DELFT OUTLOOK | NO. 1 | APR 2018 | YEAR 35
TU Delft

Wilma van Wezenbeek and Geert-Jan Houben
'Share your data'

TROPOMI
Tracking global air pollution with precision

Renovation
Turning post-war flats into energy-neutral buildings

THEME
Circularity

Cover:
Mesbah Sabur (left) and Jordi de Vos of Circularise at a metal recycling company. It is difficult here to imagine what your photo will look like. Large mountains of small material make it hard to define the proportions. But there is always a combination to find where everything falls into place. Photographer Sam Rentmeester

Editorial
Saskia Bonger

Circularity

The Netherlands (with TU Delft at the helm) as a model country in the circular economy. This, in a nutshell, is how David Peck (A+BE) envisages the future. He first introduced the term at TU Delft in 2012, and he is now sharing his vision of the future in this special issue. No more fossil fuels or mountains of recyclable refuse. Closed cycles in which critical materials are retained are commonplace.
But before we get this far, governments must bring in legislation and regulations and major companies must change their production processes. In the meantime, more and more researchers and entrepreneurs have already made a start. TU alumnus Derk-Jan van Heerden, for example. In this edition, he describes the start and work of his company Aircraft End-of-Life Solutions (AELS), which dismantles and recycles decommissioned aircraft.

At TU Delft, some one hundred researchers are working on projects concerning sustainability and circular economics. Jaco Quist and his graduate Eline Leising drew up a step-by-step plan to help one of our country's most waste-producing sectors, construction, to redefine its processes. Yongxiang Yang is conducting research into recovering metals from refuse, using a gigantic mountain of waste containing valuable metals in the Port of Rotterdam as a concrete example.
Our 'brief history of the circular economy' shows that the term circular economy relates to older movements. The concept is not new. But there seems to be a difference: the recycling concept isn't only necessary, but can and must prove profitable if David Peck's vision for the future is to become reality.

Saskia Bonger,
editor-in-chief

PHOTO: SAM RENTMEESTER

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Theme Circularity

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COLOPHON
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DELFT IN BRIEF

How a cell gathers its DNA

Before dividing, a cell must gather two metres of DNA, stored in the nucleus like a strand of spaghetti, and neatly spilt it between two daughter cells. A remarkable Science publication by Dr Mahipal Ganji, Prof. Cees Dekker et al revealed how the protein complex condensin does this. A film (on Youtube, TU Delft, Condensin Loop Extrusion) shows how a condensin molecule attaches itself to a DNA strand and pulls a long loop inwards. Thanks to these loops, the tangle of DNA is a lot better organised than it may seem at first glance.

Rowing tracker

Metamaterial for artificial hip

Dr Amir Zadpoor and staff from the biomaterials and tissue biomechanics department (Faculty of 3mE) have developed a special type of implantable material. The meta-biomaterial, composed of three-dimensional titanium structures, gets thicker perpendicular to the direction in which pressure is applied. Normally, materials become thinner when they are pulled. This is a particular problem with hip implants, and eventually causes them to detach from the surrounding bone. Zadpoor's metamaterial, by contrast, gets thicker when force is applied, bracing itself like a wedge bolt. The impact on the encasing bone is still being investigated, as is the question of how to make the material six times stronger.

The start-up Otis Insight has developed technology enabling a rowing coach to monitor up to four teams on the water simultaneously. Their Row4 product won the National Sport Innovator Prize. Physics student Sybren Zwetsloot built an on-board tracker comprising a GPS unit, a magnetometer, an accelerometer, a microcomputer and a transmitter/receiver with a six-kilometre range. The receiver plugged into the USB port of a tablet shows the speed, pace and acceleration for each of the four teams. The first series will be tested by student rowing clubs (including Laga and Nereus) and the KNRB rowing association.

Photo: Sam Rentmeester

Gentle pile-driving

The Energy Agreement is investing heavily in offshore wind energy. The projected capacity will increase fourteen-fold, to 4,450 MW by 2023, with even further increases in the future. Yet a report issued by the Ministry of Infrastructure and Water Management claims that marine mammals are suffering temporary or permanent hearing impairment caused by the pile-driving of the huge foundation pillars. The GROW (Growth through Research, development & demonstration in Offshore Wind) consortium, of which TU Delft is a member, intends to further develop current vibrating or hydraulic pile-driving methods in order to make them quieter. GROW has been awarded € 2.7 million worth of funding to study the effectiveness of high-frequency vibration pile-driving.

Delft Blockchain Lab

The opening of the Delft Blockchain Lab on 1 February attracted a lot of interest. The high value of the bitcoin, one of the most high-profile applications, has put blockchain technology in the spotlight. Director Prof. Dick Epema and scientific leader Dr Johan Pouwelse noticed the effect when the number of students applying for the Master's programme exceeded the maximum number by a factor of three. But blockchain is more than bitcoin. Blockchain technology offers an alternative that dispenses with the need for central monitoring in practically all areas where recorded transactions take place, including mortgages, energy trading, logistics etc. And this is Pouwelse's aim: to instil confidence in internet usage without central monitoring.

Nitrogen to counter earthquakes?

According to TU Professor of Reservoir systems and control Jan Dirk Jansen (CEG), reducing gas extraction to 12 billion cubic metres per year is not likely to solve the problem of earthquakes in Groningen. He is promoting the use of nitrogen injections in gas fields. He did this at a symposium on gas extraction in Groningen on 1 February last. "Injecting nitrogen into the fields prevents subsidence. You tackle the problem at its roots," argues Jansen, who is also a member of the Mining Council, which advises the Minister of Economic Affairs and Climate regarding detection and mining permits and mining plans. The NAM is not convinced, claiming that injections could cause even more earthquakes.

Photo: Sam Rentmeester

Vice Rector Magnificus

Rob Mudde was made the new Vice President of Education and Vice Rector Magnificus as of 1 March. This also makes him the new Vice President of the Executive Board. Mudde has worked at TU Delft for almost 30 years, most recently as Professor of Multiphase Flows (Applied Sciences), as distinguished professor in Science Education, and as head of the Teaching Academy and the Teaching Lab. “Education offers people opportunities,” he comments in Delta. **delta.tudelft.nl**

Plasma gasification in ship recycling

Decommissioned ocean-going giants are sold off to the highest bidder, often companies in Bangladesh, India or Pakistan, which cater to a market for second-hand ship equipment. Most of a ship’s carcass (85%) is scrap metal and a small proportion is organic waste, which is expensive to dispose of. Dr Jeroen Pruijn (Faculty of 3mE) studied whether plasma gasification of the organic waste could be profitable. This means a shipyard wouldn’t have to pay to dispose of organic material, while the gas could be used to produce fuel or chemicals. Although this is technically feasible, the market currently focuses on the value of second-hand equipment installed on board, says Pruijn.

Photo: Wikicommons

THEME

Circularity

The European Commission's action plan for the circular economy includes a list of 27 rare materials, which are hugely important to the European economy but are not naturally available in Europe (or are very scarce). These materials deserve extra attention in terms of economical use, new supply from disused equipment and other forms of recycling. The picture shows a piece of graphite, on display in the Mineral-Geological Museum (Science Centre Delft).

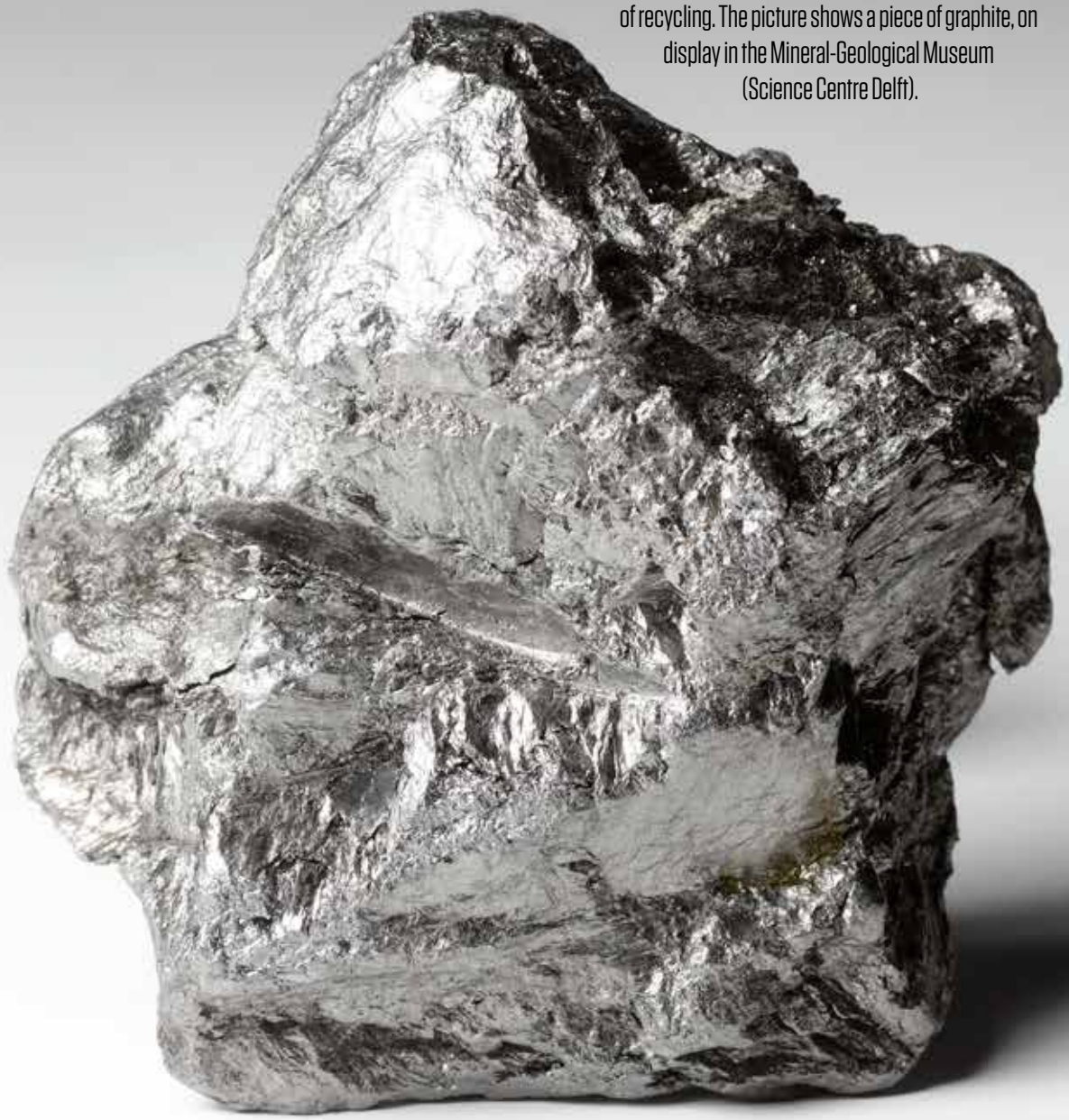
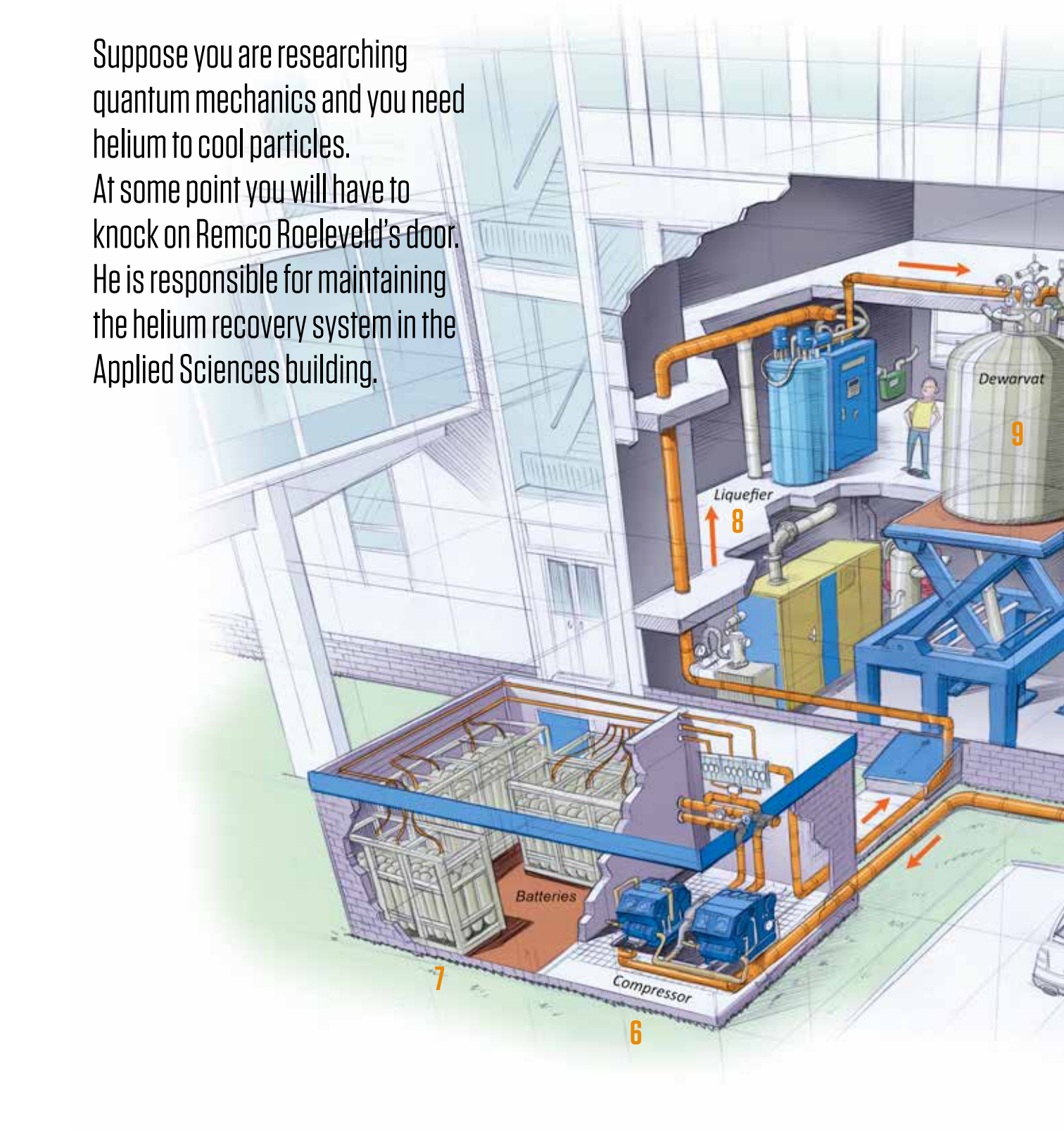


