DELFT OUTLOOK
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TU Delft

Jasper van Kuijk
About homesickness and well-being

On a deserted island
Fieldwork on the Marker Wadden

Virus inhibitors
The downside

THEME
New energy

Cover:
Entering the ESP hall is a bit of a surreal experience. The objects look as if they have come out of an electronic tinker box, but the dimensions are enormous. It feels like walking on a circuit board as a gnome. (Photographer Sam Rentmeester)

Foreword
Tim van der Hagen

New energy

TU Delft will celebrate its 180th anniversary on 14 January 2022. One hundred and eighty years of TU Delft means 180 years of research, engineering and innovation; 180 years of innovators and bridge builders; and 180 years of highly educated engineers that have contributed to welfare, development and security in the Netherlands and far beyond.

We are extremely proud of our past. It was also a past that was very focused on economic growth and industrial development. While this has undeniably brought much good to society, we are increasingly facing their negative consequences, of which climate change is the most far-reaching.

We take our responsibility for this. We are providing new generations of engineers the knowledge and expertise that they need to address these challenges. Through innovation we focus on concrete solutions and through our research we are working on new understanding that could lead to solutions that are not yet there. This will help us all to look towards a safe and thriving future.

The energy transition is a crucial weapon in the battle against climate change. Only if our energy system is CO_2 neutral by 2050 will we limit the impacts of climate change. However, if things do not speed up, we will not achieve this in 30 years. We need to make haste. Hence, 'speeding up the energy transition' is the theme of our anniversary in which we celebrate our active role in the energy transition. This year's edition revolves around this theme. Meet 10 researchers that are working on speeding up the energy transition. Professor of Energy Systems Analysis Kornelis Blok shares his future vision and Professor Peter Palensky discusses a platform to test future scenarios, his digital twin of the energy system. Finally, alumnus Mike ten Wolde finds himself at the heart of the energy transition at TenneT. He is just as optimistic as I am about the outcomes. If we all make an effort, we should achieve it.

Prof. Tim van der Hagen,
President Executive Board TU Delft

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Theme:
New energy

PHOTO: SAM RENTMEESTER

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Design researcher, comedian and columnist Jasper van Kuijk talks about his new book, his current performance, internationalisation, student wellbeing, design populism and much more.

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Virus inhibitors

Virus inhibitors disrupt the production of new viruses by the host cell. But too low doses can cause resistance to develop. Prof. Nynke Dekker showed how this works.

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Marker Wadden

Ten TU Delft Hydraulic Engineering master students were the first to do multi-day research on the Marker Wadden islands. “Put a few coastal engineers on a deserted island and they will automatically become subject fanatics.”

DELFT IN BRIEF

More news on tudelft.nl and delta.tudelft.nl.

PHOTO: JUSTYNA BOTOR

Coronavirus-proofing lecture rooms

As part of its measures against the spread of coronavirus, TU Delft has ensured that the ventilation in all of its lecture rooms meets the requisite standards. The standard being applied is thirty cubic metres of fresh air per person per hour. But that is not enough in and of itself. Professor Atze Broerstra (Building Services Innovation at Architecture and the Built Environment) says that this standard must not be taken too literally, as more factors are in play. "What's involved is a combination of measures. Ventilation can involve limiting the spread between persons, but it nevertheless remains important that you address the source at the same time. You must therefore limit the possibility of infected persons entering the lecture room as much as possible."

Walls made of dung

Doctoral candidate and engineer Yask Kulshreshtha (Faculty of Civil Engineering and Geosciences) is not afraid of getting his hands dirty. Together with two helpers, he mixed a tonne of fresh cow dung with six tonnes of mud. This smooth mixture forms the basic material for seven hundred building blocks that will be tested outdoors for one year as to its water resistance. The dung-and-mud mixture changes into building blocks when compacted and dried. If the test at The Green Village is successful, Indian-born Kulshreshtha will have provided the Netherlands with a promising building material which is inexpensive, has a low CO_2 value, saves energy and is farmer-friendly.

PHOTO: SAM RENTMEESTER

Lava Palma

The largest wave ever seen by humanity: that was what would happen if the island of La Palma were to break in half following a volcanic eruption and part of it disappeared into the ocean. In 2001, the world took note of this message from British scientists who had been studying tectonic activity around La Palma, in the Canary Islands. In 2006, researchers from Delft, including Robert Jan Labeur (Civil Engineering and Geosciences) contradicted this prediction. They found that the island was sturdier than the British study suggested. So when the volcano Cumbre Vieja became active on 19 September and started leaking lava in various places, Labeur watched closely. Two months later lava is still flowing. Labeur is relieved to note that the volcano is following the scenario from Delft and not that from Britain.

