THE MAGAZINE OF THE **PRODUCTION TECHNOLOGY CENTER BERLIN**

futur

VISION | INNOVATION | REALIZATION

SUSTAINABILITY

Fraunhofer IPK

INSTITUTE
PRODUCTION SYSTEMS AND
DESIGN TECHNOLOGY

IWF

INSTITUTE MACHINE TOOLS
AND FACTORY MANAGEMENT
TECHNISCHE UNIVERSITÄT BERLIN

»So far, there has been no way of replacing the use of fossil-based plastics on a large scale – but as the proverb goes, necessity is the mother of invention.«

↳ Page **24**

Production Technology Center (PTZ) Berlin

PROFILE The Production Technology Center (PTZ) Berlin houses two research institutes: the Institute for Machine Tools and Factory Management IWF of the TU Berlin and the Fraunhofer Institute for Production Systems and Design Technology IPK. As production-related research and development partners with a distinctive IT competence, both institutes are in international demand. Their close cooperation in the PTZ puts them in the unique position of being able to completely cover the scientific innovation chain from fundamental research to application-oriented expertise and readiness for use.

We provide comprehensive support to companies along the entire process of value creation: Together with industrial customers and public-sector clients, we develop system solutions, individual technologies and services for the process chain of manufacturing companies – from product development, planning and control of machines and systems, including technologies for parts manufacturing, to comprehensive automation and management of factory operations. We also transfer production engineering solutions to areas of application outside industry, such as traffic and safety.

DEAR READERS,

the manufacturing sector is like many other industries: When the economy is booming, manufacturers and consumers alike are doing well. As long as the supply of products is guaranteed, producers and customers are satisfied. At least one might think so.

In fact, interest and awareness in product life cycles have been on the rise in recent years: Where do products come from? How are they manufactured? And how are they ultimately reused, recycled, or disposed of? Climate protection, sustainability and resource conservation are playing an increasingly important role in purchasing decisions. We weigh up whether we should take a disposable or reusable BPA-free drinking bottle, and whether to buy a mobile phone that has been produced in an ecologically and socially sustainable way instead of the latest smartphone model. We choose green electricity from renewable energy sources and give preference to electric mobility over fossil fuel drives.

At the Production Technology Center Berlin, we devote many research projects to the question of how to make not only products, but also their production more environmentally friendly. Our goal is to find out how to achieve greater prosperity for more people, while consuming fewer resources. One solution for safeguarding our standard of living without compromising it at the expense of future generations is to reduce, reuse, and recycle. This issue features a plea for a circular economy.

Even though the potential of a circular economy has hardly been exploited worldwide to date, our expertise and experience already enable us to optimize all production steps to manufacture products with regard to sustainability. We can help our clients to keep the ecological footprint of their products and services as small as possible. We show how this works with regard to individual sustainability criteria, using energy efficiency as an example.

Conscious use of resources is essential to protect nature and the climate. The extent to which environmental pollution has reached global proportions is symbolized by beaches flooded with plastic waste all over the world. Find out about the easily degradable plastic alternatives our scientists are working on – using waste as a raw material! Also in this issue: We explore how small and medium-sized companies can operate sustainably and explain how automotive and shipbuilding companies can use balance sheets to assess the environmental effects of their welding processes.

Last but not least, you are holding another example of our sustainable research and communication: this magazine, printed on environmentally certified paper. FUTUR was first published in 1999, and after more than 20 years, we have given it a new contemporary look – hoping that you, our readers, will continue to be enthusiastic about our magazine and our research and development. You can read more about the relaunch of our customer magazine on our website.

Yours sincerely,

Eckart Uhlmann

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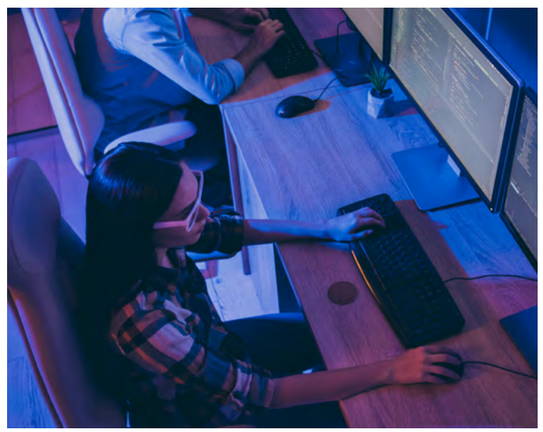

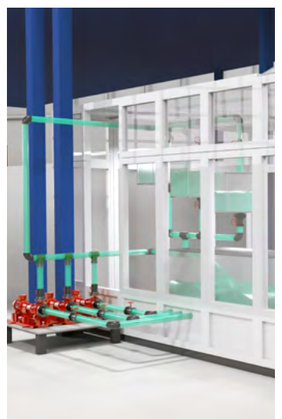

NUMBER OF THE ISSUE This is the amount of energy the German manufacturing industry consumes in a year. Find out how manufacturing companies can reduce their energy consumption automatically in the article »Automated Efficiency«. ↪ page 16

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PICTURE PUZZLE

What might this be?
Find the solution on
↪ page 46

MASTERS OF DIGITALIZATION

New textbook empowers medium-sized companies and their staff

The digital transformation poses great challenges for medium-sized businesses. One of the most common obstacles is the lack of IT competence of employees. Fraunhofer IPK experts, together with SMEs and other research institutions, have investigated how manufacturing companies can nevertheless bring Industrie 4.0 technologies to the shop floor. They have now published their solution approaches in a book that emphasizes the role of master craftsmen, among other things.

↪ **More info**
s.fhg.de/meisterlich-digitalisieren

BAUHÜTTE 4.0 is a cultural project that proposes to increase the use of wood in construction in Berlin. By interlinking the segments of forestry, production, logistics, robotic assembly, housing and city infrastructure, it follows the transformation of wood from raw material into urban space. Bauhütten were traditionally temporary sheds, where skilful workers gathered to build the most advanced constructions of their time: cathedrals. They were collective infrastructures, representing communal efforts to master unprecedented techniques. Renewing the tradition of these pop-up sheds, Bauhütte 4.0 addresses the creation of housing for all in a time of climate crisis, through advanced techniques and in response to contemporary challenges.

↪ **More info**
www.bauhuette40.com

THE NEW FUTUR

CMYK **97/69/38/24** CMYK **80/40/00/00**

CMYK **40/96/100/5** CMYK **22/20/34/00**

CMYK **04/35/95/00** CMYK **55/27/75/06**

Attentive readers will have noticed that the FUTUR completely changed its look and feel.

Insider information:
Our color scheme is based on the actual color world of the Berlin Production Technology Center!

↪ Further info and **»behind the scenes«** insights into the new FUTUR can be found here: *s.fhg.de/the-new-futur*

Exploit, Manufacture, Repeat

In the circular economy, raw materials are being recovered and prepared for future production processes.

>> How do we maintain our present level of prosperity without denying future generations the basis for a life worth living? <<

© Mika Baumeister / Unsplash

Prosperity has its price. The consumption of resources is rising along with the living standard of many people across the world. Highly industrialized countries have a particularly poor record: Every German consumes on average 16.1 metric tons of raw material each year. That is twice as much as the global average and at least ten percent more than the European average. At the same time, we Germans are producing 412 million metric tons of waste a year. That boils down to nearly five tons of trash per person.

THE END OF THE ROAD

In global terms, these worrying trends are continuing to increase. Developing and threshold countries are mainly banking on growth through industrialization, using the same means as previously industrialized nations to give their growing populations an acceptable living standard. Given the present state of production technology, just the production of steel, aluminum, plastic and cement in the 21st century will cause around 800 gigatons of CO_2 emissions. This means that emissions from these four material streams alone would be the equivalent of all the emissions permitted by the global effort to achieve the two degree goal.

Science, government and civil society are now confronted with one crucial question: How do we maintain our present level of prosperity without denying future generations the basis for a life worth living?

THE CIRCULAR ECONOMY

One of the main reasons for both our enormous consumption of resources and the enormous amount of waste we produce is our linear economy. We take raw materials and use them to make goods, which we then dispose of. If we are to hit our global sustainability targets, we need to rethink this process. Efforts to do so have given birth to the concept of the circular economy.

The circular economy is a regenerative system of production and consumption. Within this system, energy and material loops are slowed down and closed to reduce consumption of resources and energy while at the same time producing less waste and fewer emissions.

The idea is to make more efficient use of raw materials and recycling them in a loop, so that they remain valuable to us for as long as possible. Only if we succeed in recycling used materials in such a loop can we decouple consumption of resources from economic growth in the mid-term – which would not only help the environment, but also facilitate greater prosperity for more people. →

The three principles of a circular economy

RENEWABLE RAW MATERIALS

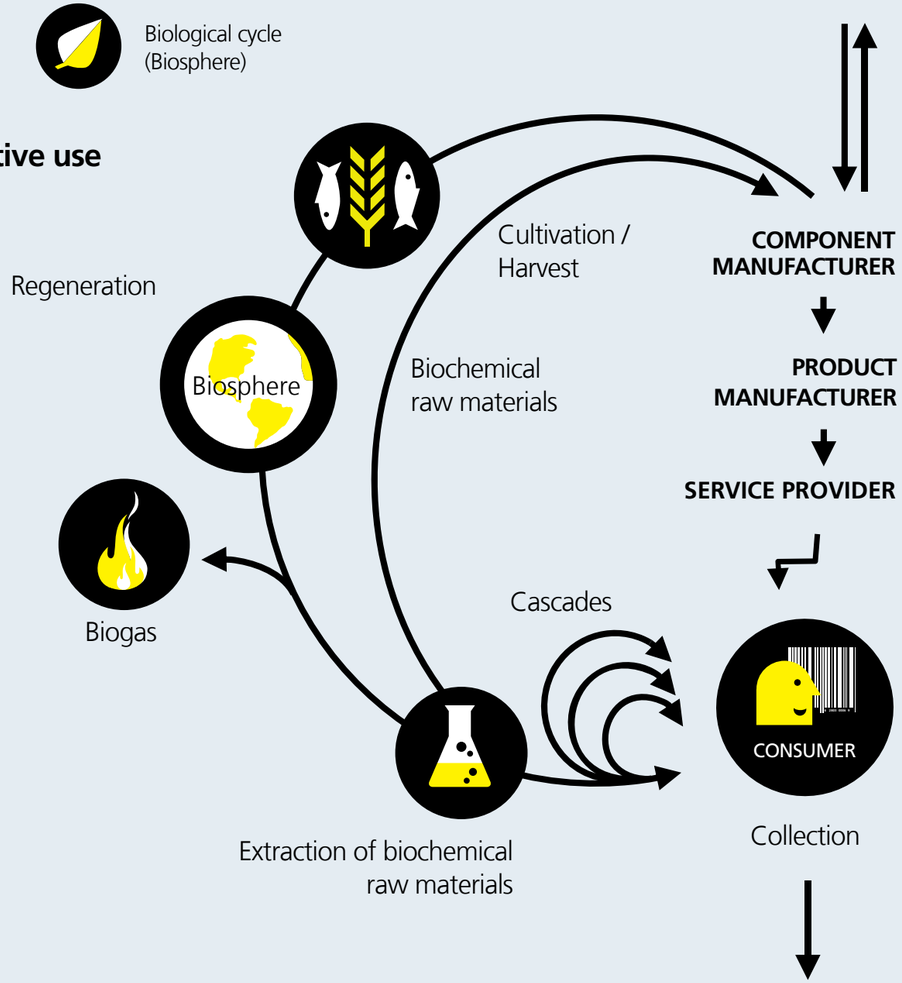
PRINCIPLE

1 Preserving natural capital

Material flow management of renewable materials | Regenerate | Replace materials

Biological cycle (Biosphere)