Photo: Sam Rentmeester

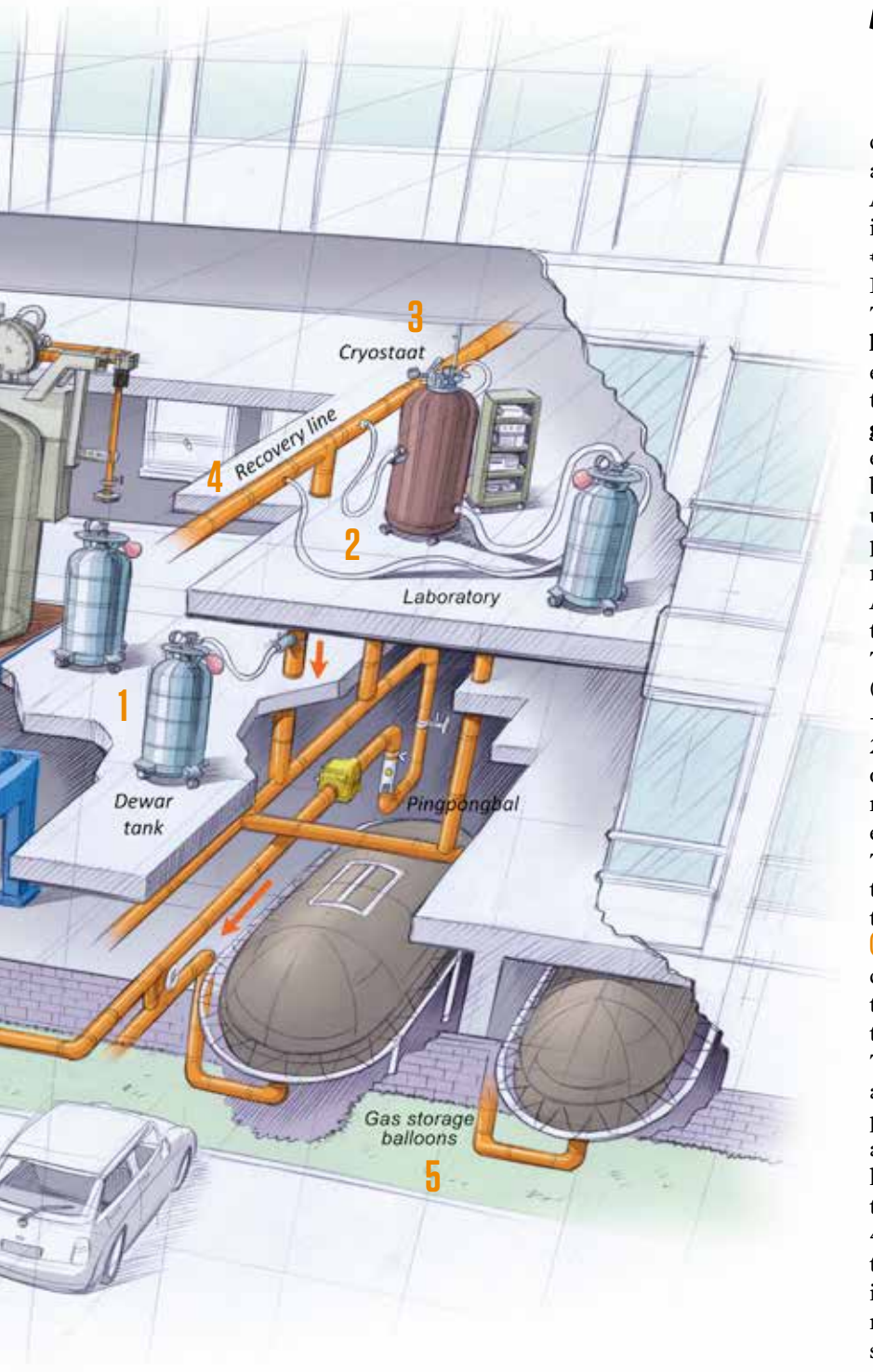
ILLUSTRATION: STEPHAN TIMMERS

Applied Sciences' hidden

Suppose you are researching quantum mechanics and you need helium to cool particles. At some point you will have to knock on Remco Roeleveld's door. He is responsible for maintaining the helium recovery system in the Applied Sciences building.



helium recovery system



The **dewartank** (1) containing cooled, liquid helium is transported to the **laboratory** (2). Here, the helium is transferred to a **cryostat** (3); a device used to maintain temperatures as low as just 20 millikelvins above absolute zero. Afterwards, the helium is recycled because it is expensive stuff: "Just off the top of my head: € 7.68 for one litre, not including VAT," says Roeleveld.

The cryostat is connected to the **recovery line** (4), a pipe system that runs through the entire building. The used helium travels through these pipes to one of the four large **gas storage balloons** (5) in the basement, each of which can hold 10,000 litres. Once the balloons are full, the **compressor** (6) starts up and empties them. A pressure relief valve prevents them from bursting. "But we almost never have to use that," says Roeleveld.

As soon as the gas storage balloons are full, the gas is discharged to a compressor shed. The compressor fills rows of gas cylinders (**batteries** (7)) and puts them under pressure – sometimes even to 200 bar so that up to 2,760,000 litres of gaseous (i.e. 3,680 litres of liquid) helium can be stored. A computer regulates which of the batteries are to be emptied.

The helium from the batteries is returned to the building via another pipe system. Once there, the recycling can begin. The **liquefier** (8) contains turbines that create a pressure difference, which cools the helium and transforms it back into a liquid. The helium then travels to the purifier, where it is cleaned. The purifier contains air and nitrogen as well as some oil, which is the result of another process. Zeolite, activated carbon particles and a low temperature are used to filter the helium. Eventually, the clean, liquid helium is transported to the large vacuum-insulated 4,300-litre **dewarvat** (9) tank. At this stage, the helium is at a temperature of 4 kelvin and is transferred into small dewars. It is now ready to be taken back to the labs for the scientists to carry out their research. RVT

Circularise uses blockchain technology to trace raw materials

The amount of electrical and electronic waste in Europe is growing rapidly. Every year, around 10 million tonnes of old computers, televisions, refrigerators, tablets and mobile phones end up on the scrap heap. But what happens then?

Photo: Sam Rentmeester

Exporting it all to Africa, India and China is a no-go. But as long as recycling in Europe is difficult and expensive, illegal dumping will continue to be popular. The WEEE (waste electric and electronic equipment) export ban was introduced due to the poor working conditions that prevail in the receiving countries, as well as the fact that this waste would poison the local populations and the realisation that electrical devices contain raw materials that will soon become scarce.

To demonstrate the arduous recycling process in Europe, Mesbah Sabur, one of the founders of Circularise, plays a video of how monitors are recycled in Italy. Some monitors have a tubular mercury lamp that needs to be removed. But because no one knows which monitors are fitted with one of these lamps, they all have to be opened by hand for inspection. Wouldn't it be great if you could just scan a QR code and find out straight away whether there is any mercury in it or not? Well, Delft-based start-up Circularise has developed such a solution, which involves a huge number of parties: mining companies, blast furnaces, component manufacturers, electronics manufacturers, consumers, collection services and recycling companies. And all these parties want to ensure their privacy; manufacturers do not want to publish their trade secrets and consumers want to protect their possessions. And nobody would ever agree to a global central database that traces the use of raw materials.

Most people would just give up at that point, but not Jordi de Vos. He is co-founder of Circularise and describes himself as a blockchain aficionado.

