
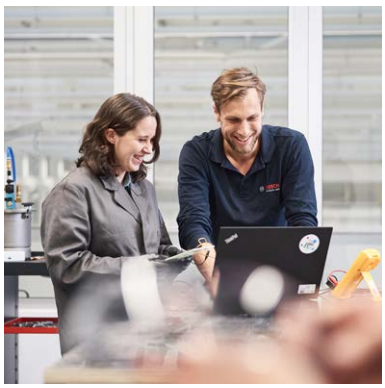



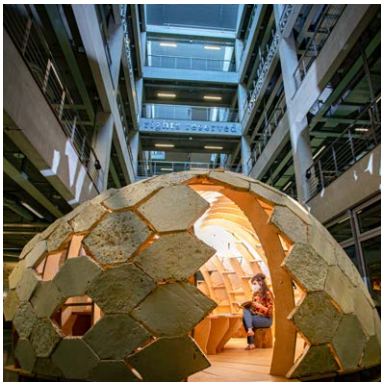


TU9

GERMAN UNIVERSITIES
OF TECHNOLOGY

# Knowledge and Technology Transfer

## Germany's Technical Universities as Key Drivers of Innovation

# TU9 ALLIANCE

**Germany's Technical Universities are key drivers of innovation. Transferring knowledge and technology plays a pivotal role in tackling the major challenges facing society today. The TU9 Universities supply ideas and approaches for efficient and effective solutions.**

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**CONTACT**

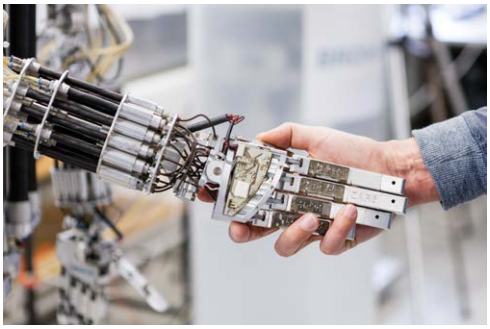
TU9 – German Universities of Technology e.V.
Dr. Nicole Saverschek, Managing Director
Tel.: +49 (0)30-278 74 76-80
» office@tu9.de
» www.tu9.de

# Knowledge That Can Change the World

**The third part of the IPCC's Sixth Assessment Report published April 2022 came to a gloomy conclusion: Although almost half of humanity are highly vulnerable to the effects of climate change, the international community still underestimates the tremendous consequences of global warming for both people and nature. The window of opportunity for effective mitigation is narrowing apace. To ensure more climate justice and in the face of the 21st century challenges the United Nations Agenda 2030 sets out in 17 Sustainable Development Goals, greater cooperation between governments, the private sector and civil society is crucial.**

Author: Kristina v. Klot

Students in a maize field use a drone to take pictures for later analysis.



Shaking hands with ZAR5, the humanoid two-armed muscle robot torso.

In science, interdisciplinary collaboration, international dialogue and exchange, and networking with partners from industry, government and society are basic prerequisites and standard practice in conducting effective, meaningful research. Be it climate change, urbanization, energy and mobility transition, health, inequality or sustainable resource use – there has rarely been a time in human history when we have been as reliant on science as we are today. Added to this come the structural challenges arising from digitalization and demographic change.

Facing these challenges, science is delivering in myriad ways – driving the development of new vaccines, finding solutions for renewable energy use and secure energy supply, developing high-tech medicines to combat widespread disease, and contributing to cybersecurity analyses and strategies to fight poverty and improve access to education.

In times of epochal transformation, Germany's Technical Universities play a key role as drivers of innovation. With the broad spectrum of work they perform, from basic research to applied research, they have long been major protagonists in knowledge and technology transfer. And as such, they assume a socially responsible role.

Nine leading Technical Universities that make up the TU9 Alliance represent the capabilities of this specific university type – from their regional locations, they promote the reach of German engineering out to the rest of the world. The TU9 Universities have long switched their focus to take in more than their core technical expertise. In line with modern engineering science, they have established a broad-based portfolio using both multi-disciplinary and interdisciplinary approaches. This is based on the conviction that pioneering spirit and creativity, not least in the entrepreneurial sector, are reliant on cross-

discipline inspiration and collaboration. Without the close link between technical and scientific knowledge and the expertise derived from industry and society overall, neither technological nor social innovations would be conceivable in the world as we know it today.

Approaches and solutions to address the pressing problems currently faced call for the kind of cross-disciplinary teamplay that is characteristic of the global players in the most recent TU9 Alliance spin-offs. The many examples of their innovative products and services include the first triple-drop delivery drone from manufacturer Wingcopter, the Emsland-based regenerative fuel producer INERATEC with the world's biggest pilot facility for the production of sustainable aviation fuel, and Novaled, the first company to develop highly-innovative OLED structures for use in displays and lighting systems. The increasing importance of European tech and deep-tech startups can be seen in their economic value, which rose from €5 billion in 2010 to €188 billion in 2020. Many of these new companies, whose innovations have ushered in major social transformation, form clusters around the Technical Universities, thereby aiding expansion of existing regional-level networks. Their best-practice examples can be used as blueprints for new projects with other partners in the region concerned. And in addition to providing solutions to the challenges of the day, they create and provide jobs for the future.

**In line with modern engineering science, the TU9 universities have long switched their focus to take in more than their core technical expertise.**

Technical Universities work as magnets in their respective regions, boosting local economies through applied science cooperation with SMEs and large companies who in turn benefit from the excellently trained graduates from the TU9 Alliance. With their extensive support and advisory services, funding programs and the well-established, well-connected technology and startup centers, the Technical Universities are ideal spin-off and startup incubators for both researchers and students.

The power of these regional innovation networks is reflected in the TU9 Universities' success in the Clusters4Future initiative, a Federal Ministry for Education and Research (BMBF) funding program designed to introduce new scientific knowledge and emerging technology fields to industry and exploit new innovation potential. Mobility and communications solutions are also promoted under the initiative, as are models such as Industry and Work 5.0. These can involve things like the resource-efficient circular economy, integrated mobility innovations in metropolitan regions, and new production methods and areas of application for living medicines, where the idea is to use personalized approaches to medicine to lower the costs of healthcare and enable broader medical application. Given their economic leverage, these innovation networks can shape entire regions.

The debate on how academic knowledge can be of social and economic benefit is as current as ever before. But having said that, a holistic, future-proof definition of transfer goes way beyond conventional notions aimed at transferring research results into innovative inventions, patents and consumption patterns, or into products and services at speed. Apart from pure technology, it also takes in knowledge transfer to and from society – calling for "beyond technology" transformation of the economy and society overall. The TU9 aim to develop strategies and solutions in yet closer collaboration with industry, society, government and administration. This will be done as part of a multi-directional dialogue and exchange in which knowledge transfer is seen not as a one-way street, but as a joint task in which all stakeholders learn and benefit from the insights and findings of others.

This can be achieved, for example, by using participative project formats such as the living labs and citizens' dialogues that have proven their effectiveness on multiple occasions, not least in facilitating more sustainable urban development and planning. Equally promising are innovative cooperation models

in which universities and urban society work side by side to come up with ways and means to achieve holistic municipal transformation – focusing on improved energy efficiency, for example.

Currently, the speed of innovation, the perspectives of participating stakeholders and the ways in which innovations are created and applied are the focus of tremendous change. Innovation cycles are getting shorter and shorter, while the perspective in each development phase becomes wider and more global. To achieve a functional innovation ecosystem for the future, greater cross-border exchange at European level is essential. The TU9 Universities are already heavily engaged in the EU Commission's European Universities Initiative to establish a European education area with the university alliances ENHANCE, EPICUR, EuroTech, EUTOPIA und Unite!. But for the initiative to be successful and to connect and form a network of economically robust regions, the level of national co-funding needs to be increased.

**How can strategies and solutions be developed in greater collaboration with industry, society, government and administration?**

Science entrepreneurship initiatives, which are already a reality in many Technical University disciplines, must become firmly established in university structures and be given adequate funding – both in the universities themselves and at Federal and Länder (state) level.

Technical Universities are a core component of the notion of Germany as a land of innovation – not just because of the ideal mix of basic university research, applied research, and knowledge and technology transfer, but also due to the historical connection between industry and science. Thanks to their wide-ranging institutes, infrastructures and networks, the Technical Universities offer optimal conditions for the creation of innovative ecosystems for the future. But then acknowledging that research and transfer are mutually dependent is only one side of the coin. The other is providing the right conditions, including financial support to establish the necessary infrastructures and for which the legal prerequisites must be in place. Equally important are tailor-made funding instruments with transparent, unbureaucratic application procedures and funding regulations.

Ultimately, what is needed is to create a new policy framework that gives all stakeholders greater ability and scope to act – the aim being to work with civil society to develop problem-solving capabilities that can be used to tackle in a confident and concerted way the complex challenges of our times, each of which are set out in the 17 UN Sustainable Development Goals.