2 Productive use



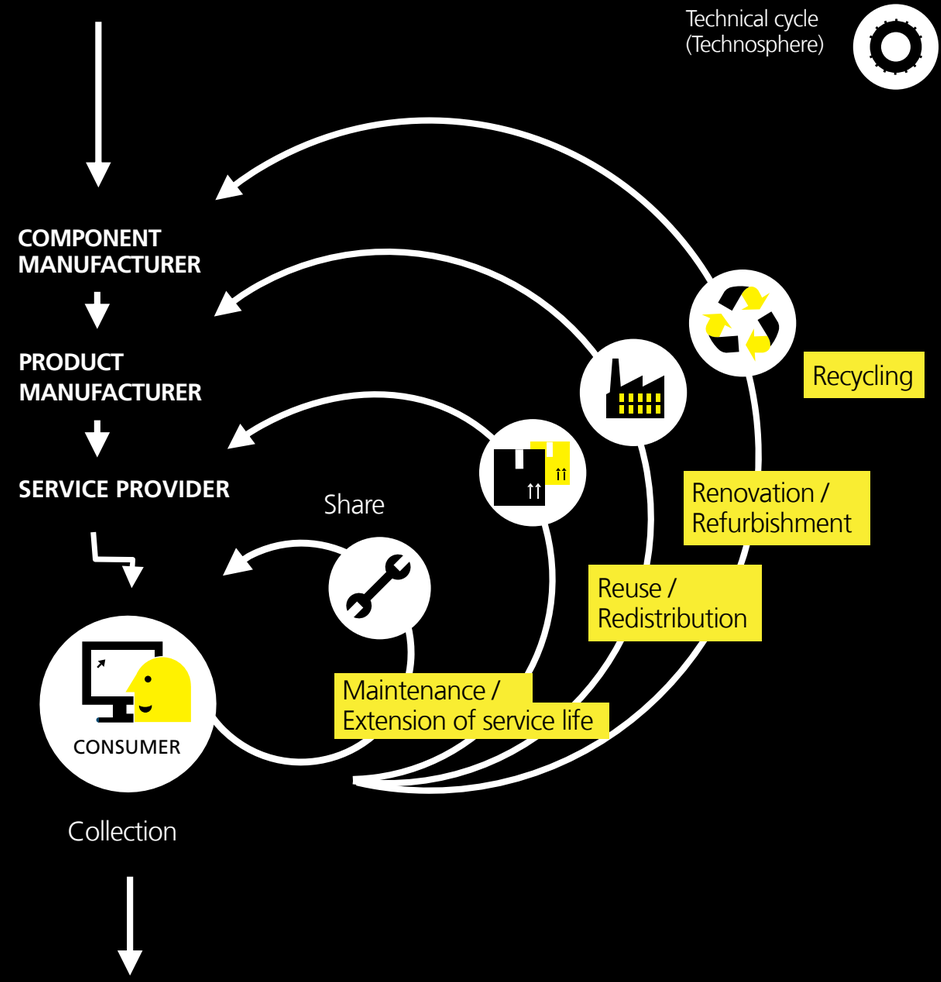
3 Promoting system effectiveness

Minimization of systematic seepage losses and negative externalities

FINITE RAW MATERIALS

Replace materials | Virtualize | Restore | Inventory Management

Technical cycle (Technosphere)



Minimization of systematic seepage losses and negative externalities

Based on acatech (2019), Ellen MacArthur Foundation and McKinsey (2013)

INITIATING THE TRANSITION

To develop a systematic approach in a macroeconomic context, the National Academy of Science and Engineering (Deutsche Akademie der Technikwissenschaften – acatech) launched the Circular Economy Initiative Deutschland in 2019. Financed by the Federal Ministry of Education and Research (BMBF), this initiative seeks solutions to the question of how we can effect a systematic transition from a linear to a circular economy in an interdisciplinary and interdepartmental dialogue between scientists and representatives of industry and civil society.

Both Fraunhofer IPK and the Institute for Machine Tools and Factory Management IWF of the Technical University of Berlin are part of the conversation, which aims to draw up a roadmap that will describe a model for circular value creation. On a less abstract level, it should also contain long-term goals for raising resource productivity. Lastly and most specifically, the roadmap should identify suitable tax measures to establish a substantial circular economy.

The process of remanufacturing or refabrication, as it is also referred to, can serve as an example to show what a real-life circular economy could look like. In principle, this simply refers to the idea of repairing or refurbishing a used product in order to restore it to its original quality. A great part of the raw material and energy can be saved, that would have been necessary for manufacturing a new product. Apart from the additional opportunity of being able to offer cheaper spare parts and replacements – thus prolonging the lifecycle of the product – closed-loop circulation of raw materials also offers considerable savings in terms of CO_2 emissions. In spite of the obvious advantages of remanufacturing, even in developed markets, remanufactured goods rarely exceed five percent of overall merchandise. This holds true even with product families that lend themselves to such a method like smartphones, household appliances or machine and plant components.

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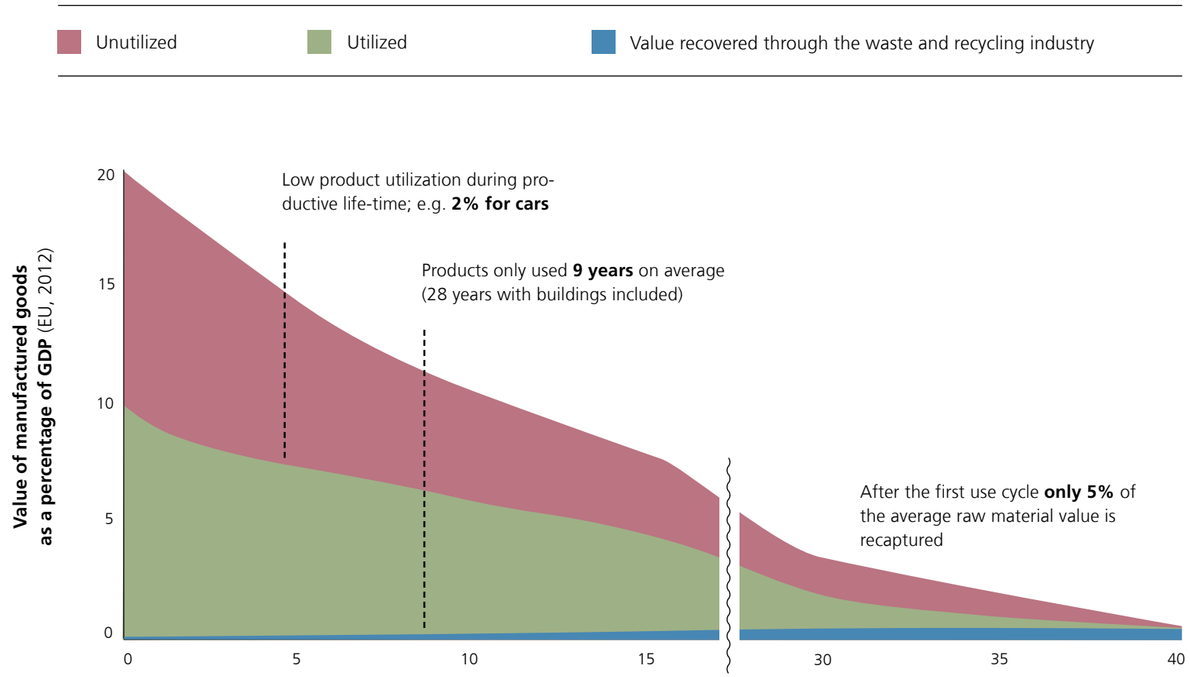
>> In spite of the obvious advantages of remanufacturing, even in developed markets, remanufactured goods rarely exceed five percent of overall merchandise. This holds true even with product families that lend themselves to such a method like smartphones, household appliances or machine and plant components. <<

Status Quo: Economy with highly inefficient use of resources

Based on acatech (2019), McKinsey Center for Business and Environment, Ellen MacArthur Foundation & SUN (2015)



Our Goal Is to Provide the Best Solution for Applications and the Environment

Dr. Ansgar Kriwet, FESTO SE & CO. KG

© Festo SE & Co. KG

DR. ANSGAR KRIWET studied engineering at the RWTH Aachen. He became a research associate at the Institute for Machine Tools and Factory Management IWF of the Technical University of Berlin and a research associate at the Fraunhofer Institute for Production Systems and Design Technology IPK before transferring to the Institute for Management and Technology (IMT) in Berlin. At Festo, Dr. Kriwet was one of the main movers behind the development of the newly founded Cybernetic division. As head of Product Management Innovation and Product Management Control, he held strategic responsibility for all product families within these segments. As head of the Product Valve Center, he was responsible for the strategic realignment of this field. In 2009, Dr. Kriwet was appointed to the Management Board and has been initially responsible for the regional and European sales and since 2013 for global sales at Festo. Dr. Kriwet has been a member of the Fraunhofer IPK Board of Trustees since 2018.

| futur | **Your company website states that Festo »thinks in terms of generations, not business years«. How does this play out in your company strategy?**

/ **KRIWET** / In our current company strategy, we phrased the claim we make about ourselves as »Progress in Motion«. This is what drives us. With our expertise in automation and technical education, we support our customers in increasing their productivity while also creating free space for sustainable development of the environment, the economy and society.

This maxim holds true for all our colleagues at Festo throughout the world. What we mean by sustainability is not just protecting the climate, but also health and safety, along with technical education as a vital pillar for our future. Festo founded Festo Didactic back in the 1950s with the aim of giving people lifelong learning and opportunity to develop their technical capabilities. Digitalization is offering many new opportunities and chances. For Industrie 4.0 to succeed, training and qualification of skilled professionals must be tailored to the new needs of digital production. Festo Didactic pours its extensive practical experience in the area of digital production into bespoke learning programs, modules and content to ensure that skilled workers and up and coming young professionals are well prepared for their new roles in the smart factory, and to meet the requirements of Industrie 4.0.

| futur | **One might think that as head of sales, you would be most concerned with sales figures and sales markets. What kind of influence do issues of sustainability have on your work?**

/ **KRIWET** / A huge one. Sustainability is playing an increasingly important role, not just for us but for our customers as well. As a B2B company, we are a traditional supplier to a large range of industries – from the automotive, foodstuffs and packaging industries through to the LifeTech sector, the electronics industry and process automation. So we must consider the entire lifecycle of our products and not just look to ourselves. Our goal is to provide the best solution for applications and the environment. Smart products for smart solutions mean more productivity for our customers and greater prosperity for the world, along with a considerate approach to the environment.

We are constantly generating information and knowledge from data. We are using this new resource to achieve the highest quality standards, a self-optimizing production, a maximum level of flexibility and minimal use of resources in our own factories and those of our customers. AI has now arrived in industrial practice. Festo already deploys AI in its product range, where it is working together with human expertise on the most highly complex system data to identify the ideal pressure points for self-learning optimization, guaranteeing even greater overall equipment effectiveness for our customers.

Here are some other examples: With its Digital Administration Shell Festo is offering a standardized, semantic and technical digital »packaging« for workpieces and components that enables manufacturer-independent interaction in digital ecosystems. Or take interoperable models for documentation, certificates, software, data sheets, 3D, EPLAN and AutomationML such as the digital type plate that will make paper manuals and operating instructions obsolete.

| futur | **A sparing use of resources is part of sustainable company management. How do you achieve this specifically?**

/ **KRIWET** / Our products and solutions are the greatest levers for reducing global CO_2 emissions. We support our customers on their way to CO_2-neutral production with smart products and comprehensive consulting to improve their energy efficiency. This is why we intend to significantly extend the scope of this approach.

There already are some current examples in our product portfolio: With the Festo Motion Terminal VTEM, we have brought digitalization to pneumatics. Valve functions are controlled by apps, and hardware need no longer be replaced when reequipping a system for new products.

What's more, Festo is also the only supplier to have adapted piezo technology for its valve technology. Piezo valves require 20 times less energy while having 20 times the service life duration. They can be used in respirators, for instance. What makes piezo valve technology particularly suitable for use in medical technology is its noiseless operation, lack of heat generation, small and light-weight design and highly precise control of even the smallest flow rates. They are non-magnetic and do not affect other medical devices.