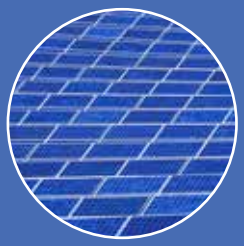
For those who are not experts like De Vos, a blockchain is a network in which all transactions between parties are secured (a block) and linked (the chain) to previous and subsequent transactions made by those parties. There is no central database. The register is divided among all participants, so it is not possible to commit fraud. Encryption ensures that each participant sees only their own transactions, and those transactions cannot be changed.

And what about trade secrets? To get around this, De Vos uses a mind-boggling logic known as zero-knowledge proof. This is a method by which questions are repeated to ensure certainty without revealing the secret itself. To determine whether a certain monitor contains mercury, for example, the network can retrieve data from parts manufacturers and producers by using smart questioning. The longer it takes to search in the network, the more certain the answer.

> The register is divided among all participants, so it's not possible to commit fraud

In practice, Circularise's raw materials inventory works using a small QR code on the product. The start-up charges 1 cent for that. But for 15 cents, Circularise offers companies a 'plus' label that allows them to keep in touch with their customers. This is perhaps the kind of added value that appeals more to companies than EU regulations. JW

circularise.com



Recyclability of solar panels

Producing electricity using solar panels is better for the environment than using coal-fired power stations. That's a no-brainer. But the service life of a solar panel is only 20 years, and then where does it end up? Miro Zeman, head of the Electrical Sustainable Energy department, has been researching solar panels for almost 30 years and explains how solar panels are recycled.

"The most significant component of 90% of solar panels is silicon," says Zeman. "Silicon is made from sand, which is the most common element on earth after oxygen. So we don't have to worry about that running out any time soon. A solar panel also contains metal electrodes; metal is somewhat scarcer than sand. We are looking for solutions to replace the metal parts with carbon layers which can conduct electricity just as well.

Another disadvantage of metal is that it needs to be protected against oxidation caused by exposure to air. That's why the solar cells in a solar panel are fitted between glass plates. Glass primarily consists of silica or silicon dioxide, which is also made from sand.

At the moment, around 2% of all the world's electricity is produced by solar panels. "We want to get that up to 50%," says Zeman. "This percentage is rising because it is getting cheaper to generate electricity from solar energy and in some places it is even the cheapest form of usable energy: 1 KWh supplied by solar panels in the Netherlands now costs less than 8 cents. This is because the production of solar panels has increased massively in China, which makes them cheaper." Zeman is pleased with this development. "At the moment we are using a lot of primary, fossil sources to generate usable energy. They are certainly not circular and they are depleting rapidly. On the other hand, renewable sources, such as solar and wind, are circular."

> 'As yet it is not commercially interesting to recycle solar panels'

And, according to Zeman, solar panels can actually be recycled. "As yet it is not commercially interesting, but there are many initiatives underway to push forward with recycling using thermal, mechanical and chemical separation methods. We expect considerable progress to be made here in the coming years. This is already being done on a small scale in Japan and Europe, for example, where 96% of silicon solar panels are recycled." RvT

Pulverising, baking and dissolving

Twenty years ago, a German company unloaded 5,000 tonnes of waste containing zinc ferrite - a compound of zinc and iron - at the port of Rotterdam. The company went bankrupt and the mountain of waste is still there. Zinc is a valuable substance; how to separate it from the iron?

Group leader of the metals production, refining and recycling research group, Dr Yongxiang Yang (3mE), has been working at TU Delft on the recovery of metals from waste since 2005. "We recently developed a very new technique for this particular waste problem in Rotterdam," he says. "We mix the material with sodium carbonate and bake the mixture at about 800°C. This dissolves the molecules." Yang can recover the metal by taking a number of extra steps, whereby the mixture is dissolved in sodium hydroxide (NaOH) and undergoes an electrolytic reaction.

Yang hopes that this technique will interest Tata Steel. For some time now, he has been cooperating with the steel manufacturer and the company Nyrstar on technologies to recover zinc and iron from waste. He recently received funding to hire two post-docs and a PhD candidate to research Tata Steel's iron processing technique, Hisarna.

Yang's team is also working on recovering the rare earth metals neodymium, praseodymium and dysprosium from electronic waste. In the lab where PhD candidates Prakash Venkatsen and Sebastiaan Peelman work, cardboard boxes are filled to the brim with cut-up magnets from hard disk drives and a mixture of finely shredded e-waste (pieces of motherboard and numerous electronic components).

The PhD candidates pulverise this material into powder and extract the earth metals via various steps of electrolysis and leaching. Venkatsen shows an Erlenmeyer flask full of pink liquid. "That pink colour comes from the neodymium. We precipitate this molecule and are left with this powder," says the researcher while he fetches a beaker containing a pinch – a few grams – of the valuable material. The harvest from a few kilos of magnets. Four PhD candidates are working on the recovery of rare earth metals. They will be defending their dissertations this summer.

From green slime to aircraft interior

Slimy green stuff. That is a pretty accurate description of the product that is left over after sewage water has been purified using the Nereda method, the aerobic granular sludge technology developed at TU Delft.

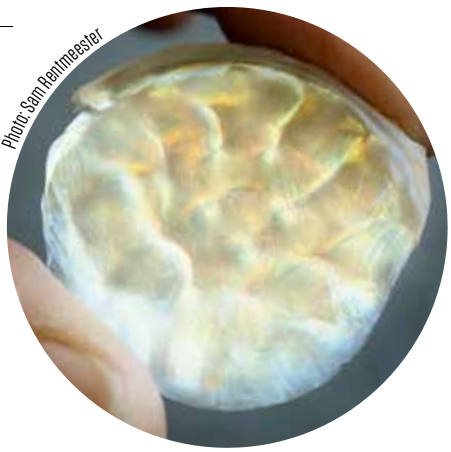


Photo: Sam Rentmeester

It costs a lot of money to dispose of and process this type of waste, even though the biopolymers from this stuff have a lot of potential. The long chains of sugars and proteins bond well to nanoclay and graphene oxide. This means that you can make lightweight materials that are both very stiff and virtually non-flammable. The products also look beautiful, like mother of pearl.

And this is where money can be made, according to professor of biotechnology Mark van Loosdrecht, the spiritual father of the Nereda technology, and professor of polymeric materials Stephen Picken (both at the Faculty of Applied Sciences). They recently started a spin-off company: Slimy Green Stuff. That name raised more than a few eyebrows. "You don't forget a name like that," says Picken. "What else should we have called it, Delft Polymeren BV? That's boring."

"You can use the material to make parts for the interior of aircraft," says Van Loosdrecht. "Or crab sticks," adds Picken. "The polymers look like alginate, but we're not going to use them to make food."

At the end of last year, the researchers signed a cooperation agreement with Royal HaskoningDHV, which is involved in the construction of numerous Nereda installations all over the world. In the coming years, the company will fund four PhD candidates who will focus on developing more efficient methods for recovering polymers from waste and converting them into promising materials.

Buildings as sources of materials

Artist impression: Project Park20|20.

A switch to circular construction? In collaboration with graduate Eline Leising, Dr Jaco Quist has developed a road map, including guidelines, in which he champions buildings as sources of reusable materials.

According to the Ministry of Infrastructure and Water Management, nearly 40% of the waste produced in the Netherlands comes from the construction sector. This sector is lagging behind when it comes to the high-quality reuse of materials, says Dr Jaco Quist (TPM). He researched constructon projects in which circularity was a priority.
A demolition project showed that while it is possible to demolish a building properly by sorting waste, there is no guarantee that these materials will be reused if you do not involve new construction projects. "Ideas about this have been around for some time," says Quist. "But you only really learn how to do it once you actually do it."
The new construction project he researched was Park20|20, an office park in Hoofddorp with closed water, waste and energy flows. If the materials were no longer required, they were either repurposed or recycled. According to Quist, parties involved in such projects have to come to other agreements and find different ways to cooperate if, for example, the lift remains the property of the manufacturer and the user only pays per use. Quist's road map in a nutshell:

ASK DIFFERENT QUESTIONS

Clients often set specific product requirements, but it is about developing a vision and ambition. What does a circular building entail exactly? What does that mean for the different phases, such as design, construction, usage, demolition and repurposing? "The idea is that the supplier remains the owner of the building material," says Quist. "This requires a different mindset."

THINK IN TERMS OF DISCIPLINES

Companies each carry out their own assignment in one of the phases mentioned above. By involving these parties, including waste processing, at the beginning of the design and construction stage, all the companies can play their part in a more sustainable way. Quist believes that this requires new revenue models, whereby materials are owned by other parties and are then offered as a service.

SHARED GOALS

Focus on shared goals in new contracts and make sure material flows are transparent for all partners. "It is vital that parties cooperate right from the start. This builds the necessary level of trust and ensures that things runs smoothly later on," says Quist.

BUILDINGS AS SOURCES OF MATERIALS

This is designing so that parts and products can be reused, and about new forms of collaboration and revenue models whereby the building itself is a source of materials. The value of materials is recorded temporarily and can be monitored via a materials passport, which documents the exact quantity that has been processed.

AUCTION SITE FOR MATERIALS

Disassembled used materials can be sold on and used for other purposes via an auction site for materials. CVU

From reuse to a circular economy

What once started out as the reuse of second-hand items, has morphed into the sustainable design of products that remain in the economic system for as long as possible. A brief history of the circular economy.

Circularity, the development of a closed-loop supply chain, has been a hot topic among designers for decades.
In 1972 the book Design for the Real World by Victor Papanek is published. Papanek then goes on to become the father of sustainable design. He links design and product development to social sustainability. Products must be useful for people living in poverty in Africa.
Following on from this idea, in 1990 the term EcoDesign (designing for the planet) is coined. There are problems with acidification, the ozone layer and climate change. How can you reduce the negative impact of products on the environment? The planet is at the heart of this concept.
In 2002 the book Cradle to Cradle: Remaking the Way We Make Things by Michael Braungart and William McDonough is published. They believe that EcoDesign only focuses on improving products, but when is a product actually good enough? Their motto is: waste = food.
Cradle to cradle principles:
1) You must be able to compost or recycle everything you design
2) Use renewable energy
3) Respect diversity: take into account differences and local conditions

Cradle to cradle focuses primarily on recycling: taking products apart to reuse materials.
Following on from this line of thought, the term 'circular economy' appears in the same year, and more attention turns to business models. Products and materials must be able to circulate within biological and technical loops. Think of re-use, repair, refurbish, remanufacture (see icons below).
In 2006 attention shifts to people-oriented sustainable design. Behaviour determines sustainability, especially of products that use electricity and water. Examples: water-saving shower heads, big and small flushes on toilets.
Trend: consumers do not buy products but take out subscriptions to use them. Examples: pay per wash, Swapfiets.

This article was written in collaboration with Professor Conny Bakker. She was appointed professor of Methodology for Sustainability and Circular Economy at the Faculty of Industrial Design Engineering at the end of December.

Re-use
Reusing the product or item without doing much to it

Repair
Product repaired by the consumer or a technician

Refurbish
Not repairing but rather refurbishing the product by testing parts and possibly replacing them

Remanufacture
Recovering and processing large, complex products so they are as good as new.