DARE cancels launch

Despite multiple attempts, the students involved in Delft Aerospace Rocket Engineering (DARE) failed to launch their Stratos IV. The rocket remained earth-bound due to technical problems. The aim had been to improve the European altitude record, but the Stratos IV rocket did not get further than the launching platform during the attempts at the launch bases of Spain's Instituto Nacional de Técnica Aeroespacial. The team had been allocated the period of 16 to 23 October in which to launch the rocket, but due to technical difficulties and adverse weather conditions the launch had to be postponed again and again. It is still unclear whether a Stratos rocket will be launched next year. The decision is up to next year's cohort.

Playground for quantum enthusiasts

ILLUSTRATION: TU DELFT

Tired of corona travel restrictions? Take a virtual voyage to the future of the internet on the new QuTech website and meet Alice, who is too smart for hackers. Alice is one of the characters in a serious game on a new QuTech website. QuTech is the partnership between TU Delft and TNO on quantum technology. One of the applications which you can experiment with on the website is Quantum Key Distribution, a technique that promises untappable communication.

Renewed Delft Outlook

In May 2022 you will receive a completely renewed Alumni Magazine on your doorstep or in your e-mail inbox. Of course we will keep you informed as usual on developments at the university and the work of Delft engineers. The focus will be more in line with the motto of TU Delft: impact for a better society. This means more attention for the major societal challenges and the role of science to solve these problems together. More science for a better society, more collaboration between university, companies, governments and civil society organisations, more about lifelong learning and life on the TU campus. Sixty pages of solid stories with people and its motives as the core. With a fresh look and a contemporary look, we hope to provide you with more connection and deepening.

Licence plate fraud

In Greece, the owners of vehicles with licence plates featuring unusual numerical combinations are likely to have paid bribes to secure the numbers. This appears from investigations done by TU Delft professor of Software Analytics Diomidis Spinellis (Electrical Engineering, Mathematics and Computer Science). The article appeared in the academic journal PLOS ONE in early September. Spinellis was Secretary-General for information systems at the Greek Ministry of Finance from 2009 to 2011. The corruption he came across there was a thorn in his side; he decided to investigate license plate fraud upon leaving the civil service.

TU Delft Groningen study disallowed

On 5 October, a motion proposed by Pieter Grinwis (ChristenUnie) and Agnes Mulder (CDA) was carried unanimously by the House of Representatives. They called on the government not to allow the institute on mining damage in Groningen (Institute Mijnbouwschade Groningen, IMG) to exclude areas in Groningen and Northern Drenthe when it came to submitting claims for damages. The IMG relied on a report by TNO and TU Delft from March 2021 regarding the direct effects of subsidence due to deep causes. In this report, TU Delft professor Jan Rots concludes that deep subsidence (and uplift) in the Norg underground gas storage and the Groningenveld does not lead and has not led to damage to buildings.

THEME
New energy

PHOTO: SAM RENTMEESTER

On January 14, TU Delft will celebrate its 180th anniversary. An good reason to take a closer look at the role of the university in the energy transition. More than 900 people are working on this important issue in Delft. Only a small number are featured in this issue. For example, we are introducing the team of accelerators, ten researchers who make an important contribution to accelerating the energy transition. In addition, Peter Palensky explains why his copy of the current electricity grid is important, John Schmitz tells about the 24/7 Energy Lab project, start-up Tarnoc presents the Turbine Boiler and Jan-Leen Kloosterman advocates the molten salt reactor.

Would you like to delve deeper and take a role in the energy transition yourself? An online course from the TU Delft portfolio might be interesting. Such as the micromaster Solar Energy Engineering, a program that provides knowledge and skills to become an expert in solar energy. Or a course in architecture and construction, to learn how to design buildings more energy-efficiently or make them circular. Scan the QR codes or visit **online-learning.tudelft.nl**.

TEXT: TOMAS VAN DIJK EN JOS WASSINK PHOTOS: SAM RENTMEESTER

Working on **accelerating** the energy transition

On its 180th anniversary in January, TU Delft will reflect on its role in the energy transition, and especially on how to accelerate it. This is a complex issue with the ultimate goal of a safe and reliable energy system. A team of 10 scientists gives this acceleration a face.

Deborah Nas

The energy transition is a 'wicked problem', explains Prof. Deborah Nas (Faculty of Industrial Design Engineering), the Coordinator of the Delft Accelerator Team. "It has many different facets that are often interrelated and often counteract each other. Moreover, everything changes over time and you cannot test solutions in isolation." That seems an insoluble issue but because of the urgency, the lustrum committee that is organising TU Delft's 180th anniversary chose it anyway. And in particular: the acceleration of the energy transition. The Chair of the Anniversary Committee Kornelis Blok, Professor of Analysis of Energy Systems at the Faculty of Technology, Policy and Management (TPM) and Director of the Delft Energy Initiative, started recruiting from among more than 900 TU Delft researchers who are working on energy. He looked for scientists who have made great progress in their own research field and who are also strongly motivated to work in a multidisciplinary context to accelerate the energy transition. The 10 person team is a good reflection of the various disciplines and research themes.

