Vittadini
Lufthansa Chief Technology Officer and Member of the Executive Team

Dr.-Ing. Anna-Katharina Wittenstein
Member of the Supervisory Board of WITTENSTEIN SE

Prof. Vanessa Wood Ph. D.
Vice President for Knowledge Transfer and Corporate Relations of ETH Zurich

Members representing government institutions
Representatives at federal level

Parliamentary State Secretary Mario Brandenburg
(until November 19, 2024)
German Federal Ministry of Education and Research (BMBF)

State Secretary Stephan Ertner
(from December 18, 2024)
German Federal Ministry of Education and Research (BMBF)

Undersecretary Dr. rer. pol. Ole Janssen
German Federal Ministry for Economic Affairs and Climate Action (BMWK)

Undersecretary Alexander Schott
German Federal Ministry of Defence (BMVg)

Undersecretary Rita Schutt
German Federal Ministry of Finance (BMF)

Representatives at federal state level

State Secretary Ayse Asar
(until January 18, 2024)
Hessian Ministry of Higher Education, Research, Science and the Arts (HMWK)

State Secretary Christoph Degen
(from January 24, 2024)
Hessian Ministry of Science and Research, Arts and Culture

State Secretary Dr. phil. Henry Marx
Berlin Senate Department for Higher Education and Research, Health and Long-Term Care

State Secretary Gonca Türkeli-Dehnert
Ministry of Culture and Science of North Rhine-Westphalia

Scientific and technical council (STC)
Prof. Dr. rer. nat. habil. Elizabeth von Hauff
(from November 28, 2024)
Director of the Fraunhofer Institute for Electron Beam and Plasma Technology FEP

Prof. Dr.-Ing. Albert Heuberger
(until November 27, 2024)
Director of the Fraunhofer Institute for Integrated Circuits IIS

Prof. Dr.-Ing. Peter Ohlhausen
(from November 28, 2024)
Deputy Chair of the STC, Head of Research Coordination at the Fraunhofer Institute for Industrial Engineering IAO

Dipl.-Ing. Stefan Schmidt
(until November 27, 2024)
Deputy Chair of the STC, Fraunhofer Institute for Material Flow and Logistics IML

Prof. Dr. rer. nat. Anita Schöbel
(from November 28, 2024)
Chair of the STC, Director of the Fraunhofer Institute for Industrial Mathematics ITWM

Prof. Dr. rer. nat. habil. Andreas Tünnermann
(until November 27, 2024)
Chair of the STC, Director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Honorary senator
Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h. c. Ekkehard D. Schulz

Permanent guests
Prof. rer. nat. Patrick Cramer
President of the Max Planck Society for the Advancement of Science

State Counselor Dr. phil. Eva Gümbel
Authority for Science, Research, Equality and Districts (BWFGB) of Hamburg

State Secretary Dr. jur. Andreas Handschuh
State Ministry of Science, the Arts and Tourism of Saxony

Prof. Dr.-Ing. Anke Kaysser-Pyzalla
Chair of the Executive Board of the German Aerospace Center (DLR)

Dipl.-Phys. Doris Rösler
Chair of the Fraunhofer Central Works Council, Fraunhofer Institute for Building Physics IBP

Stefan Rughöft
Deputy Chair of the Fraunhofer-Gesellschaft's central works council, Fraunhofer Institute for Open Communication Systems FOKUS

Prof. Dr. med. Wolfgang Wick
Chair of the German Science and Humanities Council

State Secretary Thomas Wünsch
Ministry of Science, Energy, Climate Protection and Environment of Saxony-Anhalt

Boards of trustees

In total, the boards of trustees of the institutes consist of 871 members, some of whom hold seats on the boards of trustees of more than one institute.

Scientific and technical council (STC)

The STC has 180 members, 104 of whom are delegated institute directors or senior managers, while 76 are elected representatives of the scientific and technical staff of each institute.

Chair of the STC:
Prof. Dr. rer. nat. habil. Andreas Tünnermann
(until November 27, 2024)
Director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Prof. Dr. rer. nat. Anita Schöbel
(from November 28, 2024)
Director of the Fraunhofer Institute for Industrial Mathematics ITWM

Presidium

The presidium of the Fraunhofer-Gesellschaft is made up of the members of the executive board and the chairs of the Fraunhofer groups, named below:

Prof. rer. nat. Karsten Buse
Fraunhofer Group for Light & Surfaces

Prof. Dr.-Ing. Welf-Guntram Drossel
Fraunhofer Group for Production

Prof. Dr. rer. pol. Jakob Edler
Fraunhofer Group for Innovation Research

Prof. med. Dr. rer. nat. Gerd Geisslinger
Fraunhofer Group for Health

Prof. Dr. rer. nat. Peter Gumbsch
Fraunhofer Group for Materials and Components

Prof. Dr. rer. nat. Hans-Martin Henning
Fraunhofer Group for Energy Technologies and Climate Protection

Prof. Dr.-Ing. Albert Heuberger
Fraunhofer Group for Microelectronics

Prof. Boris Otto
Fraunhofer ICT Group

Dr. rer. nat. Markus Wolperdinger
Fraunhofer Group for Resource Technologies and Bioeconomy

Presidium members that serve in an advisory capacity
Prof. Dr.-Ing. Jürgen Beyerer
Fraunhofer Segment for Defense and Security VVS

Permanent guest
Prof. Dr. rer. nat. habil. Andreas Tünnermann
(until November 27, 2024)
Chair of the STC, Director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Prof. Dr. rer. nat. Anita Schöbel
(from November 28, 2024)
Chair of the STC, Director of the Fraunhofer Institute for Industrial Mathematics ITWM

Executive board

Prof. Dr.-Ing. Holger Hanselka
(President and Chair of the Executive Board)

Elisabeth Ewen

Prof. Dr. rer. nat. Constantin Häfner
(from February 17, 2025)

Sandra Krey

Prof. Dr. rer. nat. habil. Axel Müller-Groeling

Listed information valid as of December 31, 2024

Locations

Fraunhofer Germany

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