‘There’s a lot of money in reusing materials’

Having previously worked in the waste sector, assistant professor Jan-Henk Welink (3mE) knows how to translate the sustainable management of raw materials into business concepts. He organises courses, seminars and workshops to teach senior managers about the opportunities that are available in a circular economy.

Jan-Henk Welink doesn’t just talk the talk, he also walks the walk. The corner of his chair is worn, but that is no reason to throw it away. That chair is worth at least € 50, he estimates, and the manufacturer would easily put a new cover on it. His mobile is small, outdated and covered in scratches, but he still uses it to make calls.

In 2011, he set up a knowledge platform for the sustainable management of raw materials, of which he is also the secretary. The website is full of information about circular purchasing, life-cycle analysis, the collection of separated waste, the value of electrical waste and behavioural change.

The crux of the matter can be summarised by one formula: Mp=N.W.(1-R)/L

Mp is the quantity of a particular material that is used annually, N is the number of devices, W is the quantity of that material per device, R is the part that is recycled and L is the lifetime in years. The formula applies just as well to neodymium in magnets as to gold and coltan in mobile phones. Sustainable resource management aims to minimise Mp consumption by changing the values of N, R and L.

R gets closer to 1 as people throw away less, maintain products better, and share, refurbish, reuse, repair and recycle more. To illustrate his point, Welink refers to the butterfly diagram produced by the Ellen MacArthur foundation and the cheerful Krijg de Kleertjes initiative.

N, the number of devices, decreases in a sharing economy since it is more popular to rent things like tools and cars. Greenwheels and Swapfiets are examples of successful business models that build upon the idea of sharing goods.

A longer lifetime, L, reduces the use of raw materials, but this runs counter to the linear ‘Action’ model of producing as many things as possible that have to be replaced as quickly as possible. In rental business models, however, it is actually an advantage if a device lasts a long time because more customers can use it, for example, washing machines for which people pay per wash or lift installations with long-term rental contracts.

“N and L both offer opportunities for new business models,” Welink tells his trainees from the worlds of business and manufacturing, “and the government can exert influence by setting rules and circular purchasing policies.”

JW

duurzaamgrondstoffenbeheer.nl

Recycling aircraft

If you fast-forward Derk-Jan van Heerden's work, it's a bit like watching a scene in a nature documentary in which red ants demolish a carcass. Only the TU alumnus works with metal rather than flesh and blood. "There are about 250 tonnes of aluminium at Twente Airport," says Van Heerden over the phone.

The engineer recently bought two discarded Boeing 747s that were formally part of KLM's fleet and two A340s from Air France. His company, Aircraft End-of-Life Solutions (AELS), disassembles the aircraft and ensures that the parts are reused or recycled. The planes, which are about 20 years old, were still in tip-top condition, but they were running on four engines. Nowadays, airlines prefer to cross the ocean with twin-engine aircraft because they are more economical. In the past this was not allowed due to safety reasons, but now that engines have improved, airlines have been given the green light. While he was studying Aerospace Engineering, Van Heerden did an internship at KLM and was confronted with a completely different aspect of

It is profitable to disassemble a Boeing and reuse the parts

aviation that he had not learnt about during his degree: aircraft wreckages. For KLM, he calculated that it is profitable to disassemble a stranded Boeing and reuse the parts. He discovered a gap in the market and founded AELS immediately after graduating in 2005. "The two A340s we are currently working on are very interesting because they were developed at the same time as the twin-engine A330s, which are still popular," says the entrepreneur. "Most of the equipment is the same, so a lot can be reused."

A lot of the parts are overhauled and recertified. It usually takes about two months to disassemble a complete aircraft. AELS also has a solution for recycling the cockpits; they usually go to companies that use them to build simulators. Seats go to training facilities for flight attendants or end up in waiting areas in travel agencies. Anything that AELS does not manage to resell (most of the hull, for example) is cut into smaller pieces and recycled. MD

Photo: Raymond Rutting

View

Dr David Peck (Architecture and the Built Environment, Climate Design and Sustainability) anticipates that TU Delft and the Netherlands will play a pivotal role in the circular economy.

"Switching from a linear to a circular economy is not just a matter of recycling a bit more and using less energy. For everyone – companies, organisations, education, and society – it's a completely different way of doing things. At the end of January, Stientje van Velthoven (State Secretary for Infrastructure and Water Management) and Eric Wiebes (State Secretary for Economic Affairs and Climate) presented the Raw Materials Agreement, which outlines the government's ambition to switch to a completely circular economy by 2050. The transition agenda states that, by 2030, all new products and services must be based on circular design principles.

I introduced the concept of the circular economy at TU Delft back in 2012. Now there are about 100 researchers at the university working on topics related to sustainability and circularity. By 2030 I hope it will be thousands. By then, there won't be any need for degree programmes and research to focus on the linear economic model of production, usage and disposal. Fossil fuels will have disappeared from the agenda, and designing and manufacturing short-term solutions that are destroyed at the end of their services lives and processed as waste will be the new smoking. And this development will be driven by a lack of funding for such projects. At least, that's what I hope. Twelve years ago, we also had big plans for the 2020 energy agenda, and not much has happened. I think there's a good chance things will be different this time around. Mainly because the initiative is not only being driven by the European Commission and the Dutch government, which are showing leadership and support by making substantial amounts of funding available for research, but the banks and the business community are also getting behind the idea.

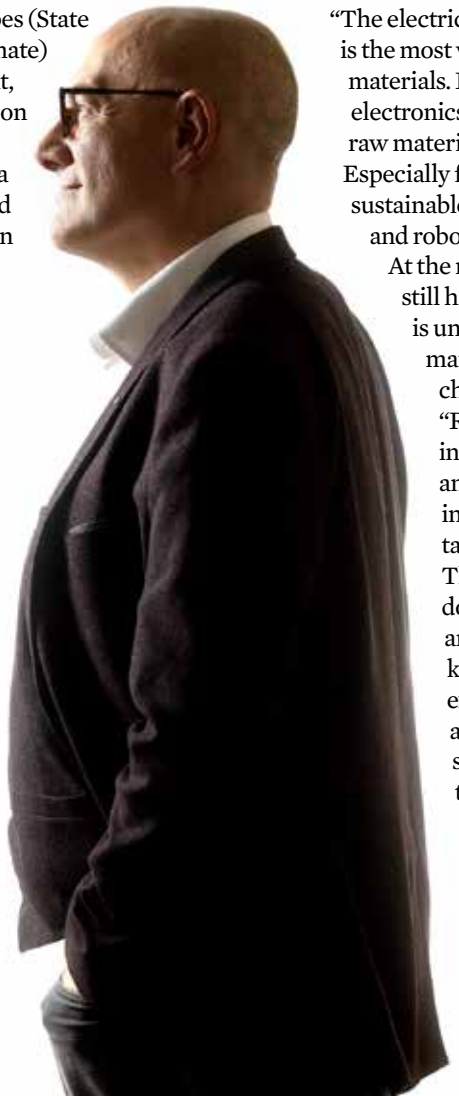
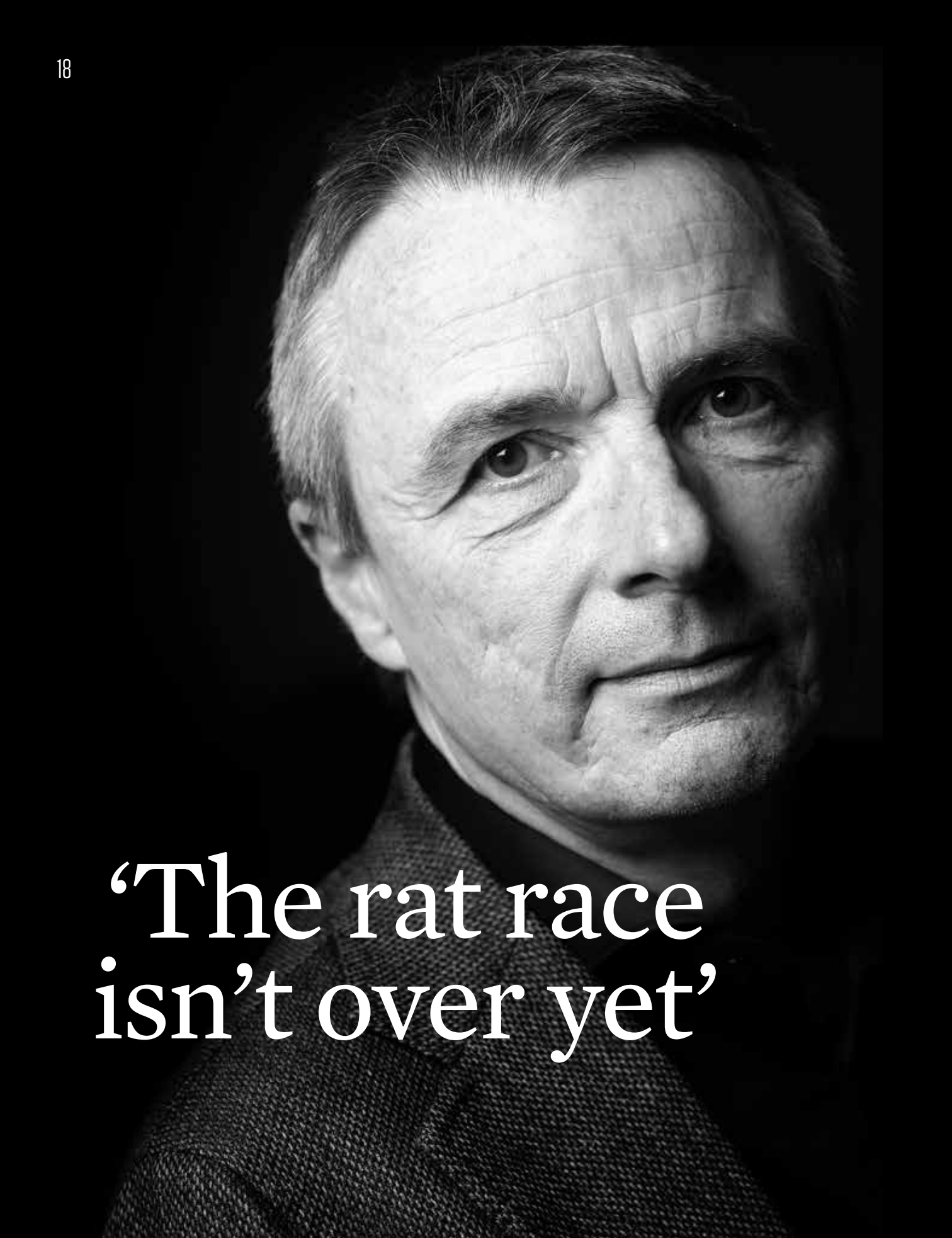


Photo: Sam Rentmeester

"The electrical appliances and electronics sector is the most vulnerable to a shortage of critical materials. But if we look at which sectors use electronics and electric motors, the scarcity of raw materials affects almost our entire economy. Especially future developments in the generation of sustainable energy, smart grids, electric transport and robotics all depend on those raw materials. At the moment, the business community still has its head in the sand about this and is underprepared for a shortage of critical materials. I think we will start to see a change, here. Companies aren't stupid.