"It's not just about technology, it's also about pricing, policies, adoption, and behaviour," says Nas. She explains that TU Delft is in a good position – with the business community, government and alumni – to accelerate the energy transition. Thanks to its diverse faculties, TU Delft has a strong multidisciplinary approach. And TU Delft research extends from the molecular to the systems level, and from fundamental research to field labs. What can we expect from this at the end of the lustrum year? Nas believes that new projects, demonstrators and field labs will emerge where technologies, in collaboration with industry and governments, are primed to make a difference in society.

We asked the 10 members of the Accelerator Team what the main acceleration obstacles are in their own domain, and how they tackle them.

LAURE ITARD, PROFESSOR OF BUILDING ENERGY EPIDEMIOLOGY

'Data scientists need to learn from building experts, and vice versa'

Prof. Laure Itard (Faculty of Architecture and the Built Environment) is Professor of Energy Epidemiology of the Built Environment. Just as epidemiologists collect data on public health, she and her team do so on the energy use of buildings. They conclude that the energy savings after building renovations often turn out to be less rosy than calculated. One reason is that the behaviour of the residents was not correctly estimated. Her research group uses data from Statistics Netherlands (CBS), housing associations, private individuals and other sources. They use this data to map the energy consumption of individual buildings to the entire national stock of buildings. And, according to Itard, there is a long way to go. "The loss of energy in buildings in the Netherlands is just as great as the total annual production of solar and wind energy." She believes that the biggest obstacle to better energy use in buildings is the lack of knowledge: there are too few people combining expertise in complex climate management and energy systems with the ability to deal with large data files. As a remedy, Itard's group is working with housing associations and the Government on better forecasting models, and is working with the installation industry to develop future energy management systems for buildings. These systems should support building managers to draw on current data in their decision-making about indoor climate, the use or storage of energy, and the current CO_2 footprint of the electricity on the grid.

OLINDO ISABELLA, PV-PROFESSOR

PV everywhere is Professor Olindo Isabella's shortest formulation of his mission to accelerate solar power. He heads the Photovoltaic (PV) Materials and Devices Research Group at the Faculty of Electrical Engineering, Mathematics and Computer Sciences. He argues that to increase the amount of solar power, solar cells and panels should be more efficient at converting sunlight into electrical power. Researchers at the TU Delft PV Technology Centre are developing a PV tandem device that combines a crystalline PV cell with a perovskite cell on top. Perovskites are a promising group of ionic semiconductor materials that are cheap and easy to produce at low temperatures. Isabella expects the perovskite top layer to add at least another 6% conversion efficiency to the 24% of their silicon cell, reaching more than 30% in the next few years. Accelerating solar power not only means boosting efficiency, but also placing the maximum number of PV panels - especially in urban environments. Any place with enough exposure to the sun and without aesthetic objections (in the case of monumental buildings) is a potential energy source.
Practicing what he preaches, Isabella now works with TU Delft Campus Real Estate to find additional PV locations on campus. He estimates that solar production on campus may grow from the current 1 GWh/year to more than 8 GWh/year, raising the share of solar in TU Delft's electricity consumption from about 1.5% to 12%.

'Perovskite can reach a conversion efficiency of 30% in the next few years'

GERDIEN DE VRIES, CLIMATE PSYCHOLOGIST

'The hassle factor keeps people from making their homes more sustainable'

The hassle factor is an enormous obstacle in accelerating the energy transition, says climate psychologist Dr Gerdien de Vries, Associate Professor at the Faculty of Technology, Policy and Management. The research, applying for subsidies, finding contractors, clearing out the attic – all these keep people from making their homes more sustainable.
The Groen & Gemak (green and easy) study (TU Delft and TNO, 2020) showed that the Dutch are discouraged by this. "The climate crisis is all about complexity and uncertainty," says De Vries. "We keep hearing about a crisis, but no point is pinpointed when anything should happen. There is no identifiable person to solve it. So what should you do as an individual?" Complexity and stress paralyse people so that not much will come of greening, even if technical or financial obstacles have been removed.
Part of the remedy lies in 'unburdening' homeowners by using an energy coach, for example, who takes over much of the arrangements. But even then people don't feel like it. Behavioural change is complex and the rising gas price and copycat behaviour also play a role. Yet society is undergoing behavioural changes that were previously difficult to imagine. "Who smokes now in someone else's car? Who still drinks when driving?" asks De Vries rhetorically. Her conclusion: major changes in social behaviour are indeed taking place. Usually through a combination of information, legislation, price and the social environment.