### Institutional Anchoring

All TU9 Universities have …

- overall **institutional transfer strategies**, in which goals and implementation measures are defined;
- **target agreements** for transfer and cooperation with external parties;
- **central transfer units** that support and accompany researchers and inventors from the idea to its implementation;
- the focus area "Transfer and Innovation" represented in the function of a **full member of the university management**.

## BASIC & APPLIED RESEARCH

### Basic Research in Engineering

**49 %**
**(787.7 million €)**
of third-party funding by the DFG in engineering[1]

### Research & Development (R&D)

**28.7 %**
**(1,351.8 million €)**
of R&D project funding by the Federal Government[2]

### Cooperation with Industry

**58.7 %**
**(167.1 million €)**
of AiF project funding in the format IGF[3]

## INNOVATION & TRANSFER

### Intellectual Property

**approx. 100**
new IP-license agreements[4]

### Inventions

**800+**
registered innovations (taken up & released)[5]

### Patents

**up to 400**
patent applications claiming priority[6]

## ENTRE-PRENEUR-SHIP

### Startups & Spin-offs

**approx. 300**
filed in the commercial register or with the trade or taxation authorities[7]

### Events

**approx. 500**
entrepreneurship workshops, presentations & evening events[8]

### Startup & Spin-off Initiatives

**850+**
supported startup & spin-off initiatives[9]

## NETWORKS

### Hubs of International Cutting-Edge Research

**21**
**out of 57 Excellence Clusters (37%)** under the German Excellence Strategy[10]

### Innovation Networks of Tomorrow

**11**
**out of 14 Zukunftscluster (79%)** of the federal funding format "Clusters4Future"[11]

### Innovation Ecosystems

**10**
**out of 15 Spitzencluster (66.6%)** of the federal funding format "Spitzencluster"[12]

### National Research Data Infrastructures (NFDI)

**13**
**out of 19 NFDI consortia (68.4%)** with overall 57 TU9 participations[13]

# TU9 Facts & Figures
## Research & Innovation

RWTH AACHEN

# New Platform for Pioneers

Zero-emission race car: In developing new models for the annual Solar Challenge, Team Sonnenwagen students can rely on Collective Incubator support. Looking ahead to the team's next success (from left to right): Johannes Schäfer from the Collective Incubator, Lina Schwering (Team Sonnenwagen), Professor Malte Brettel, Vice-Rector for Industry and Business Relations, and David Beumers from the Collective Incubator.

**Early morning in the North-African town of Merzouga. A desert storm threatened to bury the three-wheeled catamaran under a thick layer of sand. So as not to jeopardize optimal power supply on the day before the final, the members of Team Sonnenwagen Aachen helped protect the vehicle's four-square-meter panels of silicone solar cells. Later, creative solutions were called for to stabilize the rear wheel suspension. Efforts were duly rewarded with a picturesque scene as the sun rose above the sand dunes and a caravan of camels trotted by.**

The highs and lows described in the Solar Challenge Morocco 2021 blog represent the innumerable challenges involved in the five-day long-haul race across the Sahara and the Atlas Mountains. Two years of development work, more than six years of experience, support from large-scale sponsors, and outstanding engineering precision paired with smart software and strong team spirit are what make up the Covestro Photon, designed and built by a student association of RWTH Aachen University and FH Aachen University of Applied Sciences. With this third-generation of their zero-emission race car, the team produced a model sustainable mobility project – and secured fifth place in a competition where getting as far as the finishing line is the only thing that counts.

What the example of Team Sonnenwagen Aachen also shows is that forward-looking student-led initiatives don't have to be startups to become models for replication. This is the approach also taken by the Collective Incubator, a new cross-format funding program launched by RWTH Aachen, complete with the provision of co-working facilities and dedicated MakerSpace. It targets all of the 47,000 plus students at Germany's largest university for technical studies. With a budget of €23.3 million financed by the Exzellenz Start-up Center.NRW run by the NRW State Ministry of Economic Affairs and allocated for the period to 2024, the platform was created to promote the development of new technologies and spark ideas, be they commercial business startups or social innovations.

The strategy is to bring students into contact with researchers in different disciplines and with companies at an early stage, thereby laying the cornerstone for the biggest tech incubator in Europe. The dedicated Campus Jahrhunderthalle was specially created on the site of a former electronics


**CONTACT**

RWTH Aachen University
Thorsten Karbach,
Head of Department 3.0 –
Press and Communications
Templergraben 55
52056 Aachen, Germany
» thorsten.karbach
@zhv.rwth-aachen.de
» www.rwth-aachen.de

factory in Aachen. There, the teams have free, 24/7 access to rooms, workshops, and a film and sound studio spread across some 4,000 square meters of space. "We welcome not just people wanting to finalize their business plans, but also those who don't have a specific idea but want to get involved in a project by inputting their knowledge and expertise," says David Beumers, Collective Incubator Co-Founder and Managing Director. That the program is a resounding success can be seen in the fact that within just a short space of time, the community boasts more than 150 startups and student initiatives, and is one of the biggest of its kind in Germany.

**The Collective Incubator: a platform for social innovations – and commercial business startups**

The Collective Incubator, which is 50% managed by the students themselves, focuses on their interests and career aspirations, says Beumers, an industrial engineer. The many talents that make up the Collective Incubator are equally interesting for industry. As Beumers explains: "With the increasing lack of skilled workers, more and more companies are turning to us to make contact with young talents and future graduates at an early stage." This is something the Incubator has the university's reputation to thank for – according to current rankings, a degree from RWTH Aachen puts you among the most attractive graduates in the eyes of German employers.

RWTH's excellent reputation is partly the result of its numerous successful spin-offs. "The tried and tested ecosystem on the RWTH Aachen campus creates the conditions needed for the transfer of knowledge to society, and it's enriched by the Collective Incubator in a very interesting and exciting way," says Professor Malte Brettel, Vice-Rector for Industry and Business Relations at RWTH Aachen University. Support in forming spin-offs is offered by the RWTH Aachen Incubation and Innovation Sprint programs, both of which were developed by RWTH Innovation. In these programs, students acquire entrepreneurial skills, connect with potential investors and receive financial support for use in prototype construction.

**A circular economy contribution: Voltfang is giving retired electric car batteries a second life**

The program certainly benefited startup company Voltfang, which caused a sensation with its technology based on using retired electric car batteries. At RWTH Aachen, Voltfang's three-strong startup team developed special storage modules. Re-using these second-life batteries enables resources like lithium and cobalt, which occur in battery production, to be saved. Contributing to the circular economy is the company's ultimate aim. Anna Maria Jonas, Head of Sustainability at Voltfang, explains: "The increasing global demand for e-vehicles and stationary power storage systems calls for vast amounts of raw materials which negatively impact the lives of people living near the extraction sites and also harm the environment. Our lower-cost, efficient electricity storage system delivers clean energy and independence."

At RWTH Aachen, a whole range of similar approaches, not least those coming out of the Collective Incubator, are being used to address scenarios for the future. Rising to the challenge of finding solutions in the face of overstretched cities and growing e-commerce sales, startup Urban Ray is taking parcel logistics into the third dimension – and offering deliveries by air. After prototype construction was sped up thanks to the RWTH Aachen Innovation Sprint, the team won the German section of the NASA/DLR Design Challenge 2020. Other promising startup teams from RWTH Aachen's ecosystem are now waiting in the wings.

## Three Questions for …

# Ulrich Rüdiger

**Rector RWTH Aachen**

**In what research areas is RWTH Aachen especially strong when it comes to major challenges like digitalization, climate change and energy transition?**

In matters of sustainability, RWTH Aachen has developed a completely holistic view. Our profile disciplines help in tackling the technological, environmental, economic and socio-ethical challenges faced. The aim of our research networks has always been to bring about sustainable social change.

**In what ways does RWTH Aachen stand out from the competition?**

The RWTH Aachen campus is an exceptional environment where research, teaching and transfer cooperate as part of an integrated approach. Entrepreneurial thinking and collaboration with industry partners are promoted in equal measure. This creates a unique ecosystem where big ideas and future-focused visions can be pursued. With the Collective Incubator, we afford our students the broadest-possible scope in which their ideas can develop and unfold.

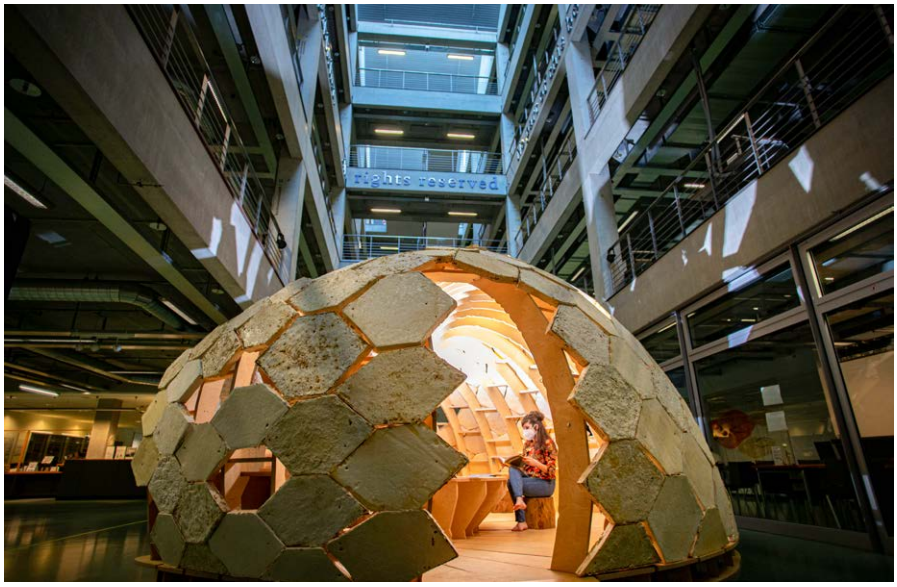
**Participative science, which is designed to familiarize society with the findings of basic research, plays an increasingly important role in university life. What is your experience so far?**

Technological, social and cultural change are closely interlinked. At RWTH Aachen, we created the Human Technology Center – or HumTec – to open a new chapter in convergent research involving natural, technology and life sciences, and humanities, social and spatial sciences. Living labs are visible components of our approach.