"Research in the field of circularity is incredibly multidisciplinary, even social and political sciences and geopolitics are involved. We need all those disciplines to tackle this difficult 21st-century problem. The circular economy also opens up many doors, and I think that the Netherlands and TU Delft can become hotspots of knowledge. We already have a lot of experience with sustainability, recycling, and building with nature, the initiative is supported by both the government and the European Commission, and a lot of partnerships have been set up with other universities and research centres in the Netherlands and abroad. There is absolutely no reason why the Netherlands cannot become a leader in circulatory." JW



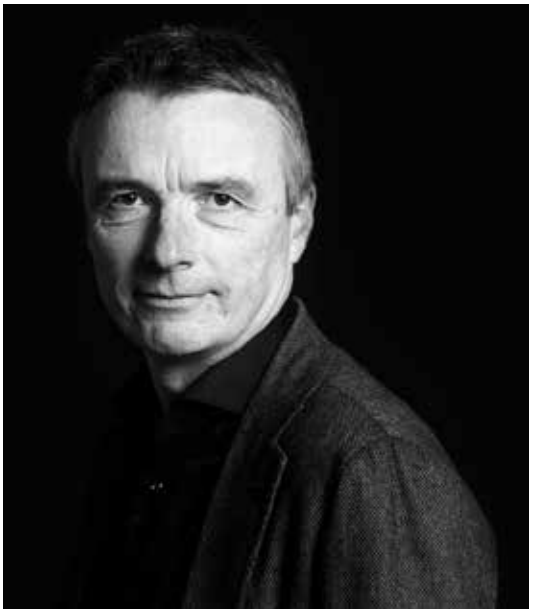
‘The rat race isn’t over yet’

Don’t sit on our research data; share it with the rest of academia. This was the case argued by TU Library director Wilma van Wezenbeek and Professor of Data Science Geert-Jan Houben at the Dies Natalis. “Sharing your data will make you a better student, lecturer or researcher.”

TEXT TOMAS VAN DIJK PHOTOS SAM RENTMEESTER

A researcher is like a photographer. Scientists collect data and use it to create a virtual impression of reality. When was the photo taken, from which angle, with which lighting and shutter speed? Only the researcher knows the details and how the photo (data) should be interpreted.
Geert-Jan Houben used this analogy in his lecture at the Dies Natalis in January, which revolved around open science. What he means is that opening up your data isn't always that simple. "You have a responsibility to consider it very carefully. You don´t want other researchers to jump to the wrong conclusions because they have a different feel for it."
We had arranged a double interview in TU Delft Library, Van Wezenbeek´s place of work. She is the director and as such very interested in open science. Houben is Professor of Data Science in the Faculty of EEMCS. He develops systems for opening up data and making it available for searches.
Now that publishing articles in public registers and open access journals (which are freely available to all) has become common practice, the open access movement is turning its attentions to data. Government-funded research, including all its derivatives, publications and data, must be freely available to all, according to the open access movement.

Why is sharing data so important?
Van Wezenbeek: "Research data must benefit society, particularly if research is funded with public money. It's a logical continuation of the scientific remit. Those who publish the data and those who use it for further research will all benefit. You get more cross-pollination between disciplines. Others will find patterns in your data that you had not seen yourself, because they look at it from a different angle."
Houben: "Generalisation is a big thing in science. Imagine that you're studying the performance of racing cyclists. You want to know how it relates to the weather, to humidity, for example. You've taken various measurements, bearing in mind all kinds assumptions and conditions. You probably think that your conclusions apply to cycling performances elsewhere in the world too. If you share your basic data, researchers around the world will be able to reproduce your work. Their studies might show, for example, that the relationship between weather conditions and cycling performance is completely different in Washington DC than it is in the Netherlands. This would provide new insights for you and your US colleagues."



Van Wezenbeek: "I'm convinced that using other people's knowledge and sharing your own will make you a better student, lecturer or researcher. That's what I believe in. We've been producing commercial scientific journals for centuries. And they only give a summary of the research. There's so much more going on now. It's all about doing your bit."

But it also means going out on a limb. Imagine that someone discovers a mistake in your data. Won't fear of this put researchers off sharing their data?
Van Wezenbeek: "There's nothing wrong with scientists having to think harder about their data and how to present it."

Researchers who deliberately manipulate data are more likely to get caught out. Will open science have a cleansing effect?
Van Wezenbeek: "If researchers are more aware that their work might be of interest to many other researchers, they will probably be more inclined to store, describe and process their work in line with the standards. I hear what you're saying, but 'cleansing effect' sounds so severe. As if there's so much sloppy science around. Open science will make researchers think twice. That's all."
Houben: "Sharing data creates a form of peer review that goes beyond the peer assessments that already apply in the world of journals. Your data can be verified by a large community. It's like open source software. You share your work with the community, and the community makes a judgement."

CV

Geert-Jan Houben (1963) is Professor web information systems and Director of Education at the EEMCS faculty. He is also scientific director of Delft Data Science and holder of the KIVI chair Big Data Science.

Wilma van Wezenbeek (1967) is Director of TU Library. She is also Programme Manager open access at VSNU and lead author of the report National Plan Open Science.

I can still imagine that researchers might not be keen to share their data. After all, it's the basis of their publications. If other scientists make a breakthrough using your data, you've wasted your own chances of publishing in a leading journal. 'Publish or perish' is what they say. Could this rat race prevent researchers from publishing their data?
Van Wezenbeek: "One of the best things to come out of the debate on open science is that we've started looking differently at how we recognise science. It's not all about high impact publications. A researcher who knows how to compile data that can be used by other researchers will also earn recognition."

But does he or she actually get that recognition?
Van Wezenbeek: "We haven't completely banished the rat race, but we're getting there."
Houben: "Competition is good. But should rivalry focus solely on the classic artefacts - publications

'Using other people's knowledge and sharing your own will make you a better student, lecturer or researcher'

- or on other artefacts in the research process as well? We could stress the importance of writing good explanatory notes for data and design a rewards system for shared data."

What do you mean by explanatory notes?
Houben: "Metadata. Descriptions of the data: the conditions under which they were gathered and how they should be interpreted. When a doctor writes you a prescription, he is responsible for telling you how to use the medicine. In the same way, researchers are responsible for explaining how their data should be used. That´s what this is all about."

Some Faculties recently introduced data stewards to help researchers release their research data. Is sharing data really that difficult?
Houben: "Every field has its own conventions on the meaning of terms. Take sports researchers. The type of rain they call drizzle could be called mist or steady rain by researchers in other fields. If these researchers use each other's data, the terms need to be clearly defined. You can't just store data in a repository without considering aspects like this. Conversely, if you use someone else's data, you must be aware of differences in interpretation between disciplines. Researchers will have to get used to each other and then to each other's fields before data exchange becomes efficient."

That sounds a bit onerous. Will standards for storing data be developed?
Houben: "I think it will be a combination. You must be careful not to 'over-standardise' or 'over-automate'. You'll always need personal contact to interpret certain data (tricky data) correctly. In many cases, you will have to safeguard the privacy of the trial subjects, while also divulging certain details. The data must be meaningful to other researchers. You'll often need to weigh this up. What needs to be published and what does not?"

We mentioned government-funded research. According to the National Open Science Plan, it must always be published. The rule doesn't apply to research funded by industry, as company interests are at stake. But there's a large grey area in between. Researchers are paid by the government and use university facilities. So, all research conducted at a university is partly government-funded. How will you deal with this grey area?
Van Wezenbeek: "The plan states that all research must in principle be made public. This can be overridden if there are good reasons for not revealing findings, such as company interests. But open access is the default setting. Data should be "as open as possible, as closed as necessary," as we put it. <<

TEXT: TOMAS VAN DIJK PHOTOS: ESA

A small wide-angle washing machine

Tropomi tracks global air pollution with unprecedented precision. KNMI and TU Delft researchers Pieternel Levelt and Pepijn Veefkind were at the conception of this satellite instrument. "We can now model plumes of nitrogen dioxide back to the chimney they came from."

Photo: ESA

The TROPOspheric Monitoring Instrument was launched into space on 13 October on board the European Sentinel-5P satellite.

A large red patch defaces Russia. 'Which city could that be?' Professor of Atmospheric Remote Sensing Pieternel Levelt wonders, clearly disturbed by so much nitrogen dioxide (NO_2) pollution.
We zoom in. It's Novosibirsk. We fly on towards America. On the way, we see plumes of carbon dioxide in North India, skirting the Himalayas on their way towards China. And on to Mexico City. The metropolis is coloured purple with NO_2.
"There's still so much to discover," says Levelt, as she and Dr Pepijn Veefkind reveal some of the first images made with Tropomi last November. Both researchers work for the national meteorological institute KNMI and have part-time jobs in the Faculty of CEG.
The TROPOspheric Monitoring Instrument was launched into space on 13 October on board the European Sentinel-5P satellite, built by ESA as part of the Copernicus European Earth observation project.
The instrument measures the concentrations of dozens of gases in the atmosphere. Scientific management of the project is in the hands of KNMI and SRON. The instrument was built by Airbus and TNO (the Netherlands Organisation for applied scientific research).
The satellite orbits the Earth from pole to pole at an altitude of around 800 km 14.5 times a day. It observes a different part of the planet during each orbit. Tropomi is the successor to OMI, an instrument that has been orbiting the Earth since 2004, and for which Levelt is the principal investigator. Levelt: "OMI still has the longest series of recordings of nitrogen dioxide and sulphur dioxide in the atmosphere and has given us almost fourteen years of excellent service."

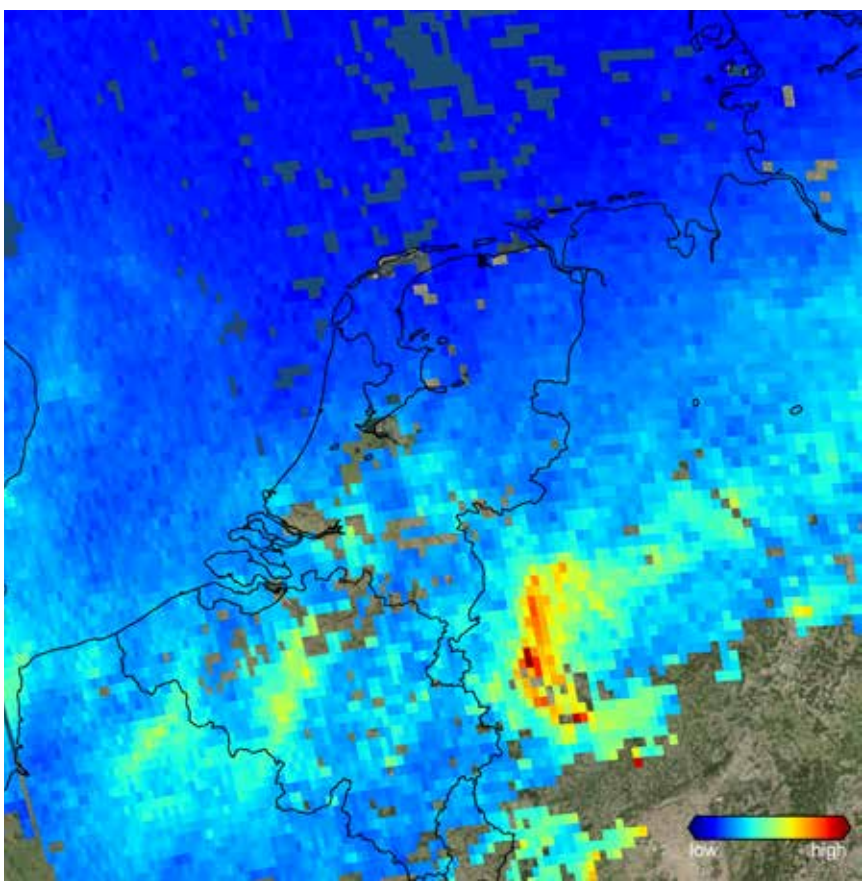
TEN TIMES HIGHER RESOLUTION

There are several important differences between OMI and Tropomi. The resolution of the new instrument is ten times higher, which gives researchers new possibilities. Levelt: "Tropomi has a spatial resolution of 3.5 by 7 kilometres, allowing us to identify various sources of air pollution."

