THE THYSSENKRUPP TECHNOLOGY MAGAZINE
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techforum

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Water stress or cloud factory?

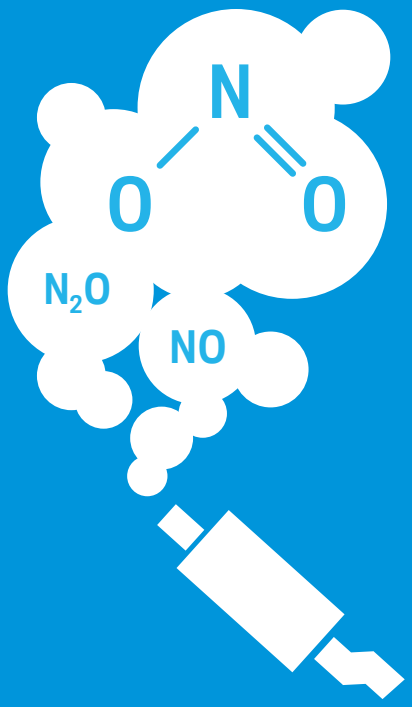
A just water supply system for the whole world is one of the major issues for the future. Three scenarios show how the world could look by about 2030 – depending on the course that humankind chooses.

"NET ZERO" CLIMATE TARGET
Technologies for a greenhouse gas-neutral economy

MAGNETS FOR MEDICINE
New bearings make computer tomographs super-silent

MOBILE TEST LABORATORY
Research platform for agile vehicle development

thyssenkrupp



CLIMATE PROTECTION:

Around **20,000 metric tons of nitrogen oxides and 56,000 metric tons of laughing gas** are avoided each year through the use of thyssenkrupp's EnviNOx systems.

→ Find out more on **page 21.**

48

ELECTROMAGNETS ARE INSTALLED IN THE NEW MAGNETIC BEARING FROM THYSSENKRUPP.

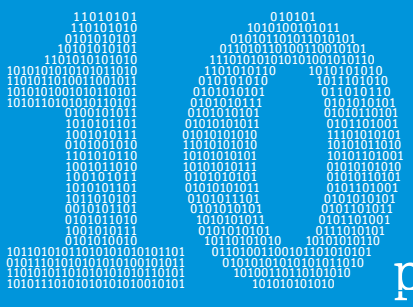
→ Discover what this has to do with computer tomographs on **page 26.**

With a maximum of **440 membranes,** a redox flow container can achieve an electrical capacity of one megawatt.

→ Details are explained in the infographic on **page 18.**

The Modifiable Underwater Mothership with fuel cell drive can dive to a depth of up to **5,000 meters.**

→ Background on this project can be found on **page 34.**



Up to programming languages and simulation tools have to interact with one another to perform an overall simulation of Carbon2Chem.

→ Read the article about this on **page 24.**

Dear readers,

Thomas Alva Edison ("99 percent perspiration, 1 percent inspiration") showed the world that innovation is a complex phenomenon. There are many ways to coming up with new products and solutions, such as continuous development work or disruptive ideas. At thyssenkrupp we employ a range of methods in our efforts to become even more innovative. You'll find examples in this current issue of techforum.

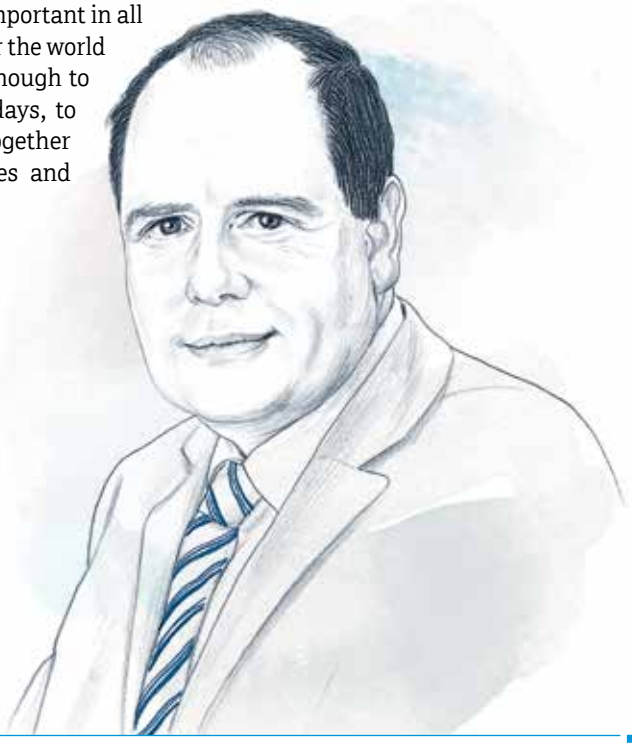
Our climate technologies, for example, are the result of traditional continuous development work. They are based on accumulated expertise in plant engineering, which we are constantly developing further. We always keep one eye on the current megatrends that define the major social challenges of our time.

We also take a systematic approach with our foresight method – though in this case with a radical change of perspective. Rather than developing our current competencies with a view to tackling future tasks, the focus here is on leaping ahead to a point 30 years in the future. From that standpoint, we evaluate what competencies we need to develop. As an example, in this issue we present our reflections on the future of water supply and the possible consequences for our engineering work.

By contrast, Beyond Conventions is an invitation for disruptive innovation. Working with other major German companies, we set off in search for start-up partners who can provide solutions for our digital challenges. It was the first time these major groups partnered with start-ups in this way, and the focus was expressly on unconventional solutions that break the mold. In this issue of techforum we present the initiative and one of its projects: drones that monitor construction progress in industrial plants.

Collaboration is becoming increasingly important in all the engineering solutions we are developing for the world of tomorrow. Knowledge alone is no longer enough to attain a real competitive advantage. These days, to generate real added value you must bring together existing knowledge from different companies and corporate cultures.

I wish you an enjoyable read.



Dr. Peter Feldhaus,
CEO of the Industrial Solutions Business Area

Cover photo: Getty Images; illustration on page 3: Anja Stiehler

Contents

06 **Short Cuts**
Smart mining | Autonomous transportation vehicles | Fertilizers from by-products | thyssenkrupp – a role model in innovation

Cover story

08 **The future of water**
Three scenarios on the topic of water management

14 **Agriculture in a state of change**
What will the makers of fertilizers have to prepare themselves for?

16 **CO_2 as a raw material**
Toward climate neutrality with closed carbon circuits

18 **Sustainability at work**
Four thyssenkrupp technologies for avoiding CO_2

24 **Combined models**
Co-simulations make complex facilities manageable

08

Essential for life: Water is the foundation for culture and human dignity. Will there be enough for everyone in the future?

"Net greenhouse gas neutrality is feasible within a specific framework."

Markus Oles, Head of Innovation Strategy and Projects at thyssenkrupp

16

Optimists: Markus Oles (left) and Thomas Fußhöller believe the global economy can become climate-neutral after 2050

30

The **Modular Research Platform** facilitates the fast, agile development of vehicles

44 **Unusual concept:** In BeyondConventions, companies challenge start-ups with specific tasks

Photos: thyssenkrupp Steel Europe Fotografie, Daniel Reinhardt/thyssenkrupp, Quirin Leppert; Illustration: Skizzomat/Marie Emmermann

Projects

26 **Silent bearing**
Magnets teach computer tomographs to whisper

30 **Modular Research Platform**
New research vehicle for fast and agile development

34 **Diving with fuel cells**
thyssenkrupp develops an autonomous underwater vehicle

Panorama

38 **Digital framework**
Alice & Bob revolutionize thyssenkrupp's materials trading

42 **Intelligent mix**
Hybrid materials from the OHLF will make automobiles lighter in future

44 **BeyondConventions**
Companies challenge start-ups with specific tasks

48 **Feel free to play!**
thyssenkrupp counts on professionals from the gaming industry

50 **Pyramids of water**
Why water is suddenly flowing freely in the desert

Fully automated: A new storage system uses radar sensors to collect data about the geometry of stockpiles and the positioning of the machine

Award for thyssenkrupp

The thyssenkrupp Industrial Solutions and indurad have been honored with the Data-based Services 2017 Award as part of a benchmarking study conducted by RWTH Aachen. The aim of the study was to identify leading solutions across the industry in the field of data-based services and digitization. The methods and solutions of 75 European companies were examined, with thyssenkrupp and indurad impressing with their customer-specific, individual solutions. Through the collection and analysis of data, the two companies generate added value for customers in the mining and mineral processing industry. The services offered in the field of condition monitoring, for example, can predict when a machine will break down. These services are based on a unique radar technology that can carry out measurements online and in real time. This technology is compatible with all devices on the market – old and new.

Self-driving transport capsules for elevator maintenance

In the digitally networked cities of the future, self-driving vehicles will be part of our everyday lives. Compact transport vehicles without drivers could replace bulky vans for deliveries, ensuring that all goods get to their destination by the shortest possible route. The Tele-Retail company is already developing this kind of self-driving transport vehicle – an ideal logistics solution for elevator maintenance for thyssenkrupp Elevator. A pilot project is currently exploring how cloud-based transport capsules could be used to transport replacement parts and other materials to the deployment site accurately and autonomously. What are the advantages? At a width of only 85 centimeters, the agile capsules are suitable for sidewalks, taking the burden off busy roads. They can also be used to deliver loads of up to 35 kg to traffic-calmed inner city areas. Users can get a quick overview of the delivery status via the "Logistics Automation" platform. "In the future, we hope to further improve our service in this way," explains Ivo Siebers, Senior Vice President of Global Logistics at thyssenkrupp Elevator.

Sidewalk logistics: Transport capsules will replace delivery vans

Photos: thyssenkrupp (3), Marcus Simaitis

From by-product to fertilizer

thyssenkrupp Industrial Solutions has developed a new process for the cost-efficient production of ammonium sulfate granules, through which the industrial by-product ammonium sulfate is turned into high-quality sulfurous nitrogen fertilizer in granulated form. The process offers significant advantages for fertilizer producers. Firstly, it is far more cost-efficient than conventional processes in which ammonium sulfate granules are produced from ammonia and sulfuric acid. Secondly, it offers better spreading and mixing properties than crystalline products. By supplying sulfur and nitrogen at the same time, ammonium sulfate encourages strong plant growth and high yields. It ensures a long-lasting supply of nutrients and promotes the availability of micronutrients contained in the earth, such as manganese, boron and iron.

Round and hard: The ammonium sulfate granules are resistant to impact and abrasion

Forward thinker: Henry Chesbrough sees in thyssenkrupp a good example for his MBA students

thyssenkrupp's innovation processes used as teaching material in Berkeley

With the transition from a materials group to a technology group, thyssenkrupp has also overhauled its innovation processes. More intensive cross-divisional collaboration, systematic product life cycle management (PLM), and new forms of innovation make the group more efficient. Henry Chesbrough, the Professor at the University of California, Berkeley who coined the term "open innovation," has examined thyssenkrupp's innovation processes and published the findings under the title Innovating Innovation @tk in the Harvard Business Review's collection of case studies. University lecturers around the world can now use thyssenkrupp's good example in their syllabuses. Chesbrough himself uses the "teaching case" on his MBA course. The postgraduate students are asked the same question that innovation leaders at thyssenkrupp ask themselves regularly: Which projects should go ahead, and in which direction? The choice is between PLM with its clearly defined processes and stringent decision points, agile innovation paths such as the #tkGarage for radical innovations, and thyssenkrupp's TechCenter for fast, cross-divisional, and technology-driven developments.

Water for a thirsty world

What does a sustainable and just water supply look like? What technologies will need to be developed to achieve it? Three **Foresight scenarios on the topic of water management** outline possible future water worlds

Text: Christian Buck **Illustration:** Skizzomat / Marie Emmermann

Wells on wheels: Trucks deliver the water for reservoirs in people's homes

Thibault and Charlotte have made it. He, a data analyst, and she, a fund manager, are standing on the veranda of their brand-new bungalow on the edge of Paris and looking proudly at their little garden. Flower beds, shrubs, and small trees create an illusion of country life – even though the center of the metropolis, with a population now numbering 15 million, is a mere twelve kilometers away. The highlight of their private park is the pond with valuable koi carp that were delivered only this morning. "Aren't they amazingly elegant?" Thibault asks his wife. "There is no trace of stress from the move – they are acting like they had never been anywhere else."

The two new homeowners belong to the class of successful young high-achievers – a fact that they are happy to show off, not only with their two electric sports cars on the driveway but also with the red-speckled precious fish in the garden. Koi have always been a sign that their owners have achieved something in life. In the case of Thibault and Charlotte, however, it is not the fish that are the real luxury. What is much more impressive is the fact that the couple can afford their own open-air garden and a big pond at all, as these are things that need a lot of water – and in 2030 water has become a truly precious commodity.

Global competition for maximum water efficiency

This development had been looming for a long time. The world's population continued to grow even after the turn of the millennium, and in 2030 it reached the nine-billion mark. In order to be able to supply enough water for the whole population and for agriculture, countries had to make great efforts and launch a technological competition for maximum water efficiency. Depending on the continent and climatic conditions, this resulted in a very wide variety of solutions that had to combine sustainability with economic viability. However, there was one motto that ran like a common theme through every approach: as much recycling as possible and as little fresh water as necessary.

There was no real alternative: In times of contaminated groundwater and alternating droughts and floods, people were no longer able to rely on natural sources of water. Instead they turned to artificial systems. But the installation of central water treatment and distribution systems could not keep pace with the population growth in major cities. Other solutions were needed.

For this reason, Thibault and Charlotte's bungalow, like every other building in Paris, is fitted with a modern »

COVER STORY → **FORESIGHT**

As far as possible, every drop of water is purified and put back into the supply circuit.

water treatment system that seeks to collect and purify every single drop of the precious liquid and put it back into the house's supply circuit. Only yesterday, the big tank truck arrived to fill up the new-build's reservoir for the first time. That should be enough for the next six months. The water comes from the closed circuit of a neighboring industrial plant that had a surplus in its system thanks to heavy rain in recent days and was therefore able to give up some of it. As the basic principle of a closed circuit is repeated at each level, from city district up to entire countries, experts speak of a fractal system.

However, Thibault and Charlotte do not want to think about their water supply just now. They are looking forward to welcoming the guests who will be arriving soon for their housewarming. "The caterer has just delivered the buffet," Charlotte announces. "Just as we wanted – fruit and vegetables in all shapes and colors!" Most of it comes from urban farming, which means it was produced only a few hundred meters away in greenhouses – in computer-controlled hydrocultures maintained by robots that make optimum use of the precious water.

Only rarely does food still come from high-tech farms farther away. However, those who can afford it like to offer their guests real Greek olives, for example, although they no longer come from small farms. Since climate change became more severe, only large farming operations have been able to afford the expensive facilities that filter moisture from the air with the help of renewable energies and use it to water their plants. Classic field-grown food has become a real luxury, as this form of agriculture is now only possible in a few regions and has to contend with increasingly frequent crop failures.

In Thibault and Charlotte's world, people live well. The global standard of living is higher than it has ever been, and rules in force worldwide have made sustainability a matter of course – although governments leave it to people and companies to decide which technologies they use to comply with these environmental standards. Of course, the world in 2030 could also look very different from this scenario, which was developed by experts at thyssenkrupp as part of a Foresight workshop on the topic of water management. They have dubbed it "Artainabl€ I$lands," because much here is both artificial and sustainable and the solutions for water supply compete with each other in individual islands.