TU BERLIN

# Fungal Architecture and POP Farms

**What does living in homes made of fungus have to do with the future? How can these microscopic lifeforms help us switch to more sustainable lifestyles? And what role does the world of mycology play in the bioeconomy trend? These and other questions are the focus of MY-CO SPACE, one of more than 20 living labs in the center of Berlin that are sparking a knowledge-to-action shift.**




A new place for people seeking peace: MY-CO SPACE, a walk-in fungal sculpture has become a popular retreat in the university library at TU Berlin. Developed by the Berlin University of the Arts (UdK), the wood construction encased in panels of fungus represents sustainable yet utopian living and housing forms, and in its current location offers students a quiet place to work. It was designed and built by artist and scientist Vera Meyer, Head of Applied and Molecular Microbiology at TU Berlin.

Acting as an interface between Technische Universität Berlin and the local population, the TU-StadtManufaktur initiative provides the platform for transdisciplinary projects of this kind. The idea is to create public spaces where the people of Berlin can exchange information on new scientific findings and bring in other topics they believe are relevant in the research field.

TU Berlin, a university of excellence and part of Germany's unique Berlin University Alliance, focuses on six areas of research. In addition to digital transformation, photonics and optics, and strategies to prevent age-related disease, they take in issues surrounding energy, mobility and sustainability – all of which are reflected in the StadtManufaktur living labs, be it strategies for climate change adaptation, promoting social cohesion and sustainable urban planning, as with MY-CO SPACE.

Visitors are treated to a walk-in sculpture whose outer casing is made from a fungal plant composite. This is based on a regionally-available fungus that was first cultivated in the laboratory on plant waste taken from the Berlin-Brandenburg agriculture and forestry sector. In a second step, its various components are digitally enhanced to ensure that the fungus demonstrates optimal load-bearing traits. This gives rise to robust but extremely light composite materials which can gradually be assembled to form a hollow sculpture. The project was initiated by Vera Meyer, Head of Applied and Molecular Microbiology at TU Berlin, who sees a great future for these new materials: "When climate change, rising sea levels and thereby migration shape our everyday lives, compostable homes made from fungi could well be a utopian answer to the challenges we face." For two decades, the artist and professor focused her work on mold fungi as potential producers of medicines, platform chemicals and biofuels – that is until she discovered innovative composites

**CONTACT**

Technische Universität Berlin
Stefanie Terp, Head of the Office of Communication, Events and Alumni/
TU Berlin Spokesperson
Tel.: +49 (0)30 314-23922
» pressestelle@tu-berlin.de
» www.tu.berlin
@TUBerlin
#TUBerlin

TECHNISCHE UNIVERSITÄT BERLIN

five years ago. Regrettably, it isn't widely known that sustainable furniture, clothing and building materials can be made from fungi, says Meyer, and nor is the ability of fungi to metabolize waste proteins and fat. It is thus all the more important that experiential lab learning spaces like MY-CO SPACE are created as part of the TU-StadtManufaktur in Berlin. As Meyer explains: "The more academic knowledge is made public and shared, the better people will be equipped to drive social transformation."

## Compostable fungal homes: utopian ideas for sustainable living

This is an aim also served by POP KUDAMM, a new pop-up art and culture venue near Kurfürstendamm in Berlin City West that is making urban development experienceable in a creative way. As the official cooperation partner, the TU-StadtManufaktur uses things like the POP Farm to showcase a prototype for urban infrastructure planning. The farm is the product of the living lab on mobile blue-green infrastructure and documents a future-focused form of local food production – a water cycle is used to grow salad, herbs and vegetables that are fed with nutrients, grow vertically and survive entirely without soil. Given their light weight, these vertical farms are especially suited to urban farming solutions that are integrated into building designs, says Dr. Anja Steglich, Project Manager of TU-StadtManufaktur Berlin. For POP KUDAMM, the site in the middle of one of Berlin's busiest shopping streets was deliberately chosen and a partnership was sought with a real estate developer and an international network of artists and creatives. The incentive behind the initiative, says Steglich, was to take discourse on urban development out of the academic arena, make research findings experimental and transparent, and test and develop those findings jointly with members of urban society. "For example," she adds, "to spark conversation with visitors and gather their questions, the POP KUDAMM restaurant uses vegetables and herbs from the farm." The goal of transferring knowledge to society and thereby initiating change is one also pursued by the research group EXPERI – *Die Verkehrswende als sozialökologisches Realexperiment* (The Transport Turnaround as a Socio-Environmental Challenge), which is headed by Julia Jarass from the Institute of Transport Research at the German Aerospace Center (DLR). The project partners are TU Berlin and the Institute for Advanced Sustainability Studies (IASS) Potsdam. One of the central questions is how can walking and cycling be promoted, and the quality of time spent in urban space improved. These are aims that stem from the Berlin transport turnaround and have led to the creation of pop-up cycle paths. Another live experiment was launched at a crossroads in Charlottenburg where a section of the road has been declared car-free since 2020. Wooden platforms, raised flower beds and urban furniture are also planned. These ideas are the results of household surveys and dialogue with residents who become actively involved in redesigning urban space to make the area outside their homes more livable, says Jarass: "It's just one example that highlights the important role that participation plays in urban development and planning."

## Participative urban development: driving the transport turnaround – and not just in Berlin

## Three Questions for …

# Geraldine Rauch

**President, Technische Universität Berlin**

**In what research areas is TU Berlin especially strong?**

We have repeatedly taken up current social issues, responded quickly and created flexible structures. That's how we came to create new professorships with the Einstein Center Digital Future 50. We've established one of five national AI centers and have a very successful mathematics department. We are also providing valuable input with the chemistry cluster as part of the excellence initiative. Climate economics and sustainable mobility are among our lighthouse projects.

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research is done at TUs?**

We are leaders in transdisciplinary research. This speeds up the transfer of science to society, makes it more sustainable and opens up new ground. The transdisciplinary approach also increases acceptance among everyone involved. And it flows into teaching. In addition to science conducting transformational research, science itself must change and take up ideas from outside.

**Participative science, which is designed to familiarize society with the findings of basic research, plays an increasingly important role in university life. What is your experience so far?**

It's a core component of our transfer strategy. We use our expertise in its execution and also as part of the Berlin University Alliance. In doing so, we send out an important message that says we are ready for and open to change.

# Self-initiative as a Path to Transformation

**The idea behind "Hey, Alter!" was convincing to say the least. It involved taking old PCs, laptops and tablets from companies and private households, installing new software and giving them to school children in low-income families so they could join in lessons online.**


Sustainable knowledge transfer: "Hey Alter!" provides fast and simple help to school children with no access to electronic devices. And by upgrading used laptops and tablets, the initiative gives them a second life.

With the devices duly delivered, the initiative sparked 32 offshoots across Germany and was recognized with numerous accolades such as the Lower Saxony Award for Civic Engagement and the Braunschweig Prevention Award. It's a success story that owes a lot to the "Sandkasten" headquarters from which the "Hey, Alter!" initiative grew. It's seen as the futures workshop of the "University of the People" initiated in 2015 by the governance board of Germany's largest TU. The aim is to step up knowledge transfer to urban districts using the lever of participative formats and using the "Sandkasten" as its showpiece. A total of 140 of these voluntary social projects were conducted in the period to 2020. Some involved making face masks for staff in social institutions, others opened up new spaces for the city's almost deserted cultural scene. Among the 15 campaigns currently underway is a swap shelf filled with model-making materials, a "nursing bar", the creation of a biotope in a small neighborhood park, and a weekly organic market to be held on the university campus itself. Six trainee teachers are also planning to run a free blog, providing new learning tools to help 10th graders in Lower Saxony graduate from school.

What the projects all have in common is the notion of promoting self-initiative and reshaping the local environment in line with the 17 UN Sustainable Development Goals. This calls for creative ideas that students and university staff submit online and for which they must attract a critical mass of "fans" – people with similar interests who support their do-it-yourself campaign. A team of full-time staff and student assistants are also on hand to provide assistance and advice. The decision on whether a project is accepted and funded is made by a committee comprising representatives from the Students' Union (AStA), the campus community, facility management, the Institute of Landscape Architecture, the Institute of Geoecology, and an external consultant from the City of Braunschweig administration.