'We can trace an NO_2 plume back to the individual polluter'

Levelt shows me her computer images of the Netherlands. We see red swathes of NO_2 over the Randstand, similar to Novosibirsk but less intense. "These are the images from one day. If we average out the data from several days, we get a higher resolution and we can distinguish the pollution above the Port of Rotterdam from pollution above the city."
"If we then construct models, we can trace an NO_2 plume back to the individual polluter, for example a power plant. You can even model the plume back to a specific chimney, as it were. It's information that will benefit policy-makers."
The extra resolution is down to Tropomi's larger optical components. The optical part of OMI is the size of two shoe boxes. In Tropomi, it's the size of a small washing machine. Tropomi also has a wider angle. Projected onto the Earth's surface, it can scan a width of 2,600 km. "That's the equivalent of 120 degrees," explains Levelt. She stands up and stretches her arms out to demonstrate the angle.

Read more on page 24



This computer animation shows clearly the pollution above the Ruhrgebiet.

Afbeelding: KNMI

Photo: Sam Rentmeester

Pieternel Levelt: "The Copernicus project ensures data continuinity but it has a clear operational and commercial mission."

"This is how Tropomi moves from pole to pole. We call this configuration the Swath." The professor walks around the room with her arms outstretched, as if imitating a bird.
The instrument also measures two important greenhouse gases: methane and ozone. There is a lot of uncertainty about the levels of ozone in the troposphere. And methane is shrouded in mist. There are numerous sources of the gas: livestock farming, rice fields, wetlands, rubbish dumps, oil and gas fields, and melting permafrost. Little is known about how much gas the various sources emit.
Researchers were thinking about a successor as early as 2003, before the launch of OMI. "The normal life expectancy of a satellite instrument is about six years," says Veefkind. "That's also about how long it takes to design and develop a new one, so we started on the next model immediately."
Levelt was the principal investigator for OMI and for Tropomi. In 2009, she handed the reins to Veefkind, when she was appointed head of R&D satellite observations at KNMI. The two have been working together for fifteen years.

LAUNCH

On Friday 13 October at 13.00 (local time at the launchpad in Plesetsk, Russia) Tropomi, on board the Sentinel-5P, was launched into space with a Russian Rockot, the thirteenth version of this type of rocket. The number thirteen plays a big part in Tropomi's history. So much so that people wondered whether it would be better to postpone the launch. "Even scientists can be superstitious," Levelt says, laughing.
After the launch, the satellite disappeared from the ESA radar for 90 minutes. After its first orbit of the Earth, a Swedish ground station picked up a signal. A streak of interference was projected onto a huge white screen at ESA-ESTEC in Noordwijk. And then a tiny peak appeared in the interference. "There was a lot of cheering," says Levelt. "We were so relieved."
Veefkind: "You need to realise that the Russians have different customs and practices. To begin, they don´t have a countdown. They just fire their rockets into space when they´re ready. And then you hear nothing more from them."
The KNMI researchers got their first measurements a month later. The instrument measures spectral lines in the atmosphere. Each gas absorbs light of a particular wavelength in its own special way. By measuring the spectra – four thousand colours of the rainbow – and looking for dips in the spectral lines, the researchers can work out the concentrations of different gases.
"The measurements proved to be highly accurate," says Veefkind.

'This project isn't a theoretical exercise; we're building a real instrument'

"Especially when you consider that the instrument had to cool down. Tropomi was heated up immediately after the launch, a protocol to repel contamination on the optical surfaces. After heating, a system was activated to cool the instrument down again. A door in the satellite had to be opened. It was a success, but obviously a very tense moment."

Photo: Dutch SPace/Sander Koenen

Final tests of Tropomi in the cleanroom of Dutch Space in Leiden.

In fact, there was no shortage of excitement in the Tropomi saga. In 2008, the team got the go-ahead to develop the satellite. This was after years of lobbying.
The Dutch government provided most of the funding: some €100 million spread across fifteen years. Levelt: "The decision was finally made by the then Minister of Economic Affairs, Maria van der Hoeven, responsible for space travel. It was time to pop the champagne. The Minister and I were both interviewed by the media. After all, it's a major project."
The Netherlands can't launch a satellite of this calibre on its own. We need help from organisations like ESA and NASA. "We worked hard on lots of different projects to get this instrument onto a mission," says Levelt. "There's never any shortage of good ideas, but only a fraction of them actually make it."
ESA finally agreed to let Tropomi be part of the Copernicus Earth observation programme and the instrument was fitted to the Sentinel-5P satellite. Following on from Tropomi, two more Sentinel satellites will be launched into space in the next two years, with instruments for monitoring the chemistry of the atmosphere.
"It´s great being part of the Copernicus project," continues Levelt. "It ensures data continuity. But it also means that we have to take a step back. OMI and Sciamachy (a spectrometer on board ESA's Envisat mission in 2002-2012, ed.) were part of purely scientific satellite missions. Scientists were the only ones operating the buttons. Copernicus, on the other hand, has a clear operational and commercial mission. The idea is for companies to develop services such as rain radar, focusing on the chemical side of the weather."

EMOTIONAL

Back to 2008. The funding was in place. "We then entered a long period of design work and document reviews," says Veefkind. "It only started to be fun after three years. That's when you start building. Milling pieces of aluminium."
Levelt: "If you want to do this work properly, you must have affinity with the actual job of constructing satellite instruments. I did a lot of experimental optical work during my PhD research. My background made it easier to understand the problems facing the industry. This project isn't a theoretical exercise; we're building a real instrument. It's fantastic. I can get quite emotional about it."
"In the clean room at TNO in Delft, we watched as the first contours of the optical part of the instrument appeared," says Veefkind. "In the years that followed, we travelled around Europe in the wake of Tropomi. We did some calibration measurements in Liege. The instrument was then taken to Toulouse for a vibration test to see whether it could withstand the intense vibrations during launch. The next stop was Germany for acoustic tests, followed by an Airbus factory in England, where Tropomi was screwed into the satellite. Finally, we went to Russia for the launch itself."
Levelt: "It's like saying goodbye to a child." Veefkind: "We do still have a copy of Tropomi's on-board computer here on Earth. If we think up new monitoring settings, we can test them here first."
KNMI will release all the measurements from Tropomi at the end of June. Everyone will be able to download the data with just a couple of hours delay. "The satellite measures spectral lines," explains Veefkind. "They are not direct pollution measurements. We use highly complex algorithms to convert the spectral lines into practical pollution data. We will make sure that everyone will have access to data they can understand." <<

Photo: Sam Rentmeester

Pepijn Veefkind: "It only started to be fun after three years."

HORA EST

Conscious decisions do not exist, the brain provides a false sense of control.
Ronald Poelman, computer science engineer

People are what they choose to be.
Pengling Wang, transport engineer

The most effective way to let North-EU colleagues loosen up is bringing tiramisu at work.
Alessio Bazzica, computer science engineer

We currently rely too much on technology.
Olga Didova, geoscience engineer

Without field observations, ice flood control is like walking on thin ice.
Chunqing Wang, hydraulic engineer

The more education one receives, the fewer the job options.
Jingfang Liao, computer science engineer

Children are better observants than scientists. They describe what they see, while scientists describe what they think they see.
Frederik Bisschop, hydraulic engineer

'Smart cities' cannot be achieved without 'smart citizens' who are aware and in control of their environment.
Merve Bedir, architect

There is no point in keeping research organizations running if scientists do not become politically active.
Santiago Gaitan-Sabogal, civil engineer

COLUMN

Lease-jeans

I recently started wearing jeans that aren't mine. I lease them for € 7.50 per month. After a year, I can choose whether I want to keep them and stop paying but get € 10 back if I return them later, or swap the jeans for a new pair and keep paying € 7.50 per month.
I know it sounds complicated but it's not. You just have to get used to it. The bonus is a slightly clearer conscience.
My jeans leasing company is called MUD Jeans (any connection with my surname is purely coincidental because I don't know anyone there), and it specialises in recycling jeans that are returned. Depending on the condition, the jeans are either given a new lease of life as vintage clothing, or cut up for use in new jeans.
The details are important: the jeans don't have leather patches, for example, so that you only have to remove the metal (zip and button) to recover the pure basic material.
Although this approach to wearing jeans is also not totally environmentally friendly and uses natural resources, it still seems better than the way I used treat my fashion items. I'd buy a pair of jeans and just throw them away a few years later because I'd worn through the knee or crutch.

If we want a circular economy, the theme of this Delft Outlook, it's crucial to take a different approach to possessions. There are countless great examples all around us. The Utrechtse Internet Courant DUIC recently featured a project in the Utrecht Lombok district. The residents use their electric cars as a battery to power their homes. Panels on the roofs collect solar energy during the day, and when everyone's home in the evenings, the electric cars provide extra energy for the dishwashers and lighting.
Obviously not everyone has to have their own electric car. According to the ANWB motoring organisation, cars are parked for 90 percent of the time. Eight electric cars probably supply enough energy for some twenty houses.
I spent many happy years driving shared cars from Greenwheels and ConnectCar, although I must admit that I had to succumb and buy my own car when the children were born. Why? Because of the child seats: fitting and removing them from shared cars was just too complicated. If anyone's found a solution: you've also found a gap in the market. The circular market obviously...

Tonie Mudde (1978) is the Head of Scientific News at de Volkskrant newspaper and graduated in Aerospace Engineering at TU Delft.

After Delft

Without him, companies and consumers would have no telephone contact and supermarket tills wouldn't work. Alwyn Voorman studied electrical engineering and is now responsible for managing KPN's fixed-line and mobile networks.

Photo: Sam Rentmeester

Voorman oversees some two hundred staff, working in The Hague and Amersfoort. His team manages and expands the networks and repairs faults. "I make sure that everyone in the Netherlands can make phone calls and use the internet," explains Voorman. "My work has a massive impact, which I like. Another advantage is being able to combine leadership with engineering. My team are engineers. They know all there is to know about the network. If there are problems, I can take a look too and decide how to organise things more efficiently."