PETER PALENSKY, EXPERT IN INTELLIGENT ELECTRICAL POWER GRIDS

"Uncertainty is the largest obstacle in accelerating the energy transition," says Professor Peter Palensky, expert in Intelligent Electrical Power Grids at the Faculty of Electrical Engineering, Mathematics and Computer Science. There is no lack of technologies for generating or storing renewable energy and there are numerous options for combining these into an electricity grid. But how can this be done fairly and reliably? The current power grid is already 'a complex beast' and it's getting far more complex with the addition of numerous and variable power sources. "The traditional grid relied on the inertia of heavy generators driven by steam or gas for stability. Renewable energy sources don't have that inherent stability. It's more like the contrary." People are notoriously bad at understanding, let alone handling, complex systems, argues Palensky. Consequently, and out of caution, people take small steps in making changes to the system. But climate change and societal pressure need acceleration: larger steps taken sooner.
The good news is that the newly opened Electrical Sustainable Power Lab houses the Real Time Digital Simulator (RTDS) that helps researchers deal with complex systems such as the consequences for grid stability when large new offshore wind parks are connected to the national grid. The RTDS can mimic these disturbances like the power grid's digital twin. Ultimately, its purpose is to reduce uncertainty and allow for a safe acceleration of the energy transition.
(Also see article on page 18).

'The power grid is getting far more complex'

ANDREA RAMÍREZ RAMÍREZ, PROFESSOR CARBON SYSTEMS AND TECHNOLOGIES

'An important part of how we contribute to the energy acceleration is training our students'

One main problem in decarbonising the industrial sector is the complexity of the system and the large number of options, says Professor Andrea Ramírez Ramírez, whose expertise is Low Carbon Systems and Technologies at the Faculty of Technology, Policy & Management. "There are many options in reducing CO_2 emissions, but many are not yet commercial and their implementation will require significant changes in the core processes of industrial sites. A lot of the work we do, is trying to support stakeholders to navigate the complexity of industrial systems. An important part of the decision making is understanding what the potential technology trade-offs are. This implies identifying the technical, environmental, and social impacts of scaling up novel technologies and understanding how they interact with the larger system. At TPM, we work on identifying those trade-offs early, even at the stage when technologies are still in the lab, so that this information can be used to further develop novel technologies that contribute to a more sustainable industrial sector. Finally, an important part of how we contribute to the energy acceleration is training our students. Education can be too easily overlooked, but it's how we shape the human capital that is needed for the transition. Without people that can do the work, the transition will not happen."

DAVID VERMAAS, ASSISTANT PROFESSOR OF ELECTROCHEMICAL SYSTEMS

Ultimately, the energy transition is about less greenhouse gas in the atmosphere. You can achieve this by emitting less, but you can also actively remove CO_2 from the environment. This is Assistant Professor of Electrochemical Systems Dr David Vermaas' preferred approach. He heads the Electrochemical Flow Systems Lab (Faculty of Applied Sciences) at TU Delft and is working on techniques to remove carbon dioxide from water.

The removal of CO_2 from flue gases is already well developed, but it only accounts for half of all CO_2 emissions. CO_2 capture from seawater is a solution, says Vermaas. "There is 150 times as much CO_2 in a litre of water than there is in a litre of air." Carbon dioxide can be captured by electrifying a membrane in the water. The water molecule then decomposes into acidic H+ and basic OH-. "If you place a membrane between the acidic and the basic part, you start two chemical reactions. Carbon dioxide is formed in the acid part. It bubbles out of the water on its own after a while and can be caught in this way. Substances such as calcium and magnesium carbonate are formed in the basic part. In other words: limestone. The main challenge now is to ramp up production. We have to introduce the public to our projects. Politicians follow what the public wants."

'There is 150 times as much CO_2 in a litre of water than there is in a litre of air'

PHIL VARDON, GEOTHERMAL EXPERT

'We hope to start extracting geothermal energy from under the campus next year'

Half of the energy consumption in the Netherlands is used for heating. "That is convenient, because there is warm water two to three kilometres deep in many places in the Netherlands," says geothermal expert Dr Phil Vardon (Faculty of Civil Engineering and Geosciences). "A lot is already known about this energy source from the drilling done in the past for gas exploration."
Vardon believes that to speed up the energy transition, we need to speed up the extraction of this energy. The Netherlands uses little geothermal energy because sourcing it can easily cost tens of millions of euros. The exploitation itself may be cheap, but you need a good destination for all that energy. Vardon explains that "In winter you can use the heat to heat houses, but not in the summer. Yet you want to gain energy all year round otherwise you won't have a good business case. One idea is to store the heat that you gain in the summer in shallower layers of the earth from which you can easily extract the heat in the winter. You have to be able to pass that heat on to heat networks."
"Next year we hope to start extracting geothermal energy under the campus. We want to research all kinds of aspects of this form of energy production. We can partly use the heat on campus as TU Delft has a heat network. And some of the heat will go to residential areas just outside campus. If everything goes well, we will have a great example project for the rest of the country."

