



ANNUAL REPORT 2012
RESEARCH FOR GREATER EFFICIENCY



Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and independent research units. The majority of the more than 22,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.9 billion euros. Of this sum, more than 1.6 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and *Länder* governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

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Ladies and gentlemen,

The last few years have been marked by revolutionary developments, which pose huge challenges in the spheres of politics, business and research alike. The euro is under pressure, and energy and commodity prices have risen worldwide in line with growing consumption and ever scarcer resources.

The transition to a renewable energy regime in Germany – a significant and prudent change in government policy – calls for our undivided attention. Even though it may trigger a certain degree of energy price inflation in the short term, in the long run it promises us competitive advantages internationally. The transition will put us in a position to develop renewable energy sources and efficiency technologies faster, and this will soon give us an enduring competitive edge in know-how in this field.

The scarcity of many raw materials constitutes a fundamental problem for the global economy because growing consumption in emerging economies more often than not now runs up against dwindling reserves. We must also bear in mind the correlation between the prices of energy and raw materials: the more we are compelled to exploit less abundant sources of raw materials, the more energy it takes to mine these valuable input materials for industrial production. Which is why, in addition to a new energy regime, we also need to rethink how we make use of raw materials – as both aspects make us dependent on expensive imports.

The consumption of resources has always cost money. What is new is the magnitude of consumption. Whereas personnel costs were once a key factor in international competitiveness, industrial production nowadays increasingly focuses on energy and raw material costs. Private enterprise and the public sector can escape this price spiral only by achieving greater efficiency. Quite simply, we need to create more value while consuming fewer resources. That will call for new efficiency technologies – and this is where Fraunhofer, with its innovative research and development services, has a great deal to contribute.

We are already very well positioned to take on this challenge. The expertise of the Fraunhofer Institutes is pooled and targeted in the “E³ factory” project, for example, in which an efficient, emissions-neutral and ergonomic production facility responds to the key challenges posed by resource conservation, climate protection and demographic change. We also have huge research capacities in other relevant fields of technology, such as power electronics, energy research, recycling or materials research – and we are in the process of further enhancing our expertise and our international technology leadership. Going forward, we aim to remain what we have always been for business, a source of powerful new ideas and a reliable R&D partner.

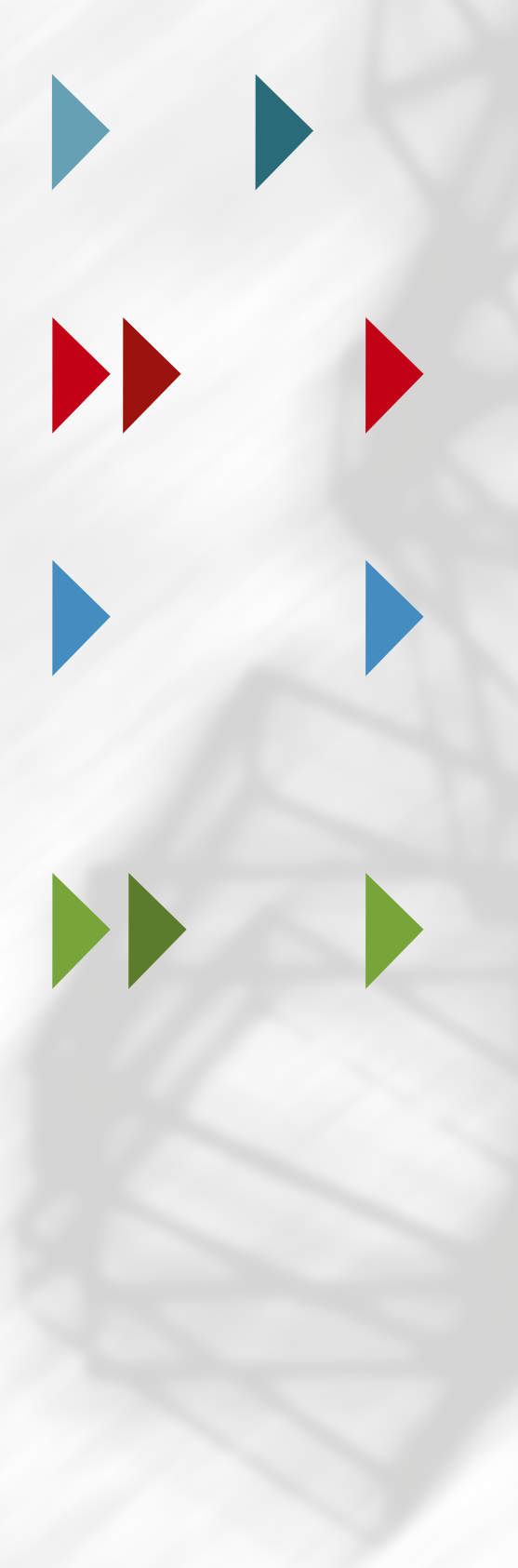
If industry, business, and the applied research community concentrate on quality, originality and efficiency, countries like Germany that are poor in resources but rich in ideas will be able to demonstrate how this situation can be turned to their advantage. Then, we will benefit from the resource that we too at Fraunhofer can call on: bright minds with excellent qualifications and a thirst for success.

The high motivation and expertise of our workforce provides a solid foundation for our ability to deliver. Human resources – a valuable and irreplaceable asset – are the most important form of capital we have. Our goal must be to exploit this potential for the benefit of the economy in both Germany and Europe. Let us make even better use of it than we have up till now!

Sincerely,

A handwritten signature in black ink, appearing to read 'R. Neugebauer', with a long horizontal flourish extending to the right.

Reimund Neugebauer
President of the Fraunhofer-Gesellschaft





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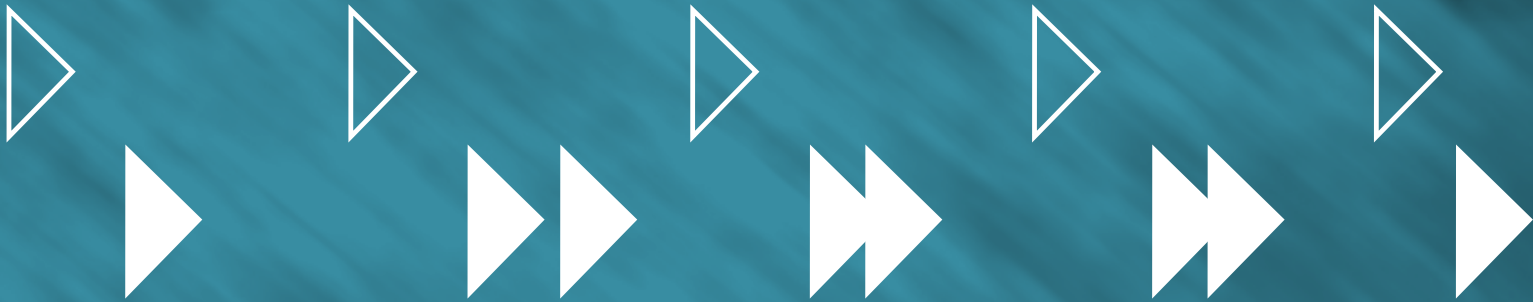
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REPORT OF THE EXECUTIVE BOARD



THE EXECUTIVE BOARD

MANAGEMENT REPORT 2012

REPORT OF THE SENATE
ON THE FINANCIAL YEAR 2012

SUSTAINABILITY REPORT 2012



THE EXECUTIVE BOARD



“If you want to survive in tomorrow’s international markets, you must be able to offer original products and technologies that improve efficiency. Our cognitive innovations and technological leadership in efficient value creation give us at Fraunhofer the key to unlocking this future.”

Prof. Dr.-Ing. Reimund Neugebauer

Corporate Management,

President of the Fraunhofer-Gesellschaft

Reimund Neugebauer is Professor of Machine Tools and Forming Technology at the Technische Universität Chemnitz (TU Chemnitz). After leadership roles in the mechanical engineering industry, he set up the Fraunhofer Institute for Machine Tools and Forming Technology IWU in 1991, which grew to become an international center for manufacturing engineering in his 21 years of service as its director. He was founding president of Industrieverein Sachsen 1828 e. V., an industrial network in the German *Land* of Saxony, and has been offered several professorships, including one at the Swiss Federal Institute of Technology Zurich. He has been President of the Fraunhofer-Gesellschaft since October 2012.





“The careful use of energy and raw materials has taken on fundamental importance for German industry. Applied research in the fields of renewable energy, efficiency technologies and recycling is a core competence of the Fraunhofer-Gesellschaft – one that we are glad to make available to industry.”

Prof. Dr. rer. nat. Ulrich Buller

Senior Vice President Research Planning

Ulrich Buller was head of the central research planning department, director of the Fraunhofer Institute for Applied Polymer Research IAP and chairman of the Fraunhofer Group for Materials and Components – MATERIALS prior to being elected a member of the Fraunhofer-Gesellschaft Executive Board in 2006.



“Fraunhofer is a model for success. The growth of recent years demonstrates that we have succeeded in aligning our range of R&D services with the needs of business. And we are also very well equipped to tackle the challenges of the future.”

Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner

Senior Vice President Finance and Controlling, IT

Alfred Gossner initially pursued a career with the Allianz Group, including various international postings. Before moving to the Fraunhofer-Gesellschaft in 2002, he served as a member of the board of management of Allianz Versicherungs-AG.



“Fraunhofer is a prime mover in the market for highly qualified professionals. Last year alone, we created over 1,000 new jobs, and we remain one of the most attractive employers for applicants in the fields of science and technology.”

Dr. rer. publ. ass. iur. Alexander Kurz

Senior Vice President Personnel and Legal Affairs

After studying to become a lawyer, Alexander Kurz worked as a manager and board member for major research organizations such as CERN and the Karlsruhe Institute of Technology (KIT). He has been a member of the Executive Board of the Fraunhofer-Gesellschaft since June 2011.

Fraunhofer-Gesellschaft's business development 2008–2012

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---------------|---------------|---------------|---------------|---------------|
| Total business volume (cash basis) in € million | 1401 | 1617 | 1657 | 1849 | 1926 |
| (operations and capital expenditure) | | | | | |
| Change | 6% | 15% | 2% | 12% | 4% |
| Contract research | 1291 | 1340 | 1402 | 1515 | 1614 |
| Defense research | 38 | 87 | 93 | 98 | 113 |
| Major infrastructure capital expenditure | 72 | 190 | 162 | 236 | 199 |
| Project revenue in € million | 902 | 1031 | 1173 | 1288 | 1254 |
| Change | 6% | 14% | 14% | 10% | –3% |
| Contract research | 859 | 916 | 1030 | 1101 | 1137 |
| Defense research | 8 | 31 | 35 | 42 | 55 |
| Major infrastructure capital expenditure ¹ | 35 | 84 | 108 | 145 | 62 |
| Breakdown of expenditure in %² | | | | | |
| Personnel expense ratio | 48 | 48 | 50 | 48 | 50 |
| Non-personnel expense ratio | 34 | 29 | 29 | 30 | 30 |
| Capital expenditure ratio | 18 | 23 | 21 | 22 | 20 |
| Breakdown of revenue in %³ | | | | | |
| Project research (total) | 69 | 68 | 72 | 71 | 70 |
| Industry | 36 | 31 | 34 | 36 | 37 |
| Public sector ⁴ | 33 | 37 | 38 | 35 | 33 |
| International | 12 | 12 | 13 | 13 | 15 |
| EU (European Commission) | 5 | 5 | 5 | 5 | 6 |
| Total assets/total equity and liabilities in € million | 1995 | 2119 | 2287 | 2440 | 2538 |
| Change | 5% | 6% | 8% | 7% | 4% |
| Employees | 15,823 | 17,907 | 19,002 | 20,326 | 22,093 |

1 Since 2012, excluding shares of *Länder* governments (2012: €37 million).

2 Total operating expenses/business volume (excluding change in license-fee revenue reserve after deduction of allocation to foundation capital).

3 Project revenue/operating budget and imputed depreciation allowance for contract research activities (including change in license-fee revenue reserve).

4 Public sector includes German federal and *Länder* governments, EU, research grants and other R&D/non-R&D.

MANAGEMENT REPORT 2012

Profile and structure of the Fraunhofer-Gesellschaft

With a workforce of over 22,000, the Fraunhofer-Gesellschaft is Europe's biggest organization for applied research, and currently operates a total of 66 Fraunhofer Institutes and independent research institutions. The organization's core task is to carry out research of practical utility in close cooperation with its customers from industry and the public sector. In this way the Fraunhofer-Gesellschaft shapes the innovation process in Germany and drives forward the development of key technologies. The organization's research focuses on the needs of people in the areas of healthcare, security, communication, mobility, energy and the environment. Fraunhofer's international sites and its representative offices in the USA, Asia and Europe act as a bridge to the regions of greatest importance to scientific progress and economic development.

The Fraunhofer-Gesellschaft's business volume amounts to over €1.9 billion, the lion's share of which (around €1.6 billion) is dedicated to contract research. The remaining funds are divided between the defense research segment and major infrastructure capital expenditure. About 70 percent of the Fraunhofer-Gesellschaft's business volume in the contract research segment stems from contracts with industry and publicly funded research projects. Around 30 percent is provided by the public sector in the form of base funding to finance pre-competitive research projects, the results of which are of relevance to the future of the economy and society as a whole. In order to carry out their contract research activities, the institutes receive proportional funding at a ratio of 90:10 from the German Federal Ministry of Education and Research (BMBF) and the *Länder* governments.

Economic background

- German economy in robust condition
- Continuing growth in industry expenditure on R&D

The German economy proved its resilience in 2012, and succeeded in avoiding the Europe-wide recession thanks to robust international and domestic demand. Like the global economy, the German economy nonetheless lost some of its momentum. Following a strong recovery – with growth of 4.2 percent in 2010 and 3.0 percent in 2011 – the German economy added just 0.7 percent to GDP in 2012. Particularly in the second half of the year, the economy weakened perceptibly, and there is indication that 2013 will be a difficult year in economic terms.

Contradictory trends were observable in the economy in 2012. While economic output in the service sector grew substantially, the manufacturing and construction industries experienced a substantial drop in output. A similar contradiction made itself felt in expenditures. Although public and private consumption together grew by 0.8 percent, gross capital expenditure – which mainly comprises expenditure on equipment, technical apparatus, machinery and vehicles as well as capital expenditure on construction and changes in inventories – was down 5.2 percent on the figure for 2011. The drop in capital expenditure on construction is primarily due to cutbacks in public-sector building, especially following the expiry of several economic stimulus programs.

Companies nevertheless remain aware of the key importance of expenditure on research and development (R&D) for ensuring their innovative strength and competitiveness going forward. According to recent surveys, German companies raised their R&D expenditure in 2011 to around €50 billion, an increase of more than 7 percent. Preliminary estimates for 2012 assume a further increase of around 2 percent.

This means that R&D expenditure on the part of German business continued growing over the last five years despite the difficult economic parameters. As industry's demand for research has grown, more and more R&D contracts have been placed with external companies, universities and public-sector research institutions. Current planning estimates for 2013 foresee an increase of around 4 percent in R&D expenditure by industry.

Political background

- Federal budget prioritizes spending on education and research to secure the country's future
- Academic Freedom Act passed

In the face of the euro and sovereign-debt crisis, the federal and *Länder* governments redoubled their efforts to control public spending in 2012. All in all, the federal, *Länder* and local governments, and the social security funds managed to achieve a modest surplus, and a substantial reduction was made in the federal budget deficit.

In order to ensure an adequate supply of highly qualified employees and to improve the transfer of scientific knowledge from universities and research institutions to industry and society, Germany's system of scientific research must be able to rely on financial and organizational parameters that best serve this objective. In addition to the Joint Initiative for Research and Innovation launched in 2009, the federal government took additional key steps toward this end in 2012.

In the 2012 federal budget, top priority was given to expenditure on education and research. Although the federal government's planned expenditure increased in 2012 by only around 5 percent overall, the budget of the German Federal Ministry of Education and Research (BMBF) rose by around

11 percent to a total of €12.9 billion. A further increase of around €800 million, to a new total of €13.7 billion, is planned for the financial year 2013. The future-oriented portfolios of education and research thus remain an important focus of the federal government.

Another important prerequisite for ensuring Germany's position as a leading research nation was fulfilled in fall 2012 with the passing of the "Law to increase the flexibility of budgetary provisions governing non-university academic institutions" – also known as the Academic Freedom Act (Wissenschaftsfreiheitsgesetz – WissFG).

The purpose of the Academic Freedom Act is to enable publicly financed research institutions to deploy their funds more flexibly, and thus more effectively and efficiently. This includes enabling the institutions to maintain a global budget for personnel and material costs as well as investment funds, while streamlining approval processes for construction projects and enhancing the transfer of knowledge and technology through spin-offs. Ever fiercer international competition means that research institutions have to be able to recruit and retain highly qualified personnel. That is why the Academic Freedom Act also enables the institutions to pay allowances in addition to the salaries set down in the public-sector collective wage agreement (TVöD). These allowances must be financed through funds earned by the institutions themselves, which means they stem neither directly nor indirectly from German public-sector grants. The Fraunhofer-Gesellschaft welcomes these reforms as a means to make research management more efficient and to enhance its international competitive position.

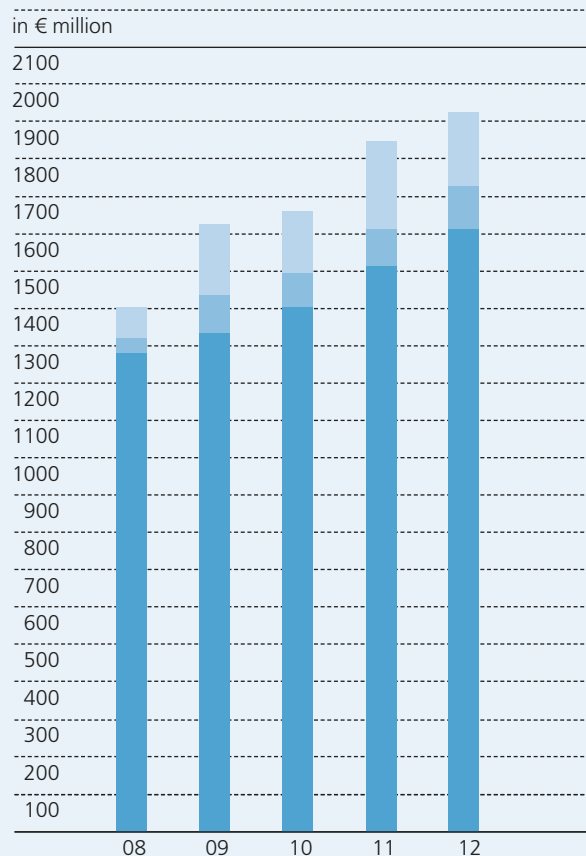
Business performance

- Business volume surpasses €1.9 billion
- Fraunhofer-Gesellschaft maintains its growth trajectory

The Fraunhofer-Gesellschaft remained on a growth trajectory in 2012. Fueled by the economic recovery in Germany and other countries, the progress made in research and development translated directly into economic gains. The Fraunhofer-Gesellschaft was thus able to continue its success and constant growth of the previous years.

In 2012, the Fraunhofer-Gesellschaft’s business volume grew by 4 percent year on year to reach a total of €1926 million. This comprises budgeted expenditure on contract research, defense research, and major infrastructure capital expenditure. In the year under review, budgeted expenditure for contract research activities grew by 7 percent to €1614 million. Budgeted expenditure in the defense research segment rose by 15 percent to €113 million. At €199 million, major infrastructure capital expenditure was again very high despite the expiry of publicly funded economic stimulus programs. In the following, we report on expenditure and income items of the performance statement for each separate research segment. For information on the accounting principles used by the Fraunhofer-Gesellschaft, please refer to the notes to the financial statements.

Fraunhofer-Gesellschaft total business volume (cash basis) 2008–2012



| | 2008 | 2009 | 2010 | 2011 | 2012 | |
|---|-------------|-------------|-------------|-------------|-------------|--------------|
| ■ | 1291 | 1340 | 1402 | 1515 | 1614 | |
| ■ | 38 | 87 | 93 | 98 | 113 | |
| ■ | 72 | 190 | 162 | 236 | 199 | |
| = | 1401 | 1617 | 1657 | 1849 | 1926 | in € million |

- Contract research
- Defense research
- Major infrastructure capital expenditure

Expenditure and income in the contract research segment 2008–2012 (in € million)

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|-------------|-------------|-------------|-------------|-------------|
| Personnel expenses | 624 | 697 | 745 | 784 | 868 |
| Non-personnel expenses | 456 | 428 | 443 | 514 | 543 |
| Change in the special license-fee revenue reserve and allocation to foundation capital | 44 | 55 | 56 | 74 | 52 |
| Current capital expenditure | 167 | 160 | 158 | 143 | 151 |
| Expenditure | 1291 | 1340 | 1402 | 1515 | 1614 |
| Imputed depreciation allowance | 128 | 143 | 151 | 135 | 136 |
| Project revenue | 859 | 916 | 1030 | 1101 | 1137 |
| Industrial revenue | 452 | 407 | 463 | 531 | 570 |
| of which license-fee revenue | 83 | 78 | 93 | 125 | 117 |
| Public-sector revenue (federal and <i>Länder</i> governments) | 248 | 317 | 406 | 405 | 382 |
| EU revenue (European Commission) | 61 | 65 | 65 | 71 | 88 |
| Other income | 98 | 127 | 96 | 94 | 97 |
| Base funding including reserves | 432 | 424 | 372 | 414 | 477 |
| Income | 1291 | 1340 | 1402 | 1515 | 1614 |

Contract research

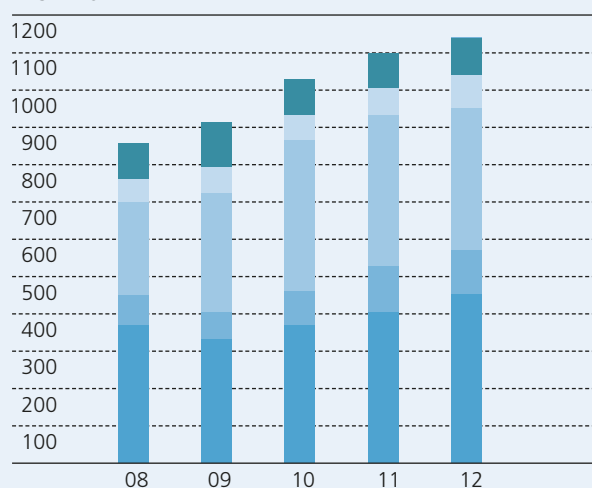
- Around 70 percent of budgeted expenditure financed through project revenue
- Industrial revenue from research contracts again records double-digit growth
- License-fee revenue remains high

Contract research forms the focus of the Fraunhofer-Gesellschaft's activities. It covers a broad range of research topics from which industrial and service companies, the public sector and society as a whole can benefit equally, and

includes areas such as manufacturing, mobility and transportation, energy and housing, information and communication as well as healthcare, nutrition and the environment. Together with its customers, the Fraunhofer-Gesellschaft develops and optimizes new technologies, processes and products, up to and including the manufacture of prototypes and preproduction series. Through its contract research activities, the Fraunhofer-Gesellschaft is a valuable provider of innovation and know-how, especially for small and medium-sized enterprises (SMEs) that do not carry out their own R&D.

Project revenue in the contract research segment 2008–2012

in € million



| | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|------------|------------|-------------|-------------|-------------|
| Industrial revenue (excluding license fees) | 369 | 329 | 370 | 406 | 453 |
| License-fee revenue | 83 | 78 | 93 | 125 | 117 |
| Public-sector revenue (federal and Länder governments) | 248 | 317 | 406 | 405 | 382 |
| EU revenue (European Commission) | 61 | 65 | 65 | 71 | 88 |
| Other income | 98 | 127 | 96 | 94 | 97 |
| = | 859 | 916 | 1030 | 1101 | 1137 |

- Industrial revenue (excluding license fees)
- License-fee revenue
- Public-sector revenue (federal and Länder governments)
- EU revenue (European Commission)
- Other income

In 2012, budgeted expenditure in the contract research segment grew by a substantial 7 percent to €1614 million, continuing on its growth trajectory of recent years. Personnel expenses rose by 11 percent to €868 million, mainly owing to the collectively agreed 3.5 percent wage increase that came into effect on March 1, 2012 and to the recruitment of more than 1700 additional employees. Non-personnel expenses increased to €543 million. This growth of 6 percent was proportionally matched by current investments, which rose to €151 million.

Project revenue in the contract research segment grew accordingly. It comprises all revenue that does not stem from base funding, but from research contracts financed by the Fraunhofer-Gesellschaft's customers, and this revenue increased by 3 percent to €1137 million in 2012. As a result, around 70 percent of budgeted expenditure was financed through project revenue.

Especially gratifying was the trend in industrial revenue, which rose by 7 percent in 2012 to a total of €570 million. It includes revenue from research projects with customers from private industry, which reached a new record level of €453 million. This extraordinarily strong increase of 12 percent underscores how successfully the Fraunhofer-Gesellschaft has aligned itself with the needs of industry. Amounting to €117 million in 2012, license-fee revenue did not reach the excellent volume achieved in 2011, although it must be said that the figure of 2011 owed much to non-recurring effects.