We are going to make major efforts to reducing our international facilities' ecological footprints. This includes our supply chain, like our logistic processes. The sustainable and environmentally conscious behavior of our employees is also an important factor in our success.

| futur | **Energy efficiency is featured prominently in this issue of FUTUR. What openings do you see to tangibly reduce the energy consumption of industrial production?**

/ **KRIWET** / The manufacturing in our facilities causes five percent of the overall CO_2 emissions of our products. The other 95 percent arise from their on-going operation on the customer side. This is why we have developed a holistic Festo Energy Saving Service, known by its acronym FESS, which inspects the configuration and operation of the equipment on the customer's side. It also identifies all the weak points and opportunities for optimization. Sensors are supplying us with data that make it transparent how much energy is being consumed by production, right down to individual components.

| futur | **Finally, think of Festo in 50 years' time. How will your children's generation benefit from the new automation solutions?**

/ **KRIWET** / On the one hand, automation releases people from tiring and stressful workplace activity. On the other, it ensures a steady supply of the goods and wares that people need. Thanks to artificial intelligence and collaborative robotics, by that time demanding physical labor in production will practically be a thing of the past. I also hope that by that time, we will have switched away from linear processes to a circular, emissions-free economy.

Automated Efficiency

Manufacturing companies must save energy. The new EnEffReg technology can automatically optimize plant operations, thanks to its smart control technology.

Of all of Germany's economic sectors, the manufacturing industry has by far the greatest energy consumption. Some 39 percent of the primary energy used in the German economy flows into the production of goods, followed by energy supply (28 percent) and transport (12 percent).

Germany's manufacturing sector alone has an annual consumption of around 4000 petajoules – more than most countries consume in total! By way of comparison: the whole of Argentina including all its economic sectors and private households consumes just under 3600 petajoules, the Netherlands around 3500. If shown in terms of joules, each of these figures would be followed by no less than 18 zeros. Such orders of magnitude quickly make it obvious, that even the smallest savings in the production sector can have a truly enormous impact.

Despite all the uncertainty about how best to protect the climate, one thing is quite certain – if Germany wants to achieve its climate goals, manufacturing companies will have to drastically reduce their energy consumption. With its Climate Protection Programme 2030, the German government is giving them incentives to do so. However, the acquisition of new efficient machinery is a long-term investment, and hardly a single company is in a position to keep its technical equipment continually up-to-date with the latest energy-saving standards. One ray of hope: Perhaps they will not need to, thanks to intelligent control technology. To allow existing plants and equipment to work automatically in an energy-saving mode, Fraunhofer IPK in cooperation with ÖKOTEC Energiemanagement GmbH has developed the technology solution EnEffReg.

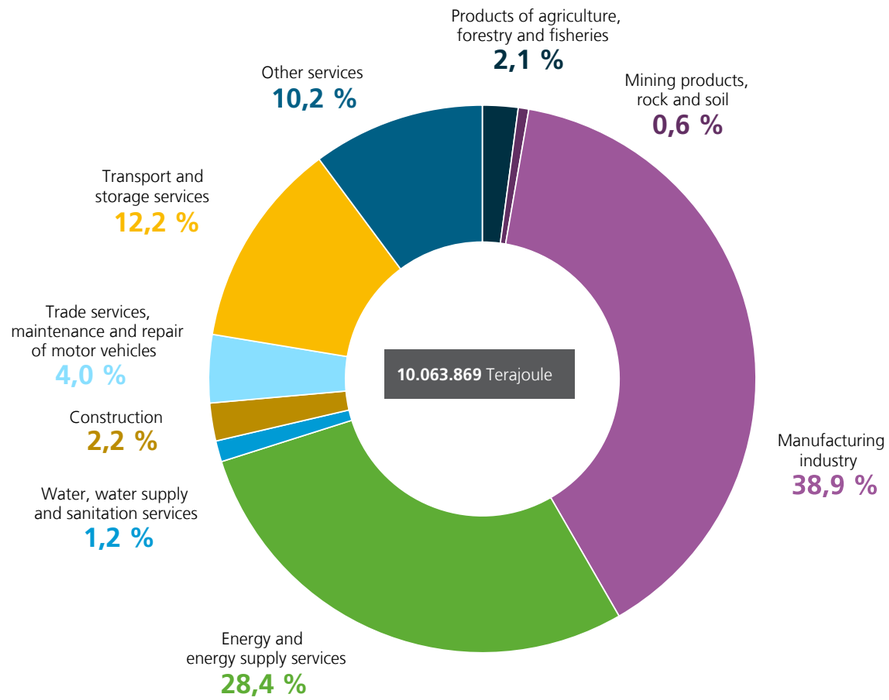
A STRONG PARTNER FOR ENERGY EFFICIENCY

Some of Germany's biggest manufacturing companies partnered up with the EnEffReg research project to bring new energy-saving technology into circulation: Bayer in Berlin, thyssenkrupp Steel Europe in Duisburg Hamborn, and Daimler at its works in Berlin Marienfelde. In close cooperation with these leading companies, research partners ÖKOTEC and Fraunhofer IPK have developed a method that calculates ideal set points from energy measurement data and automatically transmits them to the relevant machines. Not only does this identify the most efficient operating mode, but also directly programs the machine accordingly. The EnEffReg technology was tested on technical supply systems that have a particularly high energy consumption.

Control of the systems, on the one hand, is based on the energy efficiency software EnEffCo®, also developed in collaborative research between Fraunhofer IPK and ÖKOTEC, and on the other on a key performance indicator methodology commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In operation, EnEffReg extracts an extensive range of measurement data from a system in order to learn how the system behaves in terms of efficiency. It can reset networking subsystems and learn to autonomously take changes into account. As Prof. Dr. Jörg Krüger, head of the Automation Technology division at Fraunhofer IPK explains, »In the EnEffReg project, we are specifically focused on automatically boosting the energy efficiency. To this end, we do not just need to be able to measure, but also to control the machines within closed loops. We are going a step further than previous approaches to reach a much higher level of performance.«

Share in primary energy consumption of economic activities of all production sectors 2015

Source: Umweltbundesamt, based on Statistisches Bundesamt



Energy consumption (in petajoules) **of the German manufacturing industry in comparison with entire national economies and their private households**

* Figures for 2018, converted from millions of oil equivalents to petajoules *(Source: BP)*
** Figure for 2017 *(Source: Statistisches Bundesamt)*

SAFETY FIRST

Availability and safety are the highest priorities in the automated regulation of systems. Only when the stable operation of a system is ensured can the software set it according to energy efficiency criteria. Fraunhofer IPK scientists have developed a Three Stage Inspection Procedure that includes reviewing each individual component, then the connections between components, and finally the respective situation-dependent operational requirements. The proposed control can be implemented only after these three review stages showed that it will not endanger the safe operation of the system.

This data-driven approach puts the automated regulation of the system on a safe footing. However, for industrial users it is important to have a good idea of how the learning system operates. They are calling for models with a maximum level of transparency. In order to meet this requirement, the EnEffReg team used a method recently developed by American scientists: Sparse Identification of Nonlinear Dynamics. This method predicts the dynamic behavior of a system by respectively assorting a transparent combination of weighted mathematical functions from libraries. Hence, users can easily track any decision made by the artificial intelligence behind EnEffReg.

Novel methods for visualizing the energy efficiency factors of machines that were developed in the course of the project also play a vital role in ensuring transparency. As Knut Grabowski, head of the research project at ÖKOTEC, remarks: »We now have a totally new solution for scientists' and engineers' dream of a graphic representation of multidimensional interdependencies – and one, moreover, that can also be used for a great range of application problems independently of EnEffReg.«

SATISFIED USERS

The project brought plenty of new insights and even first positive results for Bayer, thyssenkrupp and Daimler. Dr. Tilman Dombrowski from Bayer comments: »The rapid changes made in the operations of our supply technology enabled us to immediately spot a technical defect in the installed sensor system. Without monitoring energy efficiency, we would have noticed this at a much later point in time.« At a Daimler plant, the measurement values revealed that the position of an installed sensor had been documented incorrectly.

In the recooling plant of a steel mill, thyssenkrupp energy manager Hans-Peter Domels achieved up to 15 percent energy savings with the help of the developed software. »We tried out new modes of operation which make better use of the cool temperatures of the cooling towers and thus take the strain off the cooling units,« he says. »This effect would not have become so apparent, if we had not been able to bring all the measurement data together in one single point and visualize it.«

Carsten Klemm, energy manager at the Mercedes-Benz Berlin Plant, states, »We have now proven the general applicability of optimization in actual operations. But we have still got a lot of work to do before we can extend it to other systems for higher energy savings.«

FULLY AUTOMATED OR RECOMMENDATION-BASED?

As always when it comes to automation, this project too had to ask itself just how far industry is prepared to go with fully automated solutions. Do companies prefer systems that merely make recommendations for optimization instead of direct intervention in the working of machines?

Daimler's Peter Voß does not think so: »I would see a recommendation-based assistance system more as a interim solution. Operating personnel need clear heads to monitor the mode of operation and address any problems should they occur.« He would certainly be positive about any further automation of energy optimization.

Concluded in 2019, the EnEffReg project was supported by the Federal Ministry of Economics and Technology (BMWi) under the funding code 03ET1313A-E.

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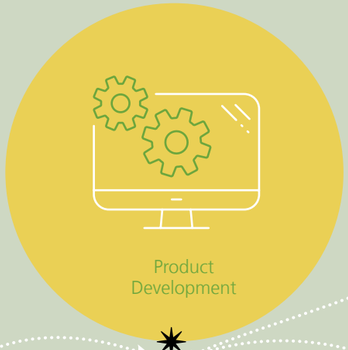
In the Bayer laboratories in Berlin, the environmental conditions must be precisely controlled. The large ventilation shafts in the photograph are among the supply engineering systems used for this purpose.
© Bayer AG

All-round Energy Savings

We develop assistance systems for energy efficient **product development** and **process planning.**

We support customers in the **sustainable strategic alignment** of their company.

Using integrated models, we analyse processes and resource consumption, and compile contextualized planning views and assessments.



As early as during **product development**, we help forecast how much energy will be used at which points in the product lifecycle.

We use digital product twins for energy optimization, develop semantic networks, and analyze data flows to map out decision-making of their energy efficiency from the very start of the production process pathways.

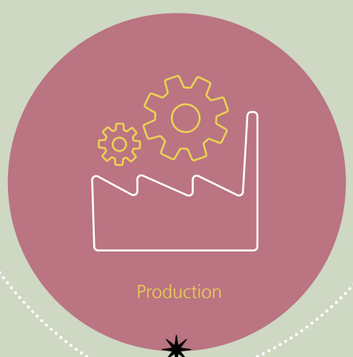
We empower companies to make energy efficient **production planning** for customized orders.

We provide methods for the ad hoc production planning of orders and assessment of their energy needs.

We develop IT system architectures, concepts and software prototypes that enable our customers to make data-supported production planning. We use feedback from running production and digital factory twins to simulate energy optimizing methods that cannot be tested on real plants and systems.

We empower companies to use open source hardware and software for **realization** of decentralized **urban production.**

In makerspaces and other innovative formats, we impart knowledge on the technologies and methods of environmentally friendly decentralized production.



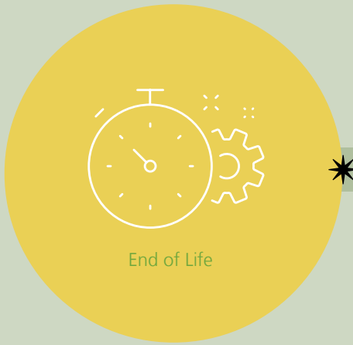
We make it easy for companies to **produce** with **maximum energy efficiency.**

We develop individual energy monitoring solutions based on flexible sensor and measurement systems. The gained data is the basis for optimizing the operations of machine tools and production systems.

We work together with our customers to develop solutions for the energy efficient automated regulation of technical supply systems. We analyze the movements of industrial robots, and optimize programs and individual trajectories.

We take close account of the **service life** and **end of life** phases of products in terms of their energy efficiency from the very start of the production process.

Feedback on energy consumption data flows into product development and product planning and is integrated on the process and IT systems level.



For many of today's companies, energy efficient manufacturing is a compelling sales argument. At Fraunhofer IPK, we are developing a broad spectrum of solutions that ensure transparency in showing that each stage of the product life cycle uses the necessary minimum of energy.

Climate-neutral Production
Small Steps, Big Effects

In addition to continuing digitalization, CO_2-free production is one of the most important industrial trend topics. Many large companies have set fixed targets in terms of saving CO_2.