RUUD KORTLEVER, ASSISTANT PROFESSOR OF LARGE-SCALE ENERGY STORAGE

According to Assistant Professor of Large-scale Energy Storage Dr Ruud Kortlever (Faculty of 3mE), a transition to sustainable energy cannot be viewed separately from a transition to sustainable raw materials. The Delft e-Refinery Institute, to which Kortlever is affiliated, plays a key role in this. Under the umbrella of the Delft e-Refinery Institute, TU Delft researchers are working on technologies for the electrochemical conversion of sustainable electricity, water and air into fuels and chemical building blocks. "We use sustainable electricity to drive chemical reactions, for example for the production of hydrogen, syngas and ethylene."
Do not underestimate the importance of ethylene, says Kortlever. "This substance can serve as a building block for plastics and polymers. If we want to be fossil-free by 2050, we also need to work on a raw material transition. How do we accelerate both transitions? There is currently a lack of long-term vision, as neither Government nor business know which technologies can ultimately be a solution. With all the knowledge that TU Delft has in-house, it can help develop new technologies and determine a joint course."

'We need to work on a raw material transition'

HADI HAJIBEYGI, UNDERGROUND STORAGE EXPERT

'Under the North Sea alone, we may eventually have to store hydrogen at hundreds of locations'

The name of the department at the Faculty of Civil Engineering and Geosciences where Dr Hadi Hajibeygi worked until a few years ago used to be called Petroleum Engineering. It seems a long time ago. Today the group is called Reservoir Engineering. "We don't do much in terms of fossil fuels anymore," Hajibeygi says. The name change has everything to do with the energy transition, says the engineer who leads a research group that focuses on underground storage of green hydrogen and CO_2.
Hajibeygi and his colleagues are interested in, among other things, the behaviour of fluids in different layers of the Earth. "That knowledge is crucial if you want to store hydrogen in the ground. This is currently only done in four places in the world, in old salt mines and empty gas fields. Three of these are in Texas and one is in the United Kingdom. If we want to get the energy transition off the ground, storage needs to be scaled up enormously. Under the North Sea alone, we may eventually have to store hydrogen at hundreds of locations. There is already a little bit of experience in this, but expanding storage to more places is not simply a matter of copy paste. There is interaction between the fields and you need to know how the fields influence each other before you pump hydrogen into them."

AXELLE VIRÉ, WIND ENERGY EXPERT

We are lucky in the Netherlands. We are adjacent to a shallow sea where you can easily attach wind turbines to the bottom. To scale up offshore wind farms, floating turbines need to be installed, says wind energy expert Dr Axelle Viré of the Faculty of Aerospace Engineering. "Once the sea is deeper than about 50 metres, you can no longer fix the mills to the bottom. At least, doing so is a lot of hassle and no longer profitable. You will have to put them on floating platforms that are held in place by cables and anchors."
The technology is still in its infancy. Off the coast of Scotland, Equinor built a park with five floating turbines. The company intends to install another 11 turbines off the coast of Norway by 2022. They're not exactly high numbers. "We will have to wait a little longer for a substantial impact of floating turbines on our energy supply. But the potential is enormous," says Viré. "You could also place the turbines far out at sea and have them produce hydrogen. You can get that energy carrier ashore cheaply."
To advance the technology, it is important to better understand how the movement of a huge float with blades affects the aerodynamics. The mill moves with the current, wind and waves. "We are trying to gain more understanding of this using simulations and calculations," says Viré.

'It is important to better understand how the movement of such a huge float with blades affects aerodynamics'

TEXT: JOS WASSINK ILLUSTRATION: STEPHAN TIMMERS

24/7 Energy Lab: local,

At present, households account for 20% of the Netherlands' energy consumption. Reason enough for the 24/7 project at The Green Village to work on a local, CO_2-neutral energy system for the built environment.

In the south west corner of the premises is a discreet container that contains all the ingredients needed for the generation, conversion and storage of low carbon power: **(1)** solar panels (6 kWp); **(2)** a 14 kWh home battery; **(3)** a 2.4 kW electrolyser that converts electricity into hydrogen; **(4)** a compressor; and, **(5)** a 2.3 kW fuel cell. Next to the container are two sets of 27 cylinders **(6)** for storing 60 kilogram H_2 under 300 bar pressure. The 24/7 Energy Lab is scaled to small households **(7)** that use 2,200 kWh a year. A regulation system with power electronics **(8)** controls the different components.

"In principle, the control is simple," explains John Schmitz, former EEMCS Dean and Chair of the Board of The Green Village. "If more solar energy is generated than used, the rest first goes to the battery. If the battery is full, the electricity is converted into hydrogen and stored for the winter. There is little solar energy in the winter, but a fuel cell supplies both heat and electricity from hydrogen."

The conversion through electrolysis followed by a fuel cell creates a chain efficiency of about 30%. This is not necessarily a bad thing, explains Schmitz. "We scale the PV cells in such a way that there is a surplus of power in summer that we can then use to produce hydrogen."