Public-sector revenue from projects with the federal and Länder governments fell by 6 percent in 2012 to €382 million. This drop was made up for by exceptionally high growth in revenues from projects with the European Commission, which rose sharply, by 24 percent, to €88 million. The goal of many

of the Fraunhofer-Gesellschaft's public-sector projects is to improve existing infrastructure, for example in the fields of energy, transportation and healthcare. Above and beyond that, these projects make an important contribution toward networking within the public research and education system and supporting innovation in the business world. At €97 million, other income was marginally higher than in the previous year.

Defense research

- Budgeted expenditure in the defense research segment exceeds €100 million for the first time
- Dual-use research model remains a success factor for innovation

Defense research comprises the expertise of the seven Fraunhofer Institutes that carry out research into defense and security. The objective of this research is to protect people and the environment in the best way possible against the threats posed by the growing global networking of society. Alongside early detection and prevention, the focus is on direct protection and rapid recovery from the consequences of catastrophic events. Within the context of dual-use research, the Fraunhofer Institutes – together with their business partners and public-sector customers – are successfully developing not only defense-related technologies, but also solutions for civil applications.

In 2012, budgeted expenditure in the defense research segment recorded exceptionally strong growth of 15 percent and, at €113 million, passed the €100 million threshold for the first time. Of that total amount, €65 million was accounted for by personnel expenses and €27 million by non-personnel

expenses. This strong growth in budgeted expenditure is primarily attributable to a sharp rise in current capital expenditure, which at €21 million was almost double the amount posted in the previous year.

In the year under review, the German Federal Ministry of Defence (BMVg) provided €58 million in base funding to cover budgeted expenditure.

Major infrastructure capital expenditure

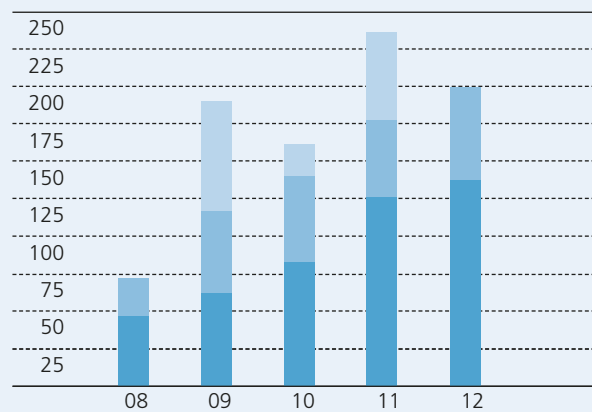
- Major infrastructure capital expenditure remains high despite expiring stimulus programs
- Higher share of spending accounted for by minor building projects

In 2012, the Fraunhofer-Gesellschaft invested a total of €199 million in the infrastructure of its research institutions. Compared with the high volume of €236 million recorded in 2011, capital spending on major infrastructure thus fell markedly. However, it must be borne in mind that 2011 was the last year in which funds were made available under the federal and *Länder* governments' economic stimulus programs, and that such funds accounted for around one-quarter of the respective volume.

In addition to new buildings and extensions, major infrastructure capital expenditure includes minor building projects that extend the functional scope of existing buildings and require a comparatively small amount of spending. In the year under review, the amount spent on minor building projects rose by 27 percent to €38 million. That was roughly one-fifth of the total amount spent on major infrastructure.

Major infrastructure capital expenditure and funding sources 2008–2012

in € million



| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|-----------|------------|------------|------------|------------|
| ■ | 47 | 62 | 83 | 126 | 137 |
| ■ | 25 | 55 | 57 | 51 | 62 |
| ■ | | 73 | 22 | 59 | |
| = | 72 | 190 | 162 | 236 | 199 |

in € million

- Federal and *Länder* governments
- ERDF (European Regional Development Fund)
- Economic stimulus programs I and II

In 2012, the federal and *Länder* governments together provided around €137 million in funding for major infrastructure projects. The European Regional Development Fund (ERDF) provided co-funding of €62 million. Leaving aside the funds from economic stimulus programs, which were allocated for the last time in 2011, regular funding for major infrastructure projects actually rose by a substantial 12 percent.

The following is a brief run-down of some of the major projects tackled.

Around €11 million was spent in 2012 on the expansion of the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe, a project that will have a total investment volume of around €37 million. The construction of a clean-room building will enhance the status of one of the world's leading development sites for microelectronics and microsystems technology, and create almost 50 new office jobs. The ERDF is covering 50 percent of the financing needs, while the remaining half will be borne in equal parts by the federal government and the *Land* of Schleswig-Holstein.

In June 2012, the Center for Virtual Engineering (Zentrum für Virtuelles Engineering [ZVE]), for which the Fraunhofer Institute for Industrial Engineering IAO is responsible, was opened in Stuttgart. The new center, which has won accolades for its unique architecture and sustainable design, cost €14 million to build and was financed jointly by the federal government and the *Land* of Baden-Württemberg. It will provide a platform for the development of virtual-reality technologies and new approaches to office space. During the construction phase, the center itself served as a pilot study for innovative project partnerships.

Major infrastructure capital expenditure 2012 (in € million)

| Institute/Research Institution | Location | Total | ERDF ¹ | Federal /Länder governments |
|---|----------------|--------------|-------------------|-----------------------------|
| Silicon Technology | Itzehoe | 11,2 | 5,6 | 5,6 |
| Institute Center Dresden | Dresden | 8,7 | 5,2 | 3,5 |
| Silicate Research | Würzburg | 8,4 | 3,1 | 5,3 |
| Integrated Systems and Device Technology | Erlangen | 8,4 | 4,2 | 4,2 |
| Applied Polymer Research | Potsdam-Golm | 8,0 | 4,0 | 4,0 |
| Center for Silicon Photovoltaics | Halle | 7,7 | 5,8 | 1,9 |
| Clinical Research Center | Hannover | 7,7 | | 7,7 |
| Machine Tools and Forming Technology | Chemnitz | 7,7 | 4,6 | 3,1 |
| Integrated Circuits | Fürth | 7,4 | 3,7 | 3,7 |
| Cell Therapy and Immunology | Leipzig | 6,5 | 3,9 | 2,6 |
| Chemical Technology | Augsburg | 5,9 | 2,1 | 3,8 |
| Competence Center for High-Tech Production | Aachen | 5,7 | | 5,7 |
| Industrial Mathematics | Kaiserslautern | 5,6 | 2,8 | 2,8 |
| Biomedical Engineering | Saarbrücken | 4,8 | 2,4 | 2,4 |
| Reliability and Microintegration | Berlin | 4,6 | 2,3 | 2,3 |
| Industrial Engineering | Stuttgart | 4,6 | | 4,6 |
| Solar Energy Systems | Freiburg | 4,1 | | 4,1 |
| Center for Chemical-Biotechnological Processes | Leuna | 3,7 | | 3,7 |
| Transportation and Infrastructure Systems | Dresden | 3,5 | | 3,5 |
| Wind Energy and Energy System Technology | Bremerhaven | 3,3 | 0,8 | 2,5 |
| Integrated Circuits | Nürnberg | 3,0 | 0,8 | 2,2 |
| Ceramic Technologies and Systems | Herrmsdorf | 2,5 | 1,9 | 0,6 |
| Secure Information Technology – CASED ² | Darmstadt | 2,2 | | 2,2 |
| Technology Centre for Semiconductor Materials | Freiberg | 1,8 | 1,1 | 0,7 |
| Marine Biotechnology | Lübeck | 1,7 | 0,8 | 0,9 |
| Microelectronic Circuits and Systems | Duisburg | 1,6 | 0,8 | 0,8 |
| Institute Center Stuttgart | Stuttgart | 1,6 | | 1,6 |
| Applied Optics and Precision Engineering | Jena | 1,5 | 1,0 | 0,5 |
| Integrated Circuits | Waischenfeld | 1,3 | 0,3 | 1,0 |
| Project Group for New Drive Systems | Pfingztal | 1,1 | | 1,1 |
| Other construction projects | | 15,0 | 4,8 | 10,2 |
| Measures financed by federal /Länder governments and/or ERDF¹ | | 160,8 | 62,0 | 98,8 |
| Minor building projects | | 38,0 | 0,2 | 37,8 |
| Major infrastructure capital expenditure | | 198,8 | 62,2 | 136,6 |

1 ERDF = European Regional Development Fund

2 CASED = Center for Advanced Security Research Darmstadt

In October 2012, the Fraunhofer Center for Chemical-Biotechnological Processes CBP in Leuna was opened with a ceremony attended by German Chancellor Angela Merkel. Construction of the center cost €24 million and was financed in equal parts by the federal government and the *Land* of Saxony-Anhalt. The various projects carried out at the center will be supported by different German federal ministries and partners from industry. The focus of research is on the chemical processing of renewable raw materials and biomolecules.

The new extension to the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig was inaugurated in January 2013. It complements the existing research infrastructure of Fraunhofer IZI, adding a further 1200 m² of experimental-medicine labs fitted out with the latest imaging technologies and equipment for developing and testing cell therapeutics. The federal government and the *Land* of Saxony provided over €4 million toward the construction costs, while a further €7 million came from ERDF funds.

Fraunhofer Groups

Collaboration in thematically oriented groups makes it possible to develop cross-institute strategies and to coordinate the procurement and utilization of strategic equipment. Through the steering committees and chairs of the Groups, the institutes can play an active role in shaping the corporate policy and implementing the functional and financing model of the Fraunhofer-Gesellschaft. The Fraunhofer Institutes belonging to the contract research segment are organized into the following six Fraunhofer Groups, each devoted to a specific area of technology:

With budgeted expenditure of €430 million in 2012, the **Fraunhofer Group for Materials and Components – MATERIALS** is the largest group within the Fraunhofer-Gesellschaft and comprises 14 institutes with a focus on material sciences. Their activities include developing new materials and improving existing ones, developing production techniques, characterizing materials, and evaluating their behavior. The group is active in the fields of energy, healthcare, mobility, information and communication as well as in building and housing. “Intelligent materials”, which feature sensor and actuator functions and have huge future potential, are one example of the group’s current focus. In 2012, the Fraunhofer Institute for Solar Energy Systems ISE was particularly successful. Dr. Andreas Bett, who is deputy director of the institute, was jointly honored with a partner from industry with the German Environmental Prize for the development of highly efficient concentrator photovoltaic modules.

At 11 percent, the group recorded the biggest growth in budgeted expenditure of all the Fraunhofer Groups. Industrial revenue rose by 8 percent to €145 million. All in all, project revenue increased by 4 percent to €316 million, and the proportion of expenditure covered by project revenue reached a very high 83 percent.

The **Fraunhofer Group for Microelectronics** unites 12 research institutions active in the field of microelectronics and microintegration. The group offers innovative SMEs, in particular, forward-looking research and application-oriented innovations in the areas of semiconductor technology, communication technology, assistance systems, energy-efficient systems and e-mobility, lighting, security and entertainment. One of the group's many recent inventions with big potential benefit for society is affordable wireless technology, which can be deployed in developing countries to grant rural areas access to broadband Internet and the cellular phone network.

The group's budgeted expenditure grew by 6 percent in 2012, reaching €346 million. Project revenue, at €251 million, and industrial revenue, at €144 million, were roughly the same as in 2011. At 45 percent, the proportion of expenditure covered by industrial revenue was the second highest of all the Fraunhofer Groups.

The **Fraunhofer ICT Group** pools together the activities of 15 research institutions. It develops strategies and visions for future research and supports the individual institutions in networking with businesses, the media and other scientific institutions. The group offers tailored IT solutions, professional consulting in technological fields, and pre-competitive research for new products and services in the fields of digital media, information/communication technologies, energy and sustainability, medicine, production, security, financial services, automotive, e-business, and e-government. Among other achievements, the group has developed imaging techniques for medical technology as well as integrated software solutions to interconnect a variety of media and to digitalize historic cultural assets.

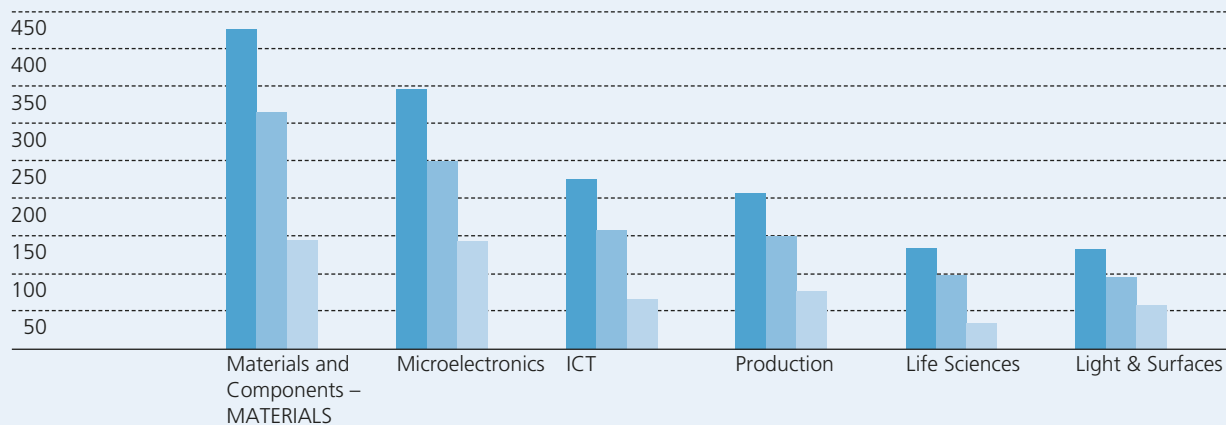
In 2012, the group's budgeted expenditure reached €226 million, an increase of 5 percent. At €159 million, project revenue was roughly the same as in 2011. By contrast, industrial revenue grew by a substantial 13 percent to €67 million.

The **Fraunhofer Group for Production** brings together 7 Fraunhofer Institutes and specializes in production-oriented research and development. Its goal is to offer holistic solutions to the problems of customers from industry, trade and services. In its business areas – namely product development, manufacturing technologies, manufacturing systems, logistics, production processes, and production organization – the group offers a range of services along the entire product lifecycle and value chain. Apart from focusing on resource-efficient production technologies, the group is currently also devoting attention to green powertrain technologies, a Fraunhofer frontline theme, and to the Beyond Tomorrow project entitled "Manufacturing in closed-cycle material flows".

The group's budgeted expenditure increased by 8 percent in 2012 to reach €208 million. Projects with partners from industry and with public-sector customers helped to raise external revenue by 7 percent to €150 million. Industrial revenue increased by 7 percent as well, reaching €77 million and an above-average share in total revenues of 41 percent.

The **Fraunhofer Group for Life Sciences**, the Fraunhofer-Gesellschaft's newest group, pools expertise in the biological sciences, biomedicine, pharmacology, food technology and toxicology. The group's 7 research institutions offer its customers innovative know-how in the areas of medical translational research, biomedical engineering, regenerative medicine, healthy foodstuffs, biotechnology, and safety issues pertaining to processes, chemicals and pesticides. Some of the group's outstanding projects include the testing of lipid-rich algal biomass as a renewable energy source, the development of artificial blood vessels that can be manufactured using 3D printing techniques, and a cryobank for storing the reagents needed to develop an HIV vaccine.

Budgeted expenditure, and project and industrial revenues of the Fraunhofer Groups in the contract research segment in 2012 (in € million)



■ Total expenditure
 ■ Project revenue
 ■ Industrial revenue

| | Materials and Components – MATERIALS | Microelectronics | ICT | Production | Life Sciences | Light & Surfaces |
|--|--------------------------------------|------------------|------------|------------|---------------|------------------|
| Operating expenditure | 381 | 320 | 212 | 190 | 114 | 114 |
| Capital expenditure | 49 | 26 | 14 | 18 | 20 | 19 |
| Total expenditure | 430 | 346 | 226 | 208 | 134 | 133 |
| Change | 11% | 6% | 5% | 8% | 11% | 7% |
| Project revenue | 316 | 251 | 159 | 150 | 99 | 96 |
| Change | 4% | -2% | 2% | 7% | 9% | 6% |
| Industrial revenue | 145 | 144 | 67 | 77 | 35 | 55 |
| Change | 8% | 2% | 13% | 7% | 21% | 21% |
| Breakdown of revenue in %¹ | | | | | | |
| Project research (total) | 83 | 78 | 75 | 79 | 87 | 84 |
| Industry | 38 | 45 | 32 | 41 | 31 | 48 |

¹ Shares of project revenue and industrial revenue in operating expenditure

In 2012, the Fraunhofer Group for Life Sciences posted exceptionally strong growth, increasing its budgeted expenditure by almost 11 percent to €134 million. The fact that project revenue grew by 9 percent to €99 million and industrial revenue by an exceptional 21 percent to €35 million indicates the enormous potential of the group's research work for future applications. The proportion of the group's budgeted expenditure covered by project revenues was 87 percent, the highest figure of all the Fraunhofer Groups.

Comprising 6 member institutes, the **Fraunhofer Group for Light & Surfaces** carries out research into surface engineering and photonics, key technologies that are deployed in a large number of applications – including manufacturing technology, optical sensor systems and biomedical engineering. The group's core competencies include the development of coating processes, the functionalization of surfaces, materials processing, optical measuring techniques, and the development of micro-optical and precision-engineering systems. In 2012, 13 employees of the Fraunhofer Institute for Laser Technology ILT and its spin-offs EdgeWave and AMPHOS won second prize at the "Berthold Leibinger Innovationspreis" awards for developing the high-performance InnoSlab laser. The third prize went to researchers at the Fraunhofer Institute for Physical Measurement Techniques IPM, who – in cooperation with the University of Stuttgart and the Technische Universität Dresden (TU Dresden) – developed a prototype for adjusting the weld depth in industrial laser beam welding processes.

In 2012, the group succeeded in raising its project revenue by 6 percent to €96 million, and expanded its budgeted expenditure to €133 million. Thanks to exceptional growth in industrial revenue – up 21 percent to €55 million – at 48 percent the Fraunhofer Group for Light & Surfaces posted the highest share of industrial revenues as a proportion of budgeted expenditure of any Fraunhofer Group in 2012.

The **Fraunhofer Group for Defense and Security VVS** comprises 7 Fraunhofer Institutes carrying out defense-related research. They joined forces in order to coordinate their activities in the areas of security research, protection and deterrence, reconnaissance and surveillance, explosives and security engineering, decision-making support for government and industry, image processing, localization and communication, and to develop innovative solutions to urgent security problems. The focal points of the group's research work include crisis and disaster management, cybersecurity and defense as well as information and communication. In addition, the group also carries out research into the protection of critical infrastructure as well as into technologies supporting the command and deployment of reconnaissance and surveillance missions.

The fact that many research topics are relevant to both military and civil applications (i.e. dual use) is an important source of the group's innovation, and a means of expanding its range of services. The Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, for instance, developed a radar system that can detect the tiniest of objects no matter what the weather conditions. The system can continuously monitor airport runways for foreign bodies – such as parts lost by aircraft – thus enhancing the safety of flight operations.

The group's budgeted expenditure increased by 10 percent in 2012 to reach €193 million, around €82 million of which was for civil research carried out by the member institutes. In 2012, project revenue amounted to €114 million. Owing to the very nature of the defense research segment, project revenue there accounts for a much smaller share of total revenues than it does in the contract research segment.

Fraunhofer Institutions and project groups in the process of establishment

The Fraunhofer-Gesellschaft's strong growth is not due solely to the organic growth of its existing institutes. It has also been driven by the integration of external institutions – such as the German Plastics Institute (Deutsches Kunststoff-Institut [DKI]), which was incorporated into the Fraunhofer Institute for Structural Durability and System Reliability LBF in 2012 – and by the establishment of new project groups. Over the last five years, five institutes and three branch institutes have been integrated in the Fraunhofer-Gesellschaft, while four further institutes have been newly established. A total of more than 30 new branch institutes and project groups, with budgeted expenditure of €139 million, are currently in the process of being set up. The operating budget of institutions of this kind rose by around 40 percent to €116 million in 2012, accounting for a share of 8 percent in the total operating budget of the contract research segment.

The establishment/integration of these institutions generally necessitates a transition period of five years, during which their operating costs are financed exclusively by the respective *Land* in which they are located. Before they can be integrated into the Fraunhofer-Gesellschaft's system of 90:10 financing – 90 percent federal government funding and 10 percent *Land* funding – the institutions are subjected to a standardized evaluation process to determine whether they qualify as a Fraunhofer Institution in the long term.

Several institutions are deserving of special mention, among them the Fraunhofer Project Group for Hearing, Speech and Audio Technology. Under the leadership of its director Prof. Dr. Dr. Birger Kollmeier, and in cooperation with the University of Oldenburg and Siemens AG, the project group has developed a novel kind of hearing aid which makes it easier for the hearing-impaired to localize sources of sound in very much the same way as the unimpaired human ear. This invention was awarded the German Future Prize 2012 by Federal President Joachim Gauck.

Financial situation and net asset position

- Solid liquidity position
- Base funding increased by 5 percent
- Higher funding ratios needed

The Fraunhofer-Gesellschaft's cash assets (cash and cash equivalents including current bank accounts) totaled €16 million at the end of 2012. In the year under review, the Fraunhofer-Gesellschaft made no use of funds carried forward under its management statutes.

The Fraunhofer-Gesellschaft's financing model rests on three pillars – base funding, revenue from contracts with industry, and revenue from public-sector projects – each of which contributes roughly one-third of total funds. Base funding in the contract research segment is split between the federal and *Länder* governments in the ratio of 90:10. These funds are made available for strategic initiatives of the Executive Board as well as for the institutes' in-house and pre-competitive research. Under the Joint Initiative for Research and Innovation, the Fraunhofer-Gesellschaft's base funding has been incremented by an annual amount of 5 percent since 2011.

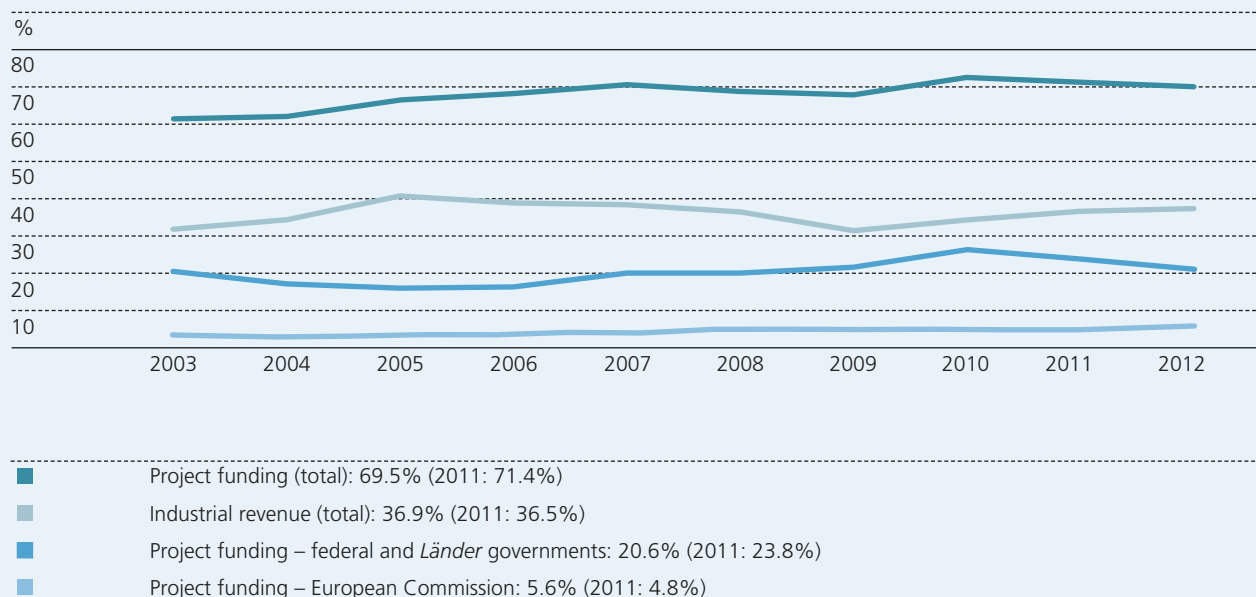
In recent years, the Fraunhofer-Gesellschaft has expanded its key research areas, actively exploiting its opportunities in the contract research segment. The organization's strong growth demonstrates how attractive its research activities are to the market. This growth is ultimately an indicator of the German economy's demand – and potential – for innovation. Increases in base funding have not kept pace with the Fraunhofer-Gesellschaft's rate of growth. Even after the current Joint Initiative for Research and Innovation runs out, Fraunhofer continues to rely on long-term increases in its base funding of at least 5 percent p.a. This will enable the organization to continue pursuing the projects it has launched

so successfully, and will prevent having to cap either its pre-competitive research or project business with industry. Limiting either of these would not be in the interests of the German economy, which relies more and more on its innovative strength in order to maintain a competitive edge in the global market.

Public-sector funding of research projects is subject to the Federal Budgetary Regulations, and the general principle of budget transparency anchored in them. Fraunhofer's political mandate also requires it to use the funds it receives to develop new areas of strategic interest in pre-competitive research. Inadequate funding ratios and forms of financing that do not cover 100 percent of the costs incurred pose problems because they tie up resources from base funding that would otherwise be used to finance pre-competitive research. That is why, some years ago, binding rules for measuring funding ratios were laid down for the project funding provided by the German Federal Ministry of Education and Research (BMBF), the key principle being that projects carried out without external partners are to be financed at a standard rate of 100 percent of the full costs. Even in the case of joint projects involving external partners, it is ensured that Fraunhofer's share of the financing is covered without the organization having to dip into its own funds. In Fraunhofer's view, this practice has proven its worth.