The UN brings clean water to everybody

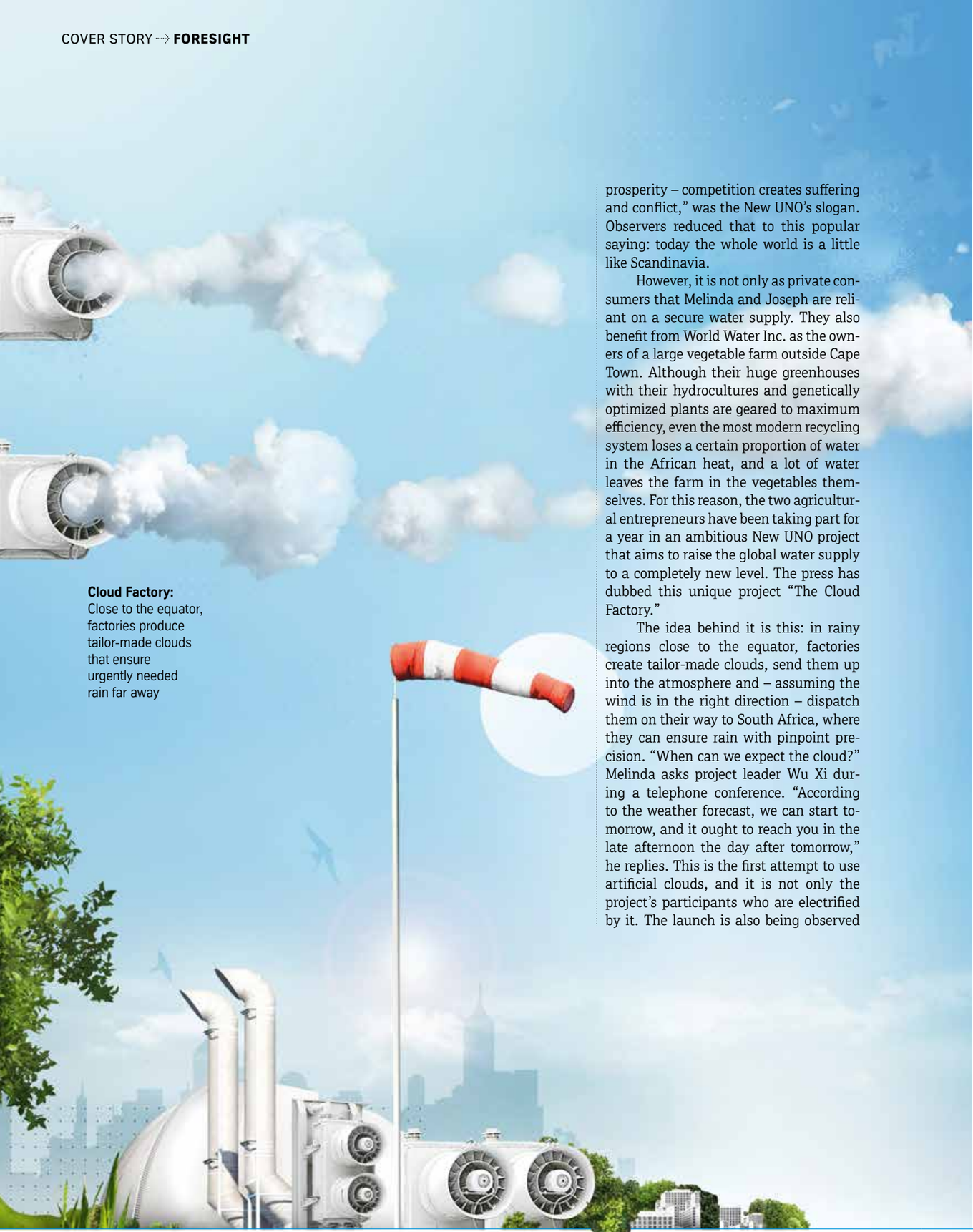
People in the world described by the "Sustainable Flat Rate" scenario also live well. However, their society is less market-driven – instead, the state here performs many central tasks. There is a good reason for this. After the wars over water that resulted from climate change, the New UNO declared supplies of drinking water to be its prime objective and passed a resolution on a completely new system for water supplies at a ceremonial general assembly in Nairobi. "We will not let anybody die of thirst again!" New UN Secretary-General Vladimir Rostov declared, to tumultuous applause from the delegates.

Maximum water efficiency through hydroculture and genetically modified plants

From 2028, a central New UNO agency, known colloquially as World Water Inc., was responsible for bringing clean water to everybody. To do this, a gigantic investment program was agreed – primarily to build a worldwide network of pipelines that could transport the precious liquid to regions that had previously been dry. However, there was also a fleet of water transportation ships to make sure nobody would have to suffer from thirst again. Conventiently, the age of fossil fuels had come to an end shortly before, and many oil tankers were waiting for a new role.

Joseph and Melinda in Cape Town are also benefiting from this. They live with their three children in a suburb on the outskirts of the metropolis and are able to rely on a secure water supply. This was not always the case. Just ten years ago, South Africa had an extreme water shortage, and rationing was a regular occurrence. Today, the tankers and pipelines ensure that all people get water of the best quality at affordable prices, subsidized by compensation payments from countries that are in a climatically more favorable location. "Solidarity creates peace and »

Urban farming: Most fruit and vegetables are produced in cities. Only rarely does food now come from farms far away



Cloud Factory: Close to the equator, factories produce tailor-made clouds that ensure urgently needed rain far away

prosperity – competition creates suffering and conflict," was the New UNO's slogan. Observers reduced that to this popular saying: today the whole world is a little like Scandinavia.

However, it is not only as private consumers that Melinda and Joseph are reliant on a secure water supply. They also benefit from World Water Inc. as the owners of a large vegetable farm outside Cape Town. Although their huge greenhouses with their hydrocultures and genetically optimized plants are geared to maximum efficiency, even the most modern recycling system loses a certain proportion of water in the African heat, and a lot of water leaves the farm in the vegetables themselves. For this reason, the two agricultural entrepreneurs have been taking part for a year in an ambitious New UNO project that aims to raise the global water supply to a completely new level. The press has dubbed this unique project "The Cloud Factory."

The idea behind it is this: in rainy regions close to the equator, factories create tailor-made clouds, send them up into the atmosphere and – assuming the wind is in the right direction – dispatch them on their way to South Africa, where they can ensure rain with pinpoint precision. "When can we expect the cloud?" Melinda asks project leader Wu Xi during a telephone conference. "According to the weather forecast, we can start tomorrow, and it ought to reach you in the late afternoon the day after tomorrow," he replies. This is the first attempt to use artificial clouds, and it is not only the project's participants who are electrified by it. The launch is also being observed by the world's media. Journalists are reporting live from the start and finish, and the cloud is also being accompanied on its journey by a fleet of solar aircraft. "The first moon landing was probably the last time that an event attracted so much global attention," Joseph says. "Except that then it was a competition between two superpowers, whereas today the whole world is pulling together."

Standing in line at the water-selling station

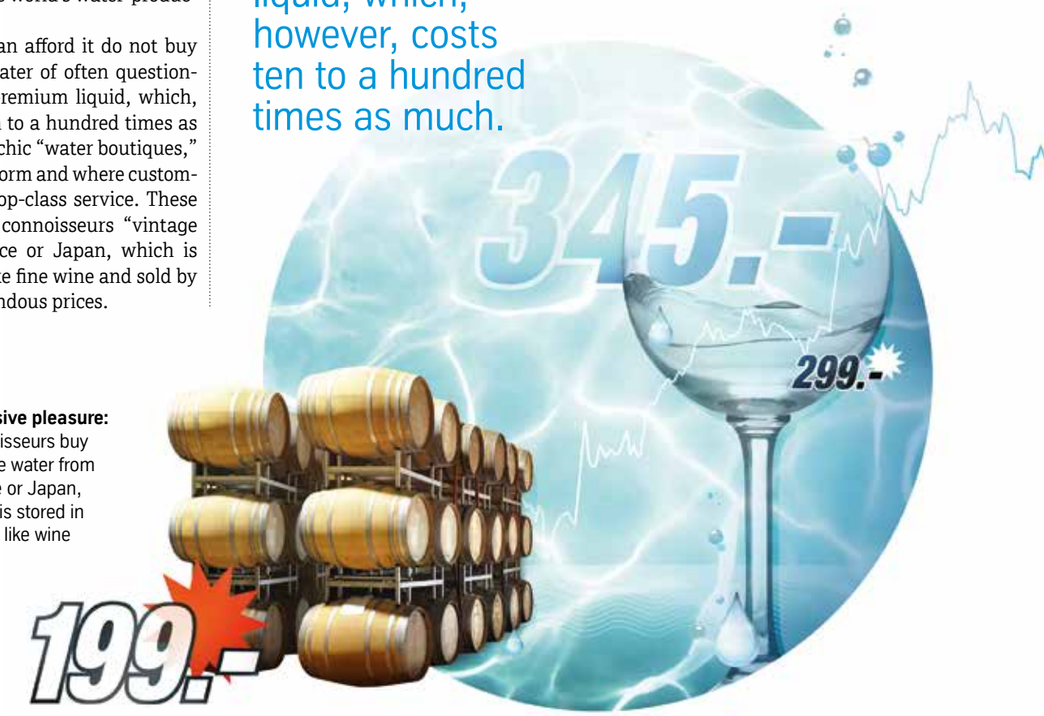
Josefina can only dream of so much solidarity. Like every morning, she has today gotten up shortly after sunrise to obtain a little water somehow for her eight children and herself. She is now standing with hundreds of other people in a long line outside a Latin American Water Corporation selling station on the northern outskirts of Mexico City. Soldiers guard the entrance to the building, which has bars on the windows, and only a small number of people are allowed to enter it at a time. The display board shows "15 coins per liter." The current daily price is set by WAPEC, a Vienna-based organization that brings together the world's water-producing nations.

Those who can afford it do not buy cheap standard water of often questionable quality but premium liquid, which, however, costs ten to a hundred times as much. It is sold in chic "water boutiques," where lines never form and where customers can expect a top-class service. These outlets also offer connoisseurs "vintage water" from France or Japan, which is stored in cellars like fine wine and sold by the bottle at horrendous prices.

Inferior quality for the poor masses, and premium water for the top ten thousand: this is how the world looks in the third Foresight scenario, which the thyssenkrupp experts have titled "Water = Life 2.0." Here, the predictions of many Hollywood dystopias around the turn of the millennium have come true: water has become scarce, and a handful of big companies have divided the small number of sources up among themselves and defend access to them with every means available. Since the great financial crash, the global standard of living has fallen, and nobody is investing any longer in the outdated public infrastructure. The state is weak, and in the struggle for water the "might is right" principle prevails. The food supply situation is not so different: A monopoly on this rests in the hands of a small number of companies that have access to water. Private gardens are now found only in the heavily guarded residential complexes of the super-rich.

While she waits in line for her daily water ration, Josefina thinks about her husband, Oscar. She has not seen him for months, since he went to the USA to work in a coal mine. The renaissance of that cheap source of energy after the failure of the climate negotiations has created a lot of jobs and sent thousands of Mexicans northward. Oscar is able to send a good 500 coins home every month, just enough to pay for water for his wife and children. However, it may soon no longer be sufficient, as WAPEC representatives are right now negotiating on new water prices at their summit in Vienna. The latest rumor is "30 percent more for a liter!" "How on Earth am I going to pay that?" Josefina wonders as she walks past the soldier into the water-selling station with her empty plastic bottles.

Those who can afford it do not buy cheap standard water but premium liquid, which, however, costs ten to a hundred times as much.



Exclusive pleasure: Connoisseurs buy vintage water from France or Japan, which is stored in cellars like wine

Nitrogen from the air: Future plants could manage completely without fertilizer or with less of it

Food for nine billion

Water and agriculture are inextricably bound up with each other. What do the Foresight scenarios mean for **the future of the production of fertilizers?**

Text: Christian Buck

Future developments in the global water supply will have a decisive impact on the future of agriculture, as the various Foresight scenarios on this topic indicate. Also, each scenario places different demands on the makers of fertilizers – without whose products it will not be possible to feed a population that is expected to number around nine billion by 2030. This is where the thyssenkrupp Industrial Solutions comes in: for decades the Fertilizer & Syngas Technologies business unit has been supplying complete production facilities for nitrogen and phosphorus fertilizers to customers worldwide.

In order to prepare themselves right now for possible developments in the future, thyssenkrupp's fertilizer experts have adapted the results of the Foresight workshops on water supplies and developed four scenarios for agriculture on that basis. These formed the foundation of a dedicated two-day workshop. "We wanted to gather all the stakeholders in this topic around one table to talk about the impact of the various scenarios on our own business," says Oliver Schwarz, who is responsible for the introduction of new innovation tools and methods at thyssenkrupp Industrial Solutions. "In addition to our own specialists from very different areas, the participants included agricultural researchers, a farmer, a fertilizer wholesaler, an expert in the legal framework relating to agriculture and the operator of a fertilizer production plant."

The aim of the workshop was to gain a better understanding of the agricultural value chain from the fertilizer factory to the end consumer and the changes that it will possibly undergo in the future. "As in all industries, the necessary adjustments in fertilizer production will need a lot of time," explains Michael Jopp, who deals with strategic business development in the Fertilizer & Syngas Technologies business unit. "If we act promptly to take a look far into the future, we can offer our customers the appropriate solutions and gain a competitive advantage for ourselves."

The adapted agriculture scenarios based on the scenarios for future water supplies formed the basis for answering central questions such as: How will agriculture work in one of these possible future worlds? What will the value chain look like? And what does thyssenkrupp need to do today in order to be able to offer the appropriate solutions tomorrow and the day after? "This all-round approach is new to us," Schwarz says. "This is the first time that we have taken a look at a whole vision of the future and done so without confining ourselves to a purely technical discussion."

Green fertilizers without natural gas

The future-focused topics identified in this process include "green fertilizers" – nitrogen fertilizers that will not be produced from the raw material of natural gas, as at present. Instead, it is planned to create the precursor ammonia from atmospheric nitrogen and hydrogen through water electrolysis, with the electricity required for this coming from renewable energies. "thyssenkrupp is already very active in the field of water electrolysis and has developed its own solution," Jopp says. "Discussions between the business units involved were stepped up even further as a result of our workshop."

Digitization and data analytics, too, will contribute to better harvests in the agriculture of the future. Up to now, it is mainly the makers of agricultural machinery who have concerned themselves with the best way to manage the use of fertilizers and plant growth. "But it does not have to stay that way," Schwarz reports. "It is conceivable that thyssenkrupp, too, will become more actively involved with the relevant biology in the future – for example, to understand better how plants absorb fertilizer." However, data will also improve the production of fertilizers. The efficiency of factories can be improved significantly by innovative approaches such as predictive maintenance, he adds.

Future plants that obtain their essential nitrogen directly from the air thanks to genetic modifications could manage either completely without fertilizer or with much less of it. "Some seed producers are already working on this idea," Jopp says. "We are now wondering whether industrial cooperation arrangements for playing a part in such forward-looking developments will be worthwhile for thyssenkrupp."

More workshops planned

It is now planned to hold two more workshops to refine these thoughts and flesh them out, as this involves questions such as who are the biggest players in the individual sectors, how the markets work, and which topics thyssenkrupp should take further. "We have successfully projected the results of the Foresight workshops on future water supplies onto our own business area," Schwarz concludes. "Without that input, we probably would not have taken such an all-round approach to this topic."

Photos: Getty Images

"Good news for optimists"

Thomas Fußhöller is Head of Sustainability, Environment, and Energy Management at thyssenkrupp. **Markus Oles** is Head of Innovation Strategy and Projects. They work closely together on climate protection and hold the view that the zero emissions target is achievable.

Interview: Bernd Overmaat

Climate protectors: Markus Oles (left) and Thomas Fußhöller support the reduction and use of carbon dioxide

techforum: At the UN climate conference in Paris in 2015, the global community agreed to reduce greenhouse gas emissions to zero in the second half of the century. You say this is already feasible with present-day technologies. Is that not a rather bold thesis?

Thomas Fußhöller: The 2015 Paris climate change accord represents a kind of turning point in the climate debate, away from absolute reduction targets for industrialized countries alone and toward a differentiated approach that allows for offsetting where emissions are unavoidable. Another way of putting this is: what I emit in future, I will have to take back out of the atmosphere somewhere else. This net greenhouse-gas neutrality is also known as "net zero" for short. Carbon cycles play a major part here.

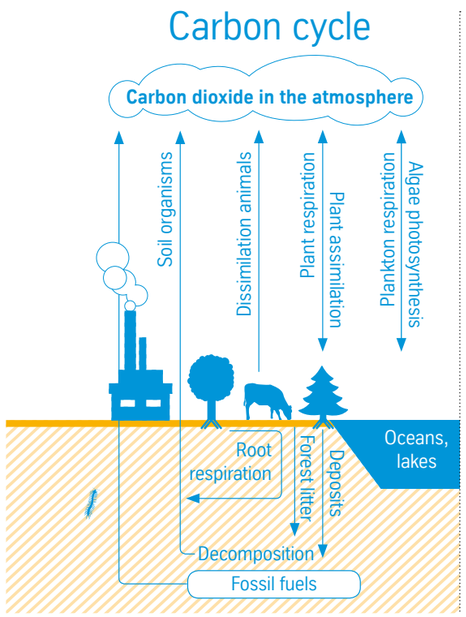
Markus Oles: This is where technology comes in. In chemical terms, CO_2 is nothing other than one of many possible carbon compounds. For industrial processes, such as those in the chemical and energy sectors or in the field of mobility, it plays a part that is fundamentally similar to that of carbon derived from coal, crude oil, or natural gas. Some of the technologies that are used in industry to separate, convert, and exploit CO_2 have existed for more than 100 years. This is why we say that net zero is feasible within a specific framework.

techforum: If that were so, it would be possible to achieve climate neutrality merely by using CO_2. Also, what is known as the decarbonization of the economy would be superfluous.

Markus Oles: No, that is not the case. More than 50 billion metric tons of greenhouse gases are generated every year. This huge volume cannot be eliminated just through carbon recycling. There has to be a combination of reduction and use. In that sense, the Paris accord is a good foundation – avoiding emissions is the paramount objective. At the same time, it is accepted that there are unavoidable emissions and that these can be offset. The much-discussed complete decarbonization of the global economy is technologically untenable.