The 24/7 Energy Lab is at the interface of three energy streams: fuel, electricity and heat. This makes a well functioning Energy Management System (EMS) a complex unit. It was developed by the Intelligent Electrical Power Grids Research Group and the Flexinet project (both at the Faculty of EEMCS). The intention is that there is an open source design of an EMS that includes the required communication protocols.

Energy independence is not the 24/7 Energy Lab's goal, says Schmitz. What can happen is that distributed energy generation for local use could reduce the pressure on the electricity grid. This would be very welcome given the context of more electric vehicles and heating. "The 24/7 Energy Lab will eventually have a residential sustainable energy lab where researchers and students from all the faculties can work with universities of applied sciences and companies," says Schmitz.

Marjan Kreijns, Director of The Green Village, emphasises that, apart from system integration and smart control, the project is also about non-technical aspects. These includes the economy (how energy is calculated); judicial aspects (permits, liability etc.); and acceptance by residents (who mostly want to avoid hassle). "With 12 real residents in the Field Lab, we see ourselves as a stepping stone between the laboratory and square kilometre scale," says Kreijns. "Researchers and entrepreneurs can test their prototypes and remove the bugs so that they can scale up to neighbourhood and district level."

autonomous and CO_2 free

"I believe that we need to leave a liveable planet behind for future generations and, thus, to my own children and grandchildren. This project is my contribution." Doing nothing is not an option for John Schmitz. As an alumnus, you too can contribute. A donation to the University Fund Delft will help expand this project and contribute to speeding up the energy transition. Scan the code here or see **tudelft.nl/techforenergy** for more information.

‘It looks like there is finally some real momentum in this technology’

Will the thorium reactor finally get off the ground? Professor of Reactor Physics Jan-Leen Kloosterman has high expectations of recent developments in China.

One-sixth scale model of Oak Ridge National Laboratory's Molten Salt Reactor Experiment. The MSRE achieved criticality June 1, 1965, and reached its full power of 7,500 kilowatts in May 1966. c. 1968 (Photo: US Department of Energy)

There is great potential: an almost inexhaustible fuel source, minimal safety issues, and no carbon dioxide emissions. While people have talked about it for years, a reactor that works on molten salt and thorium is now developing fast. A thorium reactor is quickly getting off the ground close to the city of Wuwei in China. It is due to become operational next year. At first it will run on uranium, but the hope is that later versions will also run on thorium.

For 15 years now, Professor of Reactor Physics Jan-Leen Kloosterman has researched thorium molten salt reactors, also called Thorium MSR (molten salt reactor). He is pleased with the news from China. “It looks like there is now real momentum for this technology. Hopefully European countries will also see how promising this technique is and that money needs to be pumped into it.” Kloosterman says that China is investing EUR 500 million in the test reactor that is now under construction. In Europe, only a fraction of this amount is being pumped into the technology.

The disadvantage of the recent developments in China is that his Chinese colleagues, with whom Kloosterman has close contact, are playing their cards close to their chest. “They are keeping their knowledge to themselves.”

The fuel (thorium) in the Thorium MSR is dissolved in a liquefied salt of lithium fluoride or lithium-beryllium fluoride that is simultaneously used as a coolant. The pressure in the reactor is low. The idea is that if there is a leak, the fuel and the coolant will flow out

of the reactor, causing the reactions in the reactor to cease. The reactor does not produce long-lasting radioactive waste. Instead of being hazardous for many tens of thousands of years, the waste is only hazardous for about 300 years. It can also clear away the existing waste of nuclear power plants and nuclear weapons and convert it into energy.
The technology behind the molten salt reactor is not new. Its inventor, Alvin Weinberg, had an operational MSR from 1965 to 1969 in the Oak Ridge National Laboratory in the United States. The Weinberg reactor appeared to be very promising, yet the project was halted. One of the reasons for this was that

The reactor does not produce long-lasting radioactive waste

during the energy crisis, people wanted to quickly introduce nuclear energy and light water reactors that run on uranium were immediately available.
But the technology is now resurging. Kloosterman hopes that molten salt reactors will be built in more places on earth. They will initially need to run on uranium as there are still some technical obstacles that need to be overcome. One of these is the efficient purification of the salt. Just as with dialysis for kidney patients, the molten salt solution needs to be cleaned continuously – and the fission products removed – and returned to the reactor core after the addition of thorium and other substances. "This process still needs to be improved," says Kloosterman. This is one of the aspects that he and his colleagues are researching. "We are also seeing if the materials in the innermost part of the reactor core can handle the harsh conditions there." MD

Tarnoc develops electrical central heating boiler

The Delft tech start-up Tarnoc was one of the winners of the WarmteWissel 2020 with its heat pump.