By contrast, project funding by the *Länder* governments remains quite heterogeneous owing to the wide variety of legal and financial requirements involved. Especially when funds from the European Regional Development Fund (ERDF) or the European Social Fund (ESF) are used for refinancing, allocation practice varies markedly between the *Länder*. As a result, the actual funding ratios diverge substantially as well.

Funding resources in the contract research segment 2003–2012



Given both public-funding objectives and budgetary constraints, the project funding requirements of the *Länder* governments need to be harmonized across the board to enable full financing and to acknowledge that all direct and indirect costs are eligible for reimbursement. Fraunhofer needs to have full use of its base funding resources for in-house pre-competitive research, so that it can continue enhancing its innovative strength and thus contribute towards securing Germany's growth and prosperity.

Balance sheet

- Total assets reach €2.5 billion
- Prefinancing down €21 million

The Fraunhofer-Gesellschaft's total assets at December 31, 2012, amounted to around €2538 million, up 4 percent over the previous year.

Fixed assets increased by a total of €93 million to around €1723 million, of which €1694 million was for property, plant and equipment. At December 31, 2012, property, plant and equipment represented 67 percent of total assets and was thus the predominant item on the assets side of the Fraunhofer-Gesellschaft's balance sheet. Intangible assets amounted to €13 million and financial assets to €16 million.

Accounts receivable and other current assets increased by €4 million to €502 million, with trade receivables rising by €14 million, receivables from the federal and *Länder* governments by €4 million and accounts receivable from associated companies by €2 million. Other assets decreased by €16 million.

Inventories net of advance payments by customers increased by €14 million.

Cash-equivalent, short-term marketable securities fell by €6 million to €230 million. Additions totaled €44 million, while disposals comprised transfers to the spending capital of the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation) totaling €50 million. In 2012, the Fraunhofer Fund's available assets were invested in low-risk liquid securities; on average, the split over the year was 62 percent in money market instruments, 16 percent in bonds, 14 percent in multi-asset funds, 3 percent in equities, 2 percent in commodities and 3 percent in renewable energy. In view of the uncertain market environment, the Fraunhofer Fund's asset allocation policy favored low risk investments, with the Fund steering and proactively containing its investment risks through dynamic, systematic management of the allocations to the individual segments and through risk overlay with threshold control.

Cash assets (cash and cash equivalents including the Fraunhofer-Gesellschaft's current bank accounts) decreased by €9 million to €16 million.

Prepaid expenses and deferred charges, which primarily include prepaid rent, maintenance contracts, and services, rose to €8 million.

Equity grew by €0.5 million, which represents the net profit for the year from the association's accounts, and amounted to €14 million at December 31, 2012. The non-profit organization's capital is that portion of the Fraunhofer-Gesellschaft's assets that has not been acquired out of public funds. In addition to the capital of the non-profit organization and the restricted reserves, equity is also deemed to include the special reserves for license-fee revenue and for grants relating to fixed assets.

The special reserve for license-fee revenue increased by €1.8 million in the year under review. This change reflects the balance of net license-fee revenue and net income from asset management in the amount of €91.1 million, the amount of €17.6 million consumed by the Fraunhofer Institute for Integrated Circuits IIS in Erlangen, payment of the amount of €21.7 million remaining from base funding and transfers of €50.0 million to the spending capital of the Fraunhofer Future Foundation. The license-fee revenue reserve stood at €244 million on December 31, 2012.

Funds received for the purpose of acquiring and constructing fixed assets are transferred to a special reserve, which is reduced each year by an amount corresponding to the annual depreciation expense on the related assets. The special reserve for grants relating to fixed assets increased by €93 million to €1709 million in 2012, in line with the carrying amount of the assets financed by such external funds.

The special reserve for funds used to finance current assets is used to account for income not yet received or expenses not yet paid by the balance sheet date. In 2012, prefinancing decreased €21 million to €193 million.

Provisions for pensions and similar obligations amounted to €10 million. The Fraunhofer-Gesellschaft has a reinsurance policy in place to cover its existing pension obligations, as a

means of offloading biometric risks and converting uncertain long-term liabilities into foreseeable, calculable costs. The pension provisions are measured using the capitalized value calculated by the insurance company on the reporting date.

Other provisions rose by €14 million to €132 million, especially owing to higher provisions for impending lawsuits and for compensated leave. The change in other provisions has no impact on the funding situation due to the simultaneous change in the special reserve for funds used to finance current assets. In the case of pension and compensated leave provisions, corresponding balancing amounts are entered on the assets side of the balance sheet.

In 2012, liabilities increased by €9 million to €228 million, and comprised €131 million in grants from the federal and *Länder* governments still to be appropriated, €85 million in trade payables, and €12 million in other liabilities.

Deferred income rose to €8 million, and relates primarily to lump-sum license fee payments received for mp3 technology before the reporting date and not yet recorded as revenue.

No subsequent significant events have arisen since the reporting date that are material to assessing the development of the organization's business in the year under review or which have a substantial impact on its financial position, net assets or operating results.

Employees

- Over 1700 additional employees recruited
- Guidelines enacted for the responsible treatment of temporary workers
- Focus on raising the share of women in positions as scientists and managers

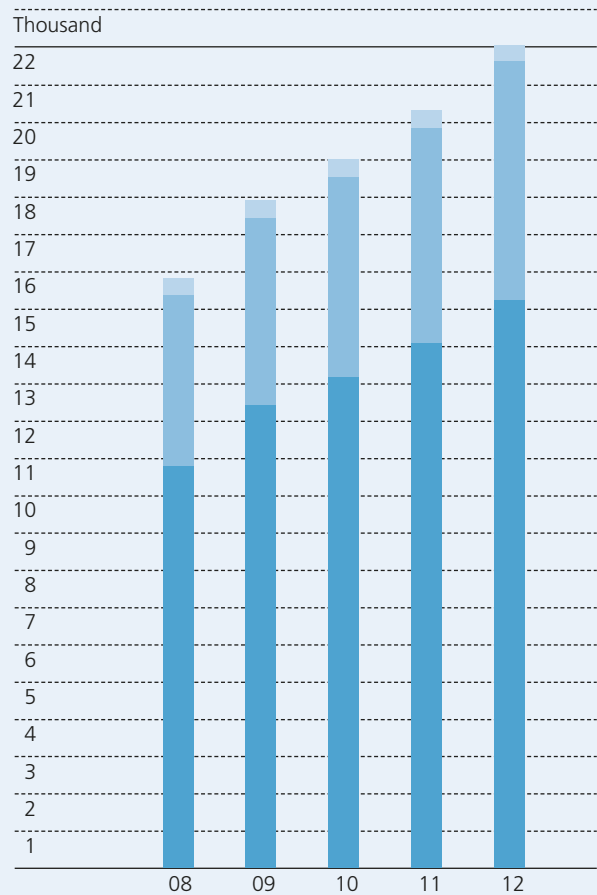
At December 31, 2012, the Fraunhofer-Gesellschaft had 22,093 employees. Thus, compared with 2011, an additional 1767 employees were available to handle the much larger number of research projects. Talented, highly qualified and motivated employees are key to the Fraunhofer-Gesellschaft's ability to perform excellent research work for its clients. Recruiting, retaining and developing skilled workers is one of the key elements in the long-term success of the Fraunhofer-Gesellschaft, where the strategic thrust and instruments comprising integrated human resources management are constantly being adapted to meet current and future requirements.

Fraunhofer is regarded as one of the most attractive employers in Germany. In the Randstad Awards 2012, the organization took first place as the most attractive employer amongst 150 major German companies (measured by size of workforce). In surveys carried out by personnel consultants Universum, Fraunhofer was ranked second most popular employer by science students, as was the case in previous years. Fraunhofer also ranks second among the target group of young professionals with scientific qualifications. The most recent Fraunhofer Employee Survey also confirms the organization's attractiveness as an employer, with over 80 percent of those taking part acknowledging that Fraunhofer's values and culture matched their own and that they were proud to work for the organization.

As the Fraunhofer-Gesellschaft is an extra-university research institution, it is usual for the organization to employ many workers on a temporary basis. That is why the responsible treatment of all temporary workers forms a key component of Fraunhofer's policy of value-oriented human resources management. To this end, corresponding guidelines were drawn up in 2012. They establish a uniform standard for the Fraunhofer-Gesellschaft as a whole, with each Fraunhofer Institute retaining responsibility for how the guidelines are fleshed out at local level. It is essential that temporary workers are granted perspectives for growth and development so that they have an opportunity to pursue a successful career, whether with Fraunhofer or outside the organization. The new guidelines were elaborated in joint discussions between the Executive Board and Presidential Council as well as the standing committee of the Fraunhofer-Gesellschaft's Scientific and Technical Council and the Central Works Council. They will be reviewed and updated on a regular basis depending on the practical experience gained in implementing and applying them.

One of the Fraunhofer-Gesellschaft's declared goals is to win over more women for scientific professions. Quite apart from the other motives behind this drive, mixed teams of men and women are of fundamental importance to innovation and creativity. Equal opportunities for women and men are a key aspect of Fraunhofer's overall diversity management policy. In this context, we are currently giving top priority to two aspects: increasing the proportion of women in scientific positions and raising the share of women managers. Fraunhofer is highly systematic in its pursuit of this goal. Among other things, it has launched an internal project entitled "Opportunities and obstacles in recruiting, retaining and developing women scientists at Fraunhofer". The aim of the project is to determine, in a targeted manner, where potential for improvement exists and to make substantial progress as soon as possible.

Growth in the Fraunhofer-Gesellschaft's workforce 2008–2012



| | 2008 | 2009 | 2010 | 2011 | 2012 |
|--|---------------|---------------|---------------|---------------|---------------|
| ■ Scientific, technical and administrative personnel | 10 784 | 12 410 | 13 202 | 14 073 | 15 220 |
| ■ Graduates, students, school students | 4 584 | 5 009 | 5 313 | 5 765 | 6 403 |
| ■ Trainees | 455 | 488 | 487 | 488 | 470 |
| = | 15,823 | 17,907 | 19,002 | 20,326 | 22,093 |

- Scientific, technical and administrative personnel
- Graduates, students, school students
- Trainees

In recent years Fraunhofer has succeeded in increasing the proportion of women in scientific positions by around 3 percentage points to just under 21 percent (as of December 31, 2012). That percentage is well above those for the industrial research sector and for the engineering professions in general, and demonstrates Fraunhofer's attractiveness for female graduates of mathematics, IT, science and technology when compared to industrial employers offering similar positions. When looking at the proportion of women in management positions, Fraunhofer can again boast a relatively high share of over 13 percent.

Nonetheless, the organization intends to raise these quotas even further and has chosen ambitious targets. The goal is to recruit women for 28 percent of vacant positions in 2012, 30 percent in 2013 and 33 percent in 2014, measured against the planned growth of the institutes. Given the current shares of women graduates in the subjects of relevance to Fraunhofer, that will be a real challenge. Despite our best efforts, we fell just short of our target in 2012.

In the course of 2012, the development of a Fraunhofer-specific cascade model similar to the one formulated in the gender equality standards of the DFG (Deutsche Forschungsgemeinschaft – German Research Foundation) was discussed in depth by the organization's internal bodies. Fraunhofer's benchmark for target growth in the proportion of women scientists – which in turn serves as a point of reference for target growth in the proportion of women managers – is the percentage of female graduates in relevant subjects of study. Also taken into account are the Fraunhofer-Gesellschaft's projected overall growth and the average fluctuation rate for scientific personnel. Based on these figures, the Executive Board has resolved to raise the number of women scientists at Fraunhofer by 872 – and the corresponding number of women managers by 100 – by 2017.

End-to-end talent management is an essential component in the recruitment of highly qualified and motivated workers. The Attract program specifically targets external scientists with innovative ideas who come from internationally renowned research institutions or industrial companies. It offers them – in the role of a group manager closely tied to one of the Fraunhofer Institutes – the opportunity to pursue their innovative ideas along the path toward practical application.

By contrast, the Vintage Class program, which was developed with Fraunhofer's own managers in mind, aims to promote succession planning and groom potential candidates for senior management positions at the institutes. Apart from being offered tailored personnel development measures, the Vintage Class members form a network that also functions as a think tank for the Fraunhofer-Gesellschaft. As part of an internal project entitled "Mobility and networking" that was organized by Human Resources, networking concepts have been developed to encourage dialog between young scientists at Fraunhofer and extend the horizons in which ideas develop. The methods were elaborated in workshops organized by Vintage Class members and attended by more than 300 employees from all levels of the hierarchy.

For the Fraunhofer-Gesellschaft, providing occupational training to young people is not only a responsibility borne toward society, but a key component in safeguarding the organization's non-scientific workforce. At the moment, Fraunhofer has 470 trainees and apprentices in 37 different occupations. The annual "Honor the Best" award marks the outstanding achievements of the top trainees/apprentices and their teachers in each training year. After completing their training, the majority of the Fraunhofer-Gesellschaft's apprentices and trainees remain with the organization, forming a talent pool for non-scientific workers.

The provisions of the new Academic Freedom Act give scientific institutions budgetary freedom to use funding provided by third parties from the private sector to pay supplementary allowances to some of their employees on top of their salaries. In addition to scientists employed either under collective wage agreements or on non-standard contracts, these provisions cover employees in science-related areas who make a major contribution to the planning, preparation, implementation, evaluation and assessment of research projects.

In close cooperation with the German Federal Ministry of Education and Research (BMBF), the Fraunhofer-Gesellschaft is in the process of compiling a guideline for dealing with cases in which the so-called Besserstellungsverbot, i.e. the prohibition on offering different payment levels to holders of positions in the same salary category, does not per se apply, such as has been set down in the Academic Freedom Act. This Besserstellungsverbot has meant that the wages paid to employees of organizations receiving public funding – such as Fraunhofer – must be directly comparable with collectively agreed wages paid to employees in similar positions at organizations providing public funding, i.e. government bodies and institutions. The Fraunhofer-Gesellschaft welcomes the introduction of the Academic Freedom Act as it will make it easier for the organization to offer competitive compensation in future. It will also grant Fraunhofer more scope in countering the dwindling availability of qualified personnel and enable it to remunerate outstanding performance on the part of its employees.

Risk management and risks

- Constant monitoring of the risk situation at Fraunhofer
- No anomalies in the overall risk situation

In carrying out its mandate as an applied research organization, Fraunhofer takes calculated risks in order to create innovations that will benefit both the economy and society at large. The 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 way that they either do not materialize at all or do not have consequences that could jeopardize the fulfillment of Fraunhofer's mission in accordance with its statutes or its ability to meet its own business objectives.

The risk management process is set down in the Fraunhofer-Gesellschaft's risk management manual. The central departments inform the Executive Board of risks – both routinely and on an ad-hoc basis – via the reporting channels in place. The Fraunhofer-Gesellschaft supplements these activities by preparing a dedicated risk report once a year, which summarizes and prioritizes the results of a survey of risk experts.

The Fraunhofer-Gesellschaft understands "risk" to mean all internal and external events and developments jeopardizing the fulfillment of its business objectives. These include both risks that can be given a monetary value and those of a qualitative nature.

Business risks include those risks arising out of changes in the political, legal and economic framework of applied research.

Political decisions can affect Fraunhofer financially, for instance through a reduction in planned funding contributions or restrictions placed on transferring unused portions of the previous year's funding. Under the current Joint Initiative for

Research and Innovation (2011–2015), Fraunhofer's base funding is being increased by 5 percent per annum. However, there are indications that some *Länder* governments, under pressure from the debt brake anchored in the German constitution, are looking for ways to achieve cost savings in the area of research. We are currently proceeding on the assumption, however, that if funding were moderately reduced in real terms, enough time would remain for us to take countermeasures.

As a non-profit organization and beneficiary of public funds, Fraunhofer is also subject to federal and *Länder* government regulations and wider EU legislation. In its R&D Framework Program "Horizon 2020", which is set to commence in 2014, the EU Commission is planning a departure from its previous practice of financing 100 percent of the full costs. Instead, it intends to introduce flat rates for overhead costs. For Fraunhofer, that would have a direct negative impact on the funding ratio for EU projects. There is also an indirect risk that this departure will influence the project funding practice of the *Länder* governments, as their projects are refinanced to a large extent with ERDF funds. Together with its partners in the European Association of Research and Technology Organizations (EARTO), Fraunhofer is lobbying the decision-makers in the European Parliament and European Commission to adopt the "full-cost" option in the rules for participation in the Horizon 2020 program. At *Länder* level, Fraunhofer is taking a proactive approach in its negotiations with the funding agencies in order to achieve recognition for the "full-cost" method of financing and to avoid ambiguities and exceptions when it comes to the billing of costs.

The diversification and ongoing enhancement of Fraunhofer's research portfolio makes it possible to spread risks and thus limit the danger of strategic misjudgments. Tried-and-tested strategy processes are in place that ensure a permanent feedback loop with market players – for instance through technology audits or advisory boards.

Financial risks are those that are rooted in the non-profit association's financial activities.

When it comes to potential tax risks, we are closely monitoring the risk that Fraunhofer or parts of its organization might be deprived, for their operational activities, of the status of a business entity, as the tax authorities are beginning to take a more restrictive approach to this subject. To this end, Fraunhofer has enacted a package of measures, and is maintaining a dialog with the relevant tax authorities so as to keep abreast of possible changes in the tax framework.

Capital market risks can arise when the non-profit organization capital and reserves of the Fraunhofer-Gesellschaft are invested with a view to earning a return. The organization pursues what is fundamentally a risk-averse investment policy and, in view of the uncertainty prevailing in the money and capital markets, keeps a constant watch on the risk situation. Comprehensive measurement and control of risks is carried out in real time, thus making it possible to respond rapidly to any market changes.

Fraunhofer channels the results of its research – such as patents – into existing companies or its own start-ups. This may involve subsequently disposing of the equity investments or generating income for Fraunhofer through research contracts. The performance of these investments is closely monitored by means of an investment controlling process.

Continual monitoring of prefinancing and accounts receivable, coupled with effective dunning and contractually agreed payment terms, help to minimize credit risk, which essentially relates to project prefinancing and unrecoverable payments.

Operational risks include the risk of losses being incurred as a result of the unsuitability or failure of internal processes, people and systems, or due to external events.

Through its contract research projects, Fraunhofer is exposed to liability and performance risks such as product liability and warranty. It manages these through suitable liability restriction clauses in its standard terms and conditions of business and in its standard contracts, as well as through a multi-tier approval process based on competent legal advice. The system for managing risks in connection with contract research projects is constantly being developed further, for example when managing risks arising out of new business areas and optimizing related processes.

Recruiting highly qualified scientists and encouraging them to stay with Fraunhofer is the key to preserving and expanding the organization's research expertise. In response to the stiffening competition for qualified workers brought about by demographic trends, Fraunhofer has adopted a human resources policy that is sustainable and geared to the long term. In terms of competitiveness the Fraunhofer-Gesellschaft is currently well placed, as is amply demonstrated by its positive image in the marketplace and the awards it receives. By continuing to strengthen its partnerships with universities, Fraunhofer will be in a position to detect young talent at an early stage and familiarize potential candidates with the organization.

For Fraunhofer, reliable and secure IT infrastructure is decisive in the provision of research services. A set of targeted measures, which are formulated in a binding IT security manual, serve to limit risks in the IT field. As the centralized provision of IT services becomes more and more the norm, risk management requirements in respect of such services are changing.

A compliance management system is in place to ensure that the subject of rules and compliance with them is dealt with in a systematic manner. The Compliance Office functions as the central point of contact for all compliance-related issues. It is also responsible for the compliance manual, which describes the key principles of the culture and organization of compliance, and of the related processes.

The **overall assessment** of Fraunhofer's risk situation contains no anomalies that could severely endanger the organization's future performance.

Patents and licenses

Given the dynamic nature of technological progress, the ability to innovate quickly has become a decisive competitive factor for industry and science. Short, expensive innovation cycles mean that new technical solutions have to be made available as fast as possible. In order to safeguard a competitive edge that is based on innovation, newly developed technical solutions have to be protected with patents, as they allow those solutions to be turned into commercially viable goods.

The Fraunhofer-Gesellschaft is one of the most active and important sources of patent applications in Germany. In 2012, its research institutions reported a total of 696 inventions, with patent applications being filed for 499 of those, i.e. over 70 percent. Fraunhofer files an average of two patent applications per working day. Fraunhofer's portfolio of active rights (patents and utility models) and patent applications had risen to a total of 6103 at year end 2012. It currently includes some 2800 patents granted for the German market. The number of exploitation contracts concluded increased from 2841 in 2011 to 3167.

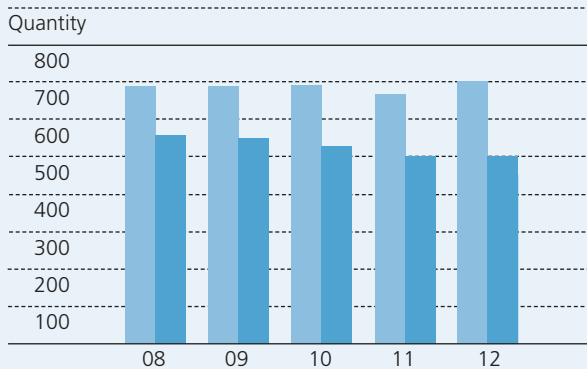
In order to better compensate the fluctuations in its traditional sources of income, the Fraunhofer-Gesellschaft has implemented a results-oriented system of intellectual property (IP) management. Its main instrument is a patent strategy process, which has already been introduced at 20 Fraunhofer Institutes. This process enables the institutes to better manage their IP and taps additional sources of income by encouraging the licensing of IP that extends beyond direct relevance to contract research.

Following an analysis of their patent portfolios, the institutes involved are given recommendations for reducing the patent-related costs of less attractive patent clusters and for stepping up their patenting and exploitation activities for economically attractive ones. Whereas the recommendations for cost reductions are largely put into practice, it is evident that the institutes need further support in implementing the recommendations for stepping up their patenting and exploitation activities. For this reason, a three-year phase was launched that targets the enhanced exploitation of patents. At three institutes, licensing projects have been identified that have the potential to generate considerable license-fee revenue in the medium term. In addition, in the pilot institutes, structures were created and tested to perpetuate the patent strategy process and support the systematic generation of license-fee revenue.

The positive trend in license-fee revenue of recent years was unbroken in 2012. Although at €117 million overall license-fee revenue did not quite reach the excellent volume achieved in 2011, it was nevertheless the second-highest figure posted in recent years. That is remarkable, especially considering that the 2011 figure owed much to non-recurring effects.

The Fraunhofer-Gesellschaft's activities in respect of industrial property rights 2008–2012

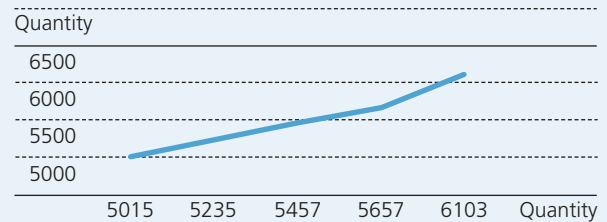
Inventions and patent applications



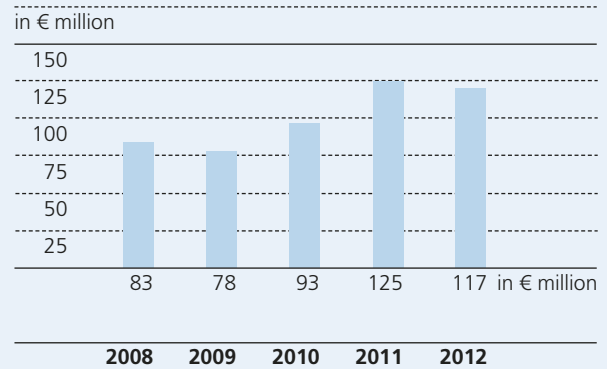
| | 2008 | 2009 | 2010 | 2011 | 2012 |
|--------------------------------|------|------|------|------|------|
| ■ Inventions reported per year | 690 | 691 | 694 | 671 | 696 |
| ■ Patents applied for per year | 565 | 563 | 520 | 500 | 499 |

- Inventions reported per year
- Patents applied for per year

Active rights and patent applications¹



License-fee revenue



¹ As of December 31

If Fraunhofer is to continue its success with license-fee revenue in the future, it needs to support a long-term program of pre-competitive research in selected fields of technology, regardless of changing economic conditions, with the aim of building up comprehensive patent clusters. In order to accelerate the licensing of research results to technological companies, the Fraunhofer Future Foundation promotes those

in-house research projects of the Fraunhofer-Gesellschaft that are of pronounced relevance to the market and look set to generate widespread demand. The Fraunhofer Future Foundation thus helps the organization to make a contribution to innovation and competitiveness in Germany.

Subsidiaries, shareholdings and spin-offs

- International subsidiaries remain on a successful course
- Stakes in a total of 83 companies
- Expansion of spin-off activities

In 2012, Fraunhofer's subsidiaries once again performed well, continuing to enhance their research activities and strengthen their customer relationships.