**CONTACT**

Technische Universität Braunschweig
Press and Communications Office
Tel.: +49 (0)531 391 4125
» presse@tu-braunschweig.de
» www.tu-braunschweig.de

Technische Universität Braunschweig

**Voluntary, social, trendsetting**

It's a similar process to the one applied in research, says Saskia Frank, Co-Head of Transfer and Cooperation: "The idea is to pose relevant questions, generate ideas, develop projects, and find cooperation partners. These are all skills that can be acquired by signing up to "Sandkasten" initiatives." And, as Frank continues, this is the "research lifecycle" that is also used to consolidate academic knowledge in a way that it can be used in the public sphere and aid social transformation: "For us, transfer calls for a bottom-up approach and broad-based interdisciplinary collaboration. At Technische Universität Braunschweig, where engineering and natural sciences are closely linked with economics, social sciences, humanities and education, the conditions are ideal."

## Three Questions for …

# Angela Ittel

President, Technische Universität Braunschweig

**In what research areas is Technische Universität Braunschweig, which you head as President, especially strong when it comes to major challenges like digitalization, climate change and energy transition?**

The cross-discipline core research areas of mobility, future cities, infection and therapeutics, and metrology consolidate our expertise in an interdisciplinary approach. Our strategy in ensuring holistic university development takes in digitalization, internationalization, equality, diversity and sustainability. We can thus draw on a strong research profile when tackling and finding solutions to the global challenges being faced.

**Participative science, which is designed to familiarize society with the findings of basic research, plays an increasingly important role in university life. What is your experience so far?**

We want to make research findings tangible. Systematic, targeted interaction with members of broad society provides a source of inspiration, brings the campus to life and reminds us of our responsibility to shape our goals in a way that they benefit society overall.

**What would you like to see from policymakers to ensure that the TU is better positioned institutionally to meet the challenges faced in the future?**

Innovative top-class research calls for ongoing investment in infrastructure and staff. Long-term, reliable cooperation is essential – especially in a world of rapid change and constantly increasing challenges.

# Catalyst for Unorthodox Solutions

**E-mobility's environmental footprint gives rise to many questions – not least in terms of the raw materials contained in batteries. What to do with valuable resources like graphite, electrolyte, manganese, copper, aluminum, lithium, nickel and cobalt? And how can these precious metals and minerals be fed back into the recyclable materials loop with minimum loss?**


Going against the flow: Thanks to an unconventional method that enables both carbon-neutral recycling of lithium-ion batteries and recovery of valuable resources, the Duesenfeld startup promises clients an "environmental footprint second to none".

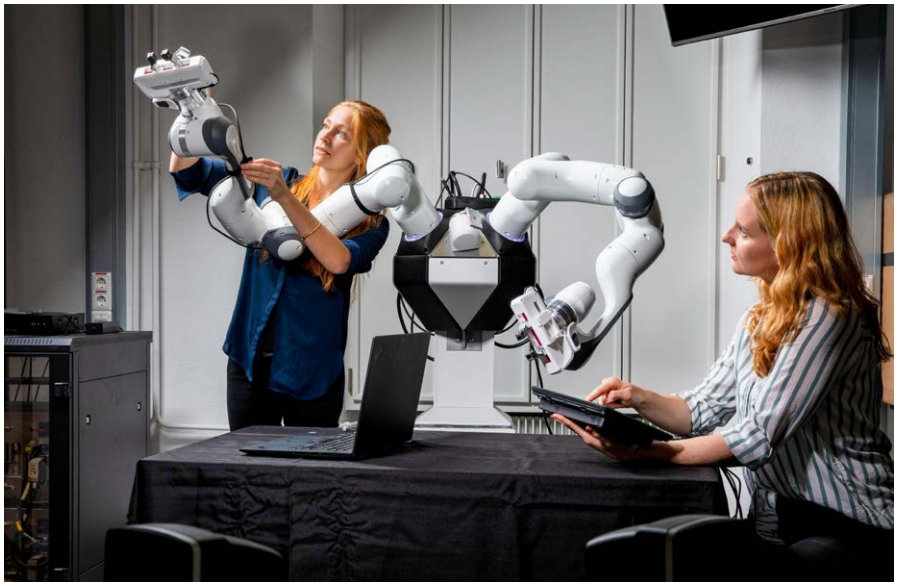
In tackling this complex recycling issue, the company Duesenfeld GmbH in Wendeburg, Lower Saxony, came up with a patented solution. Crucial to this are a vacuum process and a low-energy method that can be used to recover electrolyte solvents, graphite and lithium in addition to the remaining metals. In conventional recycling, the batteries are heated to such high temperatures that the electrolyte solution evaporates, resulting in a heavy carbon footprint. "Our method is very environment friendly, because we recycle the lithium-ion batteries in a carbon neutral way," says Julius Schumacher, Head of Project Management at Duesenfeld, which instead of creating their own facilities, sells licenses to the makers of batteries and cars.

**Be it basic research or founding a startup, the will to explore new ground is a key factor for success.**

The startup, founded in 2007, goes back to a cooperation with Technische Universität Braunschweig that saw the first laboratory-scale processes developed as part of the LithoRec joint venture project funded by the Federal Environment Ministry (BMU), says the industrial engineer: "What we have to thank Technische Universität Braunschweig for most is the willingness to explore new ground." Schumacher believes that, coupled with a strong interdisciplinary approach, it was that ability to think out of the box that paved the way for the company's success. Because the innovative yet unorthodox recycling method goes against the flow of mainstream recycling thinking, the startup has repeatedly come under fire. One recurring question they hear from customers, says Schumacher, involves exhaust air purification, which he admits can be a problem where recycling is concerned. But, as he explains: "What many people don't realize is that our process eliminates both the production of toxic gases and the emission of hazardous hydrofluorocarbons, giving you an environmental footprint that's second to none."

TU DARMSTADT

# Cooperation between Equal Partners



Intelligent autonomous systems: AI research at TU Darmstadt.

**The scenario for urban energy transition in Darmstadt seems plausible in theory: "All that's needed," says Martin Beck, Coordinator of the DELTA research project, "is to assess for each district how much energy of which type is needed for which buildings and companies in order to plan how the grids can be made more effective, more flexible and more climate friendly."**

But before it could be put into practice, there were a lot of unanswered questions that needed to be addressed. What kinds of infrastructure were needed? What transport models? And can property owners and tenants be included in the transformation? "There's no single answer to any of those questions," says Beck. But while the DELTA research project certainly has its complexities, it's full of promise, too. The DELTA team expect annual carbon savings of around 14,000 tons. DELTA is one of 20 winners in the "Living Labs for the Energy Transition" competition run by the Federal Ministry for Economic Affairs and Climate Action (BMWK). It's designed to enable the transfer of research into practical applications for broad use via exchange and knowledge transfer which in Darmstadt is described as "xchange". TU Darmstadt acts as the coordinator for the "Darmstadt Energy Laboratory for Applied Technology" (DELTA), which has its roots in construction and environmental engineering, and mechanical engineering. The mostly regional project partners are startups, SMEs, industry, and city utilities which have shown themselves to be innovators in this field. The close links with business and industry, policymakers and society along with dialogue and exchange across disciplines and sectors are characteristic of the approach taken at TU Darmstadt – as one of the leading German universities in terms of patent applications and spin-offs, the engineering sciences, which account for 50% of the subjects taught, work closely with the natural sciences, humanities and social sciences. This interdisciplinarity also plays a key role at the Hessian Center for Artificial Intelligence (hessian.AI), which is based at TU Darmstadt.

The DELTA project rests on the assumption that implementing energy efficiency measures to meet climate targets ideally starts with cities, where energy density and complex energy flows enable large savings to be made. The strategy involves connecting the various districts up via the energy grid, introducing sector coupling, and establishing hydrogen as an energy carrier. As a reference, DELTA uses TU Darmstadt's ETA-Fabrik project, from which the company ETA-Solutions GmbH emerged as a spin-off. One of its managing directors is Martin Beck. As the 38-year-old industrial engineer explains, in


**CONTACT**

Technical University
of Darmstadt
Jörg Feuck, Head of
Communications Unit,
Science Communication
Centre
Karolinenplatz 5
64289 Darmstadt, Germany
» joerg.feuck@tu-darmstadt.de
» www.tu-darmstadt.de

TECHNISCHE
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this dual role, he can draw on his expertise as an energy consultant to industry to scale best practices for local scale use. Be it machine or facility construction, building planning or municipal energy grids, the approaches used are similar. "In the beginning, it's a matter of identifying unused efficiency potential such as waste heat that can be used to supply energy elsewhere. Using efficient technology, that waste heat can then be used to cover other types of demand, such as to provide heat in residential buildings. That in turn effects a reduction in the use of fossil fuels."