The WarmteWissel – or heat exchange – is rooted in practice. Eight housing corporations that own more than 100,000 residences in the province of Brabant install 5,000 gas boilers every year and were looking for gas-free alternatives. Then Tarnoc was named as one of the winners in March last year and it received a prize of EUR 20,000 and the opportunity to test a prototype for three months in a home in Tilburg.
We already know what heat pumps are. They transport heat from low to high temperatures and have the advantage that there is significantly more heat emitted than the amount of electricity used to generate it.
The Tarnoc heat pump has special qualities, explains Tarnoc founder Vincent Wijdeveld. In contrast to other heat pumps or refrigerators, Tarnoc's Turbineketel does not circulate fluorinated coolants, but pure outdoor air instead.
The compressor heats the air by compressing it. The heat in turn heats up the water in the central heating system. The output temperature can go up to 80 degrees Celsius. After the heat exchanger, the compressed air drives a turbine that returns some of the energy. The electric engine, compressor and turbine are assembled on one axis. The thermal capacity of the boiler is 20 kW.
Co-founder Tijmen de Jong closely examined different thermodynamic cycles. He came across the Brayton

PHOTO: SAM RENTMEESTER

cycle that is used in industry in aeroplane airconditioning and in liquifying natural gas. In reverse, the Brayton cycle produces high temperature heat with a high capacity and without using coolants. This system had never been used in homes and was the start of their work on the Tarnoc Turbine boiler.
The pilot in Tilburg went well, reports Wijdeveld. The unit is now being fitted in the The Green Village campus testing ground.
The next step is to deliver eight turbine boilers to the eight housing corporations involved in the WarmteWissel. The plan is to start producing the first series in 2022.
"The equipment is fairly simple and easy to manufacture at industrial scale," says Wijdeveld. "The intelligence part is in the software." JW

Lifelike look-alike of the power grid

Professor Peter Palensky is developing a digital twin of the Dutch electricity grid, making it possible to do free research on innovations in the energy system without risking a blackout.

The digital twin of the energy network forms the ideal testing ground for research and experiments. The causes and effects are lifelike and totally virtual, with no risks of injury, damage or power cuts. But when a transformer or cable are physically connected in the new ESP Lab, they will go 'pooff' in the event of a short circuit or overload in the digital version of the grid. Palensky's goal is a supercomputer with sufficient computing power to model the entire Dutch energy network, including connections to neighbouring countries and crucial interconnectors to and from the UK, Norway and Denmark. Funding is still a barrier - hopefully a NWO application will help. "But we know it can be done," says Palensky, "because a quarter has already been completed." He is referring to the digital twin of the grid in the northern Netherlands, modelled for a study on how hydrogen may impact the energy system. Building on that experience, the 'big' twin can be ready relatively quickly, he expects.

UNFATHOMABLE COMPLEXITY

One thing such a digital twin excels in is weighing up a large number of mutually influencing variables and uncertainties. What happens when hydrogen is added to the energy mix on a large scale, what happens if the power of high voltage direct current (HVDC) technology really takes off - and what if it all happens at once? Humanly speaking, so much complexity is hard to grasp. "Especially since the demand side will also take on a completely different dynamic," says Palensky, mentioning some examples: new services such as flex-aggregators, electric vehicles that coordinate their charging and discharging behaviour via IoT. A supercomputer can easily calculate complex 'what if' scenarios - and thus provide guidance for decisions about investments or network architecture, for example. It is one of the reasons why the transmission system operator TenneT is a partner.

PHOTO: SAM RENTMEESTER

COUSINS

Palensky's digital twin is not one digital clone, but comprises a whole clone family. 'Cousins', for example, are accurate enough for education and research, but because of risks and computing power, they are not perfect images of the net. "The 'real' work remains the domain of the energy network operators. They have the real data, the real parameters - and for security reasons they don't share them," says the professor. For Palensky and his colleagues, this is not a problem. In fact, "The cousins enable us to freely investigate how the grid responds to, for example, cyber-attacks or extreme electrical forces, without the grid operators constantly getting stressed." ME

Until recently, the Netherlands had a fairly orderly energy system: power was generated in a limited number of perfectly controllable power plants, and transported from there to the customers. The energy transition is radically changing these dynamics. Sustainable energy sources such as sun and wind mean a more fluctuating and less predictable supply that is also more fragmented - with large-scale wind and solar parks and solar panels on private roofs. The demand side is also changing dramatically, with the rise of electric transport and the electrification of heat supply and industrial processes that currently use natural gas. Together, these developments have an enormous impact on the energy grid and the grid operators: balancing and stability has become much more complex whilst gaining unique momentum. As Palensky says: "We are at a turning point in history and we have a real chance of changing the world for the better."

View

Professor of Energy Systems Analysis Kornelis Blok (Faculty of Technology Policy a nd Management), who also contributes to IPCC reports on climate mitigation, is chairman of the TU Delft Energy Initiative. The world's entire energy system is to be overhauled in 20-30 years' time. How will we do that?

"Today, the final energy use consists of 20% electricity and 80% fuels and heat. The electricity is produced globally by two-thirds from fossil sources. Fuels and heat are to a much larger extend based on fossil sources, say up to 90%.