Established in 1994, **Fraunhofer USA, Inc.**, is a wholly owned, non-profit subsidiary of the Fraunhofer-Gesellschaft, with headquarters in Plymouth, Michigan. The chief motivation for this engagement in the United States is to intensify scientific expertise by cooperating with internationally renowned research centers, and to strengthen the Fraunhofer R&D portfolio. The United States market represents an important benchmark for the Fraunhofer-Gesellschaft. At the present time, there are six Fraunhofer Centers under the auspices of Fraunhofer USA. Each works in close collaboration with one or more of the Fraunhofer Institutes in Germany on development projects for industrial firms, public-sector clients and academic institutions. The provisional budgeted expenditure of Fraunhofer USA, Inc., in the financial year 2012 amounted to €30 million. With revenues of €12 million, the Fraunhofer Center for Molecular Biotechnology CMB, Delaware, remains the best-performing center, followed by the Fraunhofer Center for Sustainable Energy Systems CSE, Massachusetts, with total revenues of €5 million.

2012 was the third complete financial year of **Fraunhofer Austria Research GmbH**, which is headquartered in Vienna. The Fraunhofer-Gesellschaft is the sole owner of this non-profit, limited-liability company, which was set up for the exclusive purpose of directly promoting applied research and science. The legal entity Fraunhofer Austria Research GmbH comprises the Austrian activities of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA and the

Fraunhofer Institute for Computer Graphics Research IGD in two separate units. The subsidiary has sites in Vienna (for the Production Management and Logistics unit) and Graz (for the Visual Computing unit). With a current workforce of 30 and an operating budget in 2012 of €3 million, Fraunhofer Austria generated industrial revenue of €1 million as well as public-sector and other revenues of €0.5 million (based on the provisional financial statements).

Fraunhofer's subsidiary **Fraunhofer Italia Research Konsortial-GmbH**, a non-profit joint venture with the Trade Association of South Tyrol with headquarters in Bolzano, had its third anniversary in December 2012. The Fraunhofer-Gesellschaft holds a 99-percent stake in this subsidiary, which functions as legal representative for legally dependent centers located in Italy like the hitherto established Fraunhofer Innovation Engineering Center IEC, which the state of South Tyrol is providing with base funding for an initial period of four years. In 2012, the company generated project revenues of €0.3 million (provisional figure).

Domiciled in Glasgow, UK, **Fraunhofer UK Research Ltd.** was founded as a wholly owned subsidiary in March 2012. It operates the Fraunhofer Centre for Applied Photonics CAP and cooperates closely with the University of Strathclyde in Glasgow.

Due to the negligible effect of the revenues generated by the subsidiaries on the overall organization's net assets, financial situation and operating results, the Fraunhofer-Gesellschaft does not draw up consolidated financial statements.

Including these four subsidiaries, the Fraunhofer-Gesellschaft held equity investments in a total of 83 companies across a wide variety of sectors at the balance sheet date. The total carrying amount of these equity investments was €6.2 million. In 2012, the Fraunhofer-Gesellschaft acquired stakes in the equity capital of 6 companies, while it exited 9 others.

The establishment of spin-offs is a very important avenue for the Fraunhofer-Gesellschaft to exploit its industrial property rights. The Fraunhofer Venture department typically provides support to the entrepreneurs during the preparation phase of the spin-off and contributes its know-how; in return, the Fraunhofer-Gesellschaft receives a minority stake in the equity of the fledgling company. As well as generating returns from the transfer of technology, spin-offs also help to promote entrepreneurial thinking and the establishment of cooperative networks with businesses operating in the same sphere as the respective Fraunhofer Institutes. Moreover, spin-offs are of great economic benefit to the national economy in that they lead to the creation of new jobs and enhance Germany's competitiveness through product innovation. In 2012, the Fraunhofer-Gesellschaft provided support for 33 new spin-off projects, and 10 companies were spun off in the course of the year.

Since the Fraunhofer-Gesellschaft first launched its support program for spin-offs, known as "FFE – Fraunhofer Fosters Entrepreneurship", 92 teams have received help in starting up their own companies. In 2012, funds totaling €0.9 million were granted to seven new projects. All in all, the Fraunhofer-Gesellschaft is confident that it will be able to go on expanding its spin-off activities in the medium term.

In 2012, the pilot program "FFM – Fraunhofer Fosters Management", previously funded by the German Federal Ministry of Education and Research (BMBF), was transferred to Fraunhofer's own spin-off support program. The goal of this

program is to strengthen the management skills of the new executives and guide them through the highly critical early phase of their business. Thus far, the program has supported more than 50 projects.

In 2012, the BMBF revised its "Guidelines for the Participation of Research Institutions in Spin-Off Companies for the Purpose of Knowledge and Technology Transfer". It is worth noting that these guidelines enable the Fraunhofer-Gesellschaft to invest up to € 2.5 million (cash or non-cash funds) – but no more than an amount equivalent to 25 percent of the company's shares – in the equity of spin-offs designed to transfer knowledge and technology.

International activities

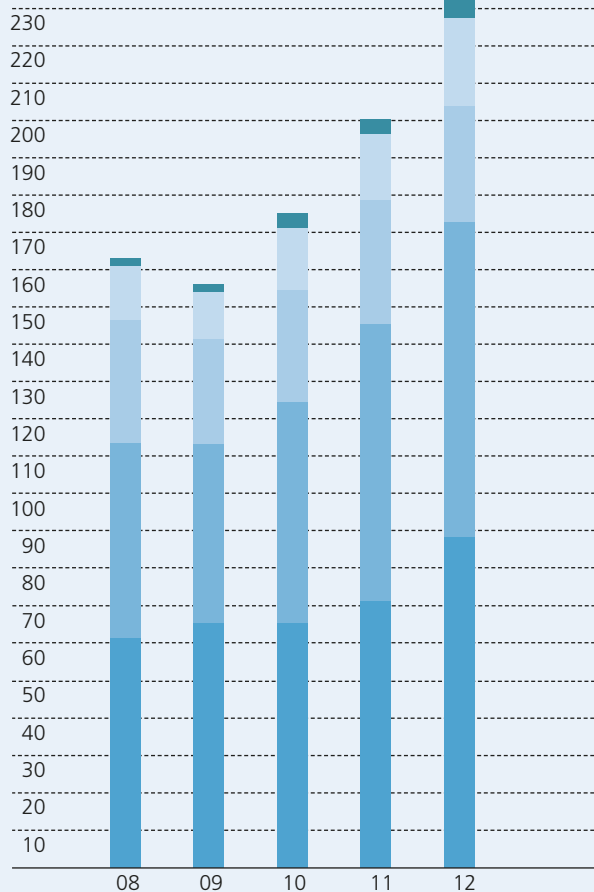
- International revenues on a growth trajectory
- New alliances with outstanding partners in Scotland, Canada, Israel and Brazil

The ongoing globalization of both science and the economy means that the Fraunhofer-Gesellschaft, too, must put its strategy on an international footing if it is to exploit the very best of knowledge in the interests of the innovation hub Germany. Only international alliances can develop best possible scientific solutions to global challenges.

Fraunhofer research services are in demand worldwide. In 2012, project revenue (excluding license-fee income) generated together with international partners reached a total of €233 million, around €19 million of which was accounted for by the Fraunhofer-Gesellschaft's foreign subsidiaries. Although the latter's revenues were roughly the same as in 2011, overall the Fraunhofer-Gesellschaft succeeded in boosting its international revenue by a substantial 16 percent.

International revenue of the Fraunhofer-Gesellschaft 2008–2012 (in € million)

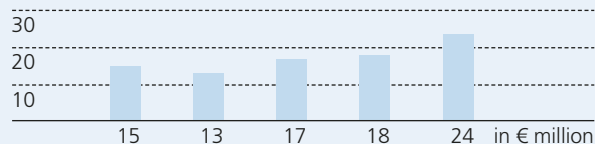
Total international revenue



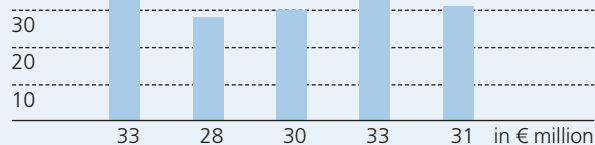
| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---------------------|------------|------------|------------|------------|------------|
| European Commission | 61 | 65 | 65 | 71 | 88 |
| European countries | 52 | 48 | 59 | 74 | 84 |
| USA | 33 | 28 | 30 | 33 | 31 |
| Asia | 15 | 13 | 17 | 18 | 24 |
| Other countries | 2 | 2 | 4 | 4 | 6 |
| = | 163 | 156 | 175 | 200 | 233 |

European Commission European countries USA Asia Other countries

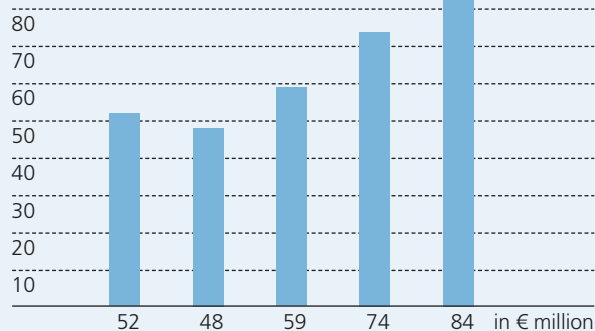
Asia



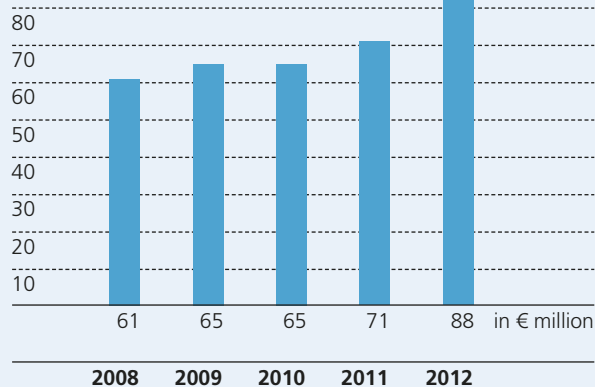
USA



European countries



European Commission



International revenue generated in Europe grew in 2012 by a remarkable 19 percent to a total of €172 million. It included not only revenue generated with various customers in other European countries (which rose by 14 percent to over €84 million), but also revenues from joint research projects funded by the European Commission (which climbed by 24 percent to a total of €88 million). In the European Research Ranking, an assessment carried out on the basis of figures published by the EU Commission, Fraunhofer was ranked the most successful German participant in EU-funded research programs in three categories – “Funding & Projects,” “Networking” and “Diversity” – for the fifth time in succession. In the last two studies, Fraunhofer ranked second overall in Europe.

Through its projects in the USA, the Fraunhofer-Gesellschaft generated revenues totaling €31 million in 2012, €17 million of which was accounted for by its subsidiary Fraunhofer USA, Inc. In Asia, the Fraunhofer-Gesellschaft earned revenues of €24 million, following an exceptional increase of 34 percent. With revenues of €9 million, Japan remains the most important market in Asia, followed by China with just under €5 million and South Korea with €4 million. International revenue from other countries totaled almost €6 million.

The Fraunhofer-Gesellschaft has strengthened its role as a key player in the international innovation arena in recent years, and continued to expand its worldwide activities in 2012. Alongside the establishment and operation of international subsidiaries, the main focus of these activities has been on forging alliances with partners of excellence around the world.

Fraunhofer UK Research Ltd., a non-profit subsidiary with headquarters in Glasgow, UK, was set up in March 2012. It is the umbrella organization for the Fraunhofer Centre for Applied Photonics CAP in Glasgow, which was established in September 2012 with base funding from the Scottish government, as well as for potential further Fraunhofer Centers financed with British funds. The center enables close cooperation in the field of photonic sensor systems between the Fraunhofer Institute for Applied Solid State Physics IAF and the Institute of Photonics at the University of Strathclyde, allowing Fraunhofer IAF to complement its portfolio of services in the field of complete sensor systems.

Under the auspices of the “Stiftelsen Fraunhofer Chalmers Centrum för Industrimatematik”, the Fraunhofer Institute for Industrial Mathematics ITWM and Chalmers University in Gothenburg have been successfully operating the joint Fraunhofer-Chalmers Center for Industrial Mathematics FCC for over ten years. Over that period, the center has earned itself an international reputation in the field of mathematical simulations, which is why the collaboration was formalized and has been jointly funded since 2012. The Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS and the Fraunhofer Institute for Open Communication Systems FOKUS have pooled their unique skills in the fields of statistical data analysis and cross-platform interoperability for the web with the know-how of the University of Southampton’s world-renowned Web Science Institute in order to carry out research into the Semantic Web and collective web intelligence. With its web science research activities, the University of Southampton has captured a top position on the international research stage. By combining their expertise, the partners will be able to play a high-profile, internationally competitive role in Europe in the dynamic field of web science, which has hitherto been dominated by the USA.

The Fraunhofer Institutes for Solar Energy Systems ISE, for Environmental, Safety and Energy Technology UMSICHT, and for Machine Tools and Forming Technology IWU are cooperating with the University of British Columbia (UBC) in the area of sustainable energy technology. They aim to tackle the challenges posed by the new renewable-energy regime. The focus of research is on wind and solar energy, hydropower, the constant and highly efficient provision of electricity using biomass, the use of hydrogen to store energy, and low-emission mobility by means of fuel cells. The UBC is Canada's second-largest university. It is not only the country's most prestigious institution in terms of research and teaching, but ranks among the top universities in the world. Fraunhofer and the UBC can use their partnership to complement each other's expertise in an ideal manner and thus carry out research faster and more efficiently.

The Fraunhofer Institute for Applied Polymer Research IAP and the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have entered into a close partnership with the Hebrew University of Jerusalem in the field of pharmacology, with particular focus on drug delivery. The Hebrew University of Jerusalem is one of Israel's leading academic institutions and ranks among the top five in the world in pharmacology.

The Fraunhofer-Gesellschaft has intensified its commitment in Brazil as well, in line with the interests of German industry. The organization has been represented there since August 2012 by a Fraunhofer liaison office located in the chamber of foreign trade in São Paulo. The Fraunhofer Institute for Experimental Software Engineering IESE has forged a partnership with the Federal University of Bahia (UFBA) covering software and systems engineering. The Fraunhofer Institute for Process Engineering and Packaging IVV is working together with the Instituto de Tecnologia de Alimentos (ITAL) to develop sustainable methods of agriculture and holistic ways of utilizing plants.

India is a key emerging market for German industry. As a result of the successful development and implementation of Fraunhofer's strategy there – the aim of which is knowledge acquisition and growth in industrial output – a Fraunhofer representative office was set up in Bangalore to function as a platform for project partnerships.

Strategic development and outlook

- Lead projects for the systematic development of solutions for Germany in its role as an industrial hub
- New application centers in partnership with universities of applied sciences
- Expansion of expertise in renewable energy and resource efficiency
- New President of the Fraunhofer-Gesellschaft

Last year, Fraunhofer launched the Markets Beyond Tomorrow program, the aim of which is to amass today, on all fronts, the skills that will be needed to tackle the challenges of tomorrow. The Beyond Tomorrow projects promote comprehensive pre-competitive research in different areas – such as renewable energy, affordable healthcare or preventive catastrophe management – so that Fraunhofer is in a position to respond to the future innovation needs of society and business alike.

In addition, Fraunhofer is funding individual **lead projects**, which focus on the competitive challenges being faced by Germany as an industrial hub. The idea is to take a flexible, interdisciplinary approach that dovetails Fraunhofer expertise from complementary fields to offer our customers tangible results.

The primary objective of the lead projects is to develop scientifically original skills with a high potential for exploitation in practice. In a concerted effort across several institutes, a single technological topic in the shape of a roadmap is developed to the point where it is ready for deployment in actual applications. The focus of one of the initial projects, for example, is on securing German industry's supply chain for rare earths. Attention is centered around elements such as neodymium and dysprosium, which are needed to construct the strong electromagnets used, for example, in wind turbines and electric motors. Projects are also being conceived with the aim of making production processes substantially more resource-efficient and less emissions-intensive in the future. The lead projects are initially funded internally by Fraunhofer, but in the medium term are intended to be funded by third parties, including industrial enterprises. The projects are closely monitored by the Executive Board so as to ensure their high quality.

In recent years, Fraunhofer has established itself as a key proponent of sustainability in Germany's national scientific communities. On behalf of the German Federal Ministry of Education and Research (BMBF), Fraunhofer has initiated a dialog between Germany's major extra-university institutions. The purpose is to build up a network focusing on the goals, strategies and lines of research in and around the subject of sustainability. It was agreed that, as part of a joint research project funded by the ministry, administrative and scientific experts from the Fraunhofer-Gesellschaft, Helmholtz Association and Leibniz Association would team up to develop a strategic action model for synchronizing sustainability-related lines of research within scientific organizations.

Fraunhofer is playing a key role in the development and transfer of sustainable technologies, innovative solutions and systems. The Fraunhofer-Gesellschaft is also working on the topic of sustainability in its capacity as an organization and employer. It sees the long-term implementation of an organi-

zation-wide system of sustainability management as an opportunity to perpetuate and formalize an ongoing professional discussion of the areas in which action is required.

In 2012, the Fraunhofer Institute for Computer Architecture and Software Technology FIRST, and the Berlin branch of the Fraunhofer Institute for Software and Systems Engineering ISST were integrated into the Fraunhofer Institute for Open Communication Systems FOKUS and brought together at a single location near the Technische Universität Berlin. The idea behind the merger is to create a benchmark institution for intelligent ICT solutions in the German capital and an effective R&D platform in the corresponding fields for industry and the public sector. Fraunhofer FOKUS aspires to shape the transformation of urban living environments, true to its vision of "ICT for the city of tomorrow".

This reorganization will also enable Fraunhofer to comply with the request from the German Federal Ministry of the Interior (BMI) to create a single point of contact for all matters related to public-sector IT. Early 2013 saw the start of a strategic partnership to establish a "Center of Competence for Public-Sector IT and E-Government", which is being financed with €6 million in funds over two years. The new center of competence, which is located at Fraunhofer FOKUS, will be officially opened at a joint kick-off event in the spring. The GovData web portal ("The data portal for Germany") developed in partnership with Fraunhofer FOKUS was officially launched by Hans-Peter Friedrich, the German Federal Minister of the Interior, at the CeBIT trade fair in March 2013.

Through its realignment of the ICT institutes in Berlin and its partnership with the German Federal Ministry of the Interior, Fraunhofer has created the foundations for becoming an independent center of competence for public-sector IT and

e-government vis-à-vis the federal and *Länder* governments. A similar, though differently structured, development is evident in the field of security research. With its broad-based technical expertise, Fraunhofer is equipped to make a major contribution toward accelerating innovation in the defense and security research sector and to become a firm link between end customers and the enterprises active in this field.

In 2012, Fraunhofer embarked on some new and promising ventures aimed at enhancing the German research community, making its existing research structures more dynamic and creating new ones. A new approach in terms of structure was the forging of partnerships with universities of applied sciences for the purpose of establishing **application centers**. The idea is to initiate research into a topic that is attractive to cooperation partners from industry and, under the leadership of the relevant professor, can be integrated into the research infrastructure of the university in question. The establishment of an application center thus presupposes willingness on the part of the university to play a more active part in the applied research field, but also that such a center dovetails well with the established structures at Fraunhofer. Application centers of this type have already been set up in the *Länder* of North Rhine-Westphalia, Lower Saxony, Baden-Württemberg, Bavaria and Rhineland-Palatinate. The German Federal Ministry of Education and Research is supporting the establishment of further partnerships with universities of applied sciences by providing €4 million in funds to create new structures in interaction with the Fraunhofer Institutes as from 2013. This positive development is also evidence of the great demand in Germany for interdisciplinary, application-oriented research of the kind offered by Fraunhofer.

Against the backdrop of Germany's **transition to a renewable energy regime**, Fraunhofer has built up key competencies in the provision of energy from renewable sources as well as in the transportation and storage of energy. Fraunhofer not only already has Europe's largest research institution for renewable energy in the shape of the Fraunhofer Institute for Solar Energy Systems ISE, but in recent years has also set up and expanded the Fraunhofer Institute for Wind Energy and Energy System Technology IWES.

Resource-efficient production is one of the key topics of future interest for industrial value creation in Germany because it will enable the country to maintain and enhance its high standards of manufacturing technology. Fraunhofer will continue to focus research on this topic, not only developing new materials, but also highlighting where resources can be conserved in existing materials and production processes.

German industry has a strong focus on the automotive sector and supporting technologies. Thanks to the funds made available through the federal government's economic stimulus packages between 2010 and 2012, Fraunhofer has succeeded in amassing cross-sector expertise to meet important challenges facing the industry – from lightweight construction and power electronics through to battery technology. The results of Fraunhofer research are marketed via two channels – directly by the individual Fraunhofer Institutes or in pooled form via research platforms.

The growing demand for resources outside the energy sector is being met through research into the recycling and reuse of materials. After its establishment in Alzenau, the Fraunhofer Project Group for Materials Recycling and Resource Strategies (IWKS) – which belongs to the Fraunhofer Institute for Silicate Research ISC – was able to commence operations at a second location, in Hanau, in June 2012. The two institutions

are being set up and expanded with the aid of funds from the *Länder* of Bavaria and Hesse. If they prove successful, the plan is to turn the two institutions into an independent Fraunhofer Institute. The strategic interlinking of recycling and substitution is the trademark of this Fraunhofer project group.

Following the retirement of Prof. Dr.-Ing. Hans-Jörg Bullinger in October 2012, a **new president of the Fraunhofer-Gesellschaft** was elected. The Executive Board would like to thank Hans-Jörg Bullinger for his exceptionally successful work while in office. Over the last ten years he delivered excellent performance in the interests of Fraunhofer and of applied research in both Germany and Europe. The Executive Board is delighted that Prof. Dr.-Ing. Hans-Jörg Bullinger is to remain with the organization as a member of the Senate of the Fraunhofer-Gesellschaft. As Prof. Bullinger's successor, the Senate elected Prof. Dr.-Ing. Reimund Neugebauer, Professor of Machine Tools and Forming Technology at the Technische Universität Chemnitz (TU Chemnitz). For twenty years, Reimund Neugebauer was director of the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz and Dresden, turning it into an internationally renowned center for manufacturing technology. He has been highly successful in promoting the networking of research and business, especially in the fields of mechanical engineering and production. He is founding president of Industrieverein Sachsen 1828 e.V., an industrial network in the German state of Saxony.

All signs indicate that Fraunhofer will be able to continue its successful path in 2013. The current volume of new contracts indicates stable ongoing demand for research services. Research and technology are increasingly being recognized as indispensable to innovation, economic strength and social prosperity.

Fraunhofer's burgeoning growth in recent years has been made possible more through third-party funds than through base funding. This demand-driven growth is altering the funding balance between public-sector revenue, industrial revenue and grants, which in the long run could compromise the Fraunhofer model. An important task for the future, therefore, will be to acquire adequate long-term funding for pre-competitive research. Fraunhofer is optimistic that the funding bodies will honor its performance to date and grasp the opportunities that arise to strengthen and expand the Fraunhofer-Gesellschaft.

The Executive Board would like to thank the organization's members, patrons, friends and, most of all, its staff for their support and dedicated work during the past year.

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

The Executive Board

Prof. Dr.-Ing. Reimund Neugebauer
Prof. Dr. rer. nat. Ulrich Buller
Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner
Dr. rer. publ. ass. iur. Alexander Kurz

REPORT OF THE SENATE ON THE FINANCIAL YEAR 2012

The financial year 2012 was marked by the efforts of European institutions to contain the euro crisis and find a lasting solution to it. Seen in this context, the German economy not only performed exceedingly well, but also served as a stable anchor for the eurozone as a whole. The decisive factor in this development was the foresighted and systematic way in which the German economy strengthened the international competitiveness of its constituent enterprises. This is where the Fraunhofer-Gesellschaft is increasingly regarded as an important and attractive innovation partner. As a result, it was again able to post strong growth in 2012. The Fraunhofer-Gesellschaft's positive financial statements for 2012 again received an unqualified audit certificate from its auditors.

In 2012, the Senate fulfilled the tasks with which it is entrusted under the statutes of the Fraunhofer-Gesellschaft. It convened twice in the course of the financial year, at the Fraunhofer Institute Center in Stuttgart on May 8, and in the Fraunhofer Forum in Berlin on October 16.

The main decisions taken in accordance with the statutes concerned structural changes:

- The Fraunhofer Institute for Computer Architecture and Software Technology FIRST and the Fraunhofer Institute for Open Communication Systems FOKUS (including the Berlin branch of the Fraunhofer Institute for Software and Systems Engineering ISST) were merged on July 1, 2012. The new institute will be called the Fraunhofer Institute for Open Communication Systems FOKUS and will be headed by Prof. Dr.-Ing. Radu Popescu-Zeletin.
- On July 1, 2012, COMEDD, previously part of the Fraunhofer Institute for Photonic Microsystems IPMS, was made into an independent institution – the Fraunhofer Research Institution for Organics, Materials and Electronic Devices COMEDD – with Prof. Dr. Karl Leo as its director.
- Since January 1, 2013, the Fraunhofer Center Nanoelectronic Technologies CNT has no longer been classified as an independent Fraunhofer Institution. The Senate noted the plans to continue pursuing certain of Fraunhofer CNT's research fields at one or more Fraunhofer Institutes in Saxony.