Ultimately, DELTA wants to be able to offer such complex engineering services to municipalities like Darmstadt in the future. Because a large number of towns and cities have declared their intention to become climate neutral by 2035, says Beck, models are needed that are tailored to urban needs. Plus, restructuring municipal energy grids requires that all stakeholders be involved. To achieve both these goals, Beck believes the initiator should have no designs on achieving financial gain: "Only public research institutions like TU Darmstadt enjoy the degree of credibility and have the expertise to initiate transformation on this kind of scale."

**Implementing energy efficiency measures to meet climate targets ideally starts with cities.**

TU Darmstadt's aspiration to make its innovation ecosystem more collaborative and more sustainable is reflected in its "IP for Shares" program – an innovative participation approach jointly developed with HIGHEST, TU Darmstadt's own innovation and startup center. This sees the university transferring rights to its intellectual property and receiving either digital or real shares in a company in return. "With the TU as a shareholder, we can use the results of my 18 years' research to develop our startup free of charge," says Professor Markus Roth, Chief Science Officer at Focused Energy. His team is exploring how nuclear fusion powered by high-tech lasers can supplement the sustainable energy mix. Their plan is to build a prototype fusion facility by the end of 2028. "It can supply virtually unlimited quantities of clean, safe electricity in the gigawatt region and provide industrial heat without the risks from nuclear power plants," says Roth. To develop this "scientific breakthrough" yet further, a financing round of €150 million is planned. "If we ever have the kind of success seen with Google and BioNTech, it would also pay off for TU Darmstadt," emphasizes Roth. That such a scenario is not improbable can be seen in the worldwide interest shown in the company located in Darmstadt and the US. Recently, the team had been invited to talks at the White House and in the Capitol, meeting with influential senators, says Roth: "As soon as we're able to combine the support from large-scale research laboratories and universities with the speed and flexibility of a startup, we'll reach our goal far faster. What we need to remember is that climate change isn't going to wait till we get where we need to be."

**Research labs, universities and startups are cooperating to accelerate technology.**

## Three Questions for …

# Tanja Brühl

**President, TU Darmstadt**

**In what research areas is TU Darmstadt especially strong when it comes to major challenges like digitalization, climate change and energy transition?**

We have consolidated our top research in three research fields – information and intelligence, matter and materials, energy and environment. In joint projects, we address topics such as AI, synthetic biology and energy storage. In our interdisciplinary research we ask questions that are relevant today to generate ideas that can be put to use tomorrow.

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research is done at TUs?**

Innovations stem from solution-focused, interdisciplinary cooperation. We're intensifying exchange and networking with local partners, as a leading member of the European University Alliance Unite! – and also worldwide. Our innovative teaching-learning settings combine online components with face-to-face interaction. As a widely networked university, we want to communicate in a future-focused way.

**What would you like to see from policymakers to ensure that the TU is better positioned institutionally to meet the challenges faced in the future?**

Technical Universities that are strong in research are driving innovative ecosystems. Stepping up the Federal and state funding they receive creates added value for all. Cooperation partnerships between universities call for well-founded legal provisions, both in Germany and especially where European alliances and networks are concerned. New (funding) models should be developed jointly with the universities themselves.

TU DRESDEN

# Mutual Learning at the Human–Robot Interface

**Be it practicing surgical skills online or wearing a data glove to identify and independently correct an awkward grip on an instrument – the ways in which smart textiles or wearables will help us learn from one another in the near future is something being explored by a 50-strong research team at the Center for Tactile Textiles with Human-in-the-Loop (CeTI), one of three Clusters of Excellence at TU Dresden (TUD).**

The human-robot interface: Be it robotics, bioelectronics or smart textiles, the ways in which everyday life will be increasingly controlled by smart systems are being explored by researchers at the CeTI Cluster of Excellence at TUD.

The team is led by Frank Fitzek, holder of the Deutsche Telekom Chair of Communication Networks (the ComNets Chair). CeTI is where knowledge from the fields of electronics and communications systems, computer science, psychology, neuroscience and medicine comes together. As Professor Fitzek explains, their research looks at the conditions under which people perceive grasping a hot coffee cup in the virtual world as real and, conversely, how human priorities might be made assessable for machines. "AI must be able to decide what's more important: initiating the braking process in a car or not disrupting the power supply to enable the kids to carry on watching YouTube videos." CeTI embodies the "Dresden Spirit" – the "thirst for interdisciplinary dialogue" is one of the high-tech eastern German city's secrets for success.

The digital world of the future will be controlled by smart systems and these are currently being explored in Dresden – at Europe's largest microelectronics hub. And at the center of that research is TU Dresden, a University of Excellence that is a symbol for spin-offs that have found success.

Wandelbots is one of them, a highly sought-after startup that attracted both Microsoft and Siemens as investors. It was founded by TUD graduates who had the revolutionary idea of developing a handheld device to give robots instructions using gestures – no programming knowledge needed. "With the current lack of skilled workers, we need to look ahead and see where deploying robots makes sense," says Co-founder Maria Piechnick. By way of example, the media communications graduate cites monotonous, time-intensive tasks such as dispensing water and towels in healthcare. The 34-year-old says the company, which now boasts 160 employees and raised USD 84 million in the last financing round, largely attributes its breakthrough to the practical approach taken by TUD's Chair of Software Technology. "That's where we learned that good ideas have to be sold and why establishing good contacts in the venture capital arena is a wise approach."


**CONTACT**

Technische Universität Dresden
Marion Schmidt, Chief Communication Officer
Tel. +49 (0)351 463-40670
» cco@tu-dresden.de
» tu-dresden.de

TECHNISCHE UNIVERSITÄT DRESDEN

Everyday routine: instructing robots using gestures – no programming knowledge needed

Regrettably, finding someone with a talent for both science and entrepreneurship is rare, says professor Karl Leo. The widely acclaimed physicist and Chair of Optoelectronics at TU Dresden has founded a wide and varied range of companies over the course of his career, ascribing success to courage. "The only bad spin-off is one that was never started." So, what kinds of challenges is the bioelectronics pioneer grappling with right now? Repairing brain damage with the aid of biocompatible electronics, he replies. "And how to ensure that the components break down in the body without leaving any traces of residue behind."

## Three Questions for …

# Ursula M. Staudinger

**Rector, Technische Universität Dresden**

**In what research areas is TU Dresden especially strong when it comes to major challenges like digitalization, climate change and the energy transition?**

At TU Dresden, digitalization for and with people comprises research ranging from complex materials, systems engineering and AI to latency-reduced communication for robotics of the future and digital disruption. Another example involves research into the circular economy as an indispensable component in climate action and responsible use of resources.

**Participative science, which is designed to familiarize society with the findings of basic research, plays an increasingly important role in university life. What is your experience so far?**

Very positive. As a university, we assume an important role in society – one that we shape actively. For example, we bring our "POP-UP KNOWLEDGE" project to the people directly – to places like the Lusatia region and the Kulturpalast in Dresden. It's been really well received.

**What would you like to see from policymakers to ensure that TU Dresden is better positioned institutionally to meet the challenges of the future?**

More courage of conviction and less bureaucracy. To be competitive in the global market, institutional cooperation between universities and non-university research institutions should be made easier. We believe that with our DRESDEN-concept research alliance, we're well equipped to explore new paths.

TU DRESDEN

# Making the Microchips of the Future

**How can electronic systems be developed in Europe that help to dramatically reduce energy use?**

Cooperation in the microchip development lab: Founded under the leadership of Thomas Mikolajick, the Nanoelectronics Material Laboratory (NaMLab) – a spin-off from TUD – has become one of Germany's most renowned semi-conductor companies.

With microelectronics seen as a key industry in combating climate change and given the worldwide shortage of chips, it's questions like this that Thomas Mikolajick and his NaMLab team are currently taking to task. Founded in 2006 as a university-industry joint venture, the Nanoelectronics Material Laboratory (NaMLab) ranks among the most innovative companies in Germany, and Mikolajick surmises that its success probably boils down to his dual function as Scientific Director at NaMLab and Professor of Nanoelectronics at Technische Universität Dresden (TUD). "On campus, we collaborate on lots of different projects. Both sides benefit from the available infrastructure and don't have to create it all from scratch."