> "Our expertise in climate protection is also confirmed by outside experts like the NGO CDP."
>
> **Thomas Fußhöller**

Photos: thyssenkrupp



Thomas Fußhöller: To develop specific solutions, companies need to analyze their CO_2 footprint in detail. This is what we at thyssenkrupp have done. The results are valid not only for us, as the focus is not just on a company's own emissions but on the whole value chain. A company's own products usually account for a substantial proportion of this, and that fact represents enormous leverage. For this reason, industry has to be a provider of solutions for a greenhouse gas-neutral economy. Take the volatility of renewables as an example. Renewable energy is not available in identical quantities around the clock, as the wind does not blow with the same force all the time and the sun does not shine 24 hours a day. In the old energy system, supply was geared to consumption. In the future, consumers will have to gear themselves to the supply that is available at a given time.

Markus Oles: Those who can master this will have competitive advantages in the future. Many large industrial consumers, such as steel or chemical plants, are currently organized so as to operate for 24 hours a day, seven days a week, at a capacity utilization rate that is kept as even as possible. The question is how to reconcile this with the volatility of the new energy system.

techforum: What are you proposing – the total conversion of industrial production?

Markus Oles: Here, too, it is true to say that the technologies already exist and need to be refined in a targeted way. thyssenkrupp, for example, offers solutions such as Carbon2Chem, redox flow batteries, or electrolysis. These energy storage systems enable buffers to be established that allow industrial processes to continue running even when not enough renewable energy is available. In the future, energy storage systems will be an integral part of industrial facilities. Processes that do not have to run continuously will be organized so as to produce goods according to supply – meaning, when enough energy is available and at an appropriately reasonable price. Incidentally, this will stabilize not just industrial production but also power grids.

Thomas Fußhöller: Net zero is also achievable under certain conditions, and thyssenkrupp is actively involved in many of these solutions, even if the social preconditions for implementing specific technological solutions still need to be improved – for example, in the construction of large wind farms or in relation to storage facilities for CO_2. Our expertise in climate protection is, incidentally, also confirmed by outside experts. In 2017, thyssenkrupp was recognized for the second time in succession by the nongovernmental organization CDP as one of the best companies in the world in relation to climate protection. This spurs us on and is good news for optimists.

Smart energy storage – driving the energy transition

Renewable energy's share in overall electricity generation is growing and costs are sinking. The challenge now is to develop efficient storage technologies: the energy produced from renewable sources is not constant, yet electricity consumers depend on and expect a constant supply.

Our solution for a constant energy supply is smart energy storage systems that can bridge these gaps and fluctuations.

Our redox flow batteries come in various storage times and outputs and can be adapted to the respective requirements. The units can efficiently store several hundred megawatt hours of energy, which can be used immediately on demand. As a point of comparison: the standard output of onshore wind power plants is 2 to 5 megawatts.

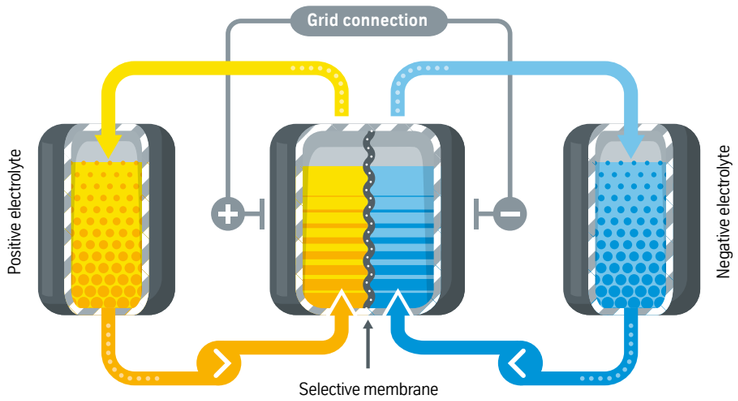
Redox flow batteries store energy in two tanks filled with salts dissolved in liquid. The liquid flows through electrochemical cells in which the charging and discharging reaction takes place. The overall active area of the cells determines the maximum output of the storage unit. With a surface area of 2.5 m², our cells are the biggest in the world. It is possible to choose the exact storage capacity needed, and this is determined by the size of the tanks. Redox flow batteries can achieve an efficiency of up to 80 percent.

A second technology employed on an industrial scale is water electrolysis. Using electrical energy, the water is broken down into hydrogen and oxygen. The hydrogen can be stored as an energy source and transformed back into electricity when required, for example in fuel cells and gas turbines. It is also a base substance in the production of chemicals such as methane, methanol and ammonia. An efficiency of up to 80 percent can be achieved here too.

Renewable energy sources

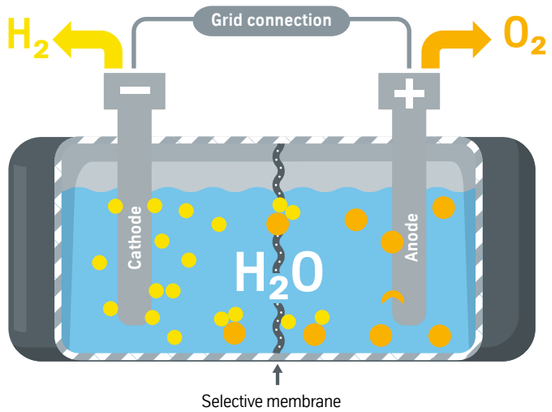
Wind and sun do not produce a constant level of electricity – the amount of energy generated is heavily dependent on the weather.

Redox flow batteries



The bigger the cell surface, the higher the battery's output; and the bigger the tanks, the more energy can be stored.

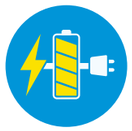
Water electrolysis



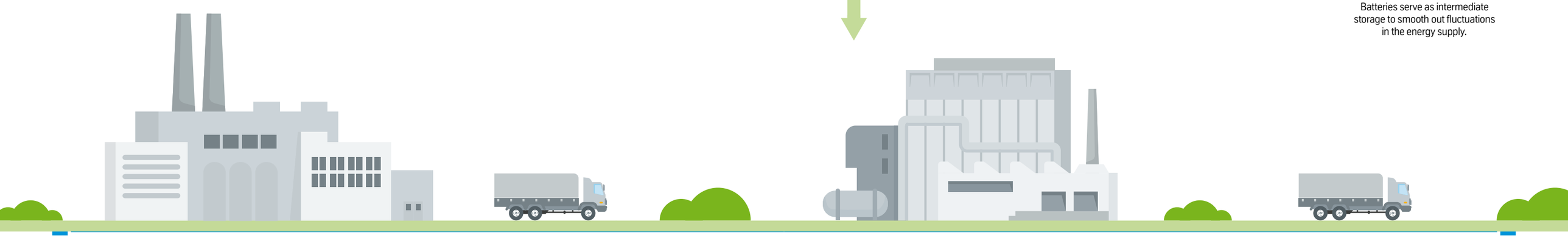
Water is broken down into oxygen and hydrogen using electricity, thus creating a clean energy source.

Industrial processes rely on a constant supply of energy without interruptions or fluctuations.

By definition, wind and solar energy are subject to weather-related fluctuations.



Batteries serve as intermediate storage to smooth out fluctuations in the energy supply.



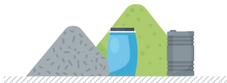
Capturing carbon dioxide with oxygen

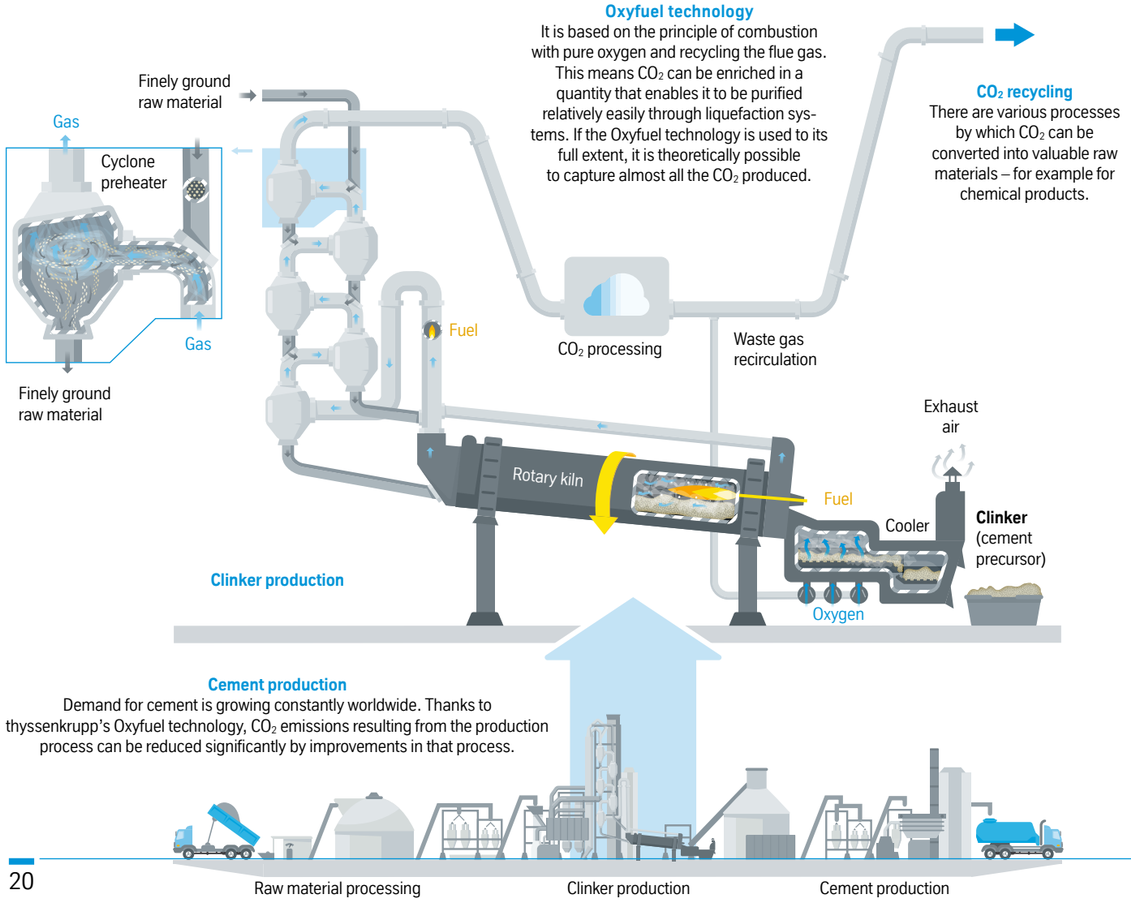
Cement production is an energy-intensive process and responsible for around 7 percent of the global CO_2 emissions caused by humans. As large individual sources of carbon dioxide, cement plants are therefore particularly well suited to CCU (carbon capture and usage) solutions. Around 60 percent of carbon dioxide emissions are generated in the process of turning limestone into clinker, a precursor to cement. This is unavoidable as the CO_2 comes from the raw material, not the fuel.

However, it is possible to capture the carbon dioxide and then convert it so that it does not get into the atmosphere and have a harmful impact on the climate. It is precisely for this purpose that thyssenkrupp has developed the Oxyfuel process, in which carbon dioxide emitted in cement production can be captured very effectively.

The combustion process that produces the clinker from limestone is carried out with pure oxygen instead of ambient air. This means that nitrogen plays no part in the combustion process and highly concentrated CO_2 is produced. This gas is much easier to recycle than waste gas from a conventional combustion system.

Another advantage of the Oxyfuel technology is that it can be retrofitted into existing cement plants. This is an argument that should not be underestimated, as such facilities are generally designed for a lifespan of 30 to 50 years.





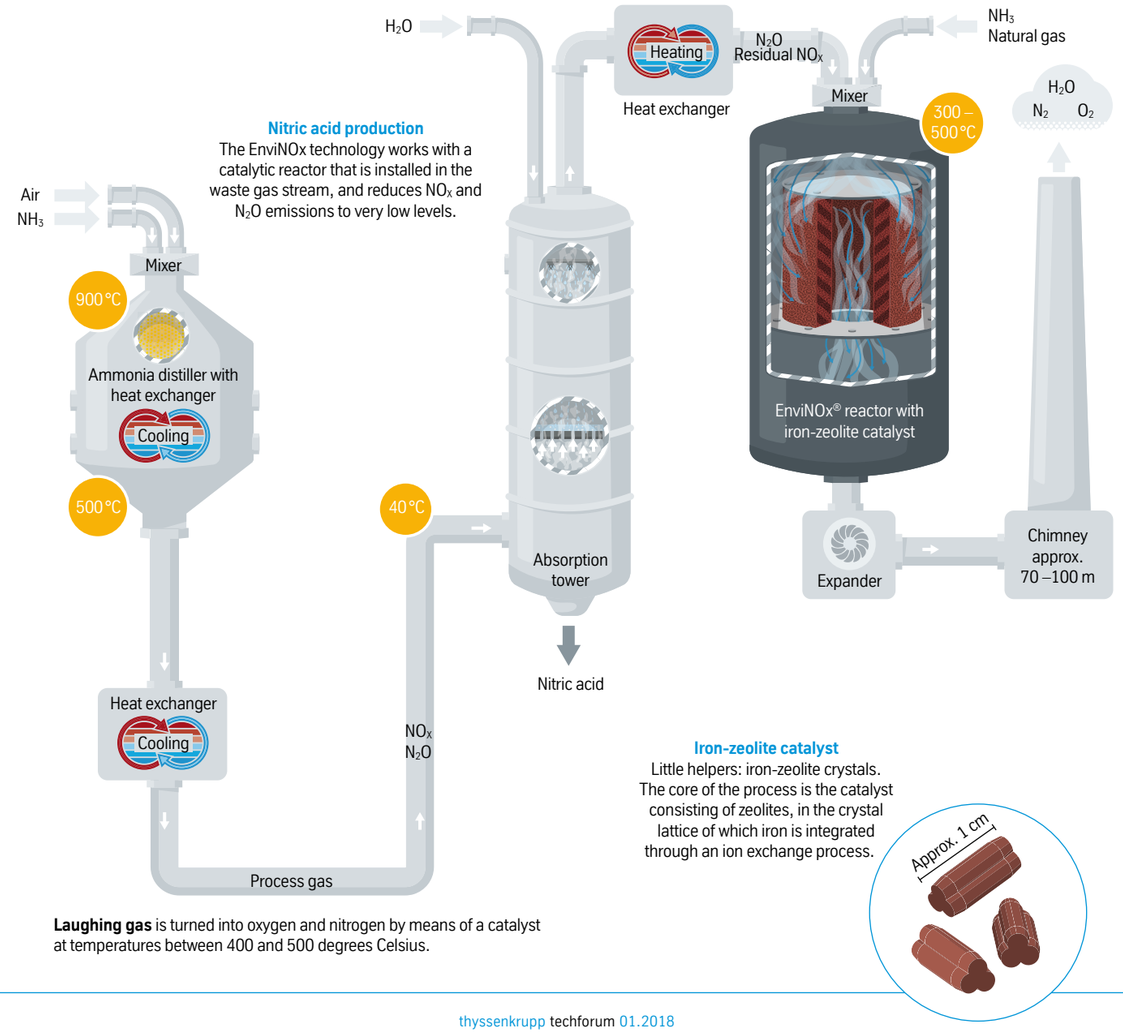
EnviNOx hunts laughing gas down

Laughing gas (N_2O) is about 300 times more harmful to the climate than CO_2. If it occurs in large concentrations, N_2O absorbs heat radiation that would otherwise escape into outer space and thus contributes to global warming.

Laughing gas is created in large quantities among other things in the manufacture of nitric acid. This is an important chemical raw material, for example in fertilizers. More than 400,000 metric tons of laughing gas are created worldwide every year in the production of nitric acid – equivalent to around 130 million metric tons of carbon dioxide.

With the EnviNOx process from thyssenkrupp, laughing gas can be almost completely removed from nitric acid production. To do this, the N_2O is passed over a special catalyst and broken down into its nontoxic components of nitrogen and oxygen. If a reducing agent such as ammonia is added at the same time, the nitrogen oxides contained in the waste gas are also turned into water and nitrogen. Around 30 EnviNOx systems are now in use worldwide, saving around 20,000 metric tons of nitrogen oxides and approximately 56,000 metric tons of laughing gas.

One more advantage is that if you want to use EnviNOx, you do not have to build a brand new plant. The waste gas purification system can be integrated very simply at the end of the nitric acid production process – one small step for a plant operator, one giant leap for climate protection.