At its spring meeting 2012, the Senate appointed Prof. Dr.-Ing. habil. Prof. E.h. Dr.-Ing. E.h. mult. Dr. h.c. Reimund Neugebauer as the new president of the Fraunhofer-Gesellschaft for a period of office from October 1, 2012, through September 30, 2017. Reimund Neugebauer had previously served as director of the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz and Dresden for twenty years, turning it into a center for manufacturing technology not only of regional importance, but also of international stature. He has been extremely dedicated in promoting the networking of research and business, especially in the fields of mechanical engineering and production. The Senate wishes him every success for his duties as president of the Fraunhofer-Gesellschaft.

Reimund Neugebauer succeeded Prof. Dr.-Ing. habil. Prof. e.h. mult. Dr. h.c. mult. Hans-Jörg Bullinger, who had steered the course of the Fraunhofer-Gesellschaft for ten years. The Senate wishes to thank Hans-Jörg Bullinger for his exceptional commitment. For a whole decade, he was the face of the Fraunhofer-Gesellschaft in the realms of politics, research and the media, maintained excellent relations with politicians, scientists and the business community, and

was an outstanding ambassador for both the Fraunhofer-Gesellschaft and applied research. He was strikingly successful in steering the organization through challenging times and keeping it on a growth trajectory. In view of his achievements, the Fraunhofer-Gesellschaft honored him with its highest award, the "Fraunhofer", which the Chairman of the Senate presented to him as he stepped down.

At its fall meeting 2012, the Senate reappointed Prof. Dr.-Ing. Dr.-Ing. E.h. Dr. h.c. Ekkehard D. Schulz as its chairman, for the period January 1, 2013, through December 31, 2015.

The Senate takes this opportunity to thank the entire staff of the Fraunhofer-Gesellschaft for their commitment and their successful work in the financial year 2012.

Prof. Dr.-Ing. Ekkehard D. Schulz
Chairman of the Senate of the Fraunhofer-Gesellschaft

SUSTAINABILITY REPORT

2012

The road to sustainability reporting

In recent years, a number of Fraunhofer Institutes have begun publishing their own sustainability reports as an extension of their intensive research into the topic of sustainability. While the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT has already published its third sustainability report, the fledgling reports of the Fraunhofer Institute for Chemical Technology ICT and the Fraunhofer Institute Center Stuttgart IZS (comprising Fraunhofer IGB, Fraunhofer IAO, Fraunhofer IPA, Fraunhofer IBP and Fraunhofer IRB) constitute a successful debut in communicating those institutes' contribution to sustainable development in their capacity as research institutions and employers.

After the experience with its first two sustainability reports, Fraunhofer UMSICHT prepared its third report in compliance with the Global Reporting Initiative (GRI) standard, which is recognized worldwide. It also set up an internal sustainability management system, which includes the appointment of a Sustainability Officer from among the scientific employees and – as a measure to verify its quality – an evaluation of the sustainability report by external experts to confirm its compliance with the reporting standards. The practical knowledge gained by Fraunhofer UMSICHT and the experience of other institutes will now be made available to the entire Fraunhofer-Gesellschaft to make it easier for interested Fraunhofer Institutes to begin compiling their own sustainability reports. The Executive Board has launched an internal project to facilitate the sharing of best practice and develop a framework for Fraunhofer-specific sustainability reporting. The project comprises the following work packages:

- Development of Fraunhofer guidelines for sustainability reporting
- Development and testing of a sustainability management training plan for Fraunhofer Institutes
- Creation of a pilot Fraunhofer sustainability report for internal discussion purposes
- Organization of dialogs with stakeholders to determine the relevance of the report's contents

The project not only aims to establish regularly published sustainability reports for the Fraunhofer-Gesellschaft, but also seeks to motivate the institutes to devote attention to this topic, to implement suitable measures, initiatives and activities in a rapid and pragmatic manner, and to introduce permanent reporting on services of relevance to sustainability.

The GRI standards mentioned above will serve as a basis for the Fraunhofer sustainability reports. That will ensure that the sustainability reports are professional and directly comparable in terms of breadth and depth with those published for a number of years by Fraunhofer customers. However, these standards, which were designed for private enterprises, need to be sensibly adapted to meet the requirements of publicly funded research institutions.

The project has already succeeded in establishing a set of Fraunhofer guidelines for sustainability reporting, comprising a selection of relevant indicators and areas of action. The guidelines create a shared understanding of the processes and areas of action of organizational sustainability management, but do not set any targets or benchmarks. In order to compile the guidelines, the requirements of the GRI reporting standard were analyzed with the relevant experts – calling on the HR, Building and Finance departments, for example – and interpreted to reflect Fraunhofer specifics. The indicators and areas of action were selected in terms of their applicability and

relevance as gaged by internal and external stakeholders. As a result, the 35 areas of action described in the GRI standard were reduced to 23, and the number of indicators was cut from 84 to 29.

This reduction highlights the limited extent to which the standard, which was conceived in particular for international industrial enterprises with production facilities, can be applied to Fraunhofer. But whereas around 90 percent of Germany's 100 largest companies in terms of revenue already publish reports on the implications of their activities for sustainability, hardly any reference systems are available to scientific organizations. As a result, only very few of them prepare such reports. Some universities, e.g. Leuphana University in Lüneburg, are acting as pioneers in this field.

In order to arrive at a common understanding of this issue within the German research community, Fraunhofer has initiated a dialog among the country's major extra-university research institutions, and conducted a series of discussions with administrative and scientific experts. It was agreed to launch a joint research project funded by the German Federal Ministry of Education and Research (BMBF), in the course of which administrative and scientific experts of the Fraunhofer-Gesellschaft, the Helmholtz Association of German Research Institutions and the Leibniz Association would cooperate to develop a cross-organizational understanding of sustainability-specific areas and options for action in scientific organizations. The project is due to start mid-2013.

Another result of the ongoing internal project at Fraunhofer is to anchor sustainability in the Fraunhofer organization. To ensure that the topic is integrated in Fraunhofer processes in the long term, a Sustainability Committee has been set up, whose members represent all parts of the organization – including the divisions and central departments, the works council, institute management, group spokespersons,

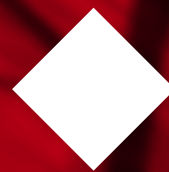
the Presidential Council and the main commission. Together, the members of the Sustainability Committee set the strategic course and determine the targets, in the process receiving support from the Strategy and Programs division. The latter acts as an interface between strategy and operations to ensure that sustainability management is actually put into practice, something the Fraunhofer Sustainability Network has been instrumental in pushing for since 2009.

The sustainability reports are expected to take the expectations and interests of all stakeholders into account in a transparent and comprehensible manner. Taking a similar methodological approach to that of the GRI standard, Fraunhofer has developed a system for the operationalized integration of stakeholders. It takes the form of dialog events, at which large groups of politicians, businesspeople and representatives of society give their attention to issues considered to be of equal importance to research and management. Implementation of this new approach will start in 2013.

Fraunhofer has begun integrating sustainability across different interfaces in a process-oriented manner, and is convinced that, once sustainability has become an integral part of the organization-wide quality management system, it will help to enhance Fraunhofer's competitiveness. This constant process of further development will ensure that Fraunhofer continues to be perceived by industry as a professional cooperation partner. The Fraunhofer-Gesellschaft plans to publish its first Sustainability Report in 2014.



REVIEW OF FRAUNHOFER RESEARCH

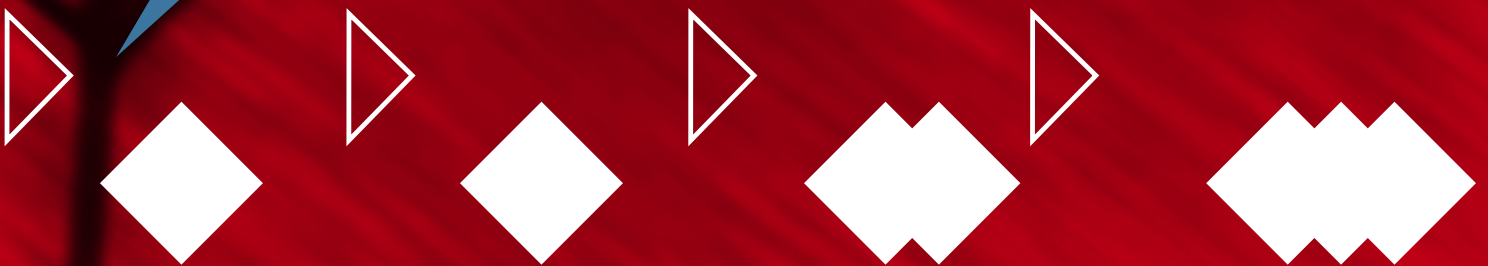


EVOLUTION AND EFFICIENCY

CREATIVE RESEARCH FOR
EFFICIENT PRODUCTION

PROJECTS AND RESULTS 2012

AWARDS 2012



EVOLUTION AND EFFICIENCY

What does “efficiency” mean?

The term “efficiency” is bandied about everywhere. We generally associate it with something positive – if you work efficiently, you perform well. Of course, if you achieve the goals you have set, then you are also working effectively. The terms “efficiency” and “effectiveness” are often mentioned in one breath – and sometimes also confused. What is the best way to distinguish them from each other?

The term “effective” is used to describe a process that achieves precisely the desired result. If I want to post a letter, and I get my car out of the garage and drive half a mile down the road to pop the letter in the mailbox, that is “effective” because I have achieved exactly what I set out to do – after all, the letter is now in the mailbox. But it wasn’t “efficient” because I could have achieved the same end and consumed fewer resources if I had gone on foot or taken my bike. If the goal had been to ensure that the message reached its recipient, it would have been even more efficient to send it by e-mail.

The Deutsches Institut für Normung (DIN) – the German Institute for Standardization – defines the difference between the two terms as follows: effectiveness is “the precision or completeness with which a user achieves a certain goal”, while efficiency is a measure of the “effort expended in relation to the precision and completeness with which a user achieves a certain goal”.

This makes it clear why the word “efficiency” is so popular, because it tells us whether we are doing something in the right way. All of us have goals, and if we can achieve them with less effort, all the better.

Is it natural to strive for efficiency?

Striving to achieve efficiency thus appears to be quite a normal human characteristic. But what is it like with nature? Don’t plants and animals behave in a way we consider unnecessary and wasteful? Why do some trees lose their leaves in fall – and so too the biomass that they have spent such time and effort to build up – whereas other trees don’t? Can nature function at all as a role model for efficiency?

If we take a closer look at the example, we gain a different impression. In our latitudes, winter is a dry season because water is virtually only present in frozen form. A tree loses a lot of moisture via evaporation through its leaves, which means the tree would dry out in frosty conditions. It therefore has to shed its leaves for the winter or seal them off completely. The first is the solution of deciduous trees; the second led to the development of hard needles, which shut down both the photosynthesis process and the exchange of gases in order to prevent the tree from drying out in winter. Viewed separately, both approaches are efficient because they help trees to achieve their goal – namely to survive the winter undamaged – with relatively minor losses.

And what about peacocks? Aren’t their colorful tail feathers a costly and inefficient way of courting a peahen? As biology teaches us, sexuality and the choice of sexual partners are important components of evolution – for genetic reasons, we cannot really do without them. The male bird could indeed demonstrate his health and strength in a fight with a competitor, but the attendant risk of being injured or even downed completely would be so great that the peacock’s fan is the more efficient courtship method after all.

Efficiency can be found everywhere in nature. One could even maintain that the development of efficiency is an inevitable evolutionary process. Those who can achieve their goals and still conserve some of their resources will have an advantage over those who achieve their goals but expend all their resources to do so. Sooner or later, the better option will prevail, and efficiency determines to a large extent what is better.

What is bionics?

Since evolution has been going on for billions of years, you would expect to find many examples of highly efficient structures and processes in the living world. That is precisely the case – and we can learn an infinite number of things from those examples. The observation of the results of evolutionary optimization has even been given a name: “bionics”. The term is a blend of the “bi-” from biology with the “-onics” in words like electronics.

Nature’s striving for efficiency is particularly evident in the design of load-bearing parts. If bones were a solid mass, they would be very stable – but also very heavy. That is why, wherever possible, nature saves on building material, preferring a structure with many struts. That achieves the goal of stability, but with considerably less effort – and thus more efficiently. Struts of this type can be found in practically all load-bearing structures in nature, whether they are bones, bamboo or wood.

In the engineering world, similar optimized load-bearing structures can be found in buildings and bridges, or in the metal foams used in the manufacture of cars, whose complex inner structure makes them very strong yet very light.

Avoiding losses is another important way of achieving efficiency. Evolution found a particularly sensible use for residual heat. This unavoidable byproduct of metabolic processes raises the temperature of an organism – and thus its agility. If the body of the organism is insulated, the heat can be kept at a continuously high level, granting the organism exceptional mobility. This principle was realized above all with mammals and birds, whose fur or feathers help their bodies to retain heat. For this reason they are able to function at much higher constant rates than reptiles of the same size.

In more and more technical fields, too, attention is being given to retaining residual heat within the process or utilizing it for other purposes. But the potential for efficiency technologies is still very great here, and often not utilized at all.

Another “role model” for bionics is sharkskin. It is covered with microscopically fine grooves that physically act to lower flow resistance by preventing the formation of small transverse vortices. Fraunhofer researchers have made use of this principle in the development of a special paint, which can be applied to the hulls of ships and aircraft to markedly reduce fuel consumption.

How important is efficiency research?

This brings us to the question of the practical significance of efficiency research. We define our prosperity to a large extent in terms of the products that are available to us. They include all the things we come into contact with on a daily basis: from a toothbrush, hair-dryer or automobile through to a computer, cell phone and, last but not least, our entire home and contents. All these objects require energy and raw materials for their manufacture, and many of them additionally consume electricity or fuel throughout their useful lives. This means that our prosperity is ultimately based on the consumption of resources – resources that are available on our planet in finite quantities only.

That gives us an idea of how important efficiency research and efficiency technologies are. As energy and raw-material resources are utilized on a continual basis, their prices rise because the search for new reserves becomes ever more costly. That heightens the economic pressure to produce more efficiently and to manufacture products that generate lower costs when in use. More economical cars and household appliances, resource-efficient computers as well as energy-autonomous houses, offices and production facilities will become ever more competitive in the markets. By developing, driving forward and utilizing such efficiency technologies, we will ultimately be working to ensure we retain our prosperity in the long run.

Can't we give ourselves more time?

As we have noted, the laws of technological development resemble those of evolution. That is why efficient products and processes will gain the upper hand everywhere. The question is how strong the pressure is to move in this direction and whether we can't allow ourselves more time to make the necessary adjustments.

The answer to this question is again provided by a glance at the processes of natural evolution. Competition is an important factor not only in natural evolution, but in technological evolution as well. We are not the only producers of goods in the world, and we will always have to compete against other companies and economic regions.

We are part of a permanent global race to develop the most resource-saving and, at the same time, high-quality products, and our disadvantage is that we have relatively few resources to fall back on in our local region. We still need to import most of our energy and raw materials, and in many areas they already constitute the largest share in production costs. What is more, our local wage costs are relatively high. However, we can make up for these system-related drawbacks by investing more effort in the development of efficiency technologies, for instance by cutting energy consumption in production, systematically recycling valuable substances, achieving zero-waste production, and developing alternative materials.

So, we in Europe cannot give ourselves more time for technological evolution, especially since resources are rapidly becoming scarcer. Both technological and biological evolution produce winners and losers, and the speed of adaptation is a crucial factor in success. It is like a race in which there are only interim goals – the most important battle is always the next one, and those who do not move forward inevitably fall back. We even have to become more efficient in *how* we develop efficiency.

Is something holding us back?

The purpose and goals of efficiency are, in essence, easy to grasp. Our own experience of times in which resources were scarce – like when we were students, for instance – or reports on the Third World can help us in this respect. People in developing countries often have only very few resources at their disposal in order to ensure their survival – so they consume comparatively little.

Why, then, do we behave completely differently – against our own better judgment? Why, for example, are our cars getting bigger and heavier even though the requirements of everyday mobility are not rising?

Things would be quite different if we could grasp mobility as being the effective transportation of people and materials from A to B. But people want something more: driving is also enjoyment, a diversion and a means of projecting one's personality or status. Driving through the city in a big off-road vehicle may be inefficient in terms of transportation, but it can enhance the driver's feeling of being socially attractive.

The question is whether it might not be possible to achieve this goal of social attractiveness in a less resource-intensive way – for example, through sport, cultural events or active participation in the web's social media. If, however, our sense of our own worth remains dependent on activities that consume huge amounts of resources, at some point we will be unable to foot the bill for those activities. Even the peacock's tail had to stop growing sometime. If its tail were only a bit bigger, the peacock would no longer be able to move fast enough – and would die a victim of its own beauty.

It is up to all of us!

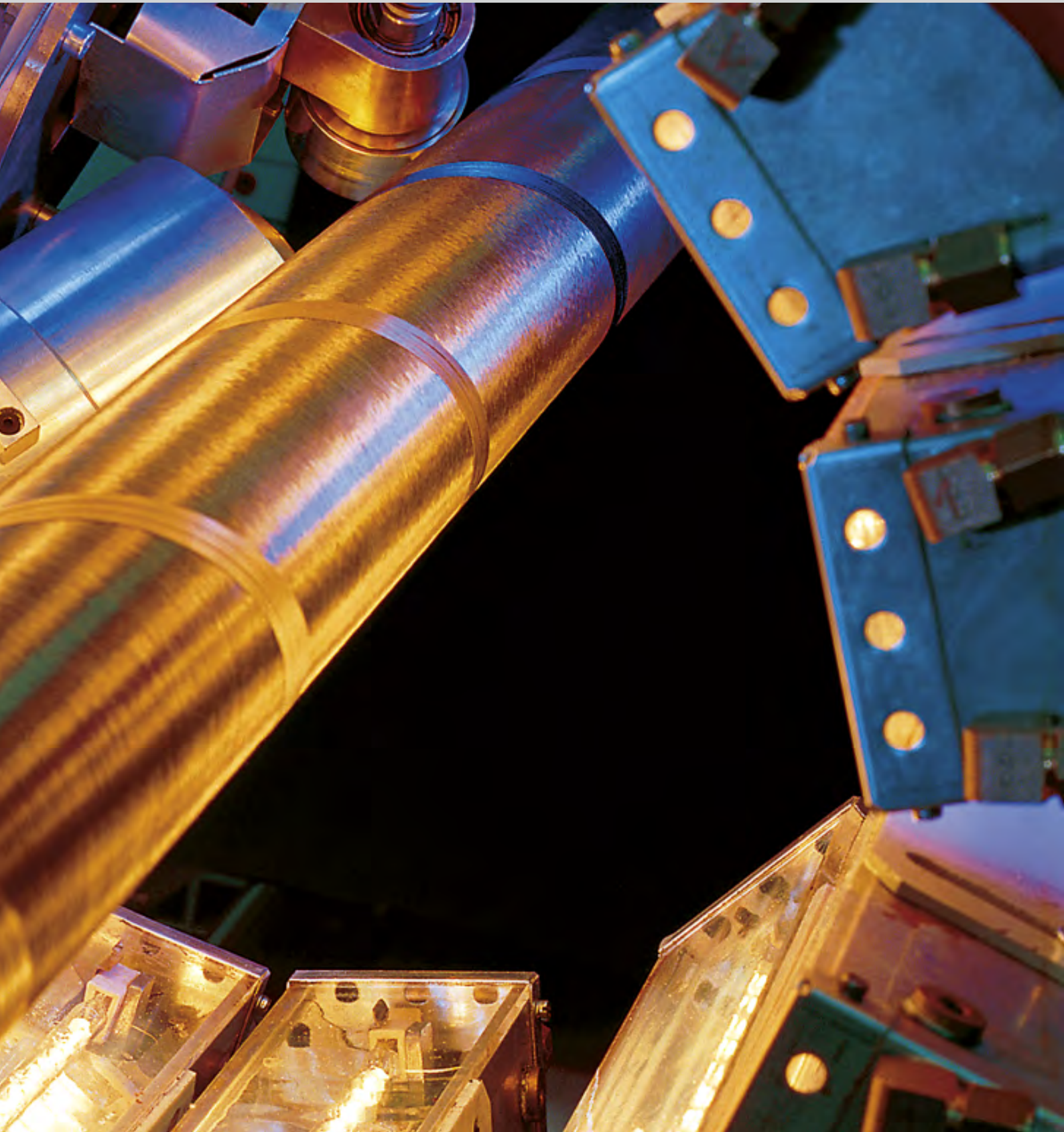
The evolutionary trend toward more efficiency is continuing whether we want it to or not. But we can steer it, accelerate it and even turn it to our own advantage. This calls for many specific solutions to different aspects, but in some cases also for a change of mindset. We need ideas, goals and tenacity. Who knows, in the end we may even succeed in making efficiency a factor in personal attractiveness ...

We have it in our power to change the way we think. Experienced and highly motivated specialists in applied research are there to help us achieve greater efficiency in production and produce more efficient products.



CREATIVE RESEARCH FOR EFFICIENT PRODUCTION

Reimund Neugebauer



In 2011, seven billion people lived on Earth. According to demographic projections, the world's population will reach nine billion by 2050, and the OECD forecasts that the global economy will quadruple in size over the same period. If the consumption of resources rises in line with this growth, humankind in 2050 will consume 140 billion metric tons of minerals, ores, fossil fuels and biomass per year – three times the amount it does today.

For the German manufacturing industry, supplies of energy and raw materials such as (precious) metals and rare earths are of prime importance. Poor in raw materials, Germany has to rely on being able to import almost all its key input materials for production. The high-tech industry's dependence on raw materials, which was at one time less important, has given rise to a new situation in the global market. This is accompanied by growing industrialization of emerging markets, triggering ever greater demand for raw materials – a trend that is already leading to supply bottlenecks, price hikes and battles to secure scarce resources.

The task of applied research is therefore to find alternative paths and new solutions in order to throttle the ever-increasing need for resources in production and simultaneously promote prosperity. Scientific creativity is what we all need in order to turn "less" into "more" in the future.

Previous page: Fiber composites for lightweight construction require new production processes, for instance the winding of textile fibers with the aid of infrared technology.

Why produce efficiently?

In Europe, €1500 billion is generated every year through manufacturing. Production is linked directly to resources and is extremely dependent on the latter's availability and price. In many industries, material and energy costs already constitute the main component in the price of the final product, and in some cases are well above labor as a cost factor. In the processing industry, for instance, materials account for more than 40 percent of production costs. If the use of raw materials could be reduced by just seven percent, it would be possible to save €48 billion per year. For these reasons, minimizing the consumption of energy and raw materials is set to become the decisive competitive factor in the years ahead. Greater resource efficiency is an important way for the manufacturing industry to escape spiraling costs – and the pressure to do so is growing every day.

The business-driven trends outlined here are being supported in Europe – and in some cases even demanded – by government and political leaders, while society's call for efficiently manufactured products continues to grow. This very much more audible call can be attributed to a greater public awareness of the environmental impact of manufactured goods and the perceptible climatic changes of recent years, and these consequences are ultimately reflected in the behavior of buyers and thus in the demand for products.

The tensions arising out of the interplay of economic, political and social demands and requirements are the main forces driving industry to produce more efficiently.



Opportunities for optimized processes

In its study “Energy efficiency in the production environment”, Fraunhofer demonstrated that, in the medium term, up to 30 percent of the energy used in industrial production could be saved. That is equivalent to around half of the electricity used by private households in Germany or the output of four 1.4 GW power plants. The savings can be achieved in various ways. The basis for energy- and resource-saving calculations of this kind is the product lifecycle, during which the product moves through the production process chain and its useful life before being recycled or disposed of. Each of these phases offers diverse possibilities for rendering processes and product properties more efficient and thus saving energy and resources. Special attention should be paid to the interactions between the phases. For example, optimizing a product to enhance its efficiency during its useful life or make it easier to recycle can lead to much higher costs during its production.

The challenge, therefore, is to factor in such dependencies and interactions as far as possible. However, the complexity of the systems and the limits of information processing mean it is not always easy to take all aspects of the product lifecycle into account. On the other hand, if we introduce observation fields with system boundaries and define the interfaces to the adjacent areas, the object under investigation can be suitably placed in an overall context.

During the production phase of the product – which in turn consists of different stages such as the mining and processing of raw materials as well as production and assembly – the value chain forms the focus of attention. All the processes and equipment used to produce a product constitute key components in the drive to make production more efficient. The four dimensions described below – namely process, process chain, production and factory – can serve as a basis for the analysis. Their delineation is determined by the system boundaries set during the observation process.

Four approaches to greater efficiency

An individual process or production technique functions as level one – the smallest observation field. Intelligent monitoring and control strategies or the deployment of what are known as efficiency technologies constitute a constructive approach to achieving an energy- and resource-efficient process. Efficiency technologies are processes that achieve the same work result but consume less energy or material. Increasing the energy efficiency of machinery and equipment also offers major savings potential. Suitable ways of achieving this include the production of lightweight mechanical components, motion optimization (especially in respect of energy-intensive startup and braking processes) or, as a comprehensive optimization strategy, the energy interaction between machine and process.