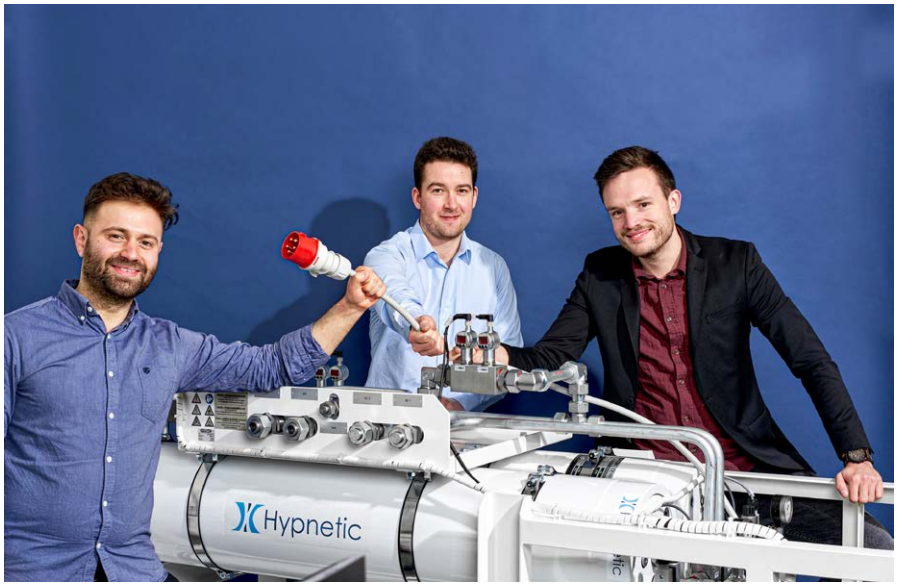
**A key industry in combating climate change: microelectronics from "Silicon Saxony" – europe's largest high-tech cluster**

The countrywide cooperation is driven by ForLab. TUD heads one of the 12 "German Microelectronic Research Laboratories" and coordinates the overarching organization. Dresden also benefits from collaboration between science and industry in "Silicon Saxony," Europe's largest microelectronics cluster. Although for decades, semiconductor technology has successively miniaturized transistors to make integrated circuits cheaper, faster and more energy-efficient, advancement is no longer possible using miniaturization as the lever. "But the aim is still to increase energy efficiency, reduce costs and either retain or improve processing speed," says Mikolajick, adding that "chameleon transistors" show great potential. These can be switched back and forth between electronic and hole conduction, enabling the same components to perform different functions at different times. This is a research area in which NaMLab benefits greatly from TUD's long-standing tradition of research excellence. Another groundbreaking innovation involves ferroelectric materials and components. "Here, the focus is on storing and processing information in the same place," says Mikolajick. "With sustainability in mind, the aim is to manufacture the most energy-efficient microchips we can."

LEIBNIZ UNIVERSITY HANNOVER

# Showing the Way in Sustainable Energy Storage

**Given the increasing global energy demand, what must energy storage systems look like to be able to provide vast quantities of power in a short space of time? This is the question the team at Hypnetic took to task. The company is attracting a lot of attention with an efficient storage system that saves on cost, energy and resources.**




Sustainable storage systems seen as a safe bet: Startup Hypnetic, a Leibniz University Hannover spin-off, promises a massive gain in efficiency, security of supply and pollution reduction.

The innovation from the startup founded in 2019 is a modular pump storage system that uses high pressure in place of potential energy and is packed inside a container – all made possible through heat recovery aided by a phase change material (PCM).

Should Hypnetic succeed in making a large-scale contribution to the energy transition, it will in part be thanks to Alexander Börgel's enthusiasm for optimization, which played a major role during his time at Leibniz University Hannover. There, in addition to the focus on cross-disciplinary clusters of excellence, the key research areas include production technology, biomedical research and technology, quantum optics and gravitational physics, Interdisciplinary Studies of Science, and optical technologies.

After the 28-year-old co-founder of Hypnetic had completed his bachelor's degree in mechatronics and founded his first company, Voltark, he decided to switch disciplines, adding a Masters in energy technology to his qualifications in 2020. The Institute for Electric Power Systems (IfES) was the perfect choice: "This is one of the few universities that offers energy storage as a separate subject," he says. What had also convinced him in making his choice was the great focus on practical relevance – in the form of lectures on subjects like Technology Startup Basics and the Student Accelerator Tutorial. These show the startup teams how to develop and finalize their business ideas, from initial prototype to business plan. Moreover, to cover initial expenditure, each startup receives an innovation voucher worth €4,000. Additional programs like the EXIST Startup Grant saved Börgel and his team a lot of time and financial worry: "After we graduated, we were all able to just continue working on our idea full-time."

How their efforts have paid off can be seen in Hypnetic's pioneering energy efficiency role. With 72% efficiency, their technology surpasses available systems by 15%. Plus, Hypnetic storage systems can be loaded and unloaded


**CONTACT**

Leibniz University Hannover
Mechtild von Münchhausen,
Head of Communications
and Marketing/Spokesperson
Welfengarten 1
30167 Hannover, Germany
Tel. +49 (0)511-762 5355
» vonMuenchhausen
@zuv.uni-hannover.de
» www.uni-hannover.de


Leibniz Universität Hannover

**Essential in education: practical relevance, and energy storage as a subject being taught in its own right**

up to 100,000 times. "That's the biggest advantage compared with lithium batteries, in which storage cycle only allow between 6,000 and a maximum of 10,000 times," stresses Börgel. One big challenge they face this year, says the startup founder, is constructing a pilot project for a wind farm. But it's not only solar and wind farm operators that can benefit from greater security of supply and pollution reduction. Tradespeople and businesses that generate their own electricity from solar or wind power also stand to benefit, he adds: "A side-effect of our technology is that the use of solar and wind power is rendered more reliable, making it more attractive to companies large and small."

## Three Questions for …

# Volker Epping

**President, Leibniz University Hannover**

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research is done at TUs?**

Challenges must be shaped and driven. The abrupt switch to online teaching during the pandemic will change the way we teach now and in the future. The shift to online forms of communication is transforming how we collaborate across all areas of the university.

**Participative science, which is designed to familiarize society with the findings of basic research, plays an increasingly important role in university life. What is your experience so far?**

It's crucial that as citizens, we all engage with the findings of science and research, and that we voice our own opinions and views so we can shape society together. It's important to boost scientific knowledge and ability within the overall population, not least in response to the antidemocratic forces among us and the trend towards misinformation.

**What would you like to see from policymakers to ensure that the TU is better positioned institutionally to meet the challenges faced in the future?**

Education and science are the success factors that will drive Germany's future development and its standing in the global market. Investment in the science sector must be stepped up, among other things, to continue attracting top researchers from abroad and uphold the university's ability to compete as an institute of higher education.

LEIBNIZ UNIVERSITY HANNOVER

# Improving Crop and Food Security

**It's a challenge of global scale and one that threatens the lives of millions of people worldwide. Almost one-third of crop plants fall victim to pests and disease. With farmers having little option than to use vast amounts of pesticides, the idea of a mobile crop doctor app was born. By sending a picture to Plantix, users receive a crop diagnosis along with "useful treatment tips", says Pierre Munzel, CFO at PEAT GmbH.**

Remote diagnosis via app: Thanks to Plantix, the world's most widely use crops diagnosis app, farmers can avoid the risk of losing an entire crop. Be it pests or disease, they get free advice on damage limitation.

"The aim is to prevent excessive, incorrect use of pesticides by enabling the community to discuss effective, sustainable alternatives." With four million users in 2021, Plantix is now the most widely used agriculture app and the biggest network of its kind.

In the beginning, the seven founders were driven by the need to improve food security, says Munzel. "But it soon became clear that smallholdings benefited most from automated crop identification because they are the most dependent on global yields." The company with 300 employees was founded in 2015 as a spin-off from the Institute of Soil Science at Leibniz University Hannover. There, the founders acquired expertise and also access to greenhouses so they could build up their image archive. As Munzel explains: "Initially, the biggest pain point was the lack of training data for use with our AI system." A series of citizen science projects became a key source of information, Munzel recalls. This included one with the Leibniz Centre for Agricultural Landscape Research (ZALF): "Suddenly, we were able to draw on a vast array of photos provided by hobby growers." Fast forward to 2022 and the self-learning Plantix software can now diagnose some 500 diseases and also nutrient deficiency in 50 crop species.

**Citizen science projects: vital sources of data for the world's most widely used agriculture app**

The app is especially popular in India, where PEAT merged with a local startup in 2020. This is hardly surprising given that 300 million people make their living from farming and mobile internet access is extremely wide spread. Despite farmers' initial skepticism, the PEAT team were able to win their trust – partly thanks to the doors opened by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), a branch of the United Nations. The startup is financed solely by investors and revenue from license fees. As the founders all stemmed from the NGO sector, they deliberately decided against commercial optimization of the app for use in the European market, says Munzel: "The fact the we give away our knowledge for free probably puts us more in the ranks of people trying to save the world."

KARLSRUHE INSTITUTE OF TECHNOLOGY

# Paving the Way for Agents of Global Change

Container-scale pioneers: With its widely acclaimed chemical reactor technology, INERATEC provides a reactor for sustainable fuel synthesis. It was developed with help from the Energy Lab 2.0, a high-tech research infrastructure at KIT.

**Making a global, widely acclaimed contribution to the energy transition is something many deep-tech startups dream of. But it's a dream come true for INERATEC, a spin-off from the Karlsruhe Institute of Technology (KIT) and a German power-to-liquid pioneer in transforming electricity and carbon dioxide into climate-neutral liquid fuels. When the four founders of the company that developed an innovative chemical reactor technology were recognized with the Next Economy Award 2022, a subcategory of the annual German Sustainability Award, the jury announced that the development of sustainable aviation fuel and of synthetic wax for the chemicals industry is essential in defossilizing these sectors, which are among the largest $CO_2$ emitters.**

"When we founded the company in 2016, we were seen as pioneers," says co-founder Tim Böltken, recalling the early days of the startup that was originally a KIT spin-off and now boasts 100 employees. "Today, the whole world is talking about sustainable fuels. They're embedded in the German Government's Coalition Agreement and are seen as a key component in efforts to meet the 2050 climate neutrality target."