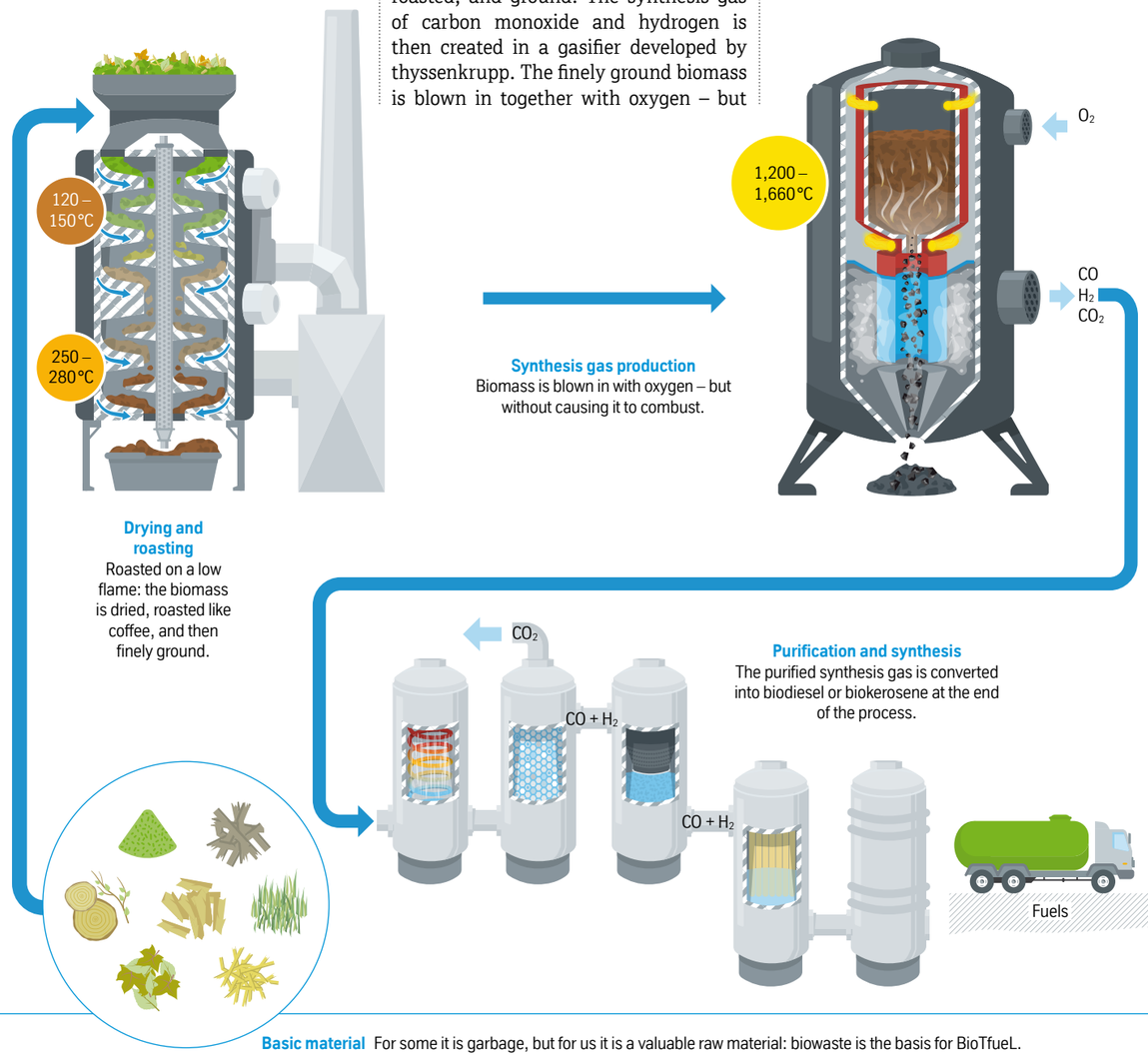
Laughing gas is turned into oxygen and nitrogen by means of a catalyst at temperatures between 400 and 500 degrees Celsius.

Sustainable fuel from biomass

The EU has prescribed that the proportion of renewable energies in the transport sector should be increased. This goal can be met to a large extent by biofuels. Fuel from biomass is especially environment-friendly when waste materials such as straw, grass cuttings, plant and wood residues or fast-regrowing energy crops are used as the raw material. This is biomass that is not in competition with food crops.

BioTfueL is an example. Here, thyssenkrupp is producing climate-friendly biodiesel and biokerosene in collaboration with European partners. These second-generation biofuels are of particularly high quality and reduce CO_2 emissions by up to 90 percent compared with conventional fuels. They can be used directly in the standard diesel engines of automobiles, locomotives and ships and in aircraft engines.

In the production of fuels by the BioTfueL process, biomass is first dried, roasted, and ground. The synthesis gas of carbon monoxide and hydrogen is then created in a gasifier developed by thyssenkrupp. The finely ground biomass is blown in together with oxygen – but only just enough oxygen to ensure that the mass does not combust. At 1,200 to 1,660 degrees Celsius, only partial oxidation occurs. This creates carbon monoxide instead of CO_2 and hydrogen instead of water. Carbon monoxide and hydrogen are the source materials for the production of biofuel. The energy for the process comes from the biomass itself, as it does in the drying and roasting.



Drying and roasting
Roasted on a low flame: the biomass is dried, roasted like coffee, and then finely ground.

Synthesis gas production
Biomass is blown in with oxygen – but without causing it to combust.

Purification and synthesis
The purified synthesis gas is converted into biodiesel or biokerosene at the end of the process.

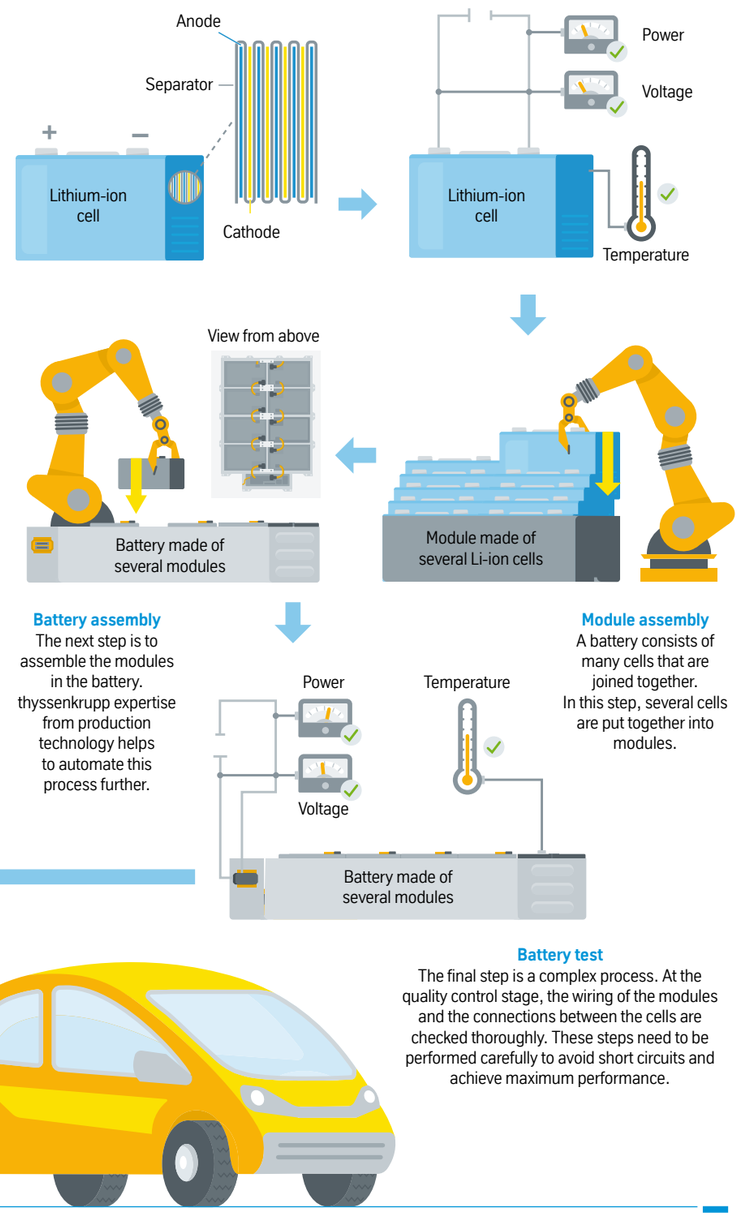
Basic material For some it is garbage, but for us it is a valuable raw material: biowaste is the basis for BioTfueL.

Higher battery capacity and greater efficiency

Two factors are of key importance for the range of an e-vehicle: the storage capacity of the batteries and the efficiency of the electric motors. The more energy is available, the greater the range. And the more economically this energy is handled, the further it is possible to drive.

That's why thyssenkrupp is working on both factors at the same time. Together with partners from research and industry, the Group is developing a new generation of battery cells with a revolutionary design: Instead of lots of separate cells with complex interconnections, cars will be powered in the future by a large sandwich structure. This can reduce production costs by up to 100 euros per kilowatt hour. At the same time, it is intended that energy density will rise to double the customary present level of 250 watt hours per liter of battery volume – with a corresponding effect on the range. In the consortium, thyssenkrupp is dealing with the production technology for the innovative cells.

The electric powertrain has at least as much potential as the battery, as soft magnetic special steels form the core of every electric motor. For hybrid and electric automobile motors, thyssenkrupp has refined these special steels so that the efficiency of the motor and, consequently, the range of the vehicle are increased significantly.



Cell assembly
One major challenge is the production of the battery cell. The mechanical processes are demanding, because they must not only be automated and fast but also extremely precise.

Formation
In this step, battery cells are completely charged and discharged for the first time. During the first charging and discharging cycles, formation processes occur in the cell and have a great influence on its future behavior.

Battery assembly
The next step is to assemble the modules in the battery. thyssenkrupp expertise from production technology helps to automate this process further.

Module assembly
A battery consists of many cells that are joined together. In this step, several cells are put together into modules.

Greater energy efficiency
The efficiency of the motor can be boosted significantly with highly efficient electrical steel.

The aim:
A greater range
More storage capacity at lower cost: thyssenkrupp is contributing its production expertise.

Battery test
The final step is a complex process. At the quality control stage, the wiring of the modules and the connections between the cells are checked thoroughly. These steps need to be performed carefully to avoid short circuits and achieve maximum performance.

A maximum of ten at once

The sustainability of individual production processes can be improved when processes from different sectors are linked together intelligently. A prerequisite for this is **coupled simulations**, which thyssenkrupp is developing with partners

Text: Hans Schürmann

Two teams want to simulate the behavior of interconnected industrial facilities, but they have different computers, operating systems, and simulation programs. Can it work? Yes, because co-simulation is paving new ways to cooperation.

Distributed co-simulations are not a new simulation model – rather, they are the combination of models produced by different project partners for individual facilities and for subprocesses and management processes into an overall model. These procedures have been used successfully since the 1980s in development areas such as circuit simulation to couple different mathematical models and simulation processes. An important advantage at that time was that available computer capacity was low, so several simulations could be run in parallel on different computers. What is new is the use of co-simulations for the cross-industry linking of simulation models, and this is now being driven by thyssenkrupp in collaboration with the Fraunhofer Institute for Environmental, Safety, and Energy Technology (UMSICHT) in Oberhausen.

Co-simulations are currently being used for thyssenkrupp's Carbon2Chem initiative. Its aim is to use process gases from steel production as a raw material for chemical industry products. Ammonia and methanol, for example, can be produced from these steel mill gases and recycled CO_2. The hydrogen required comes from the steel mill gases and from water electrolysis using renewable energies – at times of surplus supply when green electricity is particularly cheap. The aim, therefore, is to link together many different dynamic processes such as steel manufacturing, electricity production, and electrolysis in such a way as to produce an optimum yield in each case.

"The complexity of this cross-industry project is so great that it would not be possible to simulate the interplay between all the processes in a single model," says Thorsten Wack, head of the Information Technology department at the Fraunhofer Institute UMSICHT. The overall system is therefore broken down into individual subsystems, for which the various project partners develop submodels that depict the processes physically with different levels of detail. These simulations form the foundation for designing the network of facilities in an optimum way, both technically and economically. They also help in developing control concepts for safe and efficient operating procedures.

Sector coupling: In the future, processes from industry and the energy sector will be more closely integrated – thanks partly to simulations

Photo: Getty Images

The teams of experts from thyssenkrupp and Fraunhofer have the task of creating interfaces for the communication and exchange of data between the individual models, as well as the technical framework for the overall simulation.

> "Before now, very few researchers have been able to interconnect more than two models."
>
> **Thorsten Wack,** Fraunhofer Institute UMSICHT

Only then can the various simulation models interact with each other. "Up to ten programming languages and simulation tools have to be able to interact with one another in the overall system," explains project engineer Henning Wagner, who is in charge of thyssenkrupp's activities in the project.

However, this is not the only challenge, as it is also essential to protect the project participants' process expertise. For this the thyssenkrupp team has developed black box models, through which data can be transmitted without it becoming transparent how the data were produced. "They convey only the results of the simulations, but no information that would enable anyone to draw conclusions about how the facility functions," Wagner asserts.

Implementation in IT terms is also a tricky task. The individual simulations are controlled by higher-level software. They run on a variety of computer systems and exchange information over the internet, but without the data being seen by unauthorized parties. At the same time, it is necessary to bring in transmission technology that automatically makes the data from the partners' simulation models available to the central simulation computer. This is the task of the Fraunhofer developers.

Meanwhile, the development team have successfully validated the newly developed process: the IT experts have already managed to link three simulation models in different locations with each other in a co-simulation. "Before now, very few researchers have been able to interconnect more than two models," Wack says. "The distributed approach in particular is unique." The project team have also developed and tested tools for the interplay of individual simulation models. The exchange of models is working, too: a thyssenkrupp model for methanol production has been replaced in the network with another methanol model from Fraunhofer.

"The next thing we have to do is to make co-simulation ready for practical use," Wagner says. The development of co-simulation is a long-term investment, as it will still be used even after a facility has been built – for the start-up and optimization of operations and for coupling with other facilities. The Fraunhofer Institute also hopes to be able to use the technology in other sustainability projects with a similar aim of linking processes from different sectors intelligently with each other.

The Carbon2Chem initiative from thyssenkrupp aims to use process gases from steel production as a raw material for chemical industry products

Silence is the source of strength

Computer tomographs today generate background noise that many patients find very unpleasant. A new **magnetic bearing** from thyssenkrupp is providing relief: an X-Ray camera can move on it almost in silence

Text: Monika Weiner

X-ray vision: CT scanners identify problems including tumors, bone fractures, and joint disease

Photos: picture alliance/dpa, thyssenkrupp

The examination starts. "Please lie as still as possible." The radiographer closes the door and the patient is alone. Accompanied by whirring and humming sounds, the examination table moves millimeter by millimeter through a tunnel, around which the X-ray camera rotates. Although computed tomography (CT) involves absolutely no contact with the patient, many find the examination stressful. While they are alone and surrounded by technology, seconds seem an eternity, it is hard to hold still, and the whirring and humming eat at their nerves – which are already on edge if they are afraid of the impending diagnosis.

CT manufacturers are very interested in bringing scanners that are as quiet as possible onto the market. "Lower noise is a clear competitive advantage," explains Klaus Pantke, group leader for research and development at thyssenkrupp. "The second important factor is speed," he adds. "A camera that rotates quickly reduces the length of the examination and the amount of exposure to radiation and can contribute toward cost savings."

This is why Pantke's team at thyssenkrupp is developing bearings for the CT scanners of the future. The prototype is rotating on the wall of the test building in Lippstadt. There is no whirring or humming. The rotor weighing almost 300 kilograms moves silently round an inner ring the size of a CT tunnel. The "silent bearing" is stabilized by the invisible force of dozens of electromagnets.

The magnetic bearing in Lippstadt is currently one of the biggest and most powerful in the world. It is set to open up new possibilities for the makers of CT equipment. Up to now, equipment »

PROJECTS → **MAGNETIC BEARINGS**

"The technology is mature to the point that we can now test it in all kinds of applications."

Klaus Pantke,
group leader for research and development

» manufacturers have been dependent on large-diameter rolling-contact bearings. In these huge bearings, balls or rollers reduce the friction when the stationary and rotating rings move against each other. In CT scanners, for example, the bearings ensure that a heavy X-ray camera attached to the rotating ring circles at high speed round the patient and can perform the X-ray examination on them. On the opposite side of the ring, detectors capture the X-rays that have not been absorbed by the patient's tissue or bones. On the basis of these signals, the computer generates three-dimensional cross-sectional images, with the help of which the radiologist can diagnose bone fractures, joint disease, or tumor-like changes to the organs.

The movement of the camera on the rotating ring – in high-end equipment it rotates round the patient up to 300 times a minute – inevitably generates noise. It whirs and hums when the rolling elements in the bearing move. Depending on the speed, the noise to which a patient in the CT is exposed can be just as intense and annoying as that of a loud lawnmower.