1 Additive manufacturing means no waste material has to be removed from the components after they have been formed.

2 Optimized processes can help to make the manufacture of vehicle bodies much more energy-efficient.





The second observation level – the process chain – is more complex. It is often possible to reduce consumption by analyzing and improving processes in interaction with upstream and downstream processes or in relation to the production chain as a whole. As a result, for instance, heat that would otherwise be released into the environment can be harnessed and utilized for downstream stages of the production process, such as heat treatment. It is also possible to combine process steps or to integrate downstream steps in the main processing stage, thus shortening the process chain overall and lowering the consumption of resources and energy.

The production area can be defined as the third observation level. Here, energy is often neglected as a planning and control criterion. The recording and evaluation of energy parameters across process chains as well as the utilization of consumption parameters for the purpose of controlling production thus represent important steps along the path toward energy- and resource-efficient production.

The factory itself – where processes are driven by eco-friendly energy technologies such as photovoltaics, wind power and hydroelectricity – functions as a fourth observation level. Energy control stations can couple the energy supply system with the building and the processes in progress, adjusting them accordingly. A further goal should be to create closed energy and resource loops, so as to make use of unused energy. In this way, the amount of energy and resources lost during value creation can be minimized.

Achieving sustainable production with the E³ factory

Under pressure to compete, and influenced by both social changes and politically determined overall conditions, companies must not only implement energy- and resource-efficient processes and products, but also establish conditions for production that are eco-friendly and ergonomic. Energy and resource efficiency, emissions neutrality, and ergonomics are the three key pillars of the factory of tomorrow – the E³ factory. These are the enablers of economical operation that will allow producers to consolidate and expand their market position.

A comprehensive plan for energy and resource efficiency is based on the four observation levels described above and can include, for example, anything from cooling lubricants to the factory building. Viewed holistically, it is expedient to opt for a very broad observation framework so as to get as near as possible to a cradle-to-grave or cradle-to-cradle analysis. The first of these analyses covers the entire product lifecycle, while the second focuses on the cyclical use of resources, i.e. on a more or less closed resource loop. However, that presupposes that all the processes and materials used in the production and utilization of a product are known – something that is not always the case.

1 Thermoelectric elements can be employed to harness an engine's residual heat and generate electricity.

2 Creating an energy-autonomous, emissions-neutral and ergonomic factory is one of the goals of Fraunhofer research.



Apart from energy and resource efficiency, global trends and political requirements are further motives for companies to implement eco-friendly manufacturing. They include society's changing awareness of environmental aspects and the resulting habits of consumers. Environmental and climate protection – including pioneering efforts to reduce CO₂ emissions – have become competition-critical factors in recent years. Environmental labels on electrical goods or the one for automobiles introduced in 2011 have already become key factors in influencing consumers' purchasing decisions.

Demographic change is a third, very strong, trend that the manufacturing industry has to grapple with. A lack of specialized workers and a higher retirement age make it necessary to adjust production conditions to the changing structure of the workforce. That is why ergonomic conditions will have a key role to play in manufacturing going forward. The work of employees has a decisive impact on the quality and productivity of production process chains. Consequently, ergonomic and work-supporting devices as well as optimized worker-machine interaction are factors that can contribute to a company's success. In the final analysis, the ability to recruit and retain qualified personnel will be a decisive factor in the economic efficiency of tomorrow's factories.

1 Car production plays a central role in both the German and European economies.

2 The frontline theme "Green Powertrain Technologies" is pursuing the development of highly efficient motor vehicle drive systems.

Automobile production – an alliance for innovation

The automotive industry demonstrates in an exemplary way the close relationship between the deployment of resources and production. Both original equipment manufacturers (OEMs) and automotive suppliers are undergoing a radical structural transformation. Climate change, the increasing need for mobility, urbanization and the rise of megacities, and dwindling resources are all trends that are giving rise to decisive changes in vehicle and mobility concepts and a shift toward sustainable and resource-conserving solutions.

Industry is on the verge of implementing alternative vehicle concepts in mass production, which is why the demand for new approaches to sales and vehicle utilization continues to grow. In many cases, the technology needed for the series production of key cost-saving components is still not available. Several drive technologies are being developed and manufactured in parallel, but the share of alternative drivetrains in the product mix is constantly rising. This calls for fundamental structural changes in automobile production in terms of organization, technology and production systems.

The Fraunhofer-Gesellschaft is addressing this issue in the Fraunhofer Automobile Production Alliance under the management of the Fraunhofer Institute for Machine Tools and Forming Technology IWU. Fraunhofer alliances are defined as partnerships between institutes or institute departments with different areas of expertise for the purpose of carrying out joint research into a business area and of marketing the results of that research. Eighteen Fraunhofer Institutes have joined forces in the Fraunhofer Automobile Production Alliance with the goal of jointly pursuing production-oriented R&D for the automotive industry. The institutes' key research areas complement each other, allowing them to deliver inno-





1

vation – quickly, holistically and sustainably – along the entire process chain of automotive production, from the planning stage through to the finished product.

The work of the alliance is to create the manufacturing technology needed to phase out small-scale series and make the transition to profitable, energy-efficient mass production. In line with their respective fields of research expertise at the institutes, the scientists in the alliance are grouped into the business areas “Powertrain”, “Body”, “Interior” or “Vehicle assembly”. In addition, there are interdisciplinary groups such as “Methodology” and “Production research for electromobility” to cover cross-sector topics in a systematic, end-to-end manner.

The alliance carries out research along the entire automobile production process chain, supporting the OEMs’ vehicle development and closing the gap between it and the development work on components and systems carried out by their suppliers. Key tasks include the systematic virtualization and end-to-end simulation of the process chain as well as reducing the amount of materials used. In this context, further research needs to be carried out into the integration of recyclable materials that are available in the long term. In addition, extensive studies are being conducted with the goal of implementing innovative, resource-conserving technologies and energy-saving systems technology.

Thanks to its broad-based expertise, the alliance functions as a point of contact for auto makers and their suppliers, whether they are looking for answers to individual problems or for solutions requiring an integrative and interdisciplinary approach. It develops technologies and systems for the production of motor vehicles and their components up to the point where they are ready for series production. The objec-

tive is to get product innovations into series production as quickly as possible, which involves evaluating critical areas of technology – both in economic terms and from the standpoint of efficiency – during the product planning process. That includes production planning issues as well as the design of the supplier networks.

Interfaces for ideas, points of focus for efficiency

The Fraunhofer Automobile Production Alliance includes not only Fraunhofer Institutes with a focus on production (as organized in the Fraunhofer Group for Production), but also research groups in areas adjoining the field of traditional production research (for example the Fraunhofer Group for Materials and Components – MATERIALS, the Fraunhofer Group for Light & Surfaces and the Fraunhofer ICT Group). This interdisciplinary research leads to innovative processes and products as well as creative approaches for greater efficiency, especially at the interfaces between the individual disciplines.

The alliance’s different focal points determine its research themes, such as enhancing efficiency and conserving resources in automobile production. The main research areas have a direct effect on industry and are to be found in all fields of vehicle production, including adjacent ones such as the resource procurement, logistics, factory planning and organization. Another focal point is production technologies and machinery for enhancing the efficiency of conventional automobile concepts. Examples include technologies and equipment for the mass-production of a 1-liter car and the ever-relevant topic of lightweight construction.



The alliance also focuses on series-produced technologies for alternative drivetrains. The research deals, for example, with the development of new technologies – and the optimization of existing ones – for the manufacture of hybrid vehicles and all-electric vehicles. That also covers the broad-ranging topic of battery technology, which is divided up into the research areas layout, crash safety, thermal management, packaging and the associated changes to vehicle configurations. In order to achieve electromobility targets in a rapid and efficient manner, it is essential for research and industry to work hand in glove when it comes to product development and manufacturing technology innovations.

Partner for innovative change

By its own definition, the Fraunhofer Automobile Production Alliance is a strategic R&D partner to OEMs and their suppliers. This is of particular significance when one considers that large parts of the European automotive supply industry are currently forced to pursue a dual strategy. On the one hand, they need to secure their continued existence by improving their products and making efficiency gains in their traditional segment of high-quality mechanical components. On the other, they have to develop products and technologies for electromobility to ensure their survival in tomorrow's markets.

1 Batteries are taking on a pivotal role in automotive technology.

2 The distribution of goods is a central application area for mobility technology.

3 Factories can generate a large part of the energy they need, for instance by means of solar panels installed on factory roofs.

By concentrating the skills and expertise of several of its institutes in the Fraunhofer Automobile Production Alliance, Fraunhofer is in a position to provide holistic scientific and technical support to its customers as they work through this substitution process for their products and production methods. With its R&D services, Fraunhofer can thus make a major contribution toward resolving the deadlock between two current megatrends – mobility on the one hand, and the scarcity of resources and climate change on the other.

Creativity generates new options

By pooling its research expertise in the Fraunhofer Automobile Production Alliance, Fraunhofer is providing answers to a key question: what detail adjustments have to be made in order to make automobile production more efficient? The innovations that are the product of Fraunhofer research owe their success to the interdisciplinary collaboration that Fraunhofer promotes. Cooperation between different units and specialists offers an opportunity to develop new perspectives and find innovative paths and solutions. Existing processes are viewed critically and analyzed from different perspectives in order to determine the points at which changes would have the greatest effect. The result of this work is changes to “details” that improve the processes and products, and innovations that question whole processes or products and replace them entirely with new ones.

Improvement and innovation always call for new ideas. Such ideas arise through a creative process, the trigger for that process being a task or problem requiring analysis. So creativity and innovation are closely related. Translating ideas into innovations means finding beneficial solutions to problems.





Ideas and innovations for success

Creative processes are omnipresent in Fraunhofer research. Research – the key tool for the systematic search for new knowledge and its implementation in viable solutions – is founded on creativity. The major factors influencing creativity are the people involved, the products being examined and the working environment. A corporate climate that promotes openness, transparent and easily comprehensible processes and structures, and mutual trust are all conditions that further creativity. Freedom of action and varied tasks are also decisive, as is the possibility of making decisions autonomously, establishing contacts, and carrying out further training in line with one's personal preferences.

With its flexible structures and decentralized organization – comprising what are for the most part autonomous institutes – the Fraunhofer-Gesellschaft offers the right framework for creativity. What is more, collaboration across disciplines and institutes is encouraged – providing an ideal and at once indispensable basis for innovation and creative research. Close contacts with German industry ensure that the research carried out is needs-based and close to the market. Fraunhofer's international footing is another plus point, with opinions and approaches attributable to different cultures being an additional spur to creativity.

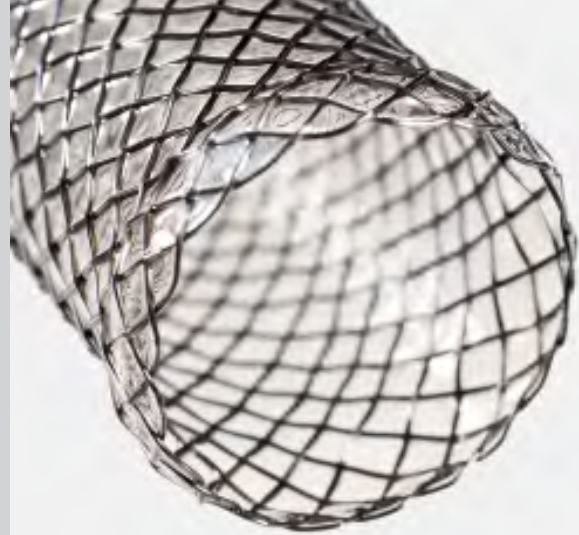
The Fraunhofer-Gesellschaft has been a successful provider of research and development services for over 60 years. Today, it is Europe's largest organization for applied research. The possibility of conducting creative research is one factor in this success, and has played a decisive role in bringing together the 22,000 researchers who now work for the Fraunhofer-Gesellschaft in its 66 independent research institutions. As partners of industry, they are all making a big contribution to ensuring that Germany remains an innovation hub.

Prof. Dr. Reimund Neugebauer has been President of the Fraunhofer-Gesellschaft since October 2012. He was previously director of the Fraunhofer Institute for Machine Tools and Forming Technology IWU and spokesman for the Fraunhofer Automobile Production Alliance.

Co-author Anett Rennau is research assistant to the director of the Fraunhofer Institute for Machine Tools and Forming Technology IWU.

1 Fiber composites will find widespread application in the cars of tomorrow.

2 Joining techniques are a key area for achieving greater efficiency in manufacturing.



PROJECTS AND RESULTS 2012

HEALTH

Keeping an eye on blood sugar levels

The trend toward the miniaturization of electronic components in medical technology is proceeding apace. Diabetics, in particular, will be pleased with a device developed by the Fraunhofer Institute for Microelectronic Circuits and Systems IMS. A new diagnostic system measures blood sugar levels indirectly, via either tear fluid or perspiration. The engineers have managed to install the corresponding sensor along with the analysis electronics and power supply on a very thin chip measuring 10 mm in length and only 0.7 mm in width. Once attached to the patient's eyelid, the sensor can be worn without any trouble for weeks or even months at a time. On request, the chip provides exact blood sugar readings at any time, saving diabetics the annoyance of finger pricks.

Non-slip stents 1

Stents are small, grid-like metal structures used to expand and support blood vessels or airways. They can be very useful in treating constriction of the coronary blood vessels or the windpipe. But if a stent slips out of position, its positive effect can be transformed into the opposite. In the case of the windpipe, there is the added problem that the conventional material used for the stents cannot be colonized by cilia cells – which continuously purify the bronchial tubes. Now, researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have developed innovative coatings that are suitable for colonization by body cells. As a result, cells can grow on the metal base, providing the stents with better protection against slippage.

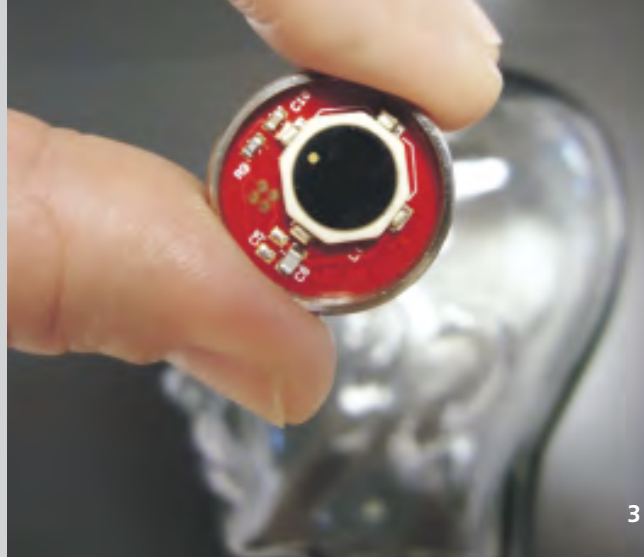


Venous valve implants 2

Venous valves and the muscles that surround them play a central role in transporting blood back to the heart. If the valves do not function properly, the blood collects in the legs, leading to edemas. Up till now, doctors have only been able to treat the symptoms of this widespread complaint. But that is set to change. In cooperation with partners from industry and research, the Fraunhofer Institute for Manufacturing Engineering and Automation IPA has developed a venous valve implant that is suitable for automated production. The researchers produce the valve implants from a plastic (polycarbonate-urethane) using additive manufacturing techniques. The plan is to deploy this production method for other thin-walled, highly durable implants, such as heart valves or intervertebral disks.

Giving foodstuffs the once-over

Frequent shoppers know that goods are not always as fresh as they look. But short of cutting open the fruit or unpacking the cheese, it is not always possible to check the freshness of foodstuffs in the store. Help will soon be available in the form of a miniature spectrometer. Researchers at the Fraunhofer Institute for Photonic Microsystems IPMS have succeeded in shrinking this technology to less than the size of a sugar cube. A special manufacturing technique means it is inexpensive to produce these robust, high-performance mini-spectrometers. The scientists even think that future devices will be small and cheap enough for installation in smartphones. Then, consumers will always be able to check the quality of their foodstuffs before they buy them.



A guard in the brain 3

Changes in intracranial pressure can have serious consequences; if the pressure is chronically high, the brain's performance can be impaired – even to the point of dementia. Conventional monitoring sensors – which are sealed in plastic and have no effective barrier against moisture – are not suitable as long-term implants in high-risk patients. At the Fraunhofer Institute for Biomedical Engineering IBMT, researchers have now developed a sensor that is encapsulated entirely in metal and can monitor intracranial pressure over long periods of time. This gives doctors a non-invasive means of obtaining pressure readings that rules out the risk of patient infection.

Non-abrasive hip prosthetics

Hip replacement surgery is no rarity among senior citizens, and is sometimes necessary even in younger patients. Up till now, metal prosthetics were implanted because of their high durability. Doctors now know, however, that metal-on-metal contact can release metal ions into the body, causing organ damage. With the aid of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, researchers in the international ENDURE project, which was funded by the European Commission, have now developed a novel hip prosthetic that combines high durability with greater biocompatibility. The artificial hip socket consists of a biocompatible polymer composite with very low abrasive qualities, while the femoral head is made of ceramic material. A special coating and the bone-like elasticity of the parts allow the prosthetic to graft well with the natural bone tissue. Doctors and developers expect the new prosthetic to deliver excellent long-term, complication-free performance.



COMMUNICATION

Hugo Geiger Prize

A opportunity for "world music"

The digitalization of music means its administration can be automated. The latest, technically demanding goal is to assign music to different world regions on the basis of its typical characteristics. Anna Marie Kruspe of the Fraunhofer Institute for Digital Media Technology IDMT developed an automated classification procedure that achieves a degree of accuracy of 70 percent – a figure comparable to the systems for classifying Western music that already exist. The aim is to integrate world music and niche genres into the international music market – to the benefit of composers and consumers alike. The researcher was awarded the Hugo Geiger Prize 2012 for her work.

Fast data transfer with infrared technology

Various options are available for transferring large volumes of data from mobile devices to stationary computers, e.g. USB cable, wireless LAN or Bluetooth. Another very convenient and efficient method of data transfer – namely using infrared light – has been developed at the Fraunhofer Institute for Photonic Microsystems IPMS. Employing this technology, a specially developed module achieves transmission rates of one gigabit per second, which is many times faster than conventional transmission techniques. The researchers are even targeting a transmission rate of 10 gigabits/second using this technology.

Joseph von Fraunhofer Prize

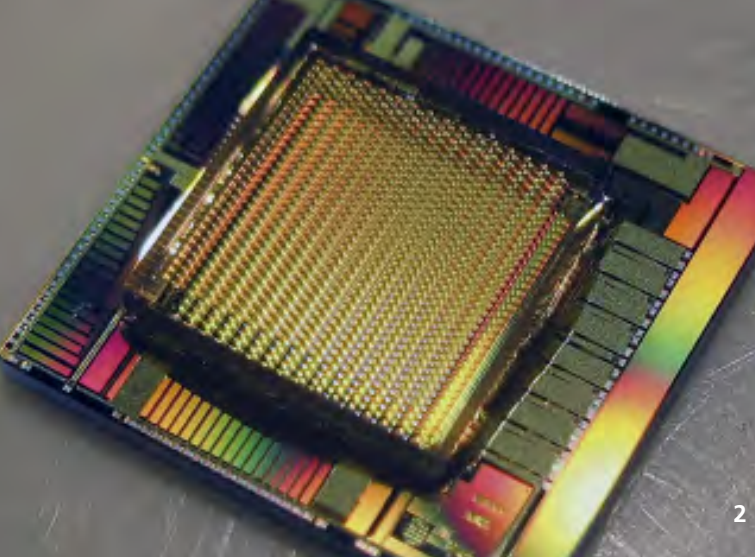
Surge in microchip performance 1

Integrated circuits are becoming ever smaller and more powerful. The microchips in today's computers already contain around two billion transistors. Extremely miniaturized components of this kind are produced through the exposure of photosensitive materials, and optical systems are key elements in that process. It has long been impossible to meet the ever-rising requirements of production through the use of normal light sources; in future, beam sources will be needed in the extreme ultraviolet wavelength of around 13.5 nm, calling for revolutionary approaches in the field of lithography. Dr. Klaus Bergmann, Dr. Stefan Braun and Dr. Torsten Feigl of the Fraunhofer Institutes for Laser Technology ILT, for Material and Beam Technology IWS and for Applied Optics and Precision Engineering IOF stand for the strategic partnership between those institutes in the area of next-generation lithography. Together with their respective teams, they have developed and optimized the beam sources as well as the collector, illumination and projection optics for extreme ultraviolet (EUV) light. Through their research, the three institutes have established themselves as important partners to domestic and international suppliers of such components. The trio of researchers received the Joseph von Fraunhofer Prize 2012 for their work.



Every photon counts 2

As optical systems become ever more powerful, they are being deployed for more and more technical functions. In their efforts to develop more efficient light sensors, researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS have taken a big step forward. They have developed a sensor chip, on which each pixel is equipped with its



own microlense. The data is processed directly on the chip, making for a significant improvement in the response time of the system as a whole. The microlense was developed in the EU-funded MiSPiA research project, in which seven partners from research and industry took part. The new technology is already being tested for deployment in motor-vehicle safety functions.

Indoor navigation 3

Anyone who has got to know driving with a satellite navigation system, is usually unwilling to go without one – the added benefits in terms of convenience and safety are simply too great. But satellite signals cannot be received indoors. In the MST Smartsense project – which is receiving financial support from the German Federal Ministry of Education and Research (BMBF) – the Fraunhofer Institutes for Manufacturing Engineering and Automation IPA, for Reliability and Microintegration IZM, for Electronic Nano Systems ENAS and the Fraunhofer Research Institution for Modular Solid State Technologies EMFT collaborated with partners from industry to develop a navigation system for use indoors. The result of their collaboration is a sensor module for smartphones that adapts to the user, loads and utilizes the corresponding building data, and safely guides the user through the rooms.

Web power sockets

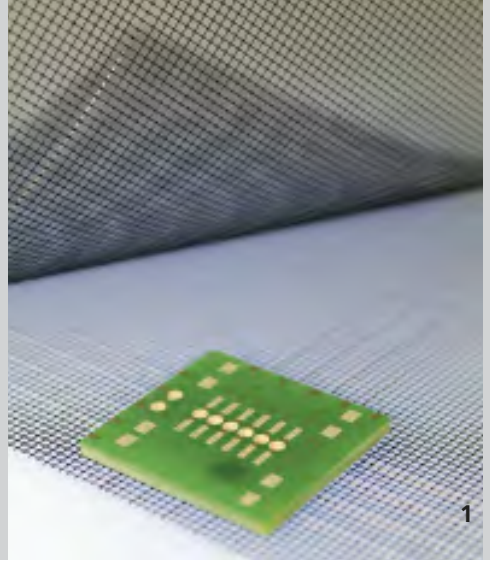
Most of today's household appliances are not "smart" – they still have to be controlled and guided by a human user. In an effort to make them more intelligent, researchers at the Fraunhofer Institute for Industrial Mathematics ITWM and the Fraunhofer Institute for Embedded Systems and Communication Technologies ESK have designed power sockets that can be controlled via the new Internet protocol IPv6. In this way, people will be able, for example, to use their smart-

phones to start their washing machines remotely so that the washing is ready to hang up when they get home. The power socket also recognizes on its own when the home solar installation is producing a lot of electricity and adapts the start time accordingly. This Internet power socket can also tell the user how much electricity the appliance in question is consuming. It forms part of the Hexabus home automation system developed at Fraunhofer ITWM as part of the "mySmartGrid" project.

Joseph von Fraunhofer Prize Spray-on functional surfaces

Functional surfaces are key to innovations in almost all areas of everyday life – whether scratch-proof smartphone cases, antibacterial surfaces for refrigerator interiors or corrosion-proof paints for aircraft bodies. However, most of the vacuum and wet-chemical coating processes used to date are complex, incur high material costs or produce large amounts of waste. Dr. Jörg Ihde and Dr. Uwe Lommatzsch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM joined forces with industrial partners to develop an innovative plasma coating process that functions at normal air pressure. In a special nozzle, a pulsed arc discharge generates a highly efficient plasma, which is directed at the surface to be treated. This coating process offers three advantages: no reactor is required, making the procedure easier to integrate into production processes; the procedure is fast, which has a positive impact on costs; and it is easily automated and suitable for large surfaces. The innovation has already been deployed successfully in industrial production at large companies. The researchers were awarded the Joseph von Fraunhofer Prize 2012 for their work.





SECURITY

Quick action after a power outage

Whether private households, businesses, hospitals, traffic lights or communication systems – everything depends on a reliable power supply. That is why it is so important to respond quickly when a power outage occurs. Up till now, however, there has been no IT-based management system enabling technical services, fire brigades, the police and emergency services to take on the function of process managers when the worst comes to the worst. A new software solution developed by the Fraunhofer Institute for Applied Information Technology FIT is designed to meet this need. It allows all those involved to prepare in advance for their collaboration in crisis situations, and optimize their response to them. The solution centers around role-based checklists with detailed instructions on what each unit has to do and which points have to be coordinated with other units.