At the end of 2021, INERATEC attracted huge attention having raised €20 million in foreign capital in its first financing round. Added to this comes its USP of 13 installed facilities so far. "The fact that we're the only company to have achieved such a large number gives us a certain competitive advantage," says the 37-year-old, who has a doctorate in chemical engineering.

But putting both pride and their global technology leader role aside, INERATEC owe their breakthrough to basic research performed at KIT. KIT is the Research University in the Helmholtz Association and as a University of Excellence, it has an outstanding reputation in computer science and in engineering and natural sciences. It is also one of Europe's largest research institutions for energy, mobility, and information sciences. Some 15 years of intensive development work at KIT preceded the discovery that green hydrogen produced from a mix of renewables-generated electricity and $CO_2$ extracted from the air can be used to produce synthetic products and fuels and make sustainable aviation fuel. It was on the basis of that discovery that INERATEC began operating as a KIT spin-off in 2016. There is huge demand in the long-haul air, ocean, and heavy transport sectors, where electric battery solutions are not a viable option, says Böltken: "Our technology opens up opportunities for these sectors to embrace carbon-neutral operations."

Among INERATEC's greatest innovations is an effective and modular container-scale technology. It was developed with the help of the Energy Lab 2.0, a high-tech infrastructure developed and established by KIT with


**CONTACT**

Karlsruhe Institute
of Technology (KIT)
Monika Landgraf, Head of
Corporate Communications
Kaiserstraße 12
76131 Karlsruhe, Germany
Tel. +49 (0)721 608 41105
» presse@kit.edu
» www.kit.edu

Karlsruhe Institute of Technology

partners from industry and science, and which the startup was able to utilize. "Working with KIT," Böltken recalls, "we were able to provide proof of concept at a larger scale and that enabled us to take it from the laboratory to industrial-scale use in slightly less than four years." And the result? A kind of blueprint for other industrial projects "that just needs to be copied," quips the scientist, referring to the first of the startup's megawatt facilities – one of which was recently inaugurated at a refinery in Hamburg, the other having been opened in Werlte, Lower Saxony, in 2021 by none other than the then Chancellor Angela Merkel. So what's next? INERATEC's plans to build the world's largest power-to-liquid plant, scheduled to go into operation at Industriepark Höchst in 2023, are causing quite a sensation.

**Providing systematic support for pioneers, KIT paves the way for transformation.**

To give credit where credit is due, the INERATEC's success story was partly written by the KIT Founders Forge, an internationally connected idea-giver and source of inspiration based in the "Silicon Valley of Germany's Southwest." As one of the ten largest university startup centers in the country, it matches spin-offs with investors, seeing itself as a breeding ground and accelerator for innovative business ideas surrounding digitalization, artificial intelligence, biotechnology, mobility, and energy. "We've supported 115 startups in the past three years," says Thomas Neumann, KIT Founders Forge Director. And again, it's quality not quantity that counts. "Our job is to assess whether a candidate has what it takes to be successful. We give all the teams who apply our honest feedback," adds Neumann, "because they won't all make the grade." That's why the KIT Founders Forge team is "extremely proud" to have contributed to another successful startup like INERATEC. As Neumann explains: "This showcase company highlights KIT's research and innovation strengths which are shaped by the most modern infrastructure for renewable energy research and sector coupling in Europe." Ultimately, the main task of the KIT Founders Forge, says Neumann, is to support startups and accompany them as they develop and unfold: "It's not us but INERATEC who are in the process of changing the world."

And looking back, what does Böltken have to say about the time he spent at KIT? He especially appreciates the fact that his university attaches particular importance to the topic of renewable energy: "As a KIT graduate, you've learned about climate change, that we have to change the way we live and do business, and you want to be part of the mission that ushers in that change." Are there any unresolved issues his team is currently taking to task? The issue of providing suitable protection for their technology against water and extreme temperatures, he replies, citing some examples of its future use in the offshore sector and desert regions. "We rely on the concept of open innovation," says Böltken. "The more complex the challenge, the more important is continued cooperation with external partners like KIT. We know we can rely on their expertise."

## Three Questions for …

# Holger Hanselka

**President of the Karlsruhe Institute of Technology (KIT) and Research Field Coordinator Energy of the Helmholtz Association.**

**In what research areas is KIT, which you head as President, especially strong when it comes to major challenges like digitalization, climate change, and energy transition?**

KIT focuses on energy, mobility, information, and climate change. In our Energy Lab 2.0, which enjoys the most modern infrastructure for renewable energy research in Europe, we test models for future-focused energy supply. In terms of the mobility turnaround, we're conducting research into high-performance batteries at the POLiS cluster of excellence. As part of that work, we're forging close links between sustainability, digitalization, and IT security.

**How does KIT stand out from its European and international competitors? In what field does it score particularly well?**

One of our USPs is that we are the only German university of excellence that conducts national large-scale research. This means that it's part of the KIT corporate culture that not only all researchers teach, but that all students work on research projects. If you've studied at KIT, you're highly sought after in the labor market. We provide intensive support for startups and our work is being recognized with Deutscher Gründerpreis awards.

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research are done at TUs?**

Energy transition and the mobility turnaround can only be achieved by taking a cross-discipline approach and engaging in dialogue with society. That's why we test scientific innovations in Real-World Laboratories and have introduced new formats like the KIT Science Week and created places for dialogue and exchange near the campus.

TECHNICAL UNIVERSITY OF MUNICH

# The Lifelong Learning Lab

**When it comes to sustainability, the desire to find inspiration from a competent source and then transfer it to a large corporation was what sparked Wiebke Holland-Nell to sign up with the TUM Institute for LifeLong Learning. Because sustainable business practices play an increasingly important role at medical technology firm Siemens Healthineers, the company where she works, she opted for a certificate program on "Sustainable Management & Technology".**

Continuous education and training in the university ecosystem: With the new TUM Institute for LifeLong Learning located on the TUM Campus in Garching, the Technical University of Munich targets specialist and management staff.

The program is designed to give people who are already enjoying an established career access to current research knowledge. "The rapid pace of change in the world of work and in technological advancement call for continuous education and training," says Claudia Peus, Founding Director of the Institute for LifeLong Learning at the Technical University of Munich (TUM). "Creating this new institute represents a unique change of course in the German university landscape, one that again underpins our claim as one of the leading universities in Europe."

In addition to the wide range of topics covered, from materials science to the circular economy, global warming, and supply chains, what product manager Holland-Nell particularly likes about her "Advanced Therapies" studies is the way the course is taught. Be it in short inspirational lectures or half-day course modules, the discussions are always based on illustrative, real-life examples. "The great thing is that you can engage as an equal discussion partner with experts in their fields," adds the qualified physicist, citing people like Hubert Röder, Professor of Sustainable Business Economics at the Weihenstephan-Triesdorf University of Applied Sciences at the TUM Campus Straubing. "It's emotion-based learning," she continues. "Not the purely abstract transfer of knowledge that you find in other forms of further education." And the more urgently the topic of sustainability is communicated, "the faster people understand how greatly their personal decisions can influence the bigger picture." As regards the course content, she's getting to grips with the three-pillar principle of "people, planet, profit", which rests on the view that sustainable development is only possible if social, environmental and economic targets are considered in equal measure.

Looking ahead to the case study she plans to use for her final exam in a few weeks' time, the 37-year-old wants to play out the use of nudging in business case decisions. It's conceivable, she says, that prior to purchase, the energy-saving potential of large appliances and their impact on achieving sustainabil-


**CONTACT**

TUM – Technical University of Munich
Ulrich Meyer, Spokesperson, Head of Media Relations
Arcisstraße 21
80333 München, Germany
Tel. +49 (0)89 289 22779
» ulrich.meyer@tum.de
» www.tum.de

ity goals could be discussed in a lot more detail. "In this way," Holland-Nell explains, "authorities could nudge people in a positive way towards more sustainable purchasing decisions rather than through regulation."

With the impact of climate change, the COVID-19 crisis and not least emerging geopolitical tensions, requirements for both skilled and management staff are becoming more and more complex, making further education and training a key competitive advantage. This is why, focusing on future technologies and action areas, the TUM Institute for LifeLong Learning provides an opportunity to refresh existing knowledge or learn something new while working. For example, the "Strategizing in Turbulent Environments" program gives answers to pressing issues concerning management – how should decision-making processes look in volatile, uncertain and complex times? And what kinds of measures are suited in sparking transformation or disruptive change in both companies and industry sectors? The "Certified Blockchain & Distributed Ledger Technology Manager" program looks at a paradigm switch surrounding systems architecture, processes and business models. In this brand-new program, corporate leaders learn how to implement and manage blockchain and DLT technology, along with ways to unlock its potential. By way of contrast, "Healthy Leadership" offers an integrated overview of the topic of mental health. As mental illness is one of the most frequent causes of workplace absence in Germany, course participants learn evidence-based strategies – ranging from ways of identifying and addressing mental stress to group coaching – that have been tried and tested in practice.