Project "Silent Bearing"

To overcome the noise problem, thyssenkrupp, a leading producer of large-diameter bearings, launched the "Silent Bearing" project some years ago. "Our aim was to develop a bearing that was as quiet, frictionless, and wear-free as possible," project leader Pantke reports. The idea was that, in this innovative bearing, the stationary stator ring and the rotating rotor ring would be kept apart not by rolling elements but by magnetic forces.

In itself, this idea is not new. In centrifuges, machine tools, pumps, and compressors, electromagnetic bearings have long ensured that rotating components moving at high speeds operate without wear. However, for large-scale applications in which large-diameter bearings have been used so far, complex control technology and the high standards required for production have meant that these bearings have been suitable only on a very limited scale.

For this reason, the thyssenkrupp engineers developed a new concept. The inspiration was the Transrapid. This high-speed train hovers on a traveling magnetic field that counteracts the Earth's force of gravity. This field is created by electromagnets. It ensures that the undercarriage does not touch the track but glides smoothly above it.

This principle is now being used by Pantke's team to make medical technology hover, too. Dozens of electromagnets integrated into the stator create a field that attracts the rotor, which is made from magnetizable steel. A thin air gap of approximately 1.5 millimeters is created between the stator and the rotor by skillful control. "The biggest challenge was to control the magnetic fields so that this air gap is constantly maintained, even when the rotor is carrying the weight of a heavy X-ray camera on one side," Pantke recalls. A total of 48 electromagnets – axial and radial, meaning along the direction of rotation and at right angles to it – had to be integrated into the stator. In addition, there are sensors that constantly measure the size of the air gap during operation.

A connected computer evaluates the data and transmits commands to the individual electromagnets. These have to align the rotor with micrometer precision– whether it is rotating or has been stopped, or whether or not it is bearing a load. The control systems for the silent bearing were developed in collaboration with the thyssenkrupp engineers at the TechCenter Control Technology and Zittau University of Applied Sciences.

Safety bearing for emergencies

The fact that they actually work is demonstrated by test on the prototype that is rotating silently on the wall of the thyssenkrupp Rothe Erde test building. It can support a load on one side of up to 750 kilograms, the theoretical maximum capacity of a CT scanner – the electromagnets keep it constantly in the correct position.

And what happens if the power fails? A rotor in a bearing of this size that was kept in balance by electromagnetic forces alone would suddenly fall onto the stator and cause considerable damage. To cope with emergencies, therefore, the engineers have included a safety bearing in the stator – a bronze ring that slows down the movement if the electromagnets are switched off accidentally.

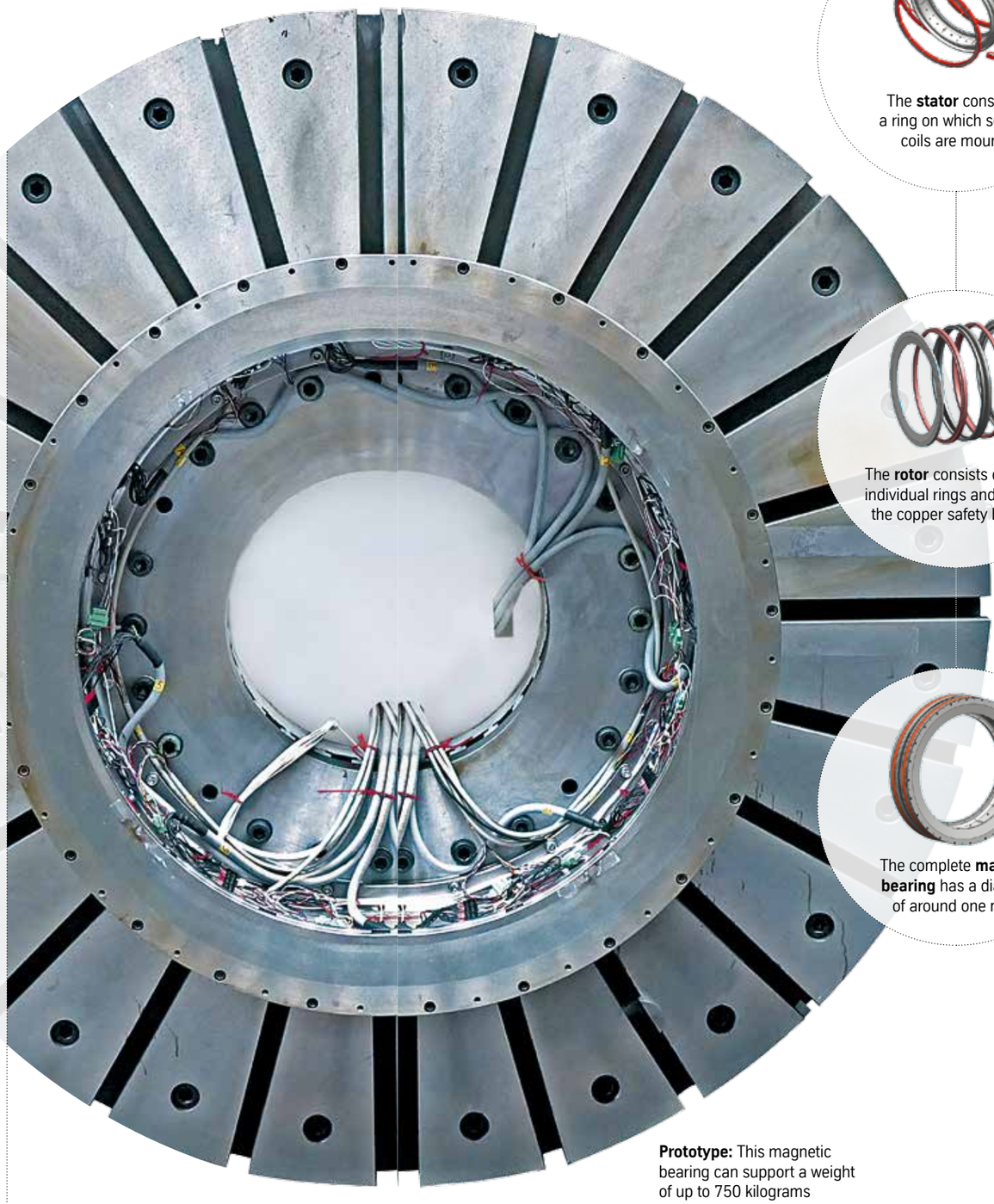
Patented technology

thyssenkrupp has already patented the new magnetic bearing. "The technology is mature to the point that we can now test it in all kinds of applications," Pantke says. This is good news for the makers of CT equipment: in the future they will be able to build silent machines that are less of a strain on patients' nerves.

The engineers at thyssenkrupp also aim to speed up the silent bearings in the future. The prototype currently achieves 150 rotations per minute, and the goal is to reach 300 and later perhaps even more by making further improvements to the control systems. That would make the magnetic bearings faster than present high-end devices that use antifriction bearings.

Speeding up the rotation would have many advantages. A CT examination would be quicker, the amount of exposure to radiation for the patient would be lower, and the radiologist would be able to monitor dynamic processes, such as the opening and closing of heart valves, in real time.

Also, Pantke stresses, it is not only medicine that can benefit from the new technology. "Contactless magnetic bearings are an alternative to traditional bearings wherever the aim is to avoid noise and lubricants and wherever maximum precision is required – for example, in controlling telescopes in observatories or radar antennae on ships or in the assembly of satellites in clean rooms," he says.

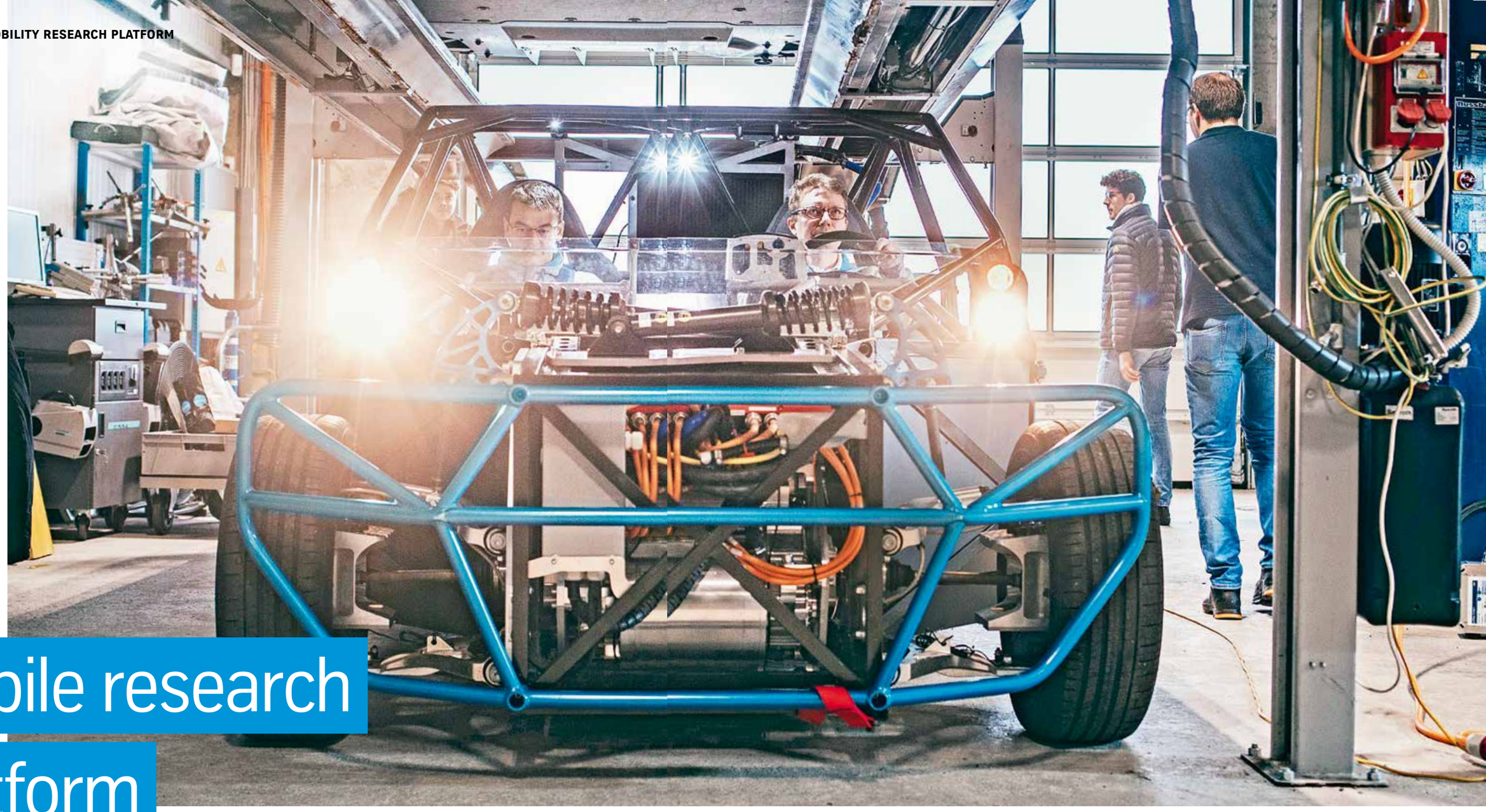


The **stator** consists of a ring on which solenoid coils are mounted

The **rotor** consists of several individual rings and contains the copper safety bearings

The complete **magnetic bearing** has a diameter of around one meter

Prototype: This magnetic bearing can support a weight of up to 750 kilograms



Mobile research platform

Ready to go: Leonard Lapis (left) and Carlo Miano prepare themselves for a test drive

In automobile construction, the future belongs to fast, agile development processes. The modular **Mobility Research Platform** enables new chassis components to be tested at an early stage

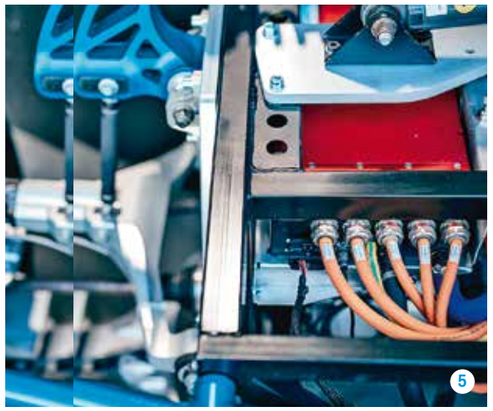
Text: Monika Weiner **Photos:** Quirin Leppert

The roller door opens with a gentle rattling sound. Fresh mountain air pours into the shop. Carlo Miano checks the battery connections once more, and then opens the cockpit's safety bar, climbs into the driver's seat and switches on the motors. The test vehicle starts moving with a soft hum. This ride is a breezy pleasure, since the vehicle has neither a body nor a windshield. At first glance, the Modular Research Platform (MRP) is reminiscent of an outsized Lego automobile. "Our vehicle actually is assembled from components, like something built with Lego. Thanks to this construction principle, we are able to replace parts of the chassis, such as the steering, brakes, or dampers, in just a few minutes," explains project leader Miano as he waits outside the shop for his co-driver to get in and the laptop to be started up.

Miano pulls the zipper of his jacket up as far as it will go. The test drive at the thyssenkrupp site in Liechtenstein can commence. It is a cool morning, and the sun is only now rising over the snow-covered mountains surrounding the principality. The MRP vehicle drives around the shop and disappears behind the office building.

There, on the second floor, is Kristof Polmans' office. "Head of Technology and Innovation" is what it says on his business card, but this trained mechanical engineer pays no attention to titles and functions. "We are all on first-name terms," he says. He is Belgian, and for three years he has led an international development team in which eleven nationalities work together. The common language is English – and sometimes also German, Italian, or Hungarian.

"Our aim is to develop the chassis technology of the future," Polmans says. The automobile industry today is facing great challenges, he explains, as electrification and autonomous driving are making new mobility concepts possible – from robot taxis to e-car sharing. "There will be new technologies and business models, but no one yet knows what they will look like and which of them will prevail in the »



Mobile test platform

1 Ready for action: side view of a steering linkage **2 Innovative concept:** with this single-wheel steering system, the wheel can be turned through 90 degrees **3 Breezy pleasure:** Leonard Lapis and Carlo Miano on a test drive on the Mobility Research Platform **4 The team** led by Kristof Polmans (third from right) comprises many students, as well as full-time employees **5 Power electronics:** orange high-voltage cables are connected to the e-powertrain's inverter **6 Conversion:** employees prepare the research platform at the workshop in Liechtenstein for its next drive

> "With the modular test vehicle, we can test integrated functions more quickly and cheaply."
>
> **Kristof Polmans,** Head of Technology and Innovation

marketplace," he says. "For suppliers, this means they will have to be able to devise a large range of technical solutions and to provide them at short notice. That cannot be done by traditional development methods – we need fast, agile processes."

Early tests without prototypes

To accelerate the development of chassis components, Polmans' team devised the Modular Research Platform. It enables parts to be tested under real-life conditions at a very early stage of development. This saves time, as in the past it was necessary to wait until a prototype could be integrated into an existing vehicle. Also, the MRP enables interactions between different chassis components to be examined as early as the development stage.

The focus of research work in Liechtenstein is on steering systems. thyssenkrupp is the world's biggest supplier of steering shafts and columns and one of the top five manufacturers of complete steering systems. However, the company is also seeking to use the new, agile testing process in the long term to demonstrate its expertise as a chassis developer.

For now, though, the agile development technology is itself in the testing phase. The MRP vehicle was completed only a few months ago. Since then, the team have been working on putting the individual systems into operation. For the first trials, the mobile research platform was fitted with traditional components: a mechanical steering gear, passive dampers, two electric motors for the individual drive of the front wheels, and one more for the rear axle. While Carlo Miano drives around the site, dozens of sensors constantly measure a number of parameters, including speed, acceleration in different directions, yaw rate, wheel speed, and steering wheel angle. All the information is sent to an on-board computer the size of a shoebox, the "autobox," which is attached to the center console. On the screen of the connected laptop, Leonard Lapis, the project member in charge of the development of the control systems, is able to follow the ups and downs of the measurement curves live while the vehicle is on the move.

The autobox contains the mobile test platform's intelligence. This is where the data from the sensors are processed by specially developed software. On the basis of the measured values, the system can at any time calculate the optimum commands for the actuators – e.g. for the brakes, the steering, the powertrain and the dampers. The engineers like to compare the autobox to the brain of an octopus: it is the place where the information that the tentacles gather during their movements is pulled together. Each tentacle is theoretically independent, but the coordination is controlled centrally. This control is extremely flexible: an octopus has no problem in making up for the loss of one tentacle. The software in the MRP's on-board computer is intended to do something similar, by controlling the components in such a way that they complement and support one another.