Securing windows with wireless technology

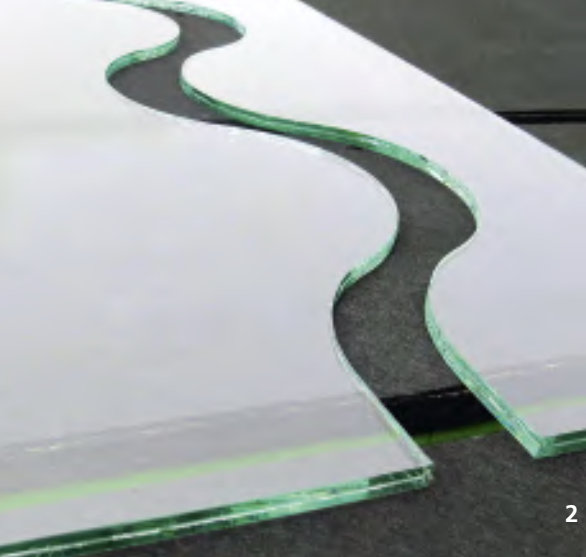
The best guards are always alert and never distracted by their own needs – they perform their job without having to be looked after. A system developed by scientists at the Fraunhofer Institute for Integrated Circuits IIS comes very close to this ideal. Together with industrial partners, they have created sensors that gain their energy from light or ambient heat, and can thus function autonomously for long periods. The electronic guard registers the position of windows and can provide the homeowner with that information over wireless transmission channels. The system is tamper-proof and thus suitable for protecting against break-ins. Already available as a prototype, it will soon see its market launch.

Delicate protective gauze 1

We often imagine that protective measures against burglary need to be as strong and solid as possible. After all, they are supposed to present intruders with major mechanical obstacles. But quite different forms of protection are conceivable. Researchers at the Fraunhofer Institute for Reliability and Microintegration IZM have developed a gauze containing electrical circuit paths. If they are severed, the connected system raises the alarm, also giving details of the exact location and extent of the damage. The electronic gauze is hard-wearing, reliable and inexpensive to produce. It opens up previously undreamed-of security applications, and also in structural safety.

Security in the cloud

It is becoming more and more popular to store personal and business data in the cloud. Understandably so, as the benefits are obvious: you do not have to invest in your own storage media and the data is readily available anywhere via the Internet – even on mobile devices. However, you do have to make certain that only authorized persons and devices can access your cloud data. The OmniCloud system being developed at the Fraunhofer Institute for Secure Information Technology SIT is designed specifically for companies that demand a high level of security for their cloud data. The system makes the storage of files and software secure and enables users to change their cloud provider easily if needed. Michael Herfert and his team were honored for their achievements with first prize in the German IT Security Awards 2012.



Getting safety glass into shape 2

Safety glass is used not only in buildings, but also in automobiles. It is particularly resistant to strain, but that also makes it hard to process. In order to make it easier to cut safety glass, scientists at the Fraunhofer Institute for Mechanics of Materials IWM have developed a new process in cooperation with an industrial enterprise. The safety interlayer in the glass sheet is first vaporized along the intended cutting line using a laser beam, after which the glass sheet is scored and broken along the same line. The process lends itself well to automation and grants designers and architects more creative freedom in their work.

Shortcut to the authorities

Companies in Germany are currently subject to 10,000 different reporting obligations, which makes for an annual bill of €40 billion for private enterprise as a whole. On behalf of the German Federal Ministry of the Interior (BMI), the Fraunhofer Institutes for Open Communication Systems FOKUS, for Industrial Engineering IAO, for Experimental Software Engineering IESE, for Software and Systems Engineering ISST, and for Secure Information Technology SIT teamed up with partners from industry, science and public-sector administration to develop the P23R principle (process data accelerator). An electronic interface between businesses and public authorities, P23R goes a long way toward simplifying complex administrative processes. The data from both areas can be merged and processed without media discontinuities. That makes for the simple, secure and rapid exchange of data between enterprises and the authorities, and lowers administration costs. In 2012, P23R was awarded the Innovation Prize of dbb beamtenbund und tarifunion, the German public servants' union.

Life-saving robots 3

Whatever their origins, catastrophes have one thing in common: they cause damage and give rise to confusing, often chaotic, situations. So if people need to be saved, any sort of useful technology is more than welcome. Robots can be of considerable help here as they are able to work where it would be dangerous for humans to do so, for example in a damaged ship or burning building. The goal of the EU-sponsored ICARUS project is to develop machines of this kind to support emergency and rescue workers on the spot. In the project consortium, which comprises 24 partner institutions, the Fraunhofer Institute for Reliability and Microintegration IZM has the task of developing an extremely light and robust thermal imaging system. Such a system needs to be reliable in detecting survivors even when they are stranded between rubble or floating on the surface of waterbodies, thus pointing the rescue workers in the right direction.

Building security

Being reliant on functioning technology and infrastructure, modern industrialized societies have many chinks in their armor where they are open to attack. At the same time, such societies also have at their disposal highly developed technologies for handling losses and damage or – even better – for preventing them from happening in the first place. In collaboration with Schübler-Plan, a construction company, the specialists of the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI are contributing their expertise to achieve greater building security in cases where disasters strike. As the experience of recent decades has shown, such disasters are not necessarily natural catastrophes, but also result from high dynamic impacts such as explosions or plane crashes.



MOBILITY

Homemade microclimate

For many people, the aircraft environment is not one they feel very comfortable in. They have trouble coping with the stress of flying and, when it comes to what they regard as a pleasant ambient climate – factors like temperature, humidity and air flow – their personal requirements are quite diverse.

Researchers at the Fraunhofer Institute for Building Physics IBP have a flight lab in the Bavarian village of Valley, in which they can test and optimize the aircraft cabin climate in detail. They have developed a novel type of air supply that allows passengers to set their own personal microclimate around their seats and avoid drafts altogether without affecting their neighbors at all. Optimized conditions like this should help reduce overall flight stress.

Well-cooled batteries

When the internal combustion engine of a car is running, it produces surplus heat, which has to be removed. That is why it is equipped with a radiator. Although electric motors produce substantially less waste heat, it is concentrated at a sensitive spot – the battery. Even temperatures barely in excess of 45°C can cause the battery to wear out faster. Scientists at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT have developed a coolant that is three times more efficient than water. CryoSol^{plus} is a paraffin-in-water emulsion. As the paraffin micro-balls in the emulsion melt, the mixture can absorb large amounts of thermal energy. This means that the cooling systems using this coolant can be small and light, which has a positive impact on the overall efficiency of the electric vehicle.

Joseph von Fraunhofer Prize

Full-speed laser scan 1

Laser systems lend themselves to high-precision and ultra-high-speed measurement techniques. Together with their team, Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfelschneider of the Fraunhofer Institute for Physical Measurement Techniques IPM have developed a 3D laser scanner that can be utilized outdoors without any problems. It is so fast and precise that it can be used, for example, to survey and monitor the position of the overhead contact lines and the track from a train traveling at 100 km/h. In stationary installations, the scanner can check passing trains to see whether their loads have shifted. To ensure the scanner is safe for the eyes, the researchers chose an infrared wavelength that cannot cause any harm. The laser system has already been successfully launched in the market, and is being deployed internationally to enhance railroad safety. The researchers were awarded the Joseph von Fraunhofer Prize 2012 for this development.



Less motor friction

Modern combustion engines are highly complex. Their manufacture calls for the highest levels of precision and for components that are perfectly matched with each other. Despite constant innovation in engine design, a large part of energy input is still lost through friction. Engineers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU have developed a process for manufacturing components that are subject to high tribological stress. During the production process, a nano-crystalline layer is applied to the surface of these components. This altered surface can help improve the engine's running-in behavior and friction/wear characteristics, leading to lower fuel consumption.



Hydrogen-powered rickshaw 2

Hydrogen-powered cars are a much-discussed idea for future mobility, and researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Dresden and the Fraunhofer Institute for Solar Energy Systems ISE have developed a concept car called Hydrogenia for this purpose. The vehicle uses hydrogen from a specially designed metal hydride tank to supply a fuel cell, which directly generates electricity. The electric bicycle, also called a pedelec, is an idea for urban mobility that relies on lightweight construction and relatively low speeds. On a full tank, a hydrogen-powered vehicle has a substantially greater range than a battery-powered one.

Fighting wing ice

The shape of its wings is decisive for an aircraft's performance. If ice forms on the wings during flight, it changes the plane's aerodynamics and weight, adds to kerosene consumption, and – in the worst case – can lead to a crash. That is why aircraft are equipped with apparatus to prevent the formation of ice and to remove any ice already there. At the Fraunhofer Institute for Structural Durability and System Reliability LBF and the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, various approaches to ice removal/prevention are being tested that are technically superior and more economical than established processes. For example, tests are being carried out on conductive, heat-producing, yet metal-free nanomaterials, shape memory materials, hydrophobic coatings and innovative sensors. Some of these technologies could also be deployed to de-ice wind turbines.

Testing technology for ship propellers 3

Ship propellers are masterpieces of metalworking. Weighing up to 150 metric tons, they are gigantic bronze alloy workpieces that are cast in one piece. They also have to withstand strong forces, because the ships they propel can weigh more than 100,000 tons. That is why it is essential that the quality of their materials is checked very carefully. At the Fraunhofer Institute for Industrial Mathematics ITWM, researchers have developed and optimized a mobile ultrasound system for rapid identification of the tiniest defects in material layers of up to 45 centimeters in thickness. The feat accomplished by the researchers was to use mathematical methods to reduce interference and, at the same time, to amplify the error signals being searched for. The system has been optimized for mobile deployment.

Crash test for electric vehicles

Although the load behavior of components and structures can be simulated very well on a computer, a real-life crash test is still the moment of truth. This is particularly true of newly developed vehicles such as lightweight or electric cars. Such vehicles are constructed using components such as batteries, lightweight structures and electric motors, and relatively little is known about their behavior in a crash situation. This prompted the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI to set up a whole-vehicle crash test facility. Such a facility can be used, for instance, to test how a battery in a lightweight vehicle behaves in a crash situation and where the design of the vehicle could be adapted to enhance safety.





ENVIRONMENT

Joseph von Fraunhofer Prize

Oil-free lubrication

Metalworking plays a central role in the manufacturing industry. In drilling, milling, turning and grinding processes, cooling lubricants are used to protect both the tools and the workpieces against overheating and excessive wear and tear. The coolants customarily used today are based on mineral oil. The disadvantage of these coolants is that they conduct relatively little heat away from the workpieces, pose a danger to health, and are flammable. Dipl.-Ing. Andreas Malberg, Dr. Peter Eisner and Dr. Michael Menner, scientists at the Fraunhofer Institute for Process Engineering and Packaging IVV, worked together with Carl Bechem GmbH, an industrial partner, to develop an interesting alternative – aqueous biopolymer solutions. Such solutions are completely oil-free, but display superior properties in terms of lubrication, cooling and disposal. They are made of renewable raw materials and, as they are not flammable, no special fire precautions need to be observed. What is more, they reduce both the production times and costs per workpiece. These new cooling lubricants have already been successfully marketed for deployment in metalworking applications. The three researchers were awarded the Joseph von Fraunhofer Prize 2012 for their achievement.



Small reactors have the edge 1

Producing substances in large reaction vessels is not always the most efficient method. There are often advantages in allowing only small amounts of chemicals to react with each other: it is easier to keep the reaction under control and ensure that it takes place faster and more steadily. With this in mind, researchers at the Fraunhofer Institute for Chemical Technology ICT developed a microreactor for the production of nitroglycerin. Energy is released during the synthesis process, and it is easier to conduct that energy away in microreactors. This helps to avoid critical temperatures during the process and enhances safety. At the same time, several work steps can be combined in a very small space. The researchers are also using microreactors of this type to produce polymers for organic LEDs, thus achieving a substantial improvement in the quality of the synthesized substances.

Hugo Geiger Prize

Mobile measurement of air quality

Air quality in cities and urban agglomerations must be constantly monitored in order to protect the health of the inhabitants. Until now, this was mainly carried out at stationary observation points. But the results gathered there are not as meaningful as they could be. Sven Rademacher of the Fraunhofer Institute for Physical Measurement Techniques IPM has developed a mobile infrared-optical filter photometer that can measure several gases simultaneously. As the device can be localized by satellite, exact mapping of the measurement data is possible. In this way, conclusions can be drawn as regards sources of pollution and targeted measures taken to counteract them – such as the imposition of localized restrictions on driving. An air pollution map available on the Internet will make the measurements transparent for everyone. The researcher was honored with the Hugo Geiger Prize 2012 for this development.



The return of rubber 2

Rubber is a fascinating and, in particular, useful material. But it has a limited life span. It can age and wear away – just think of car tires. In the past, the recycling of rubber parts generally resulted in less sophisticated products, such as foot mats and surfaces for sports fields. With funding provided by the German Federal Ministry of Economics and Technology (BMWi), the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT has developed a process for transforming old rubber products into new high-quality ones. Comminuted rubber waste is mixed, for example, with polypropylene, melted down and processed to create elastomeric powder modified thermoplasts (EPMT). Given suitable formulas, hubcaps, handles and transport rollers can be manufactured using this method.

Pellets against pests

Organic farmers have enemies too – cabbage root flies, for instance. Understandably, farmers don't have a good word to say about these insects, which can destroy whole harvests and thus threaten the farmers' livelihoods. Now, researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have thought up something against these pests. They have developed pellets using the fermentation residues from biogas production, which contain cyanobacteria. If these are placed in the soil next to the plants, they release fertilizers as well as an odor that repels cabbage root flies. In this way, farmers can comply with organic farming principles and still prevent the insect pests from destroying their vegetable crops.



It depends what you make of it 3

Every year, more than 100 million metric tons of concrete rubble is produced in Germany, and there is still no functioning process for recycling it. Concrete is the building material of our age – not least because of its versatility. Up till now, the only option was to comminute the waste concrete and use it as a foundation for roads. At the Fraunhofer Institute for Building Physics IBP, scientists are working on a process to break down old concrete into its main constituent components – cement and aggregates. To this end, they are using electrodynamic fragmentation, a process by which the pieces of concrete are submerged in water and blown apart with ultrashort high-power pulses, leaving only the original constituent components. The researchers expect to have a market-ready facility within two years.

Fertilizers from wastewater

Recycling has two fundamental effects that make it so attractive to us: it reduces the amount of waste, and provides us with new raw materials. That is particularly noticeable with wastewater. Once salts such as phosphate and ammonium have been removed from it, the wastewater can be released into the environment without the danger of eutrophication through algae. The same process also delivers raw materials for new fertilizers. Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have developed a new, chemical-free and eco-friendly electrolytic process – which is both energy-efficient and inexpensive – for precipitating nitrogen and phosphorus in the form of magnesium ammonium phosphate. This mineral – also known under the commercial name of Struvite – is an extremely high-quality fertilizer that is highly prized in the agriculture industry.



1

ENERGY

Hugo Geiger Prize

More efficient air conditioning systems

The demand for air conditioning is set to rise, especially owing to the large amounts of glass used in modern buildings and to higher average temperatures in the summer months. An interesting option to lower the amount of energy consumed by air conditioning is a thermally operated air-conditioning unit using the adsorption method. However, the corresponding technologies need to be made more efficient. At the Fraunhofer Institute for Solar Energy Systems ISE, Harry Kummer has developed a new coating system for the heat exchangers integrated in these units. This shrinks the dimensions of these units and increases the air conditioners' power density and efficiency. The process has been registered for a patent and is to be further optimized in a large-scale demonstration facility. The scientist received the Hugo Geiger Prize 2012 for his development work.

Kite power

The search for new sources of energy is constantly bringing forth good ideas. One of these is a stunt kite that can be used to generate electricity. It is based in the observation that a paper kite can generate a lot of energy on the ground as it is pulled up into the air, especially when it flies very high. NTS Energie- und Transportsysteme GmbH, a Berlin-based company, used this observation to develop an idea, and asked the Fraunhofer Institute for Manufacturing Engineering and Automation IPA to join the team tasked with implementing it.

The tests carried out thus far, in which stunt kites were used to pull cars on the ground and thus generate electricity, are very promising. The goal is to send the cars along a circular track so as to generate electricity on a continuous basis.

Streaming electricity 1

You do not have to build a dam to harness hydropower. Together with industrial partners, engineers at the Fraunhofer Institute for Factory Operation and Automation IFF are driving forward the idea of a run-of-river power plant. Power generators of this type are anchored in rivers and streams, with the flowing water driving a propeller, turbine or waterwheel. The researchers are optimizing this idea using the VECTOR test facility in operation at Magdeburg's knowledge harbor. Individual small-scale power plants of this type can generate only a relatively small amount of electricity (up to 30 kilowatts per unit), but the supply is very constant and the machines require little maintenance. Larger groups of such installations, however, could make a substantial contribution toward accomplishing the transition to a new energy regime.

Easy-as-pie home renovations

The refurbishment of private homes to conserve energy is not only a financial challenge, but also an organizational one. The rooms generally cannot be lived in during refurbishment, and that can take quite a long time. Now, researchers at the Fraunhofer Institute for Building Physics IBP have developed a new type of window to speed up and simplify the renovation work. The prefabricated window modules not only contain an insulating collar that connects with the insulation in the outside walls, but also an under-sill box for technical systems, e.g. a ventilator with a heat exchanger. Electrical lines and cables – which have to be re-laid between the outside wall and the insulation in order to facilitate refurbishment – can also be routed indoors through this box.



Knowing which way the wind blows 2

Renewable energy offers many advantages. It is inexhaustible, generates no environmentally harmful gases, and does not have to be imported. But if you want to integrate it in the energy supply infrastructure in an optimum manner, you need to know, for example, where and when the wind blows strongest. With that information it is possible to place the right-sized wind turbines in the right spot. To better gauge wind conditions while factoring in altitude and conditions on the ground, the Fraunhofer Institute for Wind Energy and Energy System Technology IWES constructed a 200-meter high wind measuring mast. The information gathered using this test mast will be used, for example, to optimize simulation processes for wind farm planning.

Zeolites as heat storage media

If you generate electricity from fuels such as oil or biogas, heat is produced as a byproduct. In order to utilize this residual heat in an optimal manner, media are needed to store the heat temporarily, releasing it later when it is required. In collaboration with industrial partners, scientists at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB are developing a new technology for storing heat – and they are using zeolites for that purpose. Better known as ion exchangers, zeolites are able to bind water vapor in their exceptionally porous surface, releasing heat in the process. In order to store heat energy, the zeolite is heated, driving out the water vapor again. Three times as much heat can be stored using this system than with water tanks.



Solar panels – even better, even cheaper 3

International competition is making life very hard for local makers of solar panels. That underscores how important it is for Germany to continue its research in this area and come up with further innovations. New coating processes from the Fraunhofer Institute for Surface Engineering and Thin Films IST are a promising development in this regard. It is important to lower production costs, especially with HIT solar cells, which can have an efficiency level of 23 percent. Fraunhofer researchers are helping here with a new coating process that makes much more efficient use of silane, an expensive basic material, than do conventional processes, thus achieving big cost savings. Innovations such as this can help the German solar industry to regain a competitive edge in the international market.

Pipes for desalination plants

Desalination plants require pipes made of high-performance steel or titanium. Pipes like these are good heat conductors and corrosion-resistant – but costly. Researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM have developed a new polymer composite that offers the desired technical properties, but at a much more favorable price. It is a plastic mixed with copper micro fibers, and can be easily processed to produce continuous tubing. It is corrosion-resistant and, thanks to the fact that it contains up to 50 percent copper, is a good heat conductor. According to experts, pipes of this kind could also be used in the foodstuffs and pharmaceuticals industries.

AWARDS 2012

In addition to many prizes for first-class scientific achievements, researchers of the Fraunhofer-Gesellschaft won a number of particularly important international awards for their achievements in the field of applied research in 2012. We wish to honor them for their achievements here.



German Environmental Award **Concentrated solar power**

Many hopes are pinned on solar power as a renewable energy source of the future. Silicon-based photovoltaics (PV) are especially suitable for generating electricity in our latitudes because they deliver good performance in an economical manner even in diffuse light conditions. Multilayer solar cells are twice as efficient, but use relatively expensive materials. In order to produce electricity efficiently, lenses are used to focus the light on cells that have been scaled down in size to save material costs. Concentrator modules of this type directly convert more than 30 percent of the available solar energy into electricity. The modules have to be steered to track the sun so that the light always remains directed at the PV cell. For this reason, concentrator modules are especially suited to regions with very little cloud cover. For their work in developing this high-performance photovoltaic system and readying it for large-scale production, Hansjörg Lerchenmüller of Soitec Solar und Dr. Andreas Bett of the Fraunhofer Institute for Solar Energy Systems ISE were honored with the German Environmental Prize of the Deutsche Bundesstiftung Umwelt (German Environmental Foundation). They shared the €500,000 prize money from this, Europe's most highly endowed environmental award, with a further prizewinner, Günther Cramer of SMA Solar Technology.





German Future Prize

One hearing aid for both ears 1

Why are glasses regularly made for both eyes, but hearing aids for only one ear? After all, both of these sensory organs function in pairs so as to enable spatial orientation. The reason lies in the complex technology required to coordinate amplification of sound waves to suit precisely the hearing of both ears simultaneously. Even the slightest delays in relaying sound signals can alter their perception, as the brain uses precisely such differences for the purpose of spatial analysis. Three Fraunhofer researchers teamed up to resolve this problem: Prof. Dr. Dr. Birger Kollmeier, a hearing researcher at the University of Oldenburg and head of the Project Group for Hearing, Speech and Audio Technology at the Fraunhofer IDMT, Prof. Dr. Volker Hohmann of the University of Oldenburg, and Dr. Torsten Niederdränk of Siemens AG. They spent several years developing a binaural hearing system comprising two wireless-coordinated hearing aids. With this system, the hearing impaired can improve their spatial hearing and focus on individual conversations despite ambient noise. The result is a substantial improvement in their overall hearing. The major hearing-aid manufacturers are already cooperating closely with the Oldenburg researchers. Federal President Joachim Gauck presented the three researchers with the German Future Prize 2012 in recognition of their achievement.

ERC Starting Grant

The very finest in prosthetics

As long as our musculoskeletal system functions properly, we hardly think about it. But if problems arise – and especially if a limb has to be amputated – we suddenly realize just how complex some movement sequences are and what prosthetics need to accomplish in order to imitate them. The work of Prof. Oliver Röhrle Ph. D. of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA focuses on biomechanical simulations of the human body, an area of research that involves medicine, physiology, mathematics and engineering. He is so successful in his chosen field that he not only received funding under the Fraunhofer Attract Program, but has now been awarded a Starting Grant from the European Research Council worth €1.6 million. Prof. Röhrle's simulation research will ensure that the prosthetics function well in the long term.



**ERC Advanced Grant
HIV vaccine**

Pharmaceutically effective biomolecules are often complex and correspondingly difficult to produce. It is thus advantageous to manufacture them using organisms, which in turn need to be endowed with the corresponding genetic information. Tobacco plants are particularly suited to this task – a fact that has been established mainly through the research work of Prof. Dr. Rainer Fischer of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME. Together with 39 partners from science and industry, he and his team have been working since 2004 to develop a process for producing an HIV vaccine using tobacco plants. The researchers in this “Pharma-Planta Project” have now been awarded an Advanced Grant by the European Research Council. The award, which is given to highly experienced scientists, is worth €2.5 million.



**Academy Award of Merit
Technical Oscar for digital film recorder 1**

The Academy Award of Merit, also known as the “technical Oscar”, is presented by the Academy of Motion Picture Arts and Sciences to people who have demonstrably made a substantial contribution to improving the film-making process. In 2012, the trophy went to Franz Kraus and Johannes Steurer of ARRI, a Munich-based manufacturer of motion picture film equipment, and to Wolfgang Riedel of the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg for developing the digital film recorder ARRILASER. This innovation enabled the film industry to switch from analog to fully digital film production.



Nominees for the German Future Prize
High-quality videos anywhere 2

Whether YouTube, video chats, video on demand, videoconferencing, it has become second nature for us to send and receive moving images via the Internet. Video data already accounts for more than half of all data transmitted across the web. To ensure that high-quality videos can be transmitted to virtually any type of terminal and to keep data volumes low, the video signals have to be compressed in accordance with an international standard. Prof. Dr.-Ing. Thomas Wiegand, Dr.-Ing. Detlev Marpe and Dr.-Ing. Heiko Schwarz – all of whom are researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI – not only delivered fundamental breakthroughs in video encoding, but also played a decisive role in developing and establishing this standard and its extensions. The H.264/AVC format has proven its worth in practice and is used today in over one billion video-capable terminals worldwide. They include Blu-ray players, HD and 3D televisions, conferencing systems, smartphones, tablets and PCs as well as camcorders and digital cameras. The three researchers were nominated for the German Future Prize in recognition of their outstanding research and development work.



The background features a blue grid pattern with a perspective effect, receding towards the top right. Large, 3D-style yellow geometric shapes, including a vertical bar on the right and a horizontal bar at the bottom, are overlaid on the grid. The text 'FINANCIAL REPORT' is centered in the upper half of the image, flanked by horizontal lines.