Where is the best leverage point for companies to start embracing carbon-neutral production – especially in the SME sector? How can they most effectively reduce the energy consumption per manufactured workpiece? Energetic measures for the infrastructure of buildings or automation solutions might be indisputably effective, but they often call for high investment. One smart – because affordable and practical – alternative is offered by mobile assistance systems for the shop floor. These do not only support production workers in ensuring energy savings in the capacity utilization of production facilities. In turn, they also often make use of their intuitive experience and know-how in operating machine tools. In short, they help small and medium-sized enterprises to optimize energy consumption on their shop floors and increase the energy-efficiency of their products.

>> Such assistance systems also offer decisive advantages for the company's employees. They broaden their scope of action, give orientation, provide support for decision-making in ever more complex duties and assignments, and lighten the workload in areas where pressure to perform is high. <<

Fact is that when it comes to machine tools, it is a spread of auxiliary units that makes for the lion's share of power consumption. Should process disturbances cause unplanned outages, they simply keep on running, using a great deal of energy without bringing the slightest added value, as the product to be manufactured is not being processed. Intelligent assistance systems use sensor data from process monitoring to immediately alert the machine operator to such process disruptions during manufacturing of the product. The operator can react quickly, even if he or she is dealing with another machine at that moment. With the help of artificial intelligence, this scenario from semi-automated production can be extended further. Assistance systems equipped with AI would use their databank of user experience to alert the operator, if they detected any signs of an impending disruption to the process. Simultaneously, the operator would receive suggestions of how the process could be rectified before the unscheduled outage occurred. This way, manufacturers could significantly improve process stability while also increasing the energy and cost efficiency of production. The comparatively low investment outlay offers a short-term return on investment that makes it very attractive to companies.

Such assistance systems also offer decisive advantages for a company's employees. They broaden their scope of action, give orientation, provide support for decision-making in ever more complex duties and assignments, and lighten the workload in areas where pressure to perform is high. All this depends on their being given a consistent and highly practical orientation. The measurement data from process monitoring should be coupled with a high level of User Experience (UX) that pays attention to the impressions and reactions of the user during interaction with the respective assistance system. On top of this, if machine operators can bring their own skills and abilities into play, perhaps even train the algorithms underpinning AI with their own expertise, and if they retain their power of autonomous decision-making over the process, all this would greatly increase the general acceptance of such systems. Not least of all, the feeling that one's own activity plays a direct role in raising resource efficiency in the company and makes a personal contribution to climate protection would serve to enhance employee motivation.

© Matthias Pilch

Born in 1978, **Prof. Dr.-Ing. Alexander Mattes,** studied engineering at the Karlsruhe Institute of Technology (KIT) and took his doctorate in cutting technologies in 2008 at Fraunhofer IPK in Berlin. After various appointments and managerial positions at Rolls-Royce Deutschland, Siemens AG and Multivac SE, in 2018 he became Professor for Production Technology at the Kiel University of Applied Sciences. At the university's Institut für CIM-Technologietransfer (CIMTT), he is mainly concerned with driving forward development of assistance apps for system operators. »Skilled workers carry production by providing the key know-how. By introducing edge computing into production systems, we enable them to make direct use of sensor data for optimization of their processes,« says the Fraunhofer alumnus, outlining his current research focus.

RESEARCH + DEVELOPMENT

Making Plastic from Waste

© Mika Baumeister / Unsplash

Scientists are developing a new kind of plastic that is produced from waste and easily degradable in under one year.

This is what the PHB biopolymer raw material looks like directly after synthesis.

Crude oil pumped from the earth is turned into plastic in a process involving toxic chemicals. The plastic is used to manufacture a bottle, which is used once and then thrown away. Months later, it ends up in the sea, to be carried by currents to join the Great Pacific Garbage Patch. There, it may languish for the next few hundred years, until finally it is ground down by the action of the waves – provided that we do not find a way of removing such debris from the ocean.

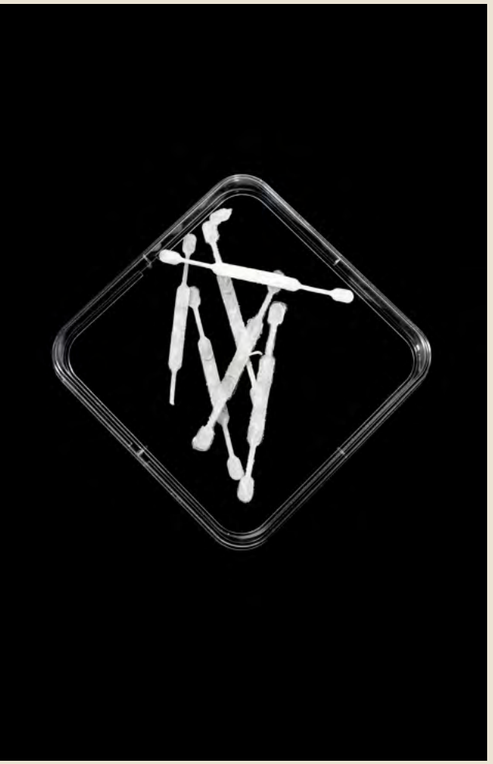
This is the typical life cycle of a disposable plastic bottle. Plastics have now become an integral part of our lives. They are used not just in packaging and a huge range of consumer goods, but are also essential for industrial applications such as vehicle manufacturing and medical technology.

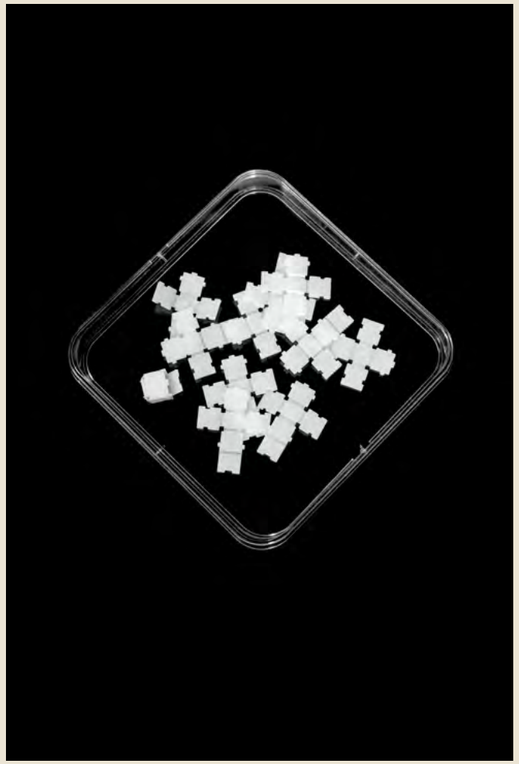
Plastics from fossil resources can only be reused and recycled to a very limited extent. They take a very long time to degrade and they permanently pollute the environment. Their downside is evident for all to see.

There is an urgent need for global strategies to deal with the plastics used all over the world and polluting all the world's seas and oceans. More and more governments are turning to bans in an effort to deal with mounting plastic garbage. So far, there has been no way of replacing the use of fossil-based plastics on a large scale – but as the proverb goes, necessity is the mother of invention.

The Federal Ministry for Education and Research (BMBF) has now launched the »Bioökonomie International« (Bioeconomy International) research initiative in close cooperation with Fraunhofer IPK, the department of bioprocess technology of the Technical University of Berlin, regional industrial partners and international research partners from Malaysia, Columbia and the USA. Its scientists have developed a method of manufacturing polymers without using high-quality substances like mineral oil, palm oil and rapeseed oil, whose production is highly damaging to the environment.

In this new process, the plastic polyhydroxybutyrate (PHB) is produced from industrial residues such as waste fats containing a high proportion of mineral residue. In special fermentation processes, microorganisms can metabolize these residues and store the





PHB biopolymers in different shapes

Clockwise from top left: compounded and granular PHB, extruded PHB foil, model components, injection molded samples

PHB as an energy reservoir in the cell. Once the plastic has been dissolved from the cell, it is still not ready for industrial use, because the hardening process takes far too long. The raw material has to be mixed with chemical additives in special post-production stages. The outcome is a plastic exhibiting similar characteristics to those of polypropylene (PP). Yet unlike PP, this plastic is completely biodegradable within a period of six to twelve months.

In this kind of plastics production, microorganisms completely synthesize the polymer in a biotechnical process that changes biogenic residue (such as waste fats) into technically usable polyester and uses molecular-genetically modified microorganisms as biocatalysts. In this way, using chemical cleaning processes and extensive material optimization, a novel family of materials has been developed that can meet the quality demands of technical plastics.

Not only is this new method completely non-reliant on petroleum-based synthesis components, it also enables environmentally-friendly recycling. The newly developed plastics are degraded by naturally occurring microorganisms and are no longer dependent on the specific decomposition conditions of industrial composting facilities. This means that single-use items can be both produced and disposed of in an environmentally-friendly manner.

Not only that: High-quality plastic components for certain technical applications and periods of use can also be manufactured in this way. Such products must obviously meet special high-quality specifications. They need to show special geometric tolerances and surface qualities, and they must be reproducible to a high standard of precision. To meet such demands, scientists have developed highly specialized replication processes. By adapting the plasticization and processing parameters, for instance, the research team has succeeded in modifying recrystallization time to match industrial requirements for processing time.

The Fraunhofer IPK team developed this injection molding tool for replicating the model components.

>> Not only is this new method completely non-reliant on petroleum-based synthesis components, it also enables environmentally-friendly recycling. <<

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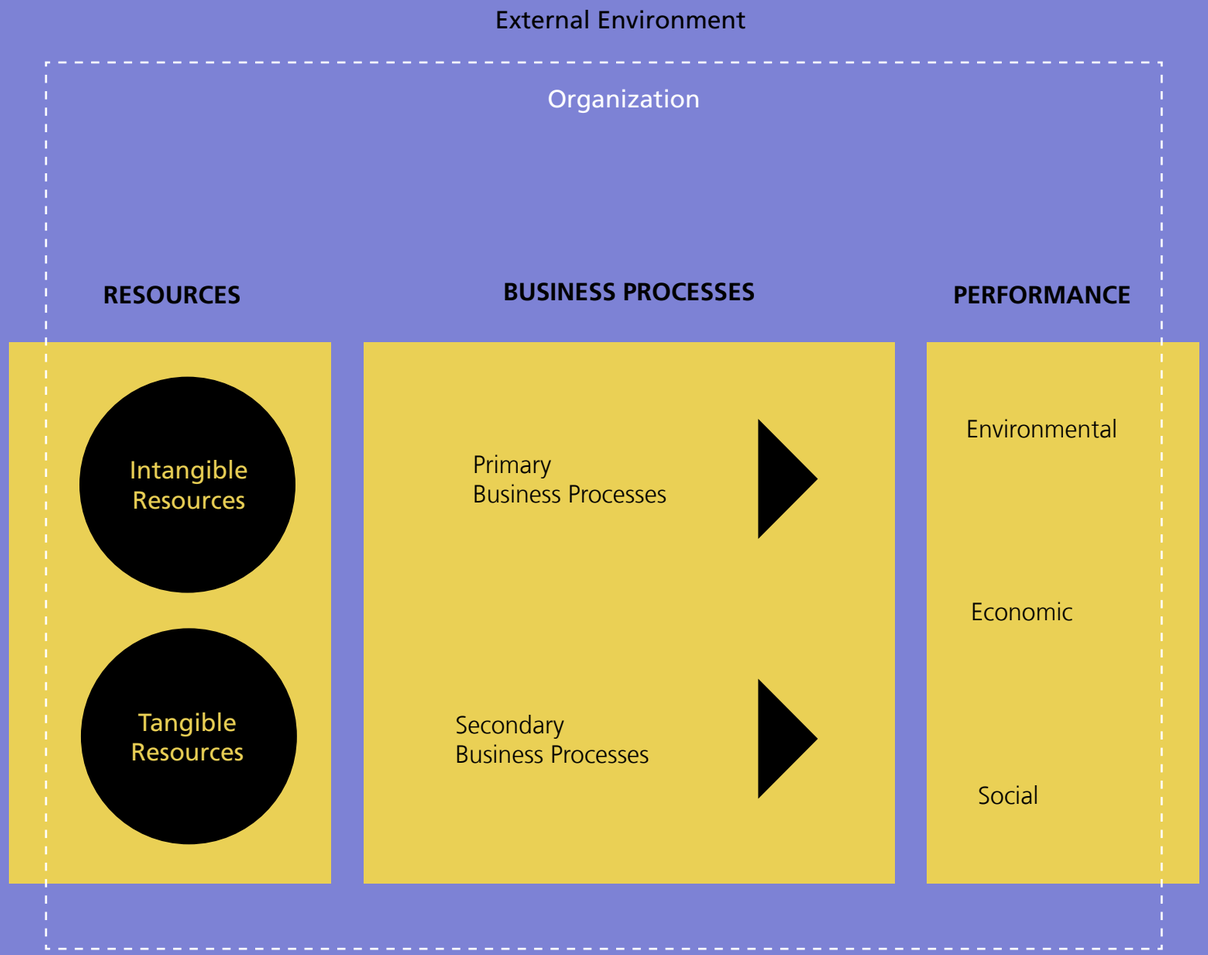
Integrated Thinking



The Fraunhofer reference model for shaping sustainable corporate development provides the basic structure for the Integrated Sustainability Cockpit.