This is important for example in the development of driver assistance systems or steering systems for autonomous driving. Such systems have to be 100 percent safe, even if one of the components fails. The steer-by-wire technology developed by thyssenkrupp, in which the traditional mechanical connection between the steering wheel and the vehicle's wheels is replaced by electric cables, needs a backup solution in case data transfer is interrupted while the vehicle is in motion, for example. Here, the idea is that the software will intervene by specifically controlling the wheels' powertrains and brakes so that they take over the steering function. "To develop such technologies in the past, you needed test vehicles, and that was complicated and expensive," Polmans says. "With the new, modular MRP test vehicle, we can now test such integrated functions more quickly and cheaply."

It is not only traditional electric steering systems, where both wheels are steered together, that can be tested by the mobile platform. In the coming months, the engineers plan to incorporate a very flexible single-wheel steering system. They have developed the prototype in collaboration with scientists at the nearby Buchs University of Applied Sciences. It can turn wheels through up to 90 degrees, so that parking or driving around tight bends becomes child's play.

Adjusting to meet customer wishes

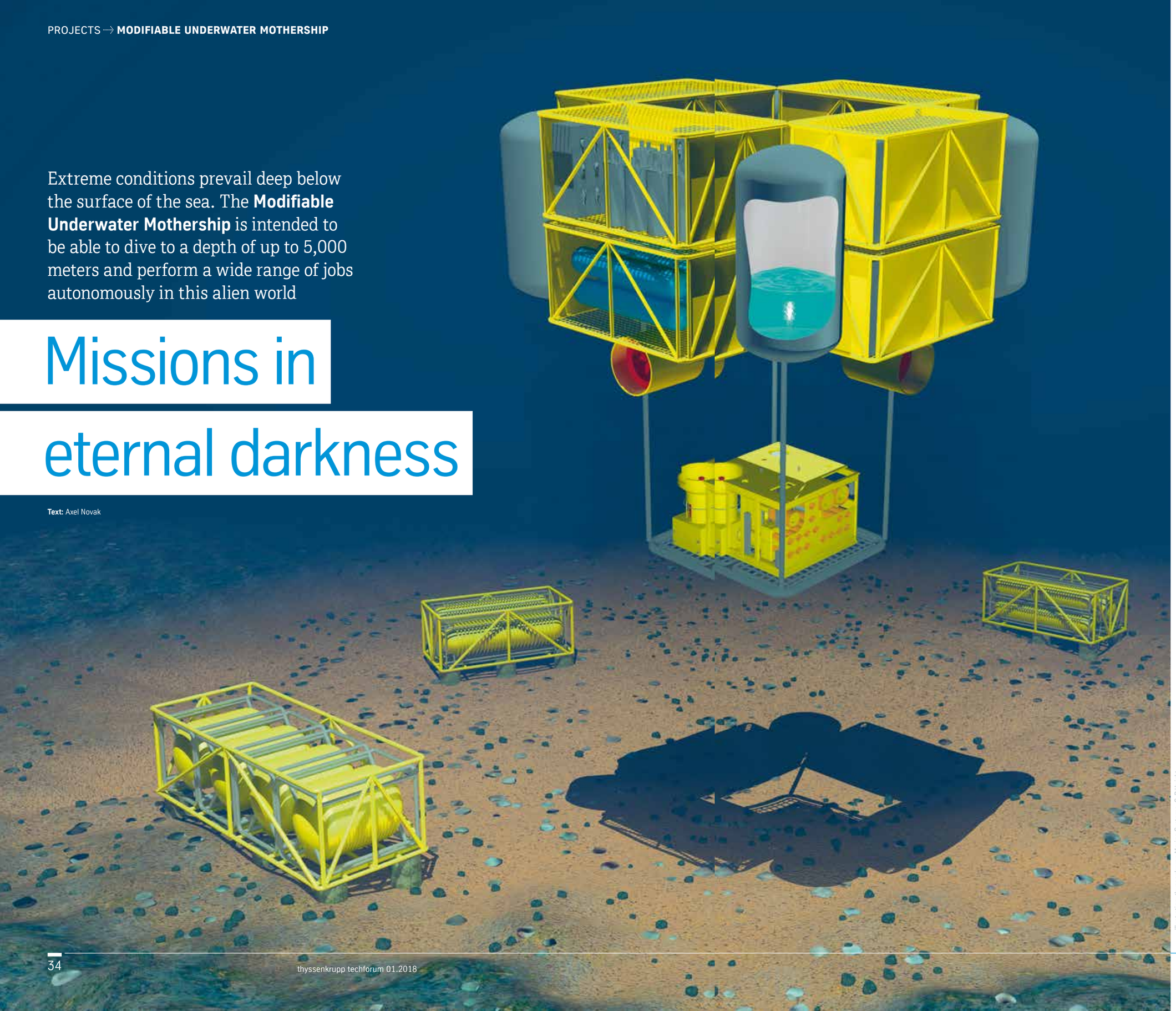
The test drive is over. Carlo Miano drives the MRP vehicle into the shop. He switches off the electric motors and fills out the test report. How does he rate the steering properties, the handling and the driving experience generally? Meanwhile, Leonard Lapis stores the data on his laptop. He will evaluate the results later today: "It is important to capture both objective and subjective information if we want not only to improve driving dynamics and safety in dangerous situations but also to enhance comfort for occupants," he says.

All three factors are crucial in the development of new mobility concepts: autonomously driven robot taxis, for example, will become established only if they can deliver their passengers to their destination in safety and comfort, Kristof Polmans explains: "A key part is played here by the development and control of chassis components – for instance, active damping systems that deaden the impact of potholes or prevent the vehicle leaning too heavily into a bend," he says. "With the Modular Research Platform, we are able to not only capture this interplay but also adjust it to meet customer wishes."

Extreme conditions prevail deep below the surface of the sea. The **Modifiable Underwater Mothership** is intended to be able to dive to a depth of up to 5,000 meters and perform a wide range of jobs autonomously in this alien world

Missions in eternal darkness

Text: Axel Novak

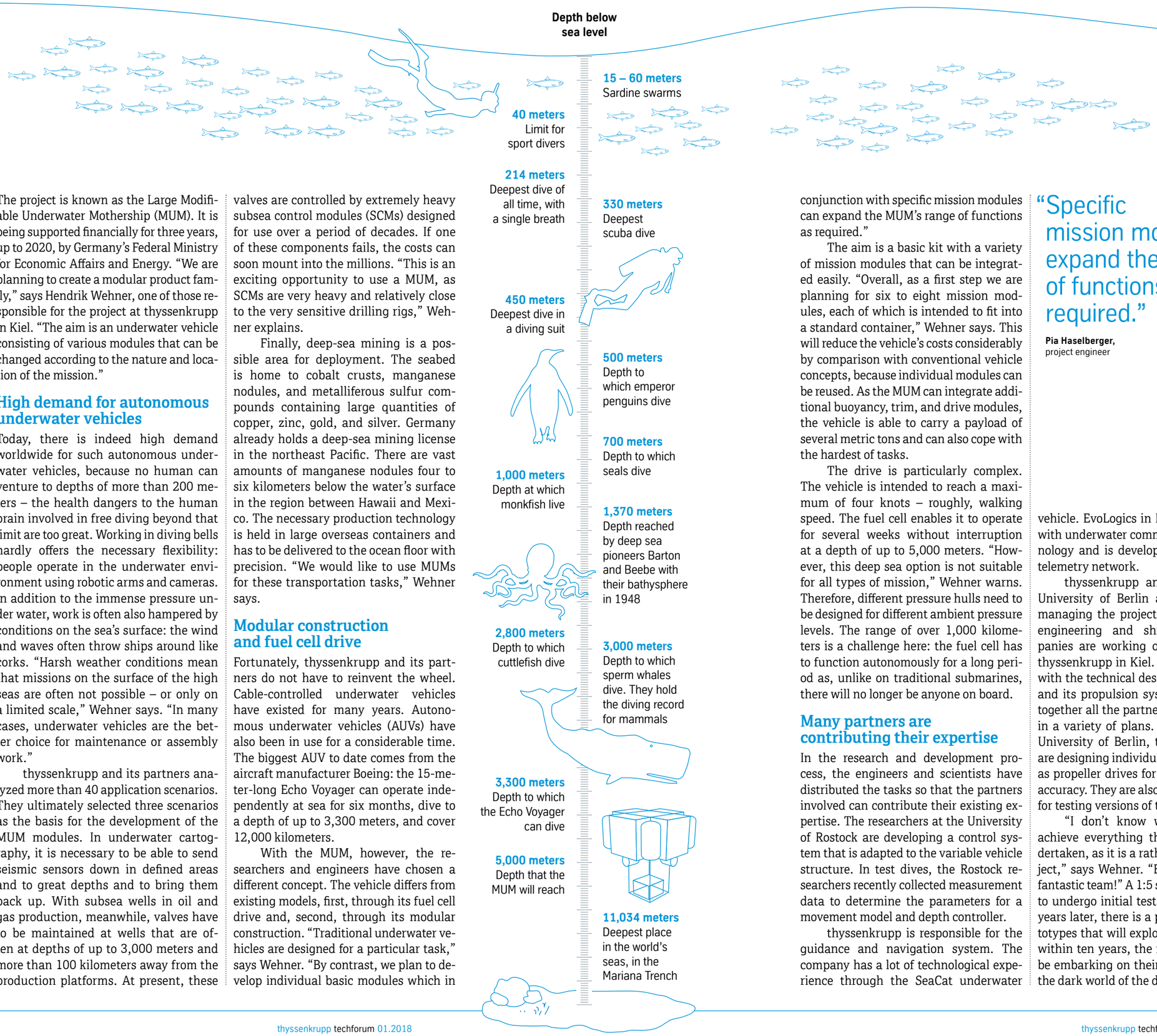


Modular construction: The underwater vehicle can be adapted perfectly for any mission

Illustration: thyssenkrupp Marine Systems, C. Röhricht

Two-thirds of the surface of our planet are covered in water. Seven seas envelop the land, and three oceans separate the continents. One thing, above all else, distinguishes the global waters: they are deep. Their bed is often unexplored, and harsh weather conditions often prevail on the sea's surface. That is bad luck for anyone who wants to explore or accomplish anything at the bottom of the sea.

For this reason, engineers from thyssenkrupp have joined forces with researchers from the Technical University of Berlin and the University of Rostock and engineers from EvoLogics. They are seeking to develop a new class of unmanned underwater vehicle to make it possible to work at the bottom of the world's seas. »



The project is known as the Large Modifiable Underwater Mothership (MUM). It is being supported financially for three years, up to 2020, by Germany's Federal Ministry for Economic Affairs and Energy. "We are planning to create a modular product family," says Hendrik Wehner, one of those responsible for the project at thyssenkrupp in Kiel. "The aim is an underwater vehicle consisting of various modules that can be changed according to the nature and location of the mission."

High demand for autonomous underwater vehicles

Today, there is indeed high demand worldwide for such autonomous underwater vehicles, because no human can venture to depths of more than 200 meters – the health dangers to the human brain involved in free diving beyond that limit are too great. Working in diving bells hardly offers the necessary flexibility: people operate in the underwater environment using robotic arms and cameras. In addition to the immense pressure under water, work is often also hampered by conditions on the sea's surface: the wind and waves often throw ships around like corks. "Harsh weather conditions mean that missions on the surface of the high seas are often not possible – or only on a limited scale," Wehner says. "In many cases, underwater vehicles are the better choice for maintenance or assembly work."

thyssenkrupp and its partners analyzed more than 40 application scenarios. They ultimately selected three scenarios as the basis for the development of the MUM modules. In underwater cartography, it is necessary to be able to send seismic sensors down in defined areas and to great depths and to bring them back up. With subsea wells in oil and gas production, meanwhile, valves have to be maintained at wells that are often at depths of up to 3,000 meters and more than 100 kilometers away from the production platforms. At present, these valves are controlled by extremely heavy subsea control modules (SCMs) designed for use over a period of decades. If one of these components fails, the costs can soon mount into the millions. "This is an exciting opportunity to use a MUM, as SCMs are very heavy and relatively close to the very sensitive drilling rigs," Wehner explains.

Finally, deep-sea mining is a possible area for deployment. The seabed is home to cobalt crusts, manganese nodules, and metalliferous sulfur compounds containing large quantities of copper, zinc, gold, and silver. Germany already holds a deep-sea mining license in the northeast Pacific. There are vast amounts of manganese nodules four to six kilometers below the water's surface in the region between Hawaii and Mexico. The necessary production technology is held in large overseas containers and has to be delivered to the ocean floor with precision. "We would like to use MUMs for these transportation tasks," Wehner says.

Modular construction and fuel cell drive

Fortunately, thyssenkrupp and its partners do not have to reinvent the wheel. Cable-controlled underwater vehicles have existed for many years. Autonomous underwater vehicles (AUVs) have also been in use for a considerable time. The biggest AUV to date comes from the aircraft manufacturer Boeing: the 15-meter-long Echo Voyager can operate independently at sea for six months, dive to a depth of up to 3,300 meters, and cover 12,000 kilometers.

With the MUM, however, the researchers and engineers have chosen a different concept. The vehicle differs from existing models, first, through its fuel cell drive and, second, through its modular construction. "Traditional underwater vehicles are designed for a particular task," says Wehner. "By contrast, we plan to develop individual basic modules which in conjunction with specific mission modules can expand the MUM's range of functions as required."

The aim is a basic kit with a variety of mission modules that can be integrated easily. "Overall, as a first step we are planning for six to eight mission modules, each of which is intended to fit into a standard container," Wehner says. This will reduce the vehicle's costs considerably by comparison with conventional vehicle concepts, because individual modules can be reused. As the MUM can integrate additional buoyancy, trim, and drive modules, the vehicle is able to carry a payload of several metric tons and can also cope with the hardest of tasks.

The drive is particularly complex. The vehicle is intended to reach a maximum of four knots – roughly, walking speed. The fuel cell enables it to operate for several weeks without interruption at a depth of up to 5,000 meters. "However, this deep sea option is not suitable for all types of mission," Wehner warns. Therefore, different pressure hulls need to be designed for different ambient pressure levels. The range of over 1,000 kilometers is a challenge here: the fuel cell has to function autonomously for a long period as, unlike on traditional submarines, there will no longer be anyone on board.

Many partners are contributing their expertise

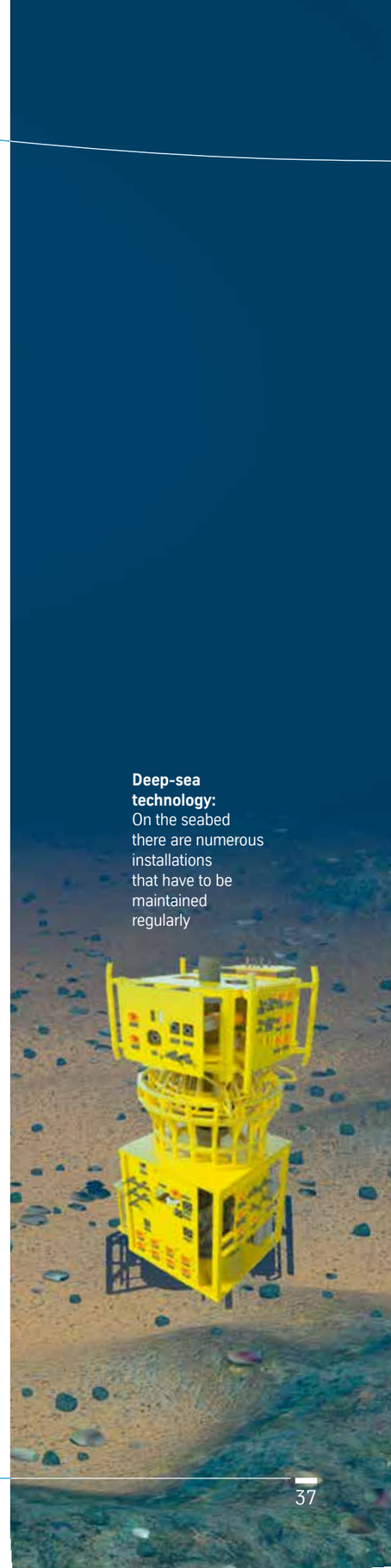
In the research and development process, the engineers and scientists have distributed the tasks so that the partners involved can contribute their existing expertise. The researchers at the University of Rostock are developing a control system that is adapted to the variable vehicle structure. In test dives, the Rostock researchers recently collected measurement data to determine the parameters for a movement model and depth controller.

thyssenkrupp is responsible for the guidance and navigation system. The company has a lot of technological experience through the SeaCat underwater vehicle. EvoLogics in Berlin is at home with underwater communications technology and is developing the system's telemetry network.