FINANCIAL REPORT

BALANCE SHEET
AT DECEMBER 31, 2012

INCOME STATEMENT FOR THE
FINANCIAL YEAR 2012

RECONCILIATION BETWEEN
INCOME STATEMENT AND
PERFORMANCE STATEMENT
(CASH-BASIS ACCOUNTING)

EXCERPTS FROM THE NOTES TO THE
FINANCIAL STATEMENTS

INDEPENDENT AUDITOR'S REPORT



BALANCE SHEET AT DECEMBER 31, 2012

FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., MÜNCHEN

| ASSETS | € | € | 2012 € | 2011 € (1000) |
|--|-----------------------|----------------|--------------------------------|-------------------------|
| Current assets | | | | |
| Cash and cash equivalents | | | 15,713,689.06 | 25,203 |
| Marketable securities | | | 230,152,071.56 | 236,018 |
| Accounts receivable and other current assets | | | | |
| Trade receivables | 184,220,030.94 | | | 169,944 |
| Receivables from the federal and <i>Länder</i> governments relating to base funding | 26,979,340.40 | | | 23,433 |
| relating to project billing including contract research | 181,643,272.87 | | | 191,168 |
| relating to pension and compensated absence provisions | 58,144,908.00 | | | 48,863 |
| | <u>266,767,521.27</u> | | | <u>263,464</u> |
| Accounts receivable from associated companies | 6,917,076.89 | | | 4,508 |
| Other current assets | <u>43,970,522.31</u> | | | <u>60,132</u> |
| | | 501,875,151.41 | | 498,048 |
| Inventories | | | 59,568,454.24 | 45,463 |
| Prepaid expenses and deferred charges | | | <u>8,397,734.11</u> | <u>6,324</u> |
| Total current assets | | | 815,707,100.38 | 811,056 |
| Intangible assets | | | 12,752,555.72 | 13,741 |
| Property, plant and equipment | | | 1,694,304,873.49 | 1,600,560 |
| Financial assets | | | <u>15,658,818.25</u> | <u>15,104</u> |
| Total assets | | | <u>2,538,423,347.84</u> | <u>2,440,461</u> |
| Trust assets | | | 41,288,068.04 | 37,681 |

| LIABILITIES AND EQUITY | € | € | 2012 € | 2011 € (1000) |
|---|-----------------------|-----------------------|--------------------------------|-------------------------|
| Current liabilities | | | | |
| Trade payables | | 84,506,244.00 | | 81,320 |
| Unappropriated grants from the federal and <i>Länder</i> governments | | | | |
| relating to base funding | 26,996,929.83 | | | 42,273 |
| relating to project billing | <u>104,283,857.93</u> | | | <u>90,948</u> |
| | | 131,280,787.76 | | 133,221 |
| Accounts payable to associated companies | | 25,000.00 | | 44 |
| Other current liabilities | | <u>12,292,422.71</u> | | <u>4,588</u> |
| Total current liabilities | | | 228,104,454.47 | 219,173 |
| Deferred income | | | 8,376,077.90 | 6,518 |
| Provisions for pensions and similar obligations | | | 10,544,908.00 | 10,863 |
| Other provisions | | | 131,595,959.00 | 117,809 |
| Special reserves | | | | |
| License-fee revenue reserve | | 244,142,209.38 | | 242,381 |
| Grants relating to fixed assets | | 1,708,854,401.88 | | 1,616,107 |
| Grants used to finance current assets | | <u>192,953,146.00</u> | | <u>214,263</u> |
| | | | 2,145,949,757.26 | 2,072,751 |
| Equity | | | | |
| Capital of the non-profit organization | | | | |
| Carried forward | 13,332,607.51 | | | 13,002 |
| Retained earnings | <u>503,308.70</u> | | | <u>331</u> |
| | | 13,835,916.21 | | 13,333 |
| Restricted reserve | | <u>16,275.00</u> | | <u>14</u> |
| Total equity | | | <u>13,852,191.21</u> | <u>13,347</u> |
| Total liabilities and equity | | | <u>2,538,423,347.84</u> | <u>2,440,461</u> |
| Trust liabilities | | | 41,288,068.04 | 37,681 |

INCOME STATEMENT FOR THE FINANCIAL YEAR 2012

FRAUNHOFER-GESELLSCHAFT
ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., MÜNCHEN

| | € | € | 2012 € | 2011 € (1000) |
|---|-----------------------|-----------------------|--------------------------------|-------------------------|
| Revenue from base funding | | | | |
| Federal government | | 536,617,024.68 | | 531,792 |
| Länder governments | | <u>111,757,369.08</u> | | <u>70,979</u> |
| | | | 648,374,393.76 | 602,771 |
| Revenue from own activities | | | | |
| Revenue from research and development activities | | | | |
| Federal government: Project funding | 305,010,012.57 | | | 346,134 |
| Contracts | 11,826,677.77 | | | 14,458 |
| Länder governments: Project funding | 184,230,746.04 | | | 221,006 |
| Contracts | 2,460,650.86 | | | 3,095 |
| Business, industry and trade associations | 558,336,186.58 | | | 520,412 |
| Research funding organizations and other sources | <u>112,061,332.79</u> | | | <u>108,083</u> |
| | | 1,173,925,606.61 | | 1,213,188 |
| Increase in work in progress | | 37,425,034.38 | | 31,980 |
| Other internally constructed and capitalized assets | | 8,184,023.79 | | 8,917 |
| Other operating income | | 35,018,255.55 | | 33,928 |
| Other interest and similar income | | <u>246,096.22</u> | | <u>278</u> |
| | | | 1,254,799,016.55 | 1,288,291 |
| Total base funding and revenue from own activities | | | 1,903,173,410.31 | 1,891,062 |
| Changes in special reserves | | | | |
| License-fee revenue reserve | | -1,760,802.41 | | -4,400 |
| Grants relating to fixed assets | | -93,384,034.06 | | -134,352 |
| Grants used to finance current assets | | <u>22,997,670.12</u> | | <u>-41,335</u> |
| | | | -72,147,166.35 | -180,087 |
| Total income available to cover expenditure | | | <u>1,831,026,243.96</u> | <u>1,710,975</u> |

| | € | € | 2012 € | 2011 € (1000) |
|--|-------------------|---|-------------------------|------------------|
| Cost of materials | 305,294,079.20 | | | 293,234 |
| Personnel expenses | 923,341,744.80 | | | 835,344 |
| Amortization of intangible assets and depreciation of property, plant and equipment | 276,428,253.62 | | | 256,696 |
| Other operating expenses | 274,910,981.16 | | | 250,776 |
| Amortization of financial assets and current marketable securities | <u>545,626.48</u> | | | <u>4,596</u> |
| Total expenditure | | | <u>1,780,520,685.26</u> | <u>1,640,646</u> |
| Net income on ordinary activities | | | 50,505,558.70 | 70,329 |
| Extraordinary expenses | | | | |
| Allocation to foundation capital | | | <u>-50,000,000.00</u> | <u>-70,000</u> |
| Net income for the year | | | 505,558.70 | 329 |
| Transfer from reserve | | | - | 5 |
| Transfer to reserve | | | <u>-2,250.00</u> | <u>-3</u> |
| Retained earnings | | | 503,308.70 | 331 |
| Allocation to capital of the non-profit organization | | | <u>-503,308.70</u> | <u>-331</u> |
| | | | <u>-</u> | <u>-</u> |

RECONCILIATION BETWEEN INCOME STATEMENT AND PERFORMANCE STATEMENT (CASH-BASIS ACCOUNTING)

| Income/receipts | Performance statement € | Non-profit organization capital € | Reconciling items € | Income statement € |
|--|----------------------------|--------------------------------------|------------------------|-------------------------|
| Income/receipts | | | | |
| from base funding | 639,092,285.76 | | 9,282,108.00 | 648,374,393.76 |
| from research and development activities | 1,211,463,713.26 | | -37,538,106.65 | 1,173,925,606.61 |
| Increase in work in progress | | | 37,425,034.38 | 37,425,034.38 |
| Other internally constructed and capitalized assets | 8,184,023.79 | | | 8,184,023.79 |
| Other income | 34,795,718.56 | 743,600.79 | -274,967.58 | 35,264,351.77 |
| Total income/receipts | 1,893,535,741.37 | | | |
| Changes in special reserves | | | | |
| License-fee revenue reserve | | | -1,760,802.41 | -1,760,802.41 |
| Grants relating to fixed assets | | | | |
| Allocations to special reserves (capital expenditure) | | | -370,001,086.37 | -370,001,086.37 |
| Reversal of special reserves (depreciation) | | 43,762.92 | 276,573,289.39 | 276,617,052.31 |
| Grants used to finance current assets | 22,997,670.12 | | | 22,997,670.12 |
| Change in grants receivable relating to pension and compensated absence provisions | 9,282,108.00 | | -9,282,108.00 | |
| Total business volume (cash basis) | 1,925,815,519.49 | <u>787,363.71</u> | <u>-95,576,639.24</u> | <u>1,831,026,243.96</u> |

| Expenditure / disbursements | Performance statement € | Non-profit organization capital € | Reconciling items € | Income statement € |
|--|-------------------------------|--|---------------------------|--------------------------|
| Expenditure/disbursements | | | | |
| Cost of materials | 308,342,599.84 | 30,682.91 | –3,079,203.55 | 305,294,079.20 |
| Personnel expenses | 933,267,107.81 | 770.00 | –9,926,133.01 | 923,341,744.80 |
| Amortization of intangible assets and depreciation of property, plant and equipment | | 160,590.71 | 276,267,662.91 | 276,428,253.62 |
| Other operating expenses | 262,400,404.90 | 89,761.39 | 12,966,441.35 | 275,456,607.64 |
| Expenditure as per the income statement | | | | 1,780,520,685.26 |
| Changes in special license-fee revenue reserve | 1,760,802.41 | | –1,760,802.41 | |
| Capital expenditure (current and major infrastructure) | 370,044,604.53 | | –370,044,604.53 | |
| Allocation to foundation capital | 50,000,000.00 | | | 50,000,000.00 |
| Net income for the year | | 505,558.70 | | 505,558.70 |
| Total business volume (cash basis) | 1,925,815,519.49 | <u>787,363.71</u> | <u>–95,576,639.24</u> | <u>1,831,026,243.96</u> |

The Fraunhofer-Gesellschaft prepares its annual financial statements in accordance with the German Commercial Code (HGB) as applicable to large corporate entities.

The annual financial statements for the year ending December 31, 2012, have been audited and fully certified by the auditing firm Rödl & Partner GmbH, Nuremberg.

The income statement is reconciled to the format required by the relevant public funding authorities.

EXCERPTS FROM THE NOTES TO THE FINANCIAL STATEMENTS

I. Accounting principles

The Fraunhofer-Gesellschaft prepares its annual financial statements in accordance with the German Commercial Code (HGB) as applicable to large corporate entities. The annual financial statements for the year ending December 31, 2012 have been audited and fully certified.

The basis of the Fraunhofer-Gesellschaft's accounting 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 standard accounting practice.

Capital expenditure on property, plant and equipment and on financial assets, on the other hand, is immediately recognized at the full cost of acquisition. Therefore, the operating budget does not include any depreciation/amortization expenses on these items.

In order to provide full accountability for grants received from funding agencies, the performance statement for the organization as a whole is reconciled to the income statement format required by public authorities by eliminating the effect of non-cash income and expense items.

Presentation of annual accounts of the Fraunhofer-Gesellschaft

| | | |
|---|---|--|
| Annual financial statements of the Fraunhofer-Gesellschaft | | Reconciliation with income statement format required by public funding authorities |
| Balance sheet | Income statement | |
| Management report | Reconciliation between income statement and performance statement | |
| Notes to the financial statements | Performance statement | |
| | Budgeted operating expenses and capital expenditure at Fraunhofer-Gesellschaft level "total business volume" | |
| | Individual financial statements of the institutes/headquarters | |
| | Operating expenses | Capital expenditure |
| | Costs (excluding depreciation/amortization) | Expenses |
| | Income | Income |

The amounts presented in the income statement include items showing the changes in payables and receivables and in depreciation/amortization charges compared with the previous year.

These reconciliation items are presented in the balance sheet as special reserves for grants relating to fixed assets and for grants used to finance current assets.

II. Recognition and measurement methods

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

Since in most cases fixed assets are financed by government grants, a corresponding amount is allocated to the special reserve for grants relating to fixed assets. These adjustments therefore have no impact on equity.

Financial assets and current marketable securities are measured at the lower of cost of acquisition or fair value.

Work in progress is measured at the lower of cost of construction or fair value. Construction costs include applicable personnel expenses, cost of materials, general administrative expenses, and depreciation/amortization charges. Prepaid expenses (including VAT) are disclosed in a separate line item. Trade receivables are recognized net of related valuation allowances, if any. Cash and cash equivalents, and other current assets, are recognized at their nominal value. Foreign currency holdings are recognized at the exchange rate prevailing on the reporting date.

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

The retained earnings presented in the Fraunhofer-Gesellschaft's annual financial statements, i.e. remaining net income for the year after transfers to/from reserves, are allocated in full to the capital of the non-profit organization, in accordance with the Executive Board resolution concerning the appropriation of net income. The special license-fee revenue reserve was created in accordance with Section 58 (6) of the German Tax Code (AO).

Excerpts from the notes to the financial statements

Funding used to finance non-current assets is allocated to the special reserve for grants relating to fixed assets. A similar special reserve exists for funding used to finance current assets.

The Fraunhofer-Gesellschaft made use of the instrument provided for in its financial statutes to recognize a balance sheet reserve that will enable the organization to use revenues from the licensing of audio-encoding technologies as a means of financing its own pre-competitive research in areas of importance to its medium-term strategy. In 2012, the special license-fee revenue reserve increased by an amount of €1.8 million. An amount of €50.0 million was transferred to the Fraunhofer Future Foundation (stated as "allocation to foundation capital").

Provisions for pensions and similar obligations for which the Fraunhofer-Gesellschaft has a reinsurance policy in place were measured on the basis of the capitalized value calculated by the insurance company at the reporting date. In all other cases, pension provisions are accounted for at the service cost as measured by actuarial methods. Other provisions consist of amounts set aside to cover all identifiable risks and contingent liabilities. These provisions are measured in accordance with Section 253 para. 1 of the German Commercial Code (HGB) on the basis of a reasonable estimate of the probable outcome, including future cost increases. Other provisions for liabilities due in more than one year are discounted at the average market interest rate for loans of a similar residual maturity as calculated by the Deutsche Bundesbank in December 2012, pursuant to Section 253 para. 2 of the German Commercial Code (HGB). Provisions for part-time early retirement working arrangements are measured on the basis of existing contracts and a forecast of expected future contracts.

Provisions for part-time early retirement working arrangements amounting to €0.8 million were offset against the existing insolvency insurance.

Liabilities are measured at the settlement amount.

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

Transactions in foreign currencies are recognized at the applicable hedging rate for the currency in question. Open items are translated at the exchange rate prevailing on the reporting date.

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

On July 1, 2012 (effective retrospectively from January 1, 2012), the assets and liabilities of the German Plastics Institute (DKI) in Darmstadt and of the ATZ Development Center in Sulzbach-Rosenberg (formerly ATZ-EVUS Application and Technology Center) were integrated in the Fraunhofer-Gesellschaft. These assets and liabilities are not included in the comparative data for 2011.

INDEPENDENT AUDITOR'S REPORT

We have audited the annual financial statements, comprising the balance sheet, the income statement and the notes to the financial statements together with the bookkeeping system, and the management report of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, for the business year from January 1 to December 31, 2012. The maintenance of the books and records and the preparation of the annual financial statements and management report in accordance with German commercial law and supplementary provisions of the articles of incorporation are the responsibility of the Company's management. Our responsibility is to express an opinion on the annual financial statements, together with the bookkeeping system and the management report based on our audit.

We conducted our audit of the annual financial statements in accordance with § 317 HGB (German Commercial Code) and German generally accepted standards for the audit of financial statements promulgated by the Institute of Public Auditors in Germany (Institut der Wirtschaftsprüfer, IDW). Those standards require that we plan and perform the audit such that misstatements materially affecting the presentation of the net assets, financial position and results of operations in the annual financial statements in accordance with principles of proper accounting and in the management report are detected with reasonable assurance. Knowledge of the business activities and the economic and legal environment of the Company and expectations as to possible misstatements are taken into account in the determination of audit procedures. The effectiveness of the accounting-related internal control system and the evidence supporting the disclosures in the books and records, the annual financial statements and the management report are examined primarily on a test basis within the framework of the audit. The audit includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the annual financial statements and management report. We believe that our audit provides a reasonable basis for our opinion.

Our audit has not led to any reservations.

In our opinion, based on the findings of our audit, the annual financial statements comply with the legal requirements and supplementary provisions of the articles of incorporation and give a true and fair view of the net assets, financial position and results of operations of the Company in accordance with principles of proper accounting. The management report is consistent with the annual financial statements and as a whole provides a suitable view of the Company's position and suitably presents the opportunities and risks of future development.

Nuremberg, March 21, 2013

Rödl & Partner GmbH

Wirtschaftsprüfungsgesellschaft, Steuerberatungsgesellschaft
(Auditors, Tax Consultants)

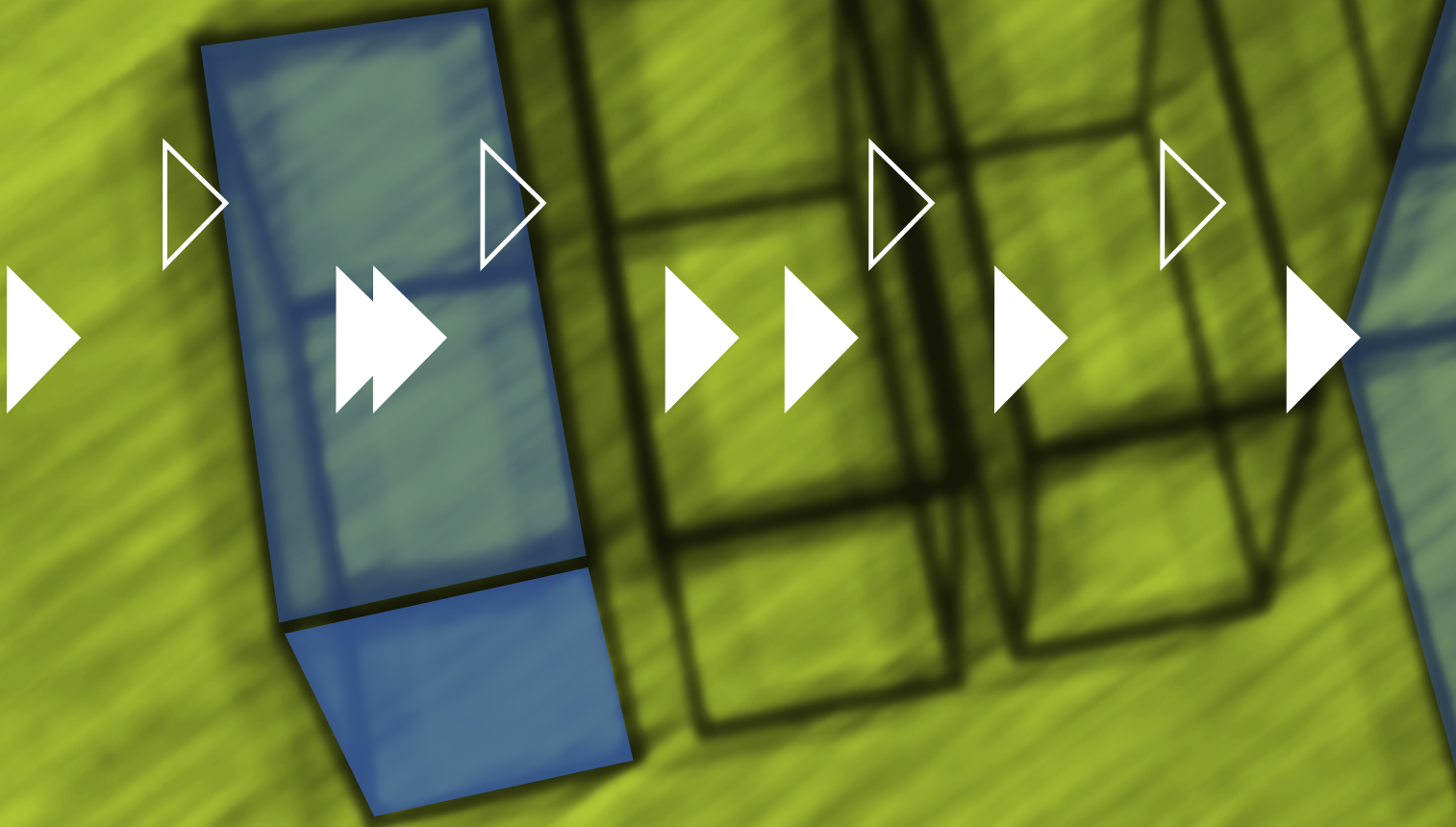
Vogel

Wirtschaftsprüfer (Auditor)

Hahn

Wirtschaftsprüfer (Auditor)

SERVICE



THE GROUPS OF THE
FRAUNHOFER-GESELLSCHAFT

THE ALLIANCES OF THE
FRAUNHOFER-GESELLSCHAFT

ADDRESSES

EDITORIAL NOTES



THE GROUPS OF THE FRAUNHOFER-GESELLSCHAFT

The Fraunhofer Groups are organizational units of the Fraunhofer-Gesellschaft in which institutes and research institutions specializing in related areas of technology have joined together to coordinate their research and development activities and present a single face to the market. They also help to formulate the organization's business policy and implement its working methods and funding model.

- Fraunhofer ICT Group
- Fraunhofer Group for Defense and Security VVS
- Fraunhofer Group for Life Sciences
- Fraunhofer Group for Light & Surfaces
- Fraunhofer Group for Materials and Components – MATERIALS
- Fraunhofer Group for Microelectronics
- Fraunhofer Group for Production

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- Applied and Integrated Security AISEC
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- Digital Media Technology IDMT
- Embedded Systems and Communication Technologies ESK (associated member)
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- Silicate Research ISC
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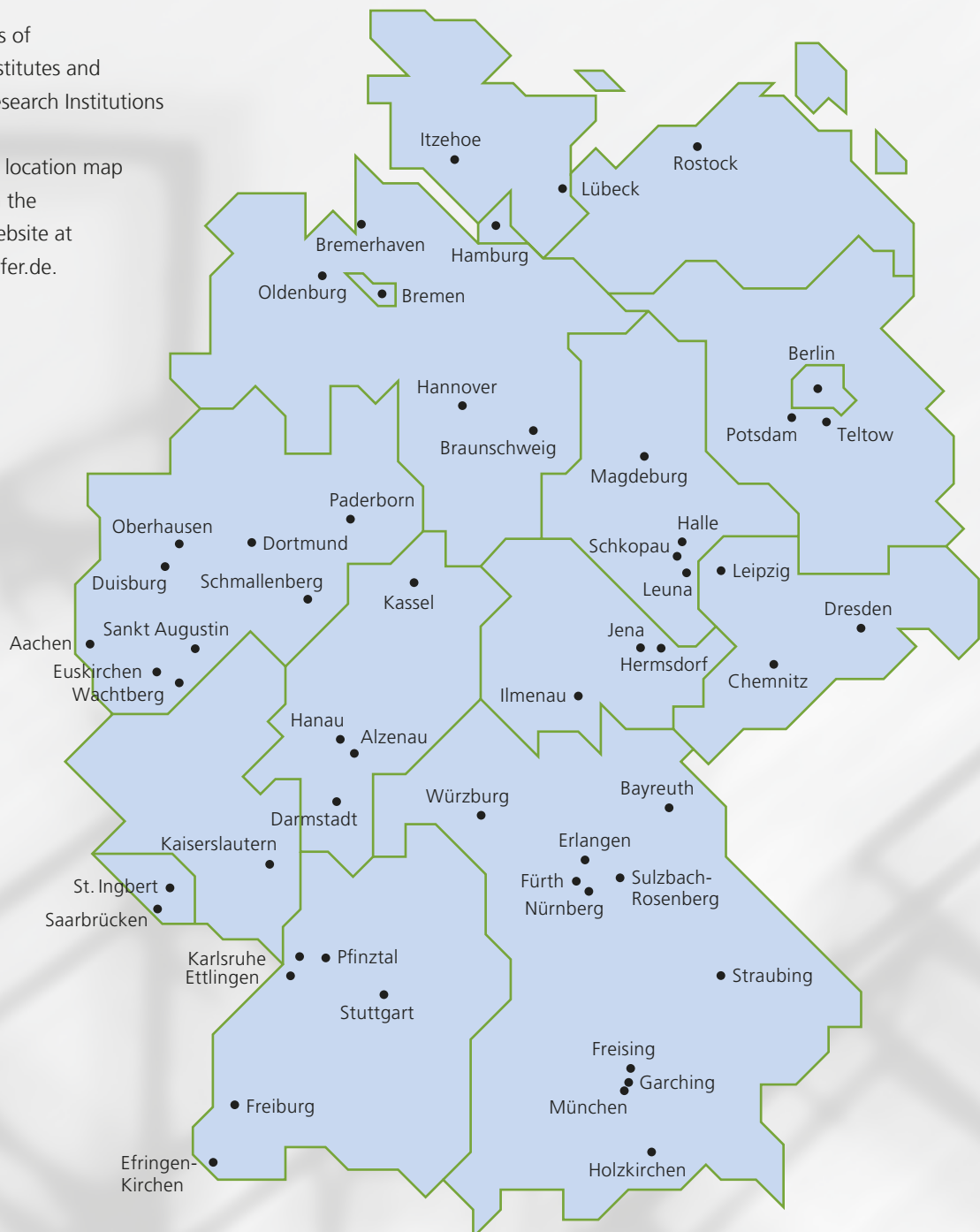
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