He was always a leader, even at university. As a student, Voorman sat on two committees: for the electrical engineering student society ETV and the volleyball club Punch. "I got more excited about organising and managing than about my studies," he says. He has fond memories of this period. "Leaving home, doing an internship at the Ministry of the Interior, graduating in London, visiting electrical engineering companies all around the world... You forge ties for life; I'm still in touch with many of the people I studied with."

After graduating in 1998, Voorman started work as a consultant at KPN. "It was very different back then," he remembers. "Very few people had a mobile phone. It was just before the SMS became so popular. Nowadays, mobile phones are more of a data service. In the old days, you had to connect through a modem but have glass fibre now. It was just after KPN had been privatised. And now there's television as well as a much larger network."

> 'I'm still in touch with many of the people I studied with'

"I've had about ten different jobs in the last twenty years. I started as a consultant and worked my way up to project manager and manager. One of the things I introduced was KPN Compleet. Customers got various benefits if they bought a package with Fixed and Mobile. It was a success and more than a million households now have these packages." Voorman still sees new challenges for KPN on the horizon. "Take the Internet of Things. We expect to see millions of devices communicating with each other in the future. And security is becoming an increasingly hot item."

Voorman isn't quite as sure about his own future. "I don't think in terms of destinations; I never had a career plan, for example. I want my work to be interesting and challenging. You can try to plan your career, but things don't always go according to plan, thank heavens... I've got ten jobs behind me and I think there'll be another ten ahead of me. This isn't the end of the road!"

RvT

Last winter, twelve staircase-access flats in Vlaardingen were made energy-neutral. TU Delft was involved in the construction and supported communication with the residents.

TEXT: JOS WASSINK PHOTOS: SAM RENTMEESTER

The flat building on the outskirts of Vlaardingen is one of many in this post-war district. An open staircase, three storeys and no lift. Thin brick walls, single glazing and mouldy wallpaper. In the summer, the temperature in the living room rises above thirty, and in the winter, the heating is on full-blast to keep the place warm.
The obvious solution is to demolish the buildings and build something with more allure. But this would make the homes unaffordable for the present tenants.

TENANTS' PERSPECTIVE

Housing corporation Waterweg Wonen opted to renovate the buildings and make them energy-neutral. The tenants can stay, even during the renovation work, and the rent stays the same.
The bottom left-hand flat serves as an office and model home. Suppliers, tenants, technicians, builders, in fact anyone, can drop in for a cup of coffee. Warm PR, we are told later, is an essential part of successful energy renovation.
The social aim of the 2nd Skin project is to save energy in order to control climate change. But this doesn't always tally with the perspective of the tenants, says researcher Dr Stella Boess (pronounced Beau-As) from the Facul-

Improving life in a staircase-access flat

ty of IDE. “It’s often a case of: I’m okay as I am, what’s it got to do with me?” Climate change is not high on their agenda. Boess: “Statistics show that most people living in the social rented sector are not well off. Their main concern is having a safe, affordable home.”

ADDITIONAL SHELL

“Like the TU Delft entry Prêt-à-Loger on The Green Village of the campus, the 2nd Skin project is based on fitting an additional shell around the buildings. All the technical installations are inside this shell,” explains Dr Sacha Silvester (IDE). By concentrating them in the shell, eighty percent of the work can be carried out outside the homes. The shell provides all-round insulation. A 20cm layer of polystyrene is attached to the wall and later plastered over. The old roof is replaced with insulated slabs and an extra layer is also added to the floor. New window frames with triple glazing are fitted and fifteen solar panels per household are mounted on the roof. One heat pump connected to warm and cold groundwater layers is used to heat

> ‘In the social rented sector, the main concern of tenants is having a safe, affordable house’

and cool three households. “It costs €69,000 to renovate each flat,” says Silvester. “We must bring this back to €55,000 to make it into a feasible business model.”
The trial is made possible by funding from the European Climate-KIC Fund, which is paying for some 10% of the project costs. KIC is short for ‘knowledge, innovation, commercialisation’. After the renovations, the flats will be gas-free and satisfy the 2050 zero-meter standard (NOM). In other words, they will be energy-neutral. The tenants will no longer receive utility bills but will be charged an energy performance charge (EPV) set at a maximum of €1.40 per square metre per month.

ENERGY CONSUMPTION

Director of BIK-bouw Onno de Wal, who is coordinating the project, explains the challenges in the model home. “It’s tricky to make staircase-access flats energy-neutral because

Read more on page 30


Stella Boess and Sacha Silvester.

the roof surface is shared by several households. A single-family house has enough roof surface for solar panels, but in these apartment buildings you have to find smart ways of using the limited amount of energy you generate to provide heat, hot water, ventilation and consumer electricity."
The group researching façades, headed by Dr Tillmann Klein (A+BE) is responsible for the energy calculations. "The main point is to guarantee energy-neutrality for the next twenty years," says Klein. They have delegated this responsibility to a company (Klimaatgarant) that will supply the installations and service the heat pumps and solar panels.
Tenants can influence their energy consumption. They will be taught how to use the new controls for heating, ventilation and energy consumption. Researcher Stella Boess started monitoring the indoor climate before the renovation. Three boxes per flat measure the temperature, humidity, light and CO_2 every five minutes. She also held a tenant survey and organised residents' evenings. At least 70% of the tenants had to agree to the plan before work could start. They all voted in favour.

PERSONAL APPROACH

"I think the personal approach made all the difference in this project," says Boess. In the model home, they were given detailed information about all the modifications.
Boess has deep respect for the knowledge and planning skills of the contractors but can see ways of improving the controls for the technology in line with the tenants' requirements.
Researcher Tillmann Klein will be interested to see how the flats work in practice. How will the technology hold up? How will the tenants get on with it? Will they meet the zero-meter standard? He would also like to scale up the project and use prefab technology for the façades instead of polystyrene and plaster.
Onno de Wal (BIK bouw) intends to keep an eye on the flats. Not only to guarantee the zero-meter performance, but also to hear about the impact on tenants. "We'll use their experiences as input for subsequent projects."

FUTURE

There are 380,000 of these apartments in the Netherlands. If they are all to be gas-free and energy-neutral by 2050, 10,000 staircase-access flats must be renovated every year. That's without considering any other types of housing.
The energy remit in the housing sector is vast, says De Wal: "We really need to get a move on. Different options for single-family homes and staircase-access flats are welcome. Contractors will need to deploy all their capacity to bring the existing stock up to standard." <<


Researcher Tillmann Klein: "The main point is to guarantee energy-neutrality for the next twenty years."

THE FIRM

Plastic waste is worth its weight in gold. Particularly if you know the precise chemical composition, so that you can recycle it as efficiently as possible. Polytential is marketing a machine that can analyse plastic waste to minutest detail.

Jeroen Cevaal (26), co-founder of Polytential, knew that he wanted to start his company when he was just fifteen. He wanted a start-up, something he could 'scale up'. He decided that it would be plastic waste recycling business during his course in 'Turning technology into business' in TPM, when he had to compile a business plan based on a patent for sorting plastic. In May 2016, before his business associates Yuri van Engelshoven and István Deák had graduated, Polytential was a reality.

"It soon became clear that we didn't have the knowledge, time and money we needed to develop a sorting method for plastic," he explains. "But after talking to compounders and recyclers, we realised that the concept of a precise plastic analysis was a good starting point for a business." Polytential is now operating a prototype of The Virtual Chemist: an analysis system that provides information about the chemical composition of plastic waste, with 99.5% accuracy - according to the makers.

This accuracy is what makes Polytential stand out, says Cevaal. "In addition, our entire analysis is computerised. A company that opts for our Virtual Chemist doesn't need manual work or expertise." Users simply feed a bag of plastic samples into the machine, which spreads them onto a conveyor belt. A special hyperspectral camera scans the flakes, and an algorithm in the cloud (built by a fellow-start-up in Amsterdam) analyses the chemical composition and presents the customer with a neat detailed report within five minutes. The customer can then decide how best to use the plastic, and which additives or plastics he needs to mix with the product to melt it into a semi-finished product for flower pots, for example. Or laptop casing.

Photo: Sam Rentmeester

Name	Polytential
Foundend:	2016
Founders:	Jeroen Cevaal and Yuri van Engelshoven
Degree programme:	Public Administration; Economics & Governance (Cevaal) and Environmental Engineering (Van Engelshoven)
Employees:	3, plus 2 interns
Turnover:	None to date
Target group:	Plastic compounders and recyclers
In five years:	Polytential wants to focus on trading plastic alongside the compounders and sorters.
Purpose:	"To be recognised as an independent certifier of quality assurance for the plastic waste trade."

'We built the prototype using prize money and grants'

The first prototype has been in use since October 2017. It will get its own hyperspectral camera at the end of this month; they're hiring one until then. Four demos are planned for the next six months. "We want customers to experience the product for themselves and give feedback about the design." The special camera alone costs €35,000, so Cevaal thinks that the most logical construction would be for customers to lease the scanner.

Cevaal and his associates can't live off the proceeds of their business yet – although they have taken on a part-timer for the design and construction of the machine. "We built the prototype using prize money and grants. We charge customers for using the prototype, but we come and supervise the operation every day for a week." RVT

TEXT: SASKIA BONGER PHOTOS: SAM RENTMEESTER, BOB BRONSHOFF, MATEUSZ BIENIASZCZYK

The best at TU Delft. What happened next?

Maaike Kroon 2004-2005

'My attitude to life is changing'

Chemical engineer Maaike Kroon was the very first 'Best Graduate of TU Delft'. Her graduation research helped to accelerate a new production method for the chemical and pharmaceutical industry, an unprecedented breakthrough for a graduation project. Not only TU Delft was in awe of her; DSM was too. Kroon wanted to continue her research. Her then-Dean, Karel Luyben, who was later to become Rector Magnificus, came up with the funding for the first part of her research, but then it was up to Kroon.

She was awarded a PhD after just two years. She'd obviously gathered all the information she needed, but there was another, more pressing problem: no more funding for her appointment. She left for Barcelona and Stanford became a Professor of Separation Technology at TU Eindhoven at just 29 years of age. Less than five years later, Kroon was appointed Professor at the Petroleum Institute in Abu Dhabi, a position she's still happy in. Why? "In the Netherlands, you spend 30% of your time writing research proposals. Here, I can get on with my research in dynamic, young surroundings, with a good salary, calm working environment and time for my family. And it's just a six-hour flight from the Netherlands."

Kroon now has time to contemplate life. "My attitude to life is changing. Other things have become more important: friends, family, new experiences. And we'll definitely return to the Netherlands when the children are older. I still want to work in science, but not in the way I used to."

Gert Kragten 2005-2006

'A good salary isn't enough'

Gert Kragten graduated on the analysis of a hand prosthesis mechanism. It was not only of mechanical interest to him, but also socially relevant. He heard about the 'Best Graduate of TU Delft' title while in India, where he and his wife were doing voluntary work. "It was a surprise. It felt like a gift," he remembers.

The prize helped him to put his doubts into perspective during his PhD research into robotic hands. "It inspired me to keep going whenever I started doubting myself. The idea that other people had seen and recognised my work was encouraging."