> "Specific mission modules expand the range of functions as required."
>
> **Pia Haselberger,** project engineer

thyssenkrupp and the Technical University of Berlin are in charge of managing the project. Six mechanical engineering and shipbuilding companies are working on the project at thyssenkrupp in Kiel. They are dealing with the technical design of the vehicle and its propulsion system and pulling together all the partners' developments in a variety of plans. At the Technical University of Berlin, three researchers are designing individual elements, such as propeller drives for high positioning accuracy. They are also building a model for testing versions of the MUM.

"I don't know whether we will achieve everything that we have undertaken, as it is a rather visionary project," says Wehner. "But we do have a fantastic team!" A 1:5 scale model is due to undergo initial tests by 2019. Three years later, there is a possibility of prototypes that will explore the sea. Then, within ten years, the first MUMs could be embarking on their real missions to the dark world of the deep sea.

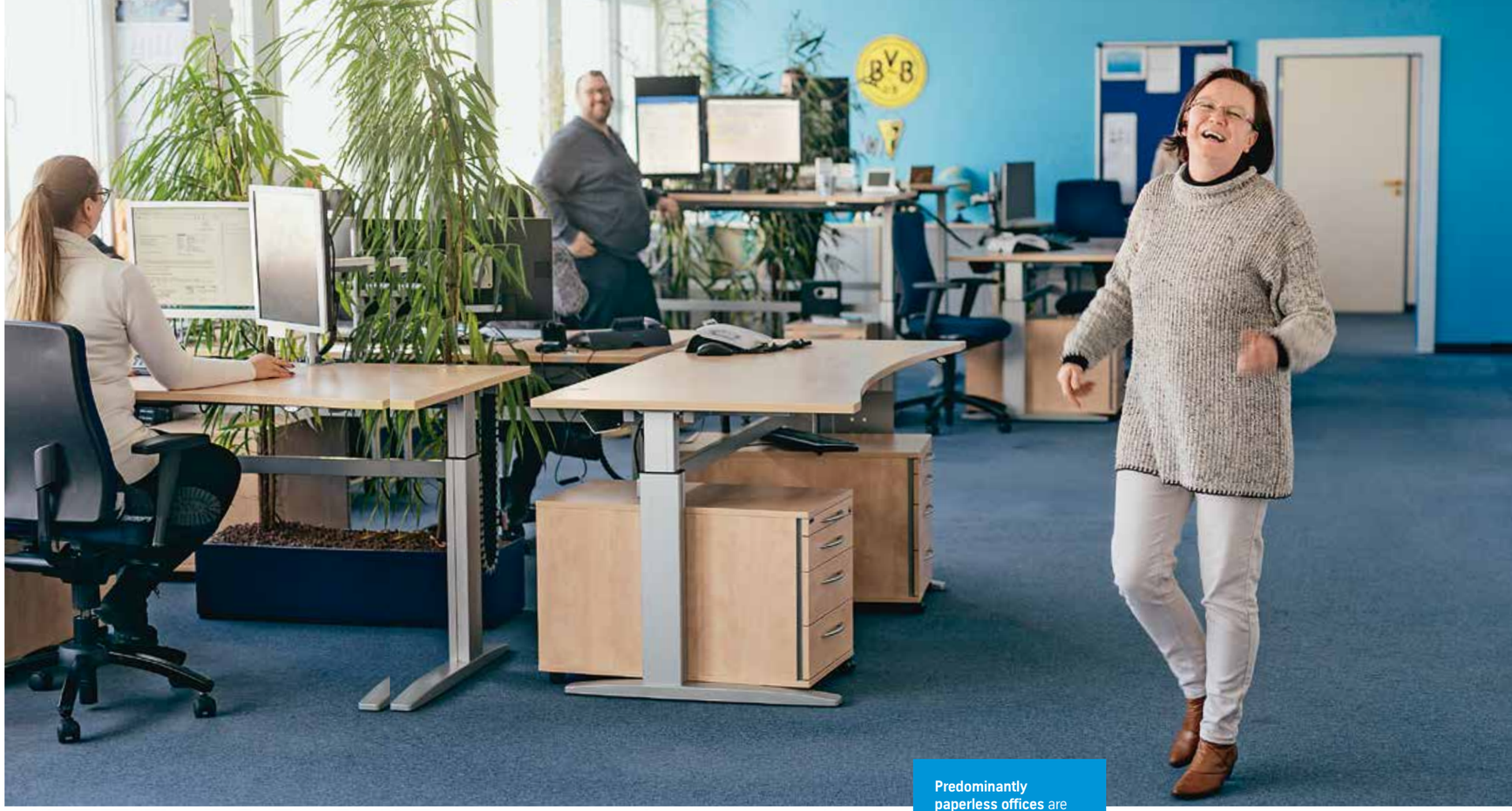


Deep-sea technology: On the seabed there are numerous installations that have to be maintained regularly

Digitization is a must

In the thyssenkrupp Materials Services division, **digital process optimization** is being driven by "Alice & Bob," with the aim of increasing customer-friendliness and margins

Text: Mirko Heinemann **Photos:** Quirin Leppert



Predominantly paperless offices are now the norm at the Munich site. Despite this, additional optimization opportunities are constantly being sought, and employees are very enthusiastic about digitization.

The materials warehouse with 50 employees mainly supplies tradespeople, metal-processing firms and industrial enterprises with a range of products, including rods, which are moved by large cranes.

When it comes to digitization in large industrial companies, anyone who conjures up images of robots, virtual reality, and the Internet of Things will not have to look far in professional materials distribution. By comparison, the greatest challenge is unspectacular: paper. This is because paper remains the leading medium. "In the steel trade, an estimated 50 to 60 percent of orders are processed by fax," explains Axel Berger, Head of Digital Transformation at thyssenkrupp Materials Services.

The digitization expert has been tasked with bridging the divide between bytes and paper and replacing the good old fax machine with modern, IT-supported process control. And that's not all. Together with his team of 25 at the head office in Essen, Axel Berger is initiating an optimization offensive throughout the entire division. The team's mission is to digitize the entire supply chain. What Berger modestly refers to as "bread-and-butter innovation" is actually extremely complex: optimizing processes while business carries on as normal. From the order to warehouse management and picking to logistics, all forms of modern IT will take their turn: sensor technology, the Internet of Things, big data, and robotics, to name a just few.

It's all about improving both customer-friendliness and margins. At just short of €12 billion, the Materials Services business area has the highest sales in the Group. With just under 20,000 employees, it operates in 40 countries with a materials portfolio that includes steel, aluminum and plastic components along with processed products such as cut sheets, sheet metal, round steel bars, and profiles. Digital solutions remove bottlenecks in the supply chain. They accelerate processes, make them more transparent for all concerned and stimulate growth. "Digitization in materials distribution isn't optional, it's a must," says Axel Berger, referring to the success of the global e-commerce platforms Amazon, eBay, and Alibaba.

> "In the steel trade, an estimated 50 to 60 percent of orders are processed by fax."
>
> **Axel Berger,**
> Head of Digital Transformation at thyssenkrupp Materials Services

Digital transformation at thyssenkrupp Materials Services has been taken over by Alice and Bob. These are the names of the complementary IT systems: the substructure and the application, or back end and front end. "Bob provides the substructure, and Alice the specific implementation of projects within the business divisions," explains Berger. Alice is the high-speed solution for customers, while Bob is the system that connects it all together. Bob needs more time than Alice. "In a two-speed IT environment, everyone – whatever side they're working on – needs to know that the other side exists," says Berger. This is why Alice and Bob are inextricably linked.

Representative pilot locations

The idea is to select a pilot location that is representative of one of the five business models that have emerged from the different levels of production depth in the two core business areas of warehouse-based distribution and supply chain management. "We organize a workshop at that location, in which all of its processes are presented," says Berger. Specialists then consider at which points the overall process could be optimized, for instance where there are media discontinuities. A classic example is the fax machine mentioned at the beginning, or when an employee enters an order into the ERP system, but uses a calculator to determine the price. Of course, it would be better if the processes were to take place entirely within an IT system. An additional benefit of this approach is that all of the »

> "We are already 97 percent paperless. That is something quite unusual in this sector."
>
> **Andreas Kellermann,** manager of the Munich site

In the creative space: Andreas Kellermann (left) agrees on future workflows with two colleagues

established processes are reviewed during the workshop. For example, if customers purchase on a contractual basis, the contracts will have to be standardized: one standard contract instead of different ones for each location.

"While many corporations introduce a digital ERP system and then adapt the processes, we're taking the opposite approach," explains Berger. "We're asking which tools we need to digitize the processes: automation, data analytics, or IoT?" So first Alice, then Bob. Alice sets the requirements, Bob has to deliver. Bob's current task, for example, is to harmonize the master data for the roughly 150,000 material items sold by thyssenkrupp Materials Services. This is taking place in parallel to the pilot projects. If they are successful, this will be rolled out.

Implementation has begun

Two pilot projects are already being implemented: one in Munich, Germany, and the other in Milton Keynes in the UK. Munich is, in a sense, the base model. This is where thyssenkrupp Materials Services operates a materials warehouse with 50 employees. The customers are tradespeople, metal-processing firms, and industry. Restructuring has already taken place, with warehouse organization and picking being converted to digital form. "We are already 97 percent paperless. That is something quite unusual in this sector," explains Andreas Kellermann, manager of the Munich site. This is why Munich volunteered to be the first pilot location for the implementation of Alice & Bob. "Here in Munich, we're always looking out for optimization opportunities," stresses Kellermann, who adds that there is much enthusiasm among the employees for digitization.

In Munich, picking notes and work orders are being digitized along with the introduction of a digital signature in the office, time window management in goods received, a digital distribution cockpit and, in the future, a digital loading and unloading inspection. There is also an integrated Kanban app for smartphones, which allows each customer to place orders digitally. "Kanban" is a working title – the term denotes a method used to control the production process. Kellermann is optimistic with regard to the success of the measures: "We do not yet have a complete picture, but there is now a business case for each of the digitization options." If the process optimizations in Munich are successful, they could be rolled out to a further 40 locations.

A similar pilot project, albeit for the supply chain management business model, has been implemented by Berger's team at thyssenkrupp Aerospace UK in Milton Keynes, near London, where materials for aircraft manufacturing are sold. Andy Cutler, Regional Manager Operational Excellence, highlights the significance of Alice & Bob for optimizing the established processes on site. "As part of the pilot project, we were able to take a fresh look at our overall end-to-end processes," says Cutler. "We identified process steps that we were able to skip. And we have now identified points where it makes sense for us to implement digital technologies." For example, metal saws now provide performance data via sensors such as service time and the quantity of material processed. The data are displayed on monitors, making it possible to analyze and optimize machine utilization. "We're streamlining the management of supply chains and thus creating a competitive advantage," says Cutler.

However, the real returns will only be achieved after rollout. For instance, even if only the picking notes and work orders are digitized, according to Axel Berger's calculations, the whole thyssenkrupp Materials Services division could theoretically save 1.5 million euros a year – and recoup their initial investment within just one year.

Digitization XXL: Around 15 meters of paper are used to describe the entire process. The sheets of paper are best rolled out on the floor. The diagram (right) details the digitization options

Cradle of new lightness

The **Open Hybrid LabFactory** is creating hybrid components for mass production. thyssenkrupp is taking part with new steel materials

Text: Bärbel Brockmann

Demonstrator: Fabian Schongen (left) and Lothar Patberg show off a hybrid body component with plastic in the middle

> "Put lightweight construction into large-scale production, with extremely high production reliability."
>
> **Dr. Lothar Patberg,** Head of Innovation at thyssenkrupp Steel Europe

Lightweight construction is the order of the day, especially in the automotive industry, as this is a sector where less weight also always means less fuel consumption and, consequently, lower CO_2 emissions. As a result, for all makers of vehicles with internal combustion engines, lightweight construction is a way of complying with the carbon dioxide limits set by the EU. In electric vehicles, energy recovery during braking and the falling cost of batteries mean that weight reduction will become less important. However, there are high expectations with regard to functional integration.

Two different ways to lightweight construction

Essentially, there are two ways of approaching lightweight construction. First, you can improve the material used so that less of it is needed. Alternatively, you can reduce weight through an optimum combination of different materials in hybrid construction and increase functional integration. Research has been going on into this for years, but so far each materials sector has usually been viewing things only from its own perspective: people in steel know little about plastics, and vice versa. The search for truly suitable hybrid solutions is also often hampered by competition between the sectors.

The Open Hybrid LabFactory (OHLF) in Wolfsburg is seeking to change this. At this lightweight construction campus, which is supported by Germany's Federal Ministry of Education and Research, steel producers, equipment manufacturers, component suppliers, and plastics suppliers have been working together since the fall of 2016 to develop hybrid components for mass production, especially in automobile manufacturing. In addition to thyssenkrupp, the participants include BASF, the injection molding machinery manufacturer Engel, the press builder Siempelkamp, the auto component supplier Magna, and Volkswagen. Coordination of the projects is in the hands of the Fraunhofer-Gesellschaft and the Technische Universität Braunschweig.

"Our aim is to put lightweight construction into large-scale production, and with extremely high production reliability," says Dr. Lothar Patberg, Head of Innovation at thyssenkrupp Steel Europe. For this to work, it is not only necessary to bring all participants around one table – you also need the same facilities as you will for future large-scale production. The OHLF has these – for example, a coil-coating line just like those found in industrial production. "However, we also need to develop new machines and tools for hybrid construction," Patberg explains. "This is why the OHLF was created – to provide a holistic perspective. That is the only way that we can get the most out of steel/plastic construction."

Investigation of steel/plastic hybrids

thyssenkrupp is involved in the OHLF with new steel materials. The company's own pre-development projects can be tested here, and initial applications can be designed in collaboration with the automobile manufacturer. Investigations are going on into, for example, steel/plastic hybrids where a plastic layer is applied to a solid steel material. The aim is to offer a steel product with a coupling layer, to which other plastics or composites such as carbon fiber reinforced plastics (CFRP) can subsequently be applied by familiar processes such as injection or compression molding.

Lightweight construction campus: The OHLF in Wolfsburg

Photos: thyssenkrupp; Detlev Wecke

A special pre-treatment activates the steel so that the plastic forms a very intimate and durable bond with it. This particular expertise was developed by thyssenkrupp's researchers to make steel/plastic hybrids possible. When steel sheets are coated with a plastic layer, this makes it possible to apply additional plastic elements. "With a completely secure bond between the materials, it is possible to combine the advantages of steel and plastic construction to a high level of quality," says Dr. Fabian Schongen, project leader in the Innovation unit at thyssenkrupp Steel Europe. Steel is used wherever high strength is absolutely essential. Where that is not a requirement, plastics can be used and functional integration can be increased with screw-fixing points, for example. Overall, this saves weight.

The possible future uses of steel/plastic hybrids are diverse, especially in automobiles. They allow the right material to be used in the right place – for example in the front end. It has to withstand a lot, especially in an accident. Therefore, this complex component is at present usually made entirely of steel. The particularly strong steel profiles have many other steel parts welded to them to support the bumper, headlamps, or cooling systems, for example. These parts do not necessarily have to be made of steel and could also be made of lighter plastic. However, unless the different materials can be bonded with absolute reliability, it will not be possible to make adequate use of the potential of lightweight construction.

Another possible use could be in cockpit crossbeams. These often consist of many elaborately joined components, to which plastic parts are attached with screws. In the future, a steel profile could be made with molded-on plastic parts, thus integrating many components. All this is no longer a pipe dream. "In projects at the OHLF, we are validating our technology with customers and processors, so that we can be in production within just a few years," Schongen says.

Show us what you can do!

In "BeyondConventions," established companies presented **aspiring start-ups with specific challenges.** Long-term collaborations beckon for the winners

Text: Christian Buck **Photos:** thyssenkrupp

The final: 35 start-ups came to the thyssenkrupp headquarters in Essen in February to present their solutions

Around the globe thyssenkrupp builds technically complex facilities for customers in the chemical and cement industry. Meticulous project management is a must, otherwise adhering to timetables and cost projections soon becomes impossible. The regular inspection of construction progress is an important aspect of this work: thyssenkrupp's employees, armed with a plethora of checklists, survey the construction sites and establish what percentage of progress has been made on a building or technical facility. It is a laborious and time-consuming task.

Drones could soon assist in this area. The tiny flying devices can be fitted with cameras and used to film construction sites, thus facilitating the analysis of building progress with the images produced. This analysis can even be automated with intelligent software. Algorithms identify relevant information such as the concrete elements, steel girders, and technical facility components in the images; they can also eliminate unimportant elements such as scaffolding or construction machines, and create a 3D model. To evaluate the progress of construction, the software compares the identified objects against the facility's original planning model – making tedious inspections a thing of the past.

That, at least, is how they imagine the future in thyssenkrupp's plant engineering division. And it could soon become reality, as the company has already found a potential partner to implement the drone-based construction site analysis concept: the start-up company Orbica from Christchurch in New Zealand. The two companies, which could not be more different, got together at "BeyondConventions," a new format that encourages collaboration between new companies and established groups based in the Ruhr region.