**Emotion-based learning in place of abstract knowledge transfer**

Environmental, economic and technical skills form the core of the "TUM.wood – Building with Wood" program. Because in the Bavarian town of Vaterstetten a heated debate is underway on the advantages and disadvantages of using timber in construction, the head of the municipal planning office suggested that, as a representative of the local community, his employee Katharina Koopmann get better informed. Although the qualified architect and engineer had not looked into the academic debate until then, she is now "up to date" in matters concerning the use of timber in construction. "Perhaps I can now help to take the heat out of the controversial council debate by adding an objective perspective and persuade the hardliners." She found it enriching to "finally be able" to engage in dialogue on her specialist subject and think about materials and building methods "like we did at uni". But regrettably, says the mother of two, she has little time to read construction magazines in the course of her everyday work. "Still," she adds, "the need to stay informed remains." So, what was her most surprising take-away from the course? "That in Germany, the share of public-sector clients in timber construction is only eight percent." Thanks to her further training, the qualified carpenter hopes she now has sufficient, academically-sound knowledge to be able to provide the building authority with convincing information and answers on matters concerning the use of wood. As a building authority representative, she wants to do all she can to see the trend reversed.

**Lifelong learning at work: the need to stay informed remains.**

## Three Questions for …

# Thomas F. Hofmann

President, Technical University of Munich

**In what research areas is TUM especially strong when it comes to major challenges like digitalization, climate change and energy transition?**

One of our biggest strengths at TUM is focusing on the future potential at the interfaces between the different disciplines. That's where the answers lie in tackling the challenges facing humanity today. We accelerate development of interdisciplinary research and teaching approaches, and we transform new findings into innovative products in our TUM Venture Labs.

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research is done at TUs?**

Only universities that are willing to take risks in transformation and are ready to embrace change will be able to hold their own in the longer term. The rest will be left behind. That's why we've adopted a highly ambitious transformation strategy that will make us more agile, dynamic and capable of taking action, empower our students in shaping the future, and enhance the way our research activities benefit society overall.

**What would you like to see from policymakers to ensure that the TU is better positioned institutionally to meet the challenges faced in the future?**

In the global race to recruit the best talents, universities have to throw off what has become an extremely tight corset of policy provisions. We need a new culture of courage in embracing change – without that, we will lose our best talents and become second rate.

UNIVERSITY OF STUTTGART

# Facilitating Mobility 4.0

**As autonomous robots make their way around the shop-floor in the research factory, engineer Annika Ackermann watches them from the window of her laboratory up on the third floor. She's conducting research into modern materials and production processes for the University of Stuttgart Institute of Aircraft Design and believes the ARENA2036 concept is the way to go: "The close cooperation with various industry partners and institutes opens up untold opportunities. Ongoing dialogue and exchange sparks new ideas that can be quickly tested and implemented on site."**

Flexible spaces and open design: The ARENA2036 research campus on Campus Vaihingen near Stuttgart, where activities focus on mobility transformation, provides startups and industry partners a place for collaboration.

By way of example, the 31-year-old doctoral student cites a collaboration with Bosch Rexroth where the focus is on using new materials to reduce losses in inductive charging in driverless transport systems, thereby improving the mechanical properties of the materials.

On the University of Stuttgart's Vaihingen Campus, research on future-proof models for mobility and production has been conducted since 2013 in the "Active Research Environment for the Next Generation of Automobiles" – ARENA2036. Vaihingen is the first research campus of nine created at new locations and funded by the Federal Ministry for Education and Research (BMBF). Situated at the heart of the industrial and automotive region in Stuttgart's conurbation, the new campus serves as a major link between science, industry, and business. This is where small and medium-sized businesses (SMEs) as well as large enterprises, startups, universities, higher education institutions, and research institutions can all benefit from each other. The 25-plus projects located at Vaihingen, all of which focus on innovative production and mobility models, involve sustainable transport, connectivity (including 5G networks), and modern approaches to intralogistics. The original focus on intensive advancement in automotive has shifted significantly since ARENA2036 was first founded. For example, the figure 2036 no longer just marks the 150th anniversary of the automobile – its meaning has evolved beyond the automotive as the objective of future mobility research. "The flexible research spaces provide ideal conditions for the highly dynamic research area of mobility and production transformation," says Peter Middendorf. As Vice Rector for Knowledge and Technology Transfer at the University of Stuttgart and Spokesperson of the ARENA2036 Research Directorate, he's aware of how important flexibility and resilience are in Industry 4.0. "And", adds Peter Froeschle, Managing Director of ARENA2036, "that's why the co-creative, interdisciplinary collaboration seen in the research factory is showcasing the many benefits to


CONTACT

University of Stuttgart
Lydia Lehmann, Deputy Head of University Communications and Press Spokesperson
Tel. +49 (0)711-685 82211
» hkom@uni-stuttgart.de
» www.uni-stuttgart.de/en/

University of Stuttgart
Germany

**Setting up a dedicated factory for research brings benefits: short paths, plus interdisciplinary dialogue and exchange with startups**

be had from creating short communication – as well as research and development paths."

In the course of the coming years, ARENA2036 is to serve as a door opener for startups, research and innovation – the idea being to bring a breath of fresh air into industry and to strengthen Germany as a land of ideas. Looking ahead to ARENA2036's potential third and final funding phase, the topics of sustainability and connectivity will no doubt play a major role.

## Three Questions for …

# Wolfram Ressel

**Rector, University of Stuttgart**

**In what research areas is the University of Stuttgart especially strong when it comes to major challenges like digitalization, climate change and energy transition?**

At the University of Stuttgart, our vision encompasses "smart systems for sustainable society". That vision defines the future research fields. We're especially strong in our profile fields of Simulation Sciences and Adaptive Building where we've attracted excellence clusters in each, and in the profile fields of Digital Humanities, Production Technology, Quantum Technology, Autonomous Systems and Biomedical Systems.

**To what extent do large-scale transformations such as those we're currently seeing require change in how teaching and research is done at TUs?**

Major challenges can only be overcome by joining forces in a combined effort and that means radical interdisciplinary collaboration and intensive exchange with both industry and society overall. These have long been a major focus at the University of Stuttgart, and not least on the ARENA2036 research campus.

**What would you like to see from policymakers to ensure that the TU is better positioned institutionally to meet the challenges faced in the future?**

Universities need wide-ranging autonomy in research, teaching, further education and training, knowledge and technology transfer, and infrastructure planning and construction. We also need reliable higher-education funding in the form of five-year agreements.

UNIVERSITY OF STUTTGART

# Pooling High-Tech Software Expertise

**Autonomous robots with flashing lights flit as if by magic around 200 square meters of research space, while in the background a large team of programmers optimize lines of code. The location? The prize-winning free-span industrial building erected in Stuttgart-Vaihingen to house the ARENA2036 Research Campus. It was here, back in 2021, that co-founders Kai Przybysz-Herz from NAiSE and Stefan Dörr from NODE Robotics, whose startups share the mission of using high-tech software to make Intralogistics 4.0 more efficient in manufacturing, got talking.**


Intralogistics 4.0 providing common ground: Two young startups whose different areas of expertise make for a perfect match (from left to right): Stefan Dörr and Lukas Teichmann from NODE Robotics and Kai Przybysz-Herz and Raphael Kusumoto from NAiSE.

As part of their mission, NAiSE assesses which transport orders are better processed by humans and which by robots, and then coordinates the journeys. NODE's software is responsible for the division of labor between the variously equipped robot vehicles and for optimizing the routes, explains Stefan Dörr. The robotics operating system developed by NODE for autonomous, mobile robots in production environments is called NODE.EDGE. Its predecessor was developed by the subsequent startup founders in 2015, at the Fraunhofer Institute for Manufacturing Engineering and Automation. It was there that the research done by the startup founded in 2020 first got off the ground. NAiSE, on the other hand, showcased its market maturity by demonstrating its manufacturer-independent master control software at automotive customer sites – including that of ARENA2036 partner Bosch Rexroth, which has since installed the software for operational use. NAiSE was also nominated for the IFOY Award 2022 as "Startup of the Year".

**A welcome synergy effect: the two companies find themselves able to offer manual, automated and autonomous vehicles from a single source.**

The synergies in the collaboration between the two startups quickly came to light: "By pooling our expertise, our clients have since been able to deploy mixed fleets of manual, automated, and autonomous vehicles," says Dörr, describing the joint product portfolio they wouldn't be able to offer on their own. The way in which the startups benefited from their encounter at the Vaihingen research campus is confirmed by Kai Przybysz-Herz from NAiSE: "Our strategic partnership was built on the spatial proximity and open exchange at ARENA2036."

# IMPRINT

TU9
German Universities of Technology e.V.
Dr. Nicole Saverschek, Managing Director

Contact
Anna-Louisa-Karsch-Straße 2
10178 Berlin – Germany

+49 (0)30-278 74 76-80
» international@tu9.de
» www.tu9.de

Design
Sebastian Lehnert, Leipzig

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