The balance sheet-oriented company report is old news. Today, company reports are reviews and outlooks rolled into one. Their preparation becomes a strategic tool.

A company report is both a duty and an opportunity. About one third of German companies are obliged by law to publish their annual accounts. Since 2018, capital market-oriented companies of a certain size are also obliged to report on non-financial aspects such as their contributions to environmental and climate protection. This might seem like a heavy burden at first sight. Yet, reporting on social responsibility offers a company a whole range of opportunities to profile itself in all its manifold aspects to make itself interesting for investors and other stakeholders. So it is not entirely due to statutory prescriptions, if for the past few years company reporting has been in a process of change. Financial reporting, which is mainly geared to the past, is increasingly being paired with forms of much more forward-looking reporting such as sustainability reports and integrated reports.

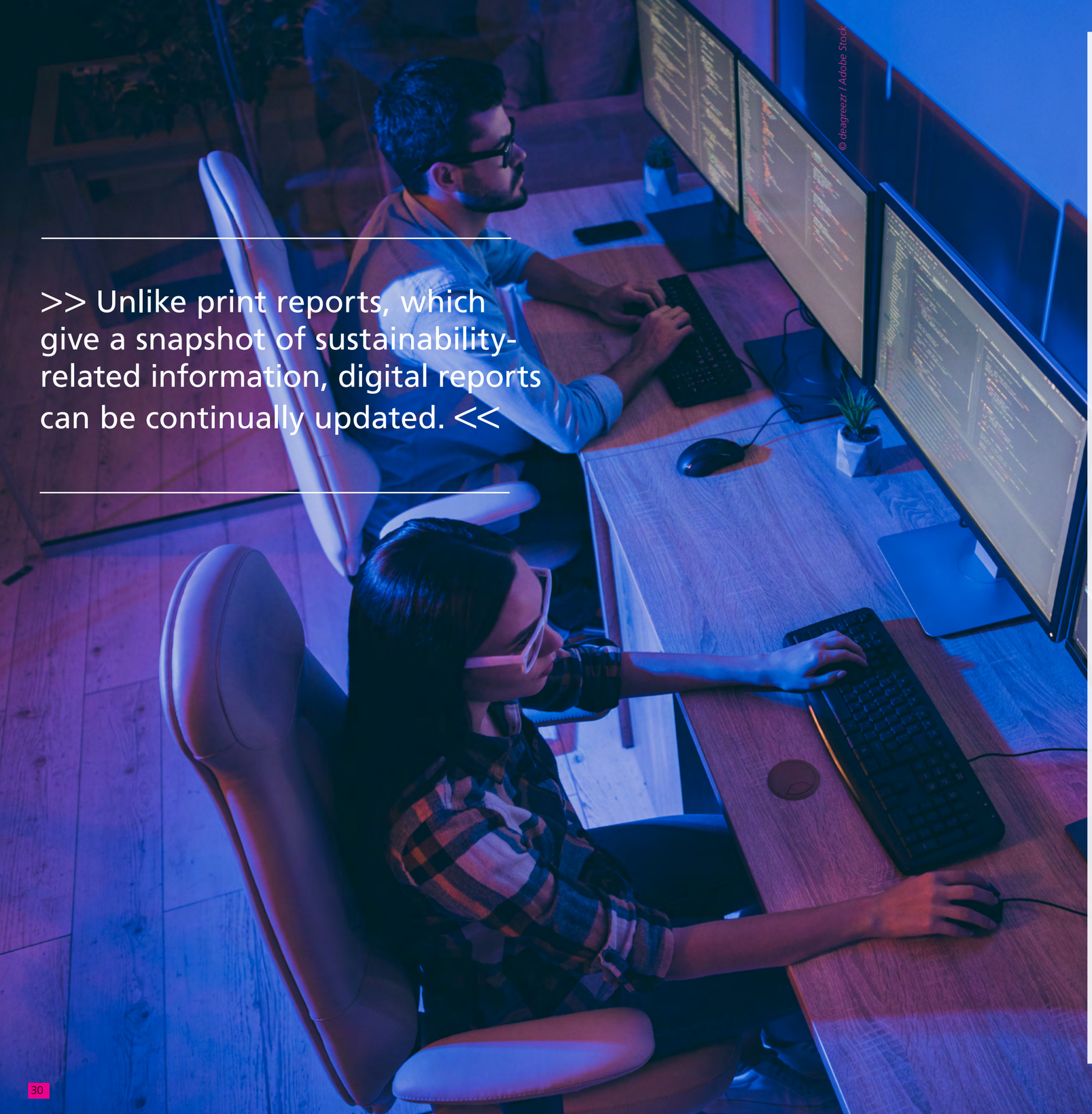
>> In line with the saying »the journey is the destination«, the very process of compiling an integrated report can in itself serve to promote integrated thinking.<<

Integrated reporting follows the goal of intermeshing a variety of reporting instruments. Ideally, a number of stand-alone financial and sustainability reports are aggregated to produce a corporate report that articulates key aspects of value creation. The framework of the International Integrated Reporting Council (IIRC), for instance, gives a set of recommendations on how to compile an integrated report. It proposes that an integrated report should put its focus on the company's business model and describe the interrelations between economic, social, environmental, and governance-related aspects of the company. The point of the exercise is to give a clear image of how the company creates value in the short, medium, and long-term perspective.

INTEGRATED THINKING MADE BY FRAUNHOFER IPK

Integrated reporting should also serve to turn the company's internal management perspective more to the outside in order to give external stakeholders a more comprehensive view of the company. In this context, it seems only logical to go a step further and use integrated reporting as a strategic management tool internally. In line with the saying »the journey is the destination«, the very process of compiling an integrated report can in itself serve to promote integrated thinking. The goal of integrated thinking, in turn, is to completely break with the isolated consideration of individual topics or fields of interest (»silo thinking«). What it proposes instead is to start with a company's business model and present the financial and non-financial impacts of company activities and the ways in which they are interconnected.

Fraunhofer IPK drives the idea of integrated thinking to the extremes: From the very outset, all relevant aspects of the company are embedded in a company model from which ultimately not only reports can be derived. This reference model can map out any company in its full individuality. It is rooted in the basic assumption that not only judicious use of tangible resources (e.g. raw materials, energy, machines) are key factors in ensuring the success of sustainable company development. Intangible resources (e.g. the knowledge, skills and abilities of its workforce, a motivational company culture, stakeholder relationships) are least as important in ensuring this goal. All of these aspects form part of the reference model. Fraunhofer IPK also endows the model with a range of coordinated instruments and procedures for analysis, planning, control and reporting in the company. These include a self-assessment procedure, a key figure



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>> Unlike print reports, which give a snapshot of sustainability-related information, digital reports can be continually updated. <<

catalogue and a reporting system for the analysis and control of operational processes, resource bases and sustainability performance.

THE SUSTAINABILITY COCKPIT

The key tool in the Fraunhofer IPK solution is the integrated Sustainability Cockpit (INC), which embeds sustainability aspects in conventional management systems. The system takes advantage of the fact that digital analysis and visualization technologies play a major role in supporting corporate decision-making today. A controlling and reporting system was evolved that draws on instruments from the field of business analytics. The tool systemizes the process of information gathering and analysis through to decision making. Thus, it not only supports integrated reporting, but above all promotes integrated thinking within the company.

Thanks to various interaction opportunities, users enjoy wide-ranging options to freely design their own analysis paths. The cockpit supports monitoring of key indicators and can be used to identify problems, track measures or for supervision of successful strategy implementation. Decision-makers can gain a better understanding of opportunities and risks, assess alternative decisions, and dialogue with one another across the whole company. What is more, the content of the cockpit can be used as a basis for both internal and external communication activities.

ADVANTAGES OF DIGITAL REPORTING

Digitalization enables us to break with traditional print and PDF formats and open ourselves to interactive formats of reporting. Unlike print reports, which give a snapshot of sustainability-related information, digital reports can be continually updated. Extensive detailed information can be prepared for particular target groups. Search and filter mechanisms allow users to rapidly search for and retrieve essential content. Moreover, digital reporting facilitates cross-references between the contents of reporting. Interdependencies can be presented in a clear and understandable manner. Interactive data analysis and visualization of a range of diagrams, portfolios and tables also enhance the communicative quality of the digital report.

ARTIFICIAL INTELLIGENCE AND REPORTING

Artificial intelligence (AI) is steadily gaining in importance in both research and industry. Experts agree that artificial intelligence and machine learning will have a massive influence on company reporting. AI applications could be useful in the evaluation and visualization of data by pointing out important causalities and optimizing repetitive processes like quality control. In the near future, new universal reporting standards will support automatic analysis regardless of language, company and industry sector.

Even so, AI-based reporting systems bring their own challenges, as they require a profound understanding of the data situation. Companies will have to build the skill sets needed. Experts agree that technology alone is not enough – solid background knowledge is still an essential.

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EARTH FRIENDLY STATES

Germany's SMEs want to know how sustainable their enterprises are. An on-going project is helping by giving them free benchmarking reports.

Germany's small and medium enterprises, the so-called Mittelstand, are a key factor for the country's economic success. So what does today's Mittelstand look like? Take, for instance, Sirri Haydar, a modern entrepreneur. His company HS Dienstleistungen GmbH is based in Mainhausen, where it has been providing cleaning services in the Rhein-Main region for over twenty years. You could hardly find a more down-to-earth firm.

For Mr. Haydar it is important that his company not just makes a profit, but that it also conducts its business in a sustainable and socially responsible manner. That is why he has developed a system that uses 80 percent less chemicals in cleaning agents while producing exactly the same results as conventional cleaning products. In a time when customers are placing increasing value on sustainability, this can be a keen competitive advantage for HS Dienstleistungen. But as Mr. Haydar says, »As a member of the Mittelstand, given the resources we have, it is difficult to justify and communicate this innovation to our customers.«

INTRINSIC MOTIVATION

What Mr. Haydar says touches the pulse of our times. His is one of many SMEs that have discovered sustainability for themselves. These enterprises generally are deeply rooted in their regional and social environment and feel a special responsibility for their region, their employees and society. Moreover, as suppliers SMEs are particularly vulnerable to any scarcity of resources and must be particularly inventive in finding alternatives.

Regina Brückner of Brückner Trockentechnik GmbH, an equipment manufacturer for the textile industry, is also an advocate of the sparse use of resources: »Our customers are under tremendous pressure from major retailers – they have to account for the measures they take to raise sustainability in their production. To help them achieve this, we offer our customers comprehensive solutions – ranging from highly efficient machines that use significantly less resources (than the machines of our competitors) to training courses and intelligent simulation tools for improving the energy efficiency of our equipment.«

SEARCHING FOR SUBSTITUTES

Another example is the cosmetics manufacturer Kneipp, which wants to reduce the amount of packaging material the company uses. Stone (i.e. mineral-based) paper now replaces a good part of the company's conventional types of paper. Substitution of packaging material are saving large amounts of water that would be used in traditional paper manufacturing.