> "Real added value is generated when you bring together knowledge from different companies and corporate cultures."
>
> **Heinrich Hiesinger,** CEO thyssenkrupp

Unconventional solutions by creative companies

In November 2017, thyssenkrupp, innogy, Open Grid Europe, Schacht One (Haniel), and FUNKE MEDIEN NRW defined a total of 17 challenges from their fields of business and called on the international start-up scene to offer creative solutions. The name "BeyondConventions" signals clearly what this is all about for these five companies: unconventional solutions by creative companies that are not afraid to break the mold. This is the first time that these major groups are partnering with start-ups in this way. "We're convinced that large companies and start-ups can learn a lot from each other, both in terms of methods and content," says Ufuk Ergen from thyssenkrupp's Innovation Department, who organized the event with his colleague Jakob Barzel from Corporate Communications. "But that can only work on the basis of concrete examples and products – and that's why we set up BeyondConventions."

In addition to monitoring construction progress, other challenges included the cost-effective analysis of scrap metal, new business models based on digital building data, and camera-based quality control in production. More than 220 start-ups took on the challenge and submitted their suggestions via the online platform beyondconventions.de. 80 percent of responses came from Germany, »

Plenary session: The challenges were presented again on the first day (top)
Supporter: Heinrich Hiesinger emphasized the importance of cross-sectoral cooperation

Congratulations: Botential's HR chatbot wins the race

with the rest coming from as far afield as Austria, France, Spain, Switzerland, New Zealand, and the USA.

After an initial selection round and bilateral discussions between the groups and start-ups, the most promising candidates for each challenge were invited to the final. Then, on February 20–21, 2017, the time had come: 35 start-ups gathered at thyssenkrupp's headquarters in Essen to pitch their solutions. On the first day, the challenges were presented once again in detail in a plenary session. Then, on the following day, the start-ups were given the opportunity to present their solutions at the company stands. "They only had seven minutes, plus three minutes for questions and answers," explains Ergen. "The people from the business divisions who set the challenges were present, as were other interested company representatives."

After exchanges before the meeting, the live presentations, and personal discussions in Essen, the winners were finally announced – with Orbica among them as the winner of the drone challenge. In thyssenkrupp's HR Chatbot challenge, the Botential start-up company from Austria came out on top. They had responded to the challenge of creating software that used artificial intelligence and digital text processing to answer frequently asked questions on the Group's careers website and Facebook page. "We received 22 applications for this challenge alone," says Ergen. "It was the most popular challenge at BeyondConventions."

Software that recognizes the customer's wishes

Communication with customers was the focus in thyssenkrupp's "Product Matching Engine" challenge. Each year, the Materials Services division receives hundreds of thousands of orders by fax and email.

> "95 percent of the start-ups would take part again and 98 percent would recommend the event to others."
>
> **Ufuk Ergen,** thyssenkrupp Innovation Department

"In many cases it's not easy to work out what the customer actually wants straight away," explains Ergen. "We often have handwritten notes that first have to be decoded." No surprise, then, that it can often take up to ten minutes before the order is correctly interpreted and entered into the system. The German start-up company FoxBase has developed a solution to this problem. It identifies the customer's wishes from the words and numbers in an order, and processes all the information so that it can be recorded without too much difficulty. With its innovative solution, FoxBase beat off tough competition in this challenge.

The winners do not receive a specified sum of prize money or a symbolic award, as BeyondConventions is about real collaboration between companies – pilot projects and contracts. Time will tell what the future holds for the groups, the start-ups, and the challenges they collaborate on. One thing is already clear, however: participating start-ups were very enthusiastic about the event. "95 percent would take part again and 98 percent would recommend the event to others," say Barzel and Ergen. "So we're already thinking about the next BeyondConventions."

Heinrich Hiesinger, CEO of thyssenkrupp, also emphasized the importance of cross-sectoral cooperation, as promoted through BeyondConventions: "These days, knowledge alone is not enough to attain a real competitive advantage. Real added value is generated when you bring together knowledge from different companies and corporate cultures. Only those who are in a position to work with others in this way can successfully shape the digital transformation."

Photos: thyssenkrupp

Moment of truth: On the second day, the start-ups pitched their solutions to the groups

The players

A 20-strong team at thyssenkrupp Marine Systems have invented **a virtual training solution** for ships' crews. Many of the team members previously developed computer games

Text: Mirko Heinemann

Training on the high seas: In the virtual world, it can be done in optimum conditions

The helicopter thunders in. It is due to land on a Sachsen-class frigate. The flight deck officer (FDO) stands on the flight deck and waves his arms to guide the helicopter in. The weather is stormy. The wind pulls at his clothing and whistles around his ears. At least, that is how it feels, as in reality the FDO is standing in a converted warehouse on the site of the former Blohm & Voss shipyard in Hamburg. He is wearing a special suit and a large pair of spectacles – devices that use visual and acoustic stimuli to lead him to imagine that he is standing on the flight deck.

This virtual world was developed by a 20-strong team at the thyssenkrupp site in Hamburg. The IT experts are working on creating a virtual version of the operations on ships and submarines for training purposes. To do this, they have designed ViSTIS, the Virtual Ship Training and Information System. Like all the solutions they have devised, the FDO simulation is part of ViSTIS. Stephan Braß, 52, is in charge of the team. He praises the creative working atmosphere and flat hierarchies. "On the one hand, we feel like a kind of start-up, but on the other we are very process-oriented," he says. "We work creatively, and we also put unconventional ideas into practice, but we naturally always operate within the guidance set by our customers and our own company."

Before they joined the ViSTIS team, some of its members developed computer games. They appreciate the creative freedom they are given at thyssenkrupp. "What we do here is very similar to the work of games developers," explains Carsten Brüggmann. "Some things are harder, because we have to adapt to the IT specifics and requirements of the Group. Others are easier, because, as a start-up within the company, we have the Group's structures and its financial security in the background."

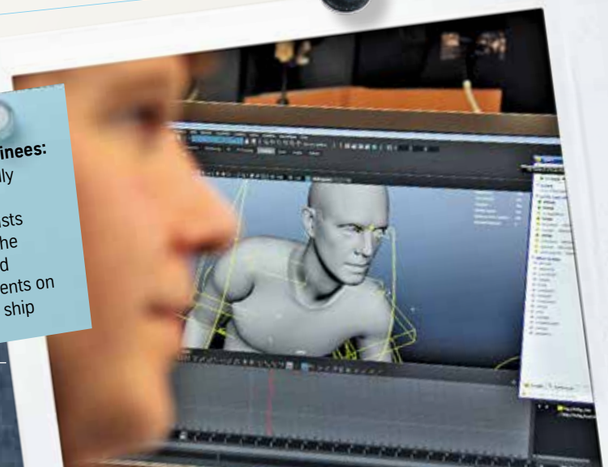
"We are given enough time to test things," Jörg Klüver adds. "If they don't work out, we have still gained experience." In the games industry there is often heavy production pressure, and games have to be ready quickly, he says. "This leads to many games looking very similar. Here, by contrast, we do things that are completely new," he comments. In addition, he notes, the games industry is fast-moving, with fashions changing in the space of a few months. "Designs and concepts that are popular today can be filed away in a drawer by tomorrow," he says.

The ViSTIS experts gain momentum from their success: the FDO simulator earned them the thyssenkrupp Innovation Award in 2015. They have applied for a patent for the Shore Based Training Solution, the system for training ships' crews on land. For this innovative solution, the team specially developed a virtual ship, in the control rooms of which all crew members can act and interact as virtual avatars. Accidents and crises can be simulated there cheaply and without risk.

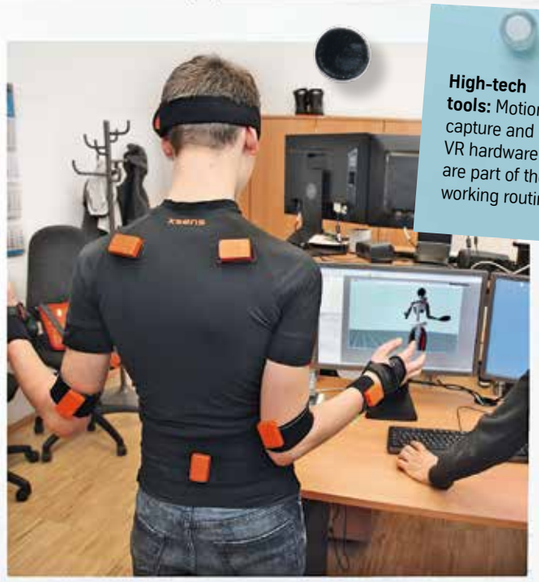
"All aspects of the virtual ship can be operated with this solution," explains Michael Specht, who is responsible for quality control. "That means we can train the entire crew." The system is becoming more and more sophisticated: the next step is for the virtual world to be supplemented with simulators similar to flight simulators. Also, as with the Flight Deck Officer simulation, VR (virtual reality) hardware will be used to make the whole thing even more realistic – including simulated waves.

The IT experts at ViSTIS have ample space to try things out. The team are based in a former warehouse with high ceilings, reminiscent of the buildings of the nearby Speicherstadt district. "We can get from the St. Pauli area to the shipyard site in 20 minutes, either on foot through the Elbe Tunnel or by ferry across the Elbe," says team leader Braß. "This gives us a connection to the city and, at the same time, to the shipyard and the company." There is just one subject that gives rise to a little regret. Here, as everywhere else, programming is a male preserve. "Out of the 20 colleagues in the team, only three are women," Braß says. "We naturally all hope this will change in the future."

Start-up atmosphere: The Hamburg research team has a very informal atmosphere, and its members appreciate their creative freedom



Virtual trainees: The digitally created protagonists operate the simulated components on board a ship



High-tech tools: Motion capture and VR hardware are part of the working routine

Photos: thyssenkrupp

Pyramids of water

Blooming landscapes instead of deserts: a rediscovered ancient Egyptian technology brings prosperity and peace

The year is 2050. All over the world, great pyramids are being built again – to produce drinking water! Back in 2030, researchers had revived an old, rather obscure theory about the function of those monumental ancient Egyptian structures with the help of new materials and scientific research findings. Made from a new, hyper-hygroscopic substance and coated with copper, they function as giant condensers that can harvest large quantities of pure drinking water from the air.

This is because there are huge volumes of water flowing through the atmosphere. Every second, around 165,000 metric tons move in the form of humidity from the tropics to the temperate latitudes – a great potential that is now being tapped on an industrial scale thanks to the pyramid-shaped water transformers. They also came not a moment too soon. According to UNICEF, at the beginning of the 2020s around 750 million people worldwide had no access to clean drinking water. And studies were forecasting continued sharply rising demand in the region between Morocco and Iran.

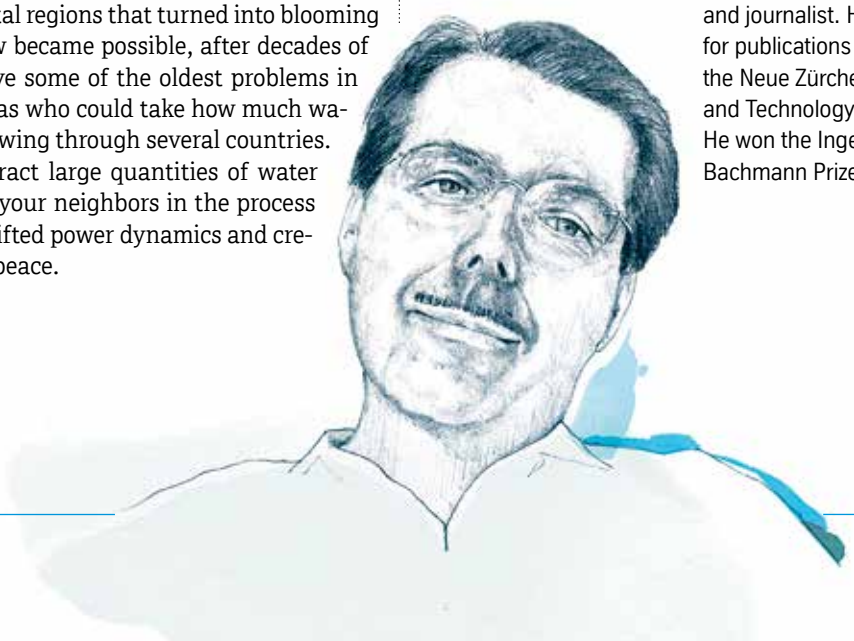
The pyramids' shape is of crucial importance for water production. It enables the copper shell to interact with the extremely hydrophilic substrate that is used instead of traditional stone blocks. Prior to this, many countries had opted for the energy-intensive seawater desalination route, but economic and political problems repeatedly delayed the implementation of those ambitious plans and ultimately thwarted them completely.

In this difficult situation, the pyramid technology for producing water came as an unexpected piece of good fortune. It brought new prosperity to desert regions and led to a "green revolution." However, it was not only coastal regions that turned into blooming landscapes. It now became possible, after decades of disputes, to resolve some of the oldest problems in the region – such as who could take how much water from a river flowing through several countries. The ability to extract large quantities of water without harming your neighbors in the process fundamentally shifted power dynamics and created long-lasting peace.

The new great pyramids became symbols of independence. Many of the areas where people enthusiastically embraced this rediscovered form of water production had previously been dependent on the water flowing down a single river – and often on governments that claimed the main right to its use for themselves. The mere announcement of a plan to build a dam on a river such as the Jordan, the Nile, the Tigris, or the Euphrates could lead in the past to threats of war, as rivers were the region's central lifelines, and any attempt to increase one riparian state's control over them was regarded by the others as an existential threat.

These water pyramids operating on a local, decentralized basis eased the political situation at once. Autonomous access to this precious liquid is today making many areas independent for the first time, and they can now also no longer be blackmailed by neighbors that used to enjoy more power through water. On the contrary, those neighbors now find themselves compelled to offer fair talks among equal partners instead of continuing to use water to exert political pressure.

In the digital age, a state's size is increasingly unimportant, because even a small country can now secure algorithmic advantages. The new water pyramids work in a very similar way: thanks to this new technology, people can now resolve all their problems by negotiating with each other on equal terms – spurred on by a flourishing economy and sated with an abundant availability of water that also quenches the thirst for peace.



Peter Glaser is an author and journalist. He writes for publications including the Neue Zürcher Zeitung and Technology Review. He won the Ingeborg Bachmann Prize in 2002.

Illustration: Bianca Classen/Photos U3: PR/ Cover photo: Marcus Simaitis

Water-stressed world

For how many people does the Earth have a sufficient supply of water? What impact is climate change having on water supplies? What "water ethos" do we need to manage this vital resource sustainably? These and many other questions surrounding the topic of "water" are the subject of this book. It traces what happens to raindrops, explains the difference between "green" and "blue" water, and indicates ways to save water in agriculture.

Wasser
Dieter Gerten
C.H.Beck
14,95 €

Travels to water

The writer and economist Erik Orsenna takes the reader along on his worldwide journeys of discovery to meet water experts and users in countries including Australia, Singapore, India, Israel, China, France, and Algeria. Very tangible examples illustrate how complex all questions surrounding this precious liquid are and how greatly solutions depend on specific conditions on the ground.

Die Zukunft des Wassers
Erik Orsenna
C.H.Beck
21,95 €

Panorama of climate research

On more than 700 pages, the well-known climate researcher Hans Joachim Schellnhuber sets out a readable and, in parts, very personal panorama of his science from early research in the 19th century to the present state of climate science. The book airs both the possible consequences of climate change and sensible countermeasures. His insights into the dramas of the major climate conferences are also of interest.

Selbstverbrennung
Hans Joachim Schellnhuber
C. Bertelsmann
29,99 €

A classic on the climate change issue

Never in a past covering nearly a million years has the concentration of CO_2 in the atmosphere been as high as it is today. The two climate researchers, Rahmstorf and Schellnhuber, report succinctly on what science knows today about the history of the climate. They explain the greenhouse effect and the consequences that a continued increase in global temperatures would have. They also express a view on the sometimes heated debate on the climate among politicians and in the media.

Der Klimawandel
Stefan Rahmstorf,
Hans Joachim Schellnhuber
C.H.Beck
8,95 €

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"With our sustainable products and solutions we not only assume responsibility for future generations – I am also firmly convinced that they are solid investments for our customers and our stakeholders."

Dr. Markus Oles is Head of Innovation Strategy and Projects at thyssenkrupp. Together with his team, the trained physicist investigates topics and trends which might become relevant for the Group in the future. Where the prospects of success are good he launches and heads appropriate projects – nearly always in cooperation with other departments at thyssenkrupp. Sustainability is of great importance in his work, for instance in the form of closed cycles for CO_2 or raw materials. **Page 16 –17**