Kragten was awarded a PhD in 2011. As his work had always been theoretical and solo, he was keen to do something practical. Lely in Maassluis, a company that builds milking robots (among other things), offered him both practical challenges and teamwork: organising, experimenting, arranging, visiting farms. "I experienced team spirit and honed my practical skills. But every now and then, I worried about not using my academic skills to the full."

This brought Kragten to his current employer, fluid and motion control company Gevasol. Kragten acts as 'a bridge between customers and engineers, and engineers and production'. "I try to avoid blinkers."

But Kragten is also considering his future. He'd like to take Gevasol's engineering department to Delft, and attract students, children and people who difficulty finding work. "The gap between theory and practice can be huge, while these two aspects can actually feed off one another. It's hugely stimulating, even for me. A good salary isn't enough."

The 'Best Graduate of TU Delft' title (rewarded by the University Fund Delft) has been around since 2004. How are the first four best graduates doing now, and what's their message to 'ordinary' students and alumni?

Helma van Rijn 2006-2007

'I love discovering new worlds'

Helma van Rijn knew that her supervisors were pleased with her, but she hadn't expected to get a ten. For her graduation research, Van Rijn designed interactive toys to help children with autism develop their language skills. She is genuinely interested in target groups who are difficult to reach.

"I love discovering new worlds," explains Van Rijn. She's keen to use this trait to improve the care system. "My current job at Muzus involves a project with the homeless. I want to understand people better, find out what they need, how I can help them, design something useful. I do this by asking lots of questions and listening carefully."

It was the same during the PhD research that followed her graduation. She wanted to learn from her dealings with people suffering from dementia and autism. She even initiated a product that people with dementia could activate with memories. She hadn't been planning this PhD field as a student, explains Van Rijn. "It was the 'best graduate' title that spurred me on. It raised my profile and helped me to get funding."

Van Rijn has always been prepared to go the extra mile. "I'm a perfectionist and I want to contribute," she explains. She gained a first-year diploma in psychology alongside her degree in Industrial Design Engineering, did a research internship with IDE, brought products onto the market and still gives the odd guest lecture at TU Delft. Her tip for others? "Show people what you're capable of and show some initiative."

Dawid Strebicki 2007-2008

'You must show employers that you're keen'

Dawid Strebicki didn't plan to start his own architect's office in Poland, the country he left at the age of ten. In 2011, he and his girlfriend (also Polish) were facing a dilemma: stay here or embark on a new adventure? "Her parents in Poland had a huge attic room. We set up office there, taking on projects in Belgium and Poland."

In 2008, Strebicki was given a ten for his graduation project, a design for a secondary school in a deprived district in Amsterdam-North. He puts the mark into perspective: "Emotion is a big part of architecture. I worked hard. I've fond memories of our graduation group: we inspired one another, urged each other on."

Strebicki graduated in the middle of a construction crisis. But two weeks later, he had a job in Rotterdam. It was good, but not his thing. "It didn't get my juices flowing. I soon moved to the smaller Flemish office owned by my former supervisor, where I learned a lot. I found myself consulting with everyone at the same time; from politicians to bricklayers."

It's a competitive field, says Strebicki, designers have a lot of responsibility. It starts while you're still training. "To my mind, the teaching methods pushed you in the direction of your own office. I don't know whether this was intentional, or if it's just my perception or if most of us look back on our degree programme like this." But if there's one thing Strebicki learned, it's this: "You must show customers and employers that you're keen, they must be able to trust you. On the other hand, you're judged on what you achieve. This turned out to be more important than any diploma."

ALUMNI NEWS

Alumni activities

12 April
Visit D:DREAM hall for TU Delft Alumni (Delft)

12 April
First EPA Alumni Event (The Hague)

17 April
Dutch Engineers Alumni Event (Madrid)

24 April
TU Delft Alumni Backstage Tours (Delft)

16 May
Presentation Marina van Damme grant (Delft)

25 May
First Indian Alumni Event – in association with Indian student association Delft

25 May
TU Delft Alumni Backstage Tours (Delft)

6 to 8 June
International Festival of Technology (Delft). With the Alumni & Relations Event on 7 June

CONTACT
Questions, comments or ideas?
e-mail: alumnirelations@tudelft.nl
website: alumni.tudelft.nl
community: tudelftforlife.nl

'TU Delft for Life' is the online community for all Delft alumni. Expand your network, rediscover old friends from uni and keep abreast of all the latest news and events. You can register at tudelftforlife.nl, where you can also change your address or contact details.

One of the locations of the Backstage Tour is the D:DREAM hall .

TU Delft Alumni Backstage Tours

Although a lot of things on our 161-hectare campus stay the same over the years, some things have definitely changed. This turns a backstage tour into a mix of nostalgia and promises for the future. Visit familiar and not so familiar places, learn about education and research today, and take a peek behind the scenes of some of our unique research labs. Go to the website for dates and to register: **alumni.tudelft.nl**

International Festival of Technology 2018 (IFoT)

'Prove It - Proef 't'

From Wednesday 6 to Friday 8 June, the IFoT will offer a mix of technology, music and art. It's become something of a tradition to organise our annual meeting of alumni and associates of the Delft University Fund during this festival. You are warmly invited to attend a special part of the IFoT programme on **Thursday 7 June**, at which we will announce the Alumnus of the Year 2018. There are also various TU Delft Theme Tours for alumni and associates, and you can learn about the latest developments in the university. In the evening, the faculties will organise their own alumni gatherings. The perfect opportunity to catch up with old friends or even meet new ones. You will be sent a personal invitation to this private part of the programme. Visit the website for further information: **alumni.tudelft.nl/ifot**

From the Delft University Fund

Delft University Fund launches **crowdfunding**

On 15 January, Delft University Fund launched its supporttudelft.nl crowdfunding platform to raise money for influential research projects and student initiatives at the University. In this way, we can all help find solutions to societal challenges.

The Delft University Fund instigated and manages the platform. Evelyne Esveld, director: "We want to inspire people who are interested in supporting TU Delft and involve them in our brightest teaching and research gems. The special projects don't only show what we're good at, they also show what we're good for."

Purified water is one of the projects of supporttudelft.nl.

Purified water in India

Take the 'Purified water in India' project. Dozens of Indian, Dutch and other international students and PhD candidates are working with TU Delft on water management and sanitation in India. "On the one hand, it makes future Indian engineers aware of the importance of treating and recycling polluted water, and on the other, TU Delft scientists will learn more about the cultural context in India, giving them more insight into the most effective technological solutions," says Dr Ralph Lindeboom from the Faculty of Civil Engineering and Geosciences (CEG).

The crowdfunding platform has been live for six weeks. "We can already report that many researchers, students and the public are pleased with this additional opportunity to make donations, raise awareness and generate public interest," says Jacqueline Leemkuil, contact person and coordinator of the crowdfunding platform.

Want to know more?

Visit the supporttudelft.nl website. For questions and information about the crowdfunding platform, please contact Jacqueline Leemkuil at crowdfunding@tudelft.nl or +31 (0)15 278 23 81.

The lab of...

Applied Physics

PhD student Ingrid Pinel (environmental biotechnology, faculty of Applied Sciences): "Fouling of membrane elements is a major issue in water treatment facilities, including drinking water production. In our research we use membrane fouling simulators to reproduce and characterize biofouling occurring in full-scale installations. In this way we can efficiently investigate biofouling control methods leading to a better operation of the industrial membrane processes."

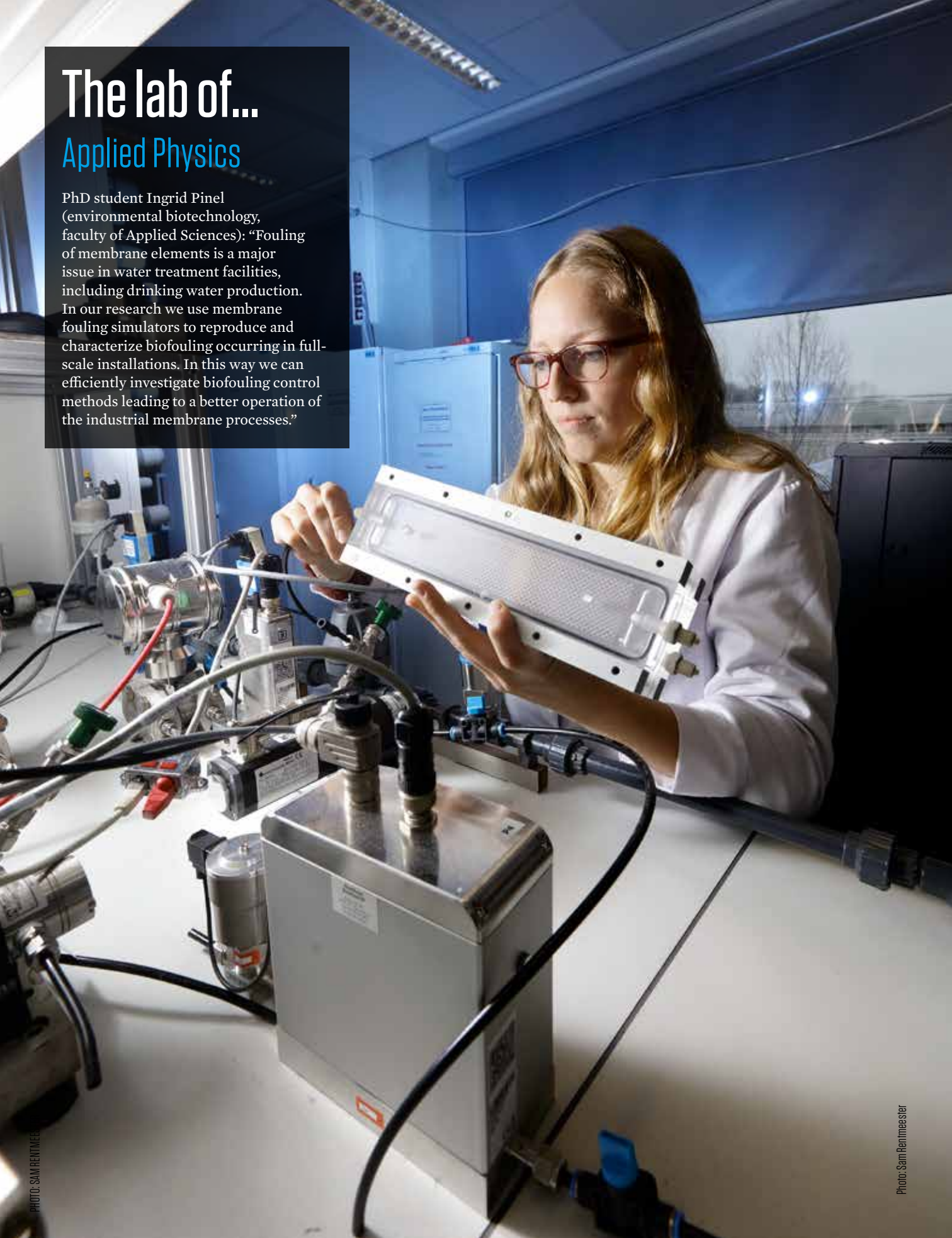


Photo: Sam Rentmeester