Yet the search for substitutes has its own challenges. As Manuela Fischer, managing director of the architecture firm planen + bauen in Osnabrück, explains: »It is difficult to find affordable alternatives to petroleum-based construction materials. On the one hand, there is a lack of independent portals where you can find information about sustainable substitute products and their suppliers, while on the other, when you do find them, often enough they cannot deliver what you want in sufficient quantity. Long delivery distances are another problem. If a supplier is sitting at the other end of Germany, this does not necessarily make procurement of the material any more sustainable.«

SUSTAINABILITY AS OPPORTUNITY

So what advantages do entrepreneurs hope to gain from putting sustainability on the agenda? First of all, they see direct and very obvious advantages. Using less material and using it efficiently, means they save money. By taking on sustainability measures, they can give their company a more advantageous forward-looking position vis-à-vis the market competition. What is more, they enhance their attractiveness as an employer for the younger generation which serves as a pre-emptive measure against the impending lack of skilled professionals.

»It is important for Mittelstand companies to scope out what opportunities and risks climate change, dwindling resources, and demographic change hold in store for their own business model, just as it is important for them to know what impact their own business operations are having,« says Max Kettner of the Federal Association of Small and Medium-sized Businesses (Bundesverband mittelständische Wirtschaft – BVMW). »With the insights gained from collecting the relevant data, you can both communicate this externally to your customers, business partners and investors, and use it internally for management purposes.«

SUPPORT FOR MITTELSTAND COMPANIES

The project »Mittelstand.Ressource – Sustainable Key Figure Benchmarking for Small and Medium-sized Enterprises« is financed by the German Federal Foundation for the Environment (Deutsche Bundesstiftung Umwelt) and run by the BVMW and Fraunhofer IPK. It offers small and medium-sized companies a gateway into strategic sustainability management. Companies can analyze their strengths and weaknesses with the help of the catalogue of criteria compiled by the project, compare their sustainability performance and recognize their own individual potential. In compiling the catalogue, over 1,700 existent key figures from standard market sustainability analyses were audited and specially tailored to meet the needs of the Mittelstand. The outcome is a catalogue of questions with 43 key figures tested and finalized by the project in a variety of industry sectors.

GOOD TO KNOW

Mittelstand.Ressource – Sustainable Key Figure Benchmarking for Small and Medium-sized Enterprises: Over the course of the project, which will terminate at the end of 2020, companies have the opportunity to collect key figures in their own operations and receive a free benchmarking report. *www.mittelstand-nachhaltig.de*

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Ecologically Sound
Products from Makerspaces

A student of the Wilma-Rudolph-Oberschule designing a small sound box during a hackathon at Fab Lab Berlin. Previously, the students had received introductions to sustainability and 3D modelling. © *IWF TU Berlin*

The »ecoMaker« research project has scientists from the Institute of Machine Tools and Factory Management IWF at the TU Berlin join forces with partner labs to examine the sustainability of open workshops.

Decentralized, flexible, individual, collaborative – these are the criteria by which modern types of production are now measured. More and more Makerspaces and FabLabs are opening up, not just in big cities but rural regions as well. These open workshops put the latest technology trends like 3D printing as well as traditional manufacturing technologies like laser cutting and milling at the disposal of a broad group of users. The participants range from private technology enthusiasts and researchers to innovation managers of business start-ups. In German speaking countries alone, there are now over 270 such Makerspaces. The accent here is very much on trying out new materials and technologies, and doing it with like-minded people. Mistakes are explicitly allowed. But how sustainably do the users of Makerspaces and FabLabs actually work? How eco-friendly are the products, prototypes and hacks they produce?

In a project financed by the German Federal Foundation for the Environment (Deutsche Bundesstiftung Umwelt), scientists of the IWF at the TU Berlin have investigated the German maker scene and checked it for ecological sustainability. The conclusion reached by the »ecoMaker« project: Even though the scene is distinguished by its social and ecological awareness, it is still too heterogeneous to systematically funnel this awareness into local product development. Working together with two FabLabs in Berlin and Brandenburg, the IWF experts have developed specific solutions for the establishment of methods and approaches for environmentally friendly product development in open workshops. Alongside workshops on the eco-friendly use of resources and moderated ecoMaker design sprints, a web-based product configurator should support future development of ecologically sustainable products. The ecoMaker Check allows users to conduct a simplified environmental lifecycle assessment for their prototypes or products before making them – from the selection of resources to the end of life scenario. As an outcome, they receive a prediction of its CO_2 footprint.

Instructions on how to replicate products, best practice examples, and in-depth expertise are all freely available on a learning platform. This platform is designed to inspire users, but also to offer them the chance to actively present their products and have them assessed by their peers in the community. Interested parties can also visit a virtual exhibition and familiarize themselves with the most common materials and processes or explore various design approaches to the environment.

In a three months' workshop series, the project partners have also shown how successful »makers« – the users of Makerspaces and FabLabs – can be when they tackle sustainability in a systematic manner. Two start-up teams developed and presented various products during the course of this series, from the first design concept to the final prototype. These included a modular work bench and an app for real-time tracking and visualization of water consumption.

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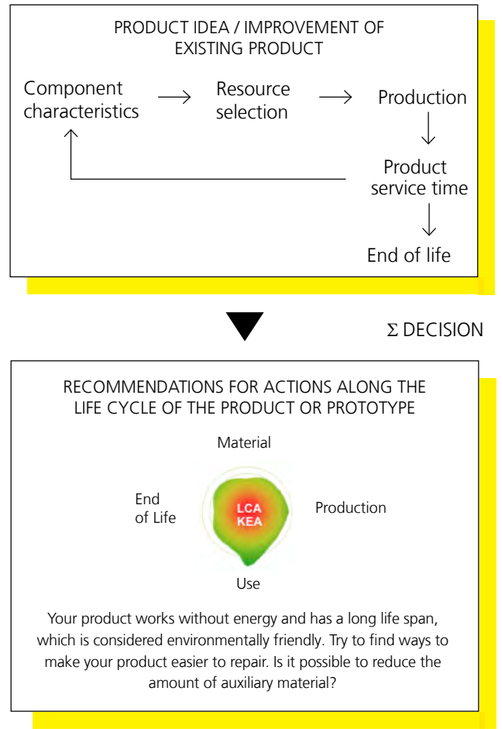
Based on specific questions, the makers are guided through the decision-making process for their own project.



Eco-friendly Welding

To guarantee the eco-friendliness of welded products, their environmental impact must be accounted for along their whole lifecycle in a transparent manner.

From medical technology to the automotive industry and shipbuilding, no industry sector can do without welding. Today's welding processes are so highly flexible that hardly a single major industrial product can be manufactured without some form of welding. Many metal parts are now produced using additive manufacturing – which is also a production process involving welding.

Even so, very little is known about what kind of impact welding techniques have on the environment. This makes it difficult for manufacturing companies to factor environmental considerations into the development process of a product. Unsurprisingly, there is a huge demand from industry for methods of assessing the environmental impact of welding – after all, welding is a highly energy- and resource-intensive manufacturing process.

The method of lifecycle assessment (LCA) has long been established as a tool in other methods of production. So why have manufacturing companies so far failed to establish it as a tool for assessing the environmental impact of welding? One of the reasons is that decision-makers frequently do not know which contributing factors are relevant for LCA. This makes it difficult for them to estimate the expense and efforts needed for such an assessment. To make it easier for companies, the individual work stages of lifecycle assessment need to be automated. Companies can then include them in their technical welding documentation without too much trouble.

INPUT PLUS OUTPUT EQUALS LCA

The key element in lifecycle assessment is inventory assessment, which involves collection of all the relevant inputs and outputs related to the welding process. This includes the resources used across the welding manufacturing chain (e.g. filler materials, electrical energy, shield gas, etc.) and the occurring waste products and emissions. The environmental impact of the process can then be calculated from the aggregated values using categories such as CO_2-equivalence, acidification potential and photo-oxidation.

The factors to be considered are digitalized so that by accessing the LCA database, the respective values can be automatically »translated« into the corresponding effects on the environment. Users can thus clearly identify the ecological footprint of a welded component with minimal effort.

WHAT ARE THE KEY FACTORS?

The environmental impact of a welding process can be derived from the resources it consumes (input) and the waste and emissions it produces (output). However, it is more difficult to quantify the impact of individual inputs and outputs on selected impact categories. Scientists at the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung – BAM) have succeeded in identifying the input factors with which, according to the World Steel Association, the relevant impact categories of a LCA can be precisely analyzed:

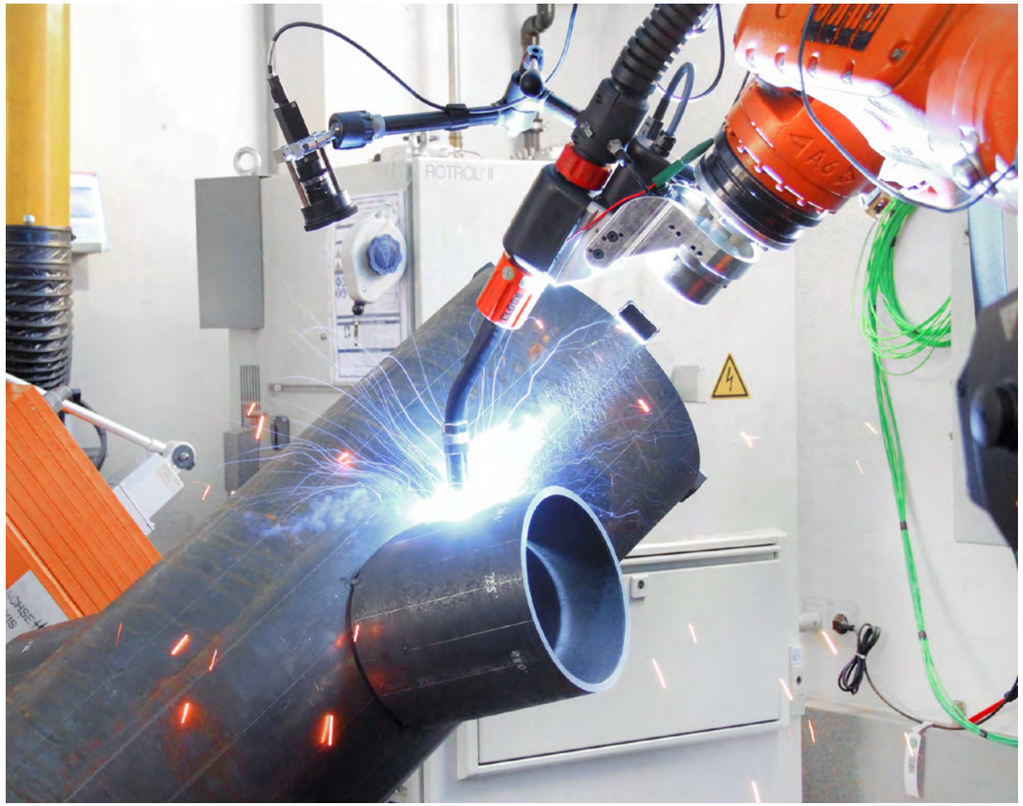
- **Materials consumption**
(e.g. basic/additional material, etc.)
- **Energy consumption**
(e.g. effective power used by all electricity consumers during process time)
- **Gas consumption**
(process gas, shield gas or compressed air)
- **Assistive devices**
(e.g. protective glasses)

Comparing various welding techniques in terms of their environmental damage is an interesting challenge with direct relevance to praxis. To this end, the BAM team performed the same welding job with a variety of different welding techniques and made a lifecycle assessment for each of them. The set target was always the same: making a welding seam of one meter in length.

The experiment compared three different welding techniques: manual electrode welding, gas shielded metal arc welding (GMAW) and laser-GMAW welding (hybrid).

Cooperation with BAM

Fraunhofer IPK and BAM are strategic partners in the field of joining and coating technology. This cooperation facilitates the rapid transfer of solutions from materials research to industry.

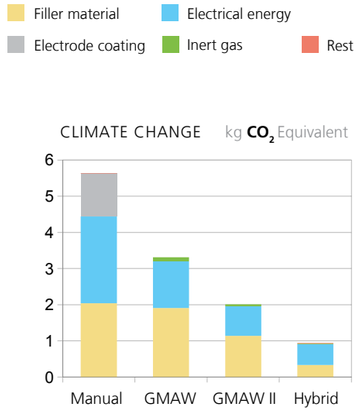


Gas shielded metal arc welding (GMAW) is used for the automated welding of pipe nodes. Tube nodes are an important structural element in steel construction, for example for the foundation structures of offshore wind turbines. © *BAM*

Two input factors in particular were found to have an influence on the LCA of a technique: the need for additional materials and energy. Thanks to this insight, scientists were able to limit the influencing variables to be reviewed to these two factors. In practical terms, this means that companies intending to make an LCA of their welding technology now have much less outlay. The test found that the techniques with the best ecological assessment were those with low use of materials, in extreme cases autogenous techniques. These insights can be invaluable for design feedback.

To standardize the workflow in the LCA and keep it easy to understand, BAM scientists directly fed their research results into DIN SPEC 35235 »Sustainability in Welding Technology – The Environmental LCA of Welding Technology«. Offering a proven basis for comparing assessments of the environmental impact of different welding technologies also helps raising acceptance in the industry.

Comparison of the environmental impact of different welding processes for selected effect categories.
Source: BAM



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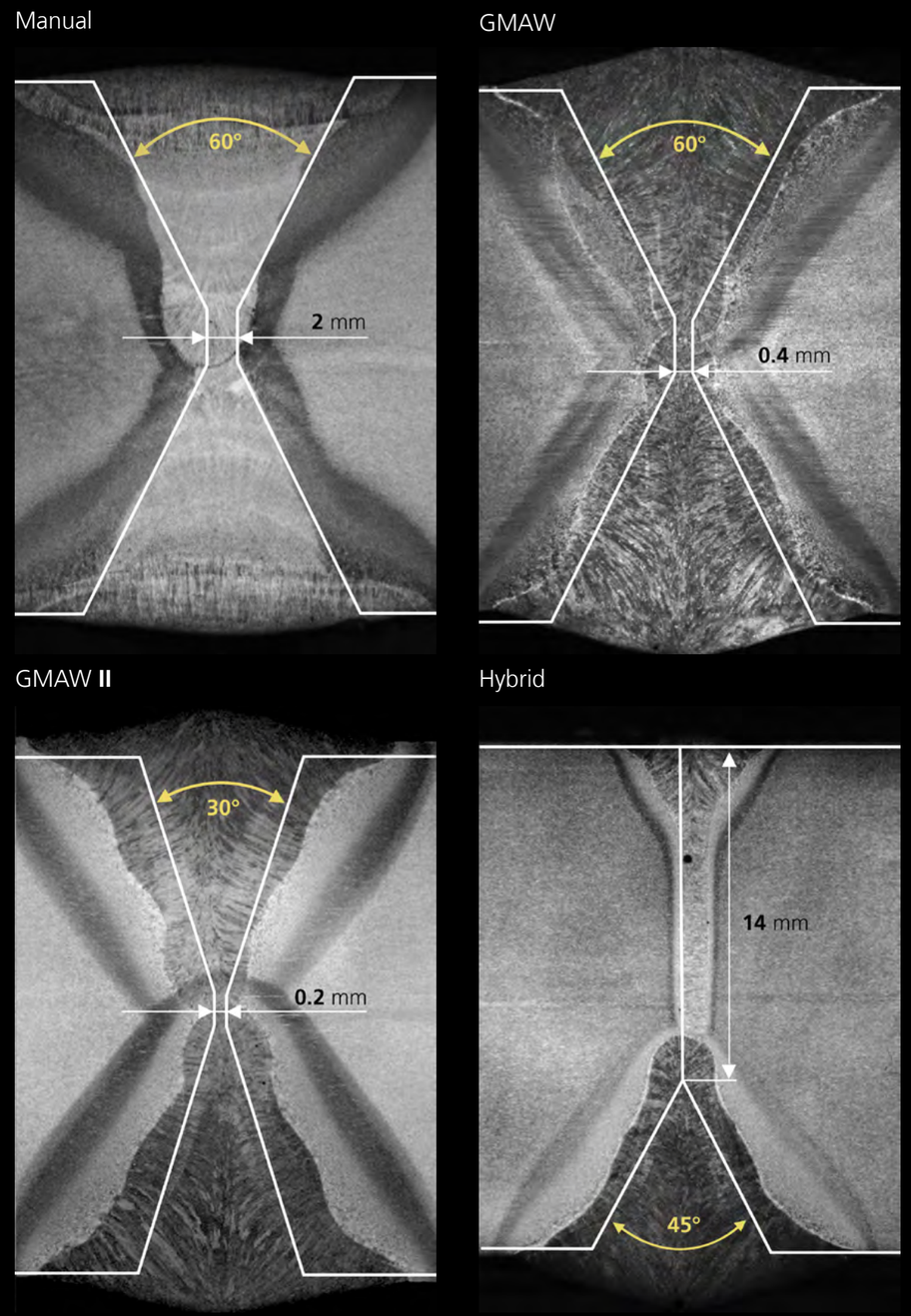
Microscopic photographs of the melt seam area for various procedures



Smart Maintenance for High-end Machines

If machines and systems are to function reliably in the long-term, they need intelligent monitoring and maintenance. In the age of digitalization, AI-driven smart maintenance is the name of the game. In conversation with FUTUR, Christoph Plüss, CTO of the UNITED GRINDING Group, and Claudio Geisert, research engineer in maintenance and overhaul at Fraunhofer IPK, talk about the advantages of smart maintenance and how industry can make the best use of them.

Christoph Plüss has been with United Grinding for ten years. In April 2019, he was appointed Chief Technology Officer (CTO) of the company. *Photo: Private*

With an annual turnover of some 700 million euros, **UNITED GRINDING Group** is one of the world's leading manufacturers of precision machinery for grinding, eroding, laser cutting, measuring, and combined machining.

Claudio Geisert is head of the Industrie 4.0 Transfer Center Berlin at Fraunhofer IPK. His research focus is predictive maintenance.

| futur | **Mr. Plüss, what is the importance of maintenance for an engineering group like United Grinding? As a manufacturer of grinding machines, would integrated smart maintenance solutions be a factor that sets you apart from the competition?**

/ PLÜSS / It most definitely would. This topic is going to be one of the big differentiating factors of the future. Generally speaking, this overhaul business, or »rebuild«, as we call it, is one of major pillars of services. Our machines are high-end investment goods; some of them cost as much as a house. So we want to offer our customers a maximum degree of investment security – and that comes with digital solutions.

| futur | **Mr. Geisert, in which area do you see the greatest potential for smart maintenance?**

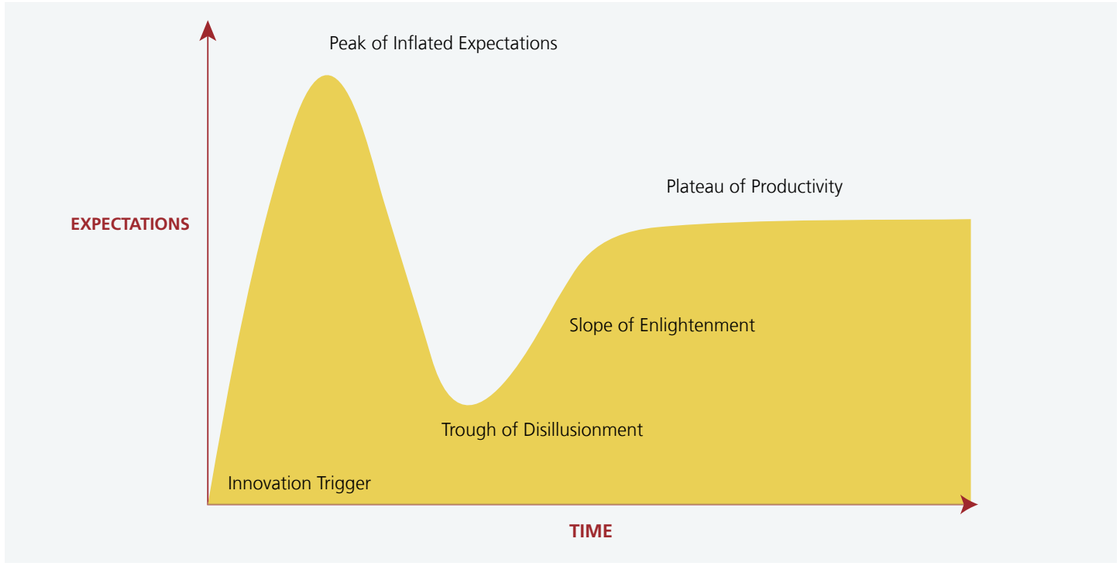
/ GEISERT / Smart maintenance is no stand-alone solution. It is predicated on a holistic view of things. At the end of the day, databased comprehensive smart maintenance is trailblazing the implementation of innovative business models, the kind of business models that industrial product service systems are calling for. With Pay-Per-X models, the focus is on the user benefits and not solely on selling the product. I need to have a very deep understanding about the condition of my systems in order to provide such benefits.

| futur | **Since we started talking about Industrie 4.0, smart maintenance has also been one of the main issues. Yet even today, many companies are struggling when it comes to digitizing maintenance. Where are the biggest hurdles, in your opinion?**

/ GEISERT / For one thing, maintenance tends to be a rather down-to-earth sector. The whole point is to keep machines up and running. So having to cope with digitalization can prove difficult. On the whole, I would say that the expectations placed on digitalization have been a little too high. Following the Gartner Hype Cycle for Emerging Technologies *(see the graphics on the following page),* I would say that some of the technologies that could be used for smart maintenance have not yet reached the Slope of Enlightenment. Maintenance is often viewed as inferior, or not as valuable as production, because production brings in the profits while maintenance costs money. Companies need to recognize that maintenance itself makes a significant contribution to value creation.

/ PLÜSS / Strictly speaking, there is nothing earth-shatteringly new about digitalization. The difference is that today, for the first time we are in a position to store and process huge amounts of data within our IoT systems and analyze them at lightning speed. What is holding up digitalization at the moment is the readiness of customers and companies to embrace such networking. We can still sense a great deal of reluctance and have to be very persuasive. People are terrified of data theft, and the issue of data security usually crops up in every second sentence. The concepts are there, the technical possibilities are in place, but we still need a great number of good arguments and in many cases a proof of concept, solid evidence that it really does work. This is why we are totally transparent in our work with our customers and show them which data we are drawing from the system. We are going to need a certain change of mindset here. Perhaps it is also

Gartner Hype Cycle for emerging technologies



a generation thing – the generation of our children will have quite a different take on it all. For today, there is still a lot of anxiety and misgivings around.

| futur | **Apart from promising transparency, do you have any other winning arguments for your customers when it comes to networking?**

/ PLÜSS / Customers today are mostly unwilling to have their machines continuously online. Our solution is that customers should aggregate their machine data on the company intranet locally on an edge device. Only at the customer's request will this device network with our system via a remote service. Customers can decide for themselves, when they want to open the data tunnel and when they want to close it.

| futur | **Is it still the case that production takes precedence and maintenance is seen as a downstream service? How can maintenance improve its image to be seen as a vital part of value creation?**

/ GEISERT / All of the decision makers must wrap their heads around the fact that production can only be efficient when all production systems are functioning perfectly. When talking about Industrie 4.0, we are talking about an ecosystem in which all stakeholders must cooperate with one another to make production efficient. As Mr. Plüss just said, that is not a technical hurdle, it is more a matter of organization.

/ PLÜSS / When it comes to digitalization, we like to cater to customer benefits, not to hype. That is why we have plotted the whole of the value creation chain in a »customer journey«, and why we support our customers across the whole of the product lifecycle. The maintenance phase is the longest phase in the life of a machine. Our machines spend several decades in operation, so this phase is actually the most elementary one in terms of the lifecycle. Software solutions, updates and upgrades can make a huge contribution to optimizing performance. Data collection is essential, because it allows us to make conclusions about whether certain processes are working the way they are supposed to. It allows us to avoid unnecessary service operations that could involve high costs for labor and spare parts.

/ GEISERT / This is where digitalization and acquisition of a great deal of sensor data helps to shed light on the darkness. How does my machine wear correlate with the machine's production load? When we have better findings – findings based on the evidence of the data collected – that will make it much easier to relay to those in charge why certain measures are necessary.

/ PLÜSS / One big problem has been the highly proprietary mindset that is widespread in the industry. After all, the end customer does not depend solely on a single supplier. There is a huge range of components, like sensors and control options, and everybody is jealously guarding their own ecosystem. This makes analysis and data evaluation really tedious. That is why we are working with the VDM (*editor's note: Verein Deutscher Werkzeugmaschinenfabriken – German Machine Tool Builders' Association*) on a universal machine tool specification.

/ GEISERT / It would also be great to have standardized evaluations and analyses, not just standardized interfaces. We have often found that the results of various machine tool providers are not comparable, because they do not reveal their algorithms.

| futur | **What kind of a role, if any, do sustainability issues play in maintenance?**

/ PLÜSS / We view the machine overhaul business as one of the services we offer in our one-stop solution package. For instance, if a customer wants to scrap a machine, we offer to take it back and overhaul it. There is a high demand for our »second life machines« on certain markets – for instance, as entry-level machines for customers who cannot afford a new one. When it comes to sustainability, this is a clean solution.

/ GEISERT / Maintenance per se is sustainable, as it seeks to keep resources useful for as long as possible. It is pretty obvious that a poorly maintained system is going to use more energy than expected. We also use and evaluate the drive currents for condition monitoring. This is where we see a direct connection with progressive wear and tear. And with the acquired data, we can also pinpoint optimization potential for present and future systems and give feedback to designers.

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ÖKOTEC

Efficiency Experts Serving the Environment

As a modern consulting company, ÖKOTEC combines forward thinking with a long and proven track record. Since 1999, it has been synonymous with intelligent solutions in the field of energy efficiency.

Having run projects at over 850 industrial and commercial sites both in Germany and abroad, ÖKOTEC is one of the leading experts for energy saving. The company philosophy interweaves economic and ecological aspects: »Our business activities aim to make a significant contribution to the containment of global climate change, to the success of the transition to green energy, and the transformation necessary for the decarbonization of the economy,« says Dr. Christoph Zschocke, founder and managing partner of ÖKOTEC.

ÖKOTEC supports companies in various stages, from energy analysis and development of energy concepts, to operation and controlling of a DIN EN ISO 50001-certified energy management system. ÖKOTEC's EnEffCo® software solution, developed in a joint project with Fraunhofer IPK as one of the partners, enables companies to control their energy efficiency holistically. It allows systematic tracking, monitoring and evaluation of energy data on both the plant and process level.

EnEffCo® was successfully launched in autumn 2013. ÖKOTEC poured its wealth of expertise in process and plant technology into its development – an expertise gained from working on a large range of energy efficiency and energy-saving projects. EnEffCo® is now the established solution at more than 100 factories, and 1,000 commercial sites in Germany and abroad.

Since 2010, ÖKOTEC has successfully completed over ten further R&D projects, in cooperation with companies and research institutions.

In the EnEffReg project, financed by the Federal Ministry for Economics and Energy (BMWi), the aim was to use an intelligent system for automatic controlling of processes according to energy efficiency criteria. You can find more information about this joint ÖKOTEC-Fraunhofer IPK project on page 16 of this edition of FUTUR.

With the advance of climate change and more complex framework conditions for companies, ÖKOTEC has advanced from energy and environmental management to climate management. In addition to developing CO_2-neutral supply concepts or preparing greenhouse gas balances, ÖKOTEC also promotes the exchange and development of know-how in companies through networks and training.

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ÖKOTEC has its headquarters on the **Berlin EUREF Campus,** a location for companies in the fields of energy, sustainability and mobility. © *EUREF AG*

Energy Efficient with Industrie 4.0

The Lab for Energy Efficiency makes solutions hands-on and tangible.

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The Lab for Energy Efficiency demonstrates instrumentation and control technologies in direct relation to the miniature exhibits and real systems in the testbed.

The fluid loop demonstrates the mode of action of the outside pumps in the laboratory.

The developments of digitalization, and in particular those of Industrie 4.0, are offering manufacturing companies ever more new opportunities to monitor and increase their energy efficiency. As the GreenTech made in Germany report published by the Federal Ministry for the Environment shows, Germany boasts a broad range of providers of such products.

Industry actors have, however, pointed out the lack of a clear overview of practically tested possibilities and solutions for increasing energy efficiency. Users find that many procedures with controlling interventions cannot be directly adopted in running operations, particularly when it comes to serial production. There is a high demand for testbeds to demonstrate and test methods on real machines and systems with direct opportunity for user participation and interaction.

With its broad-based testbed at the Production Technology Center (PTZ) Berlin and the domain-specific expertise of its research scientists and engineers, Fraunhofer IPK is ideally situated to test and demonstrate solutions for monitoring and raising energy efficiency.

LIVING INNOVATION AT THE BERLIN TESTBED

The Lab for Energy Efficiency (L4EE) is scheduled to open at PTZ Berlin in autumn 2020. The Lab's exhibits will exemplify how Industrie 4.0 technologies can be used to increase the energy efficiency of industrial processes. To ensure a maximum level of practical relevance companies will be invited to contribute their use-cases and act as mentors to the exhibits built at Fraunhofer IPK.

Control of supply technology is one important entry domain, as both substantial energy saving potential and the possibilities for controlling intervention are amply documented in this field. Moreover, the L4EE has an additional focus on production processes. For instance, single aggregates of processing machines can be manipulated with regard to their energy efficiency without endangering the entire manufacturing process. The closer the intervention is to the actual manufacturing process, the more critical integration of automated machines becomes, and the more urgent the need to test it experimentally under real conditions outside of serial production.

An interdisciplinary team at Fraunhofer IPK is drawing up the L4EE agenda. The technologies on offer will be regularly updated in line with the findings of on-going projects. Customers are going to be able to take part in open workshops and seminars or in individually arranged consultations and training programs.

The graphics show the plans for the first development stage of the L4EE. Industrial control systems are mounted on a rack in the interior to keep them out of sight of the modelled control room. Monitors on a master computer display various tools for monitoring and optimization. A typical process can be modelled in a fluid loop. In this case, it is a pump control. Visitors to the lab can use hand valves to cause deviations to put the AI-assisted processes to the test. Is reinforcement learning more suitable for my application than conventional model-based regulation? What information does the operator need? And what skills and knowledge are needed to use current communication and controlling technologies for machine learning?

Pahl-Beitz Prize 2019
for Dr. Konrad Exner

Dr. Exner was awarded the Pahl-Beitz Prize 2019 for his dissertation entitled »Prototyping of Product-Service Systems and Smart Services in the Concept Phase of the Development Process«.

Since 2003, the prize has been awarded for doctorates with outstanding engineering relevance and high innovative content. Prof. Dr. Dr. Dr. Herbert Birkhofer (TU Darmstadt) presented the prize on behalf of the Scientific Society for Product Development (WiGeP). In his laudation he said: »Dr. Exner's outstanding thesis, which focused on the testing of the increasingly important product-service systems during their development, was groundbreaking scientifically, methodically and in the use of the latest virtual techniques, not only for research in product development within the Scientific Society for Product Development, but also for the national and international industry, which clearly highlighted the importance and significance of this doctoral thesis with its letter of recommendation.«

Dr. Exner is the deputy head of the Information and Process Control department at Fraunhofer IPK. We congratulate him warmly!

Left to right: Prof. Stahl, Dr. Exner and the laudator, TU Darmstadt emeritus Prof. Birkhofer, successor to Prof. Pahl © *WiGeP*

Good Neighbors – Good Partners

Czech Deputy Prime Minister Karel Havlíček and his delegation discussed possible German-Czech cooperation in the field of automation during their visit at Fraunhofer IPK in Berlin.

On Wednesday, February 5, PTZ opened its doors and laboratories to His Excellency Karel Havlíček, Deputy Prime Minister and Minister of Industry and Trade and Minister of Transport of the Czech Republic. Together with his eleven-member delegation, Havlíček had accepted the invitation of the automation and machine vision experts, Prof. Dr. Jörg Krüger and Dr. Bertram Nickolay.

The scientists presented the work of Fraunhofer IPK to the neighboring country's delegates. A guided tour through the central test area and the in-house Industrie 4.0 Transfer Center demonstrated the practical applications of the research. Afterwards, the attendees talked about the German-Czech project activities at Fraunhofer IPK so far and possible opportunities for future cooperation. Prof. Krüger sees points of contact above all in the automotive industry and in the field of artificial intelligence.

Excavate – Scan – Glue
Digital Archaeology with »DigiGlue«

Original fragments of Roman wall paintings discovered in the European Culture Park Bliesbruck-Reinheim © *Landesdenkmalamt Saarland*

On behalf of the Saarland State Office for the Preservation of Historical Monuments (Landesdenkmalamt Saarland), MusterFabrik Berlin and Fraunhofer IPK are developing an IT-based assistance system for the digitalization and virtual restoration of archaeological findings.

The findings consist of some 5000 fragments of painted Roman wall plaster that were excavated on the German side of the European Culture Park Bliesbruck-Reinheim in Saarland. The challenge facing archaeologists and restorers is that any handling of these fragile limestone mortar pieces will cause further damage to their substance.

This is where Fraunhofer IPK and MusterFabrik Berlin come in with a technology for the digitalization, visualization and reconstruction of fragmented multi-dimensional objects. As Dr. Bertram Nickolay, head of the Machine Vision department explains, »The project leverages those skills and abilities we have built up at Fraunhofer IPK, together with MusterFabrik Berlin, in the digitalization and reconstruction of fragments of glass mosaic.« Dr. Georg Breitner, director of the Landesdenkmalamt Saarland at the Ministry for Education and Cultural Affaires adds: »The DigiGlue project offers our archaeologists and restorers the chance to digitally capture and virtually reconstruct cultural assets, following the model of the Roman wall plaster fragments. We are creating added value for subsequent scientific processing.« The project was co-financed by Saarland-Sporttoto GmbH.

To kick-off the project, experts from the Landesdenkmalamt Saarland, MusterFabrik Berlin and Fraunhofer IPK recently met to specify the requirements for the IT-based assistance system to be developed. Digitalization of the fragments is done by a 2.5D scanner that captures the motifs painted on the front side with optics and uses sensors to measure the volume data on the reverse side of each fragment. All information needed for reconstruction like the motifs, colours and contours of an element must be taken at this stage. The following visualization and repositioning of the fragments builds on Fraunhofer IPK's award-winning reconstruction technology, which will virtually recompose the digitalized fragments into as complete a mural as possible.

Honoring the »Father of Reconstruction Technology«

Fraunhofer-Taler © *Fraunhofer*

Left to right: Chairman of the board of trustees Prof. Dr. Klaus Wucherer, director Prof. Dr. Dr. Eckart Uhlmann, Dr. Bertram Nickolay, laudator Prof. Dr. Alexander Kurz

Dr. Bertram Nickolay has been conducting research on machine vision at Fraunhofer IPK since the 1980s. His services to the Fraunhofer-Gesellschaft were now honored with an award.

Prof. Dr. Alexander Kurz of the Fraunhofer board of directors presented Dr Nickolay with the so-called »Fraunhofer-Taler« at the annual meeting of the Fraunhofer IPK board of trustees. Dr. Nickolay had earned it for his services to the Fraunhofer-Gesellschaft in the acquisition of high-profile projects. »We are proud and happy to have colleagues of such calibre!« said Prof. Kurz.

Dr.-Ing. Bertram Nickolay joined the Fraunhofer Institute for Production Systems and Design Technology IPK in 1981 as a research associate. His work on the automated virtual reconstruction of destroyed documents received worldwide recognition. It was through his idea and initiative that the project for computer-assisted reconstruction of the destroyed files of the former GDR secret police – the »Stasi-Akten« – was born.

In recent years, Dr. Nickolay has turned his attention to numerous projects of great cultural significance. These include restoration of documents destroyed by the collapse of the City Archive of Cologne and by a bomb attack on the Jewish Library of the Fundación IWO in Buenos Aires. Digital reconstruction of textual contexts in the manuscripts of the universal scholar Gottfried Wilhelm Leibniz and virtual reconstruction of the prayer book of Narek, one of the great cultural treasures of Armenia, are among the latest projects of Dr. Nickolay and his team.

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You can find **current information** about our program on our website *www.ipk.fraunhofer.de/weiterbildung*

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