In the EU, where we now see a stable energy use, energy efficiency improvement could lead to a reduction of the energy consumption. On a global scale the situation would be different. Because of the much stronger increase in population and economic growth, energy efficiency improvement could still lead to a stabilisation of global energy use.

One of the important by-products of energy efficiency is electrification. We see in most long-term low-carbon scenarios that the share of electricity increases a lot. Where it is now 20%, it will probably go to 40-50% in the long run. In most scenarios solar energy and wind energy are most important. That has to do with the fact that the cost of these two sources has gone down substantially over the last ten years. But others like hydropower, nuclear energy and fossil fuels with carbon capture and storage will play a role as well.

The large share of solar and wind will also lead to challenges for the electricity system. One of them is the larger flexibility that is required. Production of solar and wind normally does not match with the demand for electricity. So, we need flexibility that can be achieved in many ways. For example, through grid expansion, which makes international exchange easier.

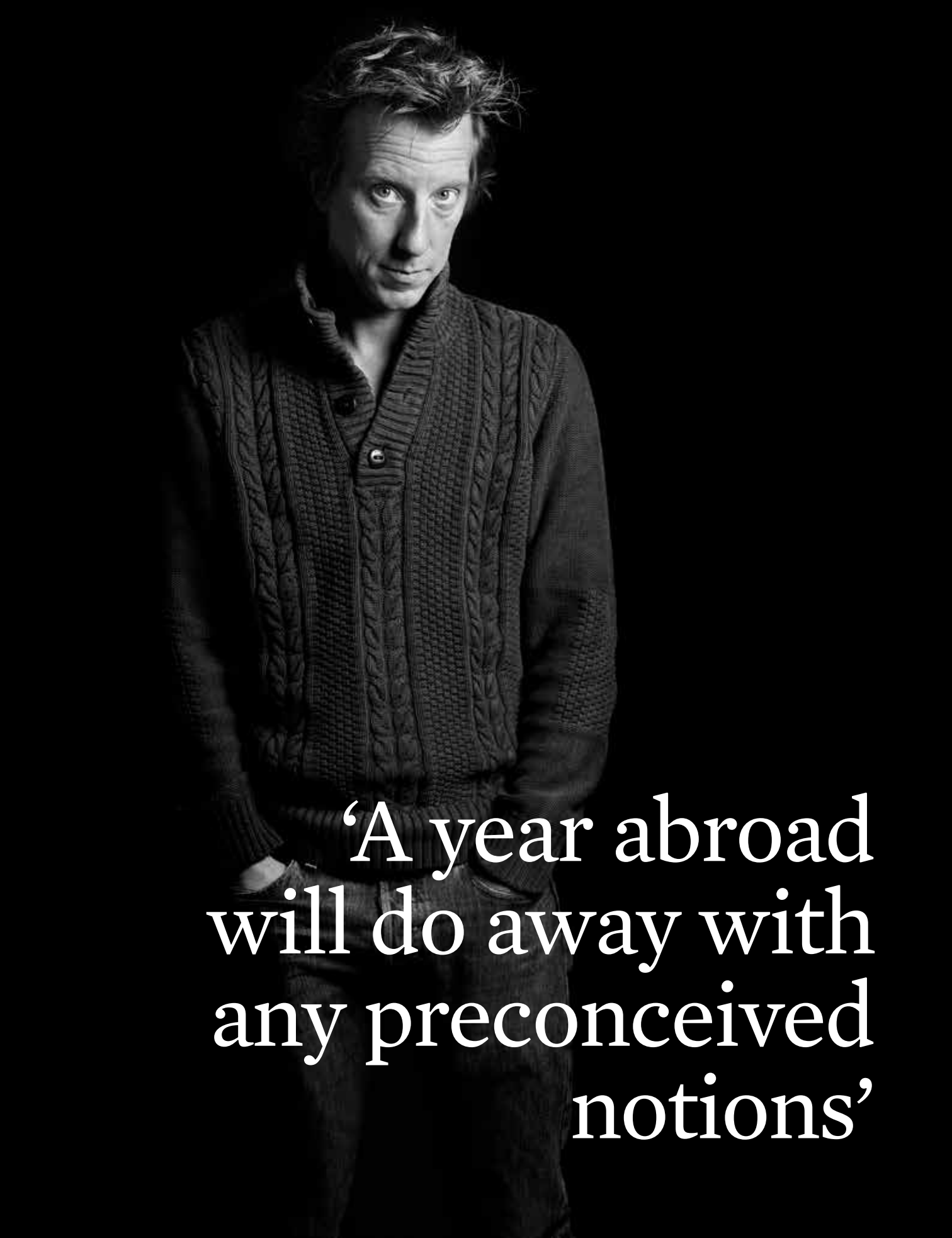
PHOTO: SAM RENTMEESTER

Demand response also increases the grid's flexibility, as do short-term and long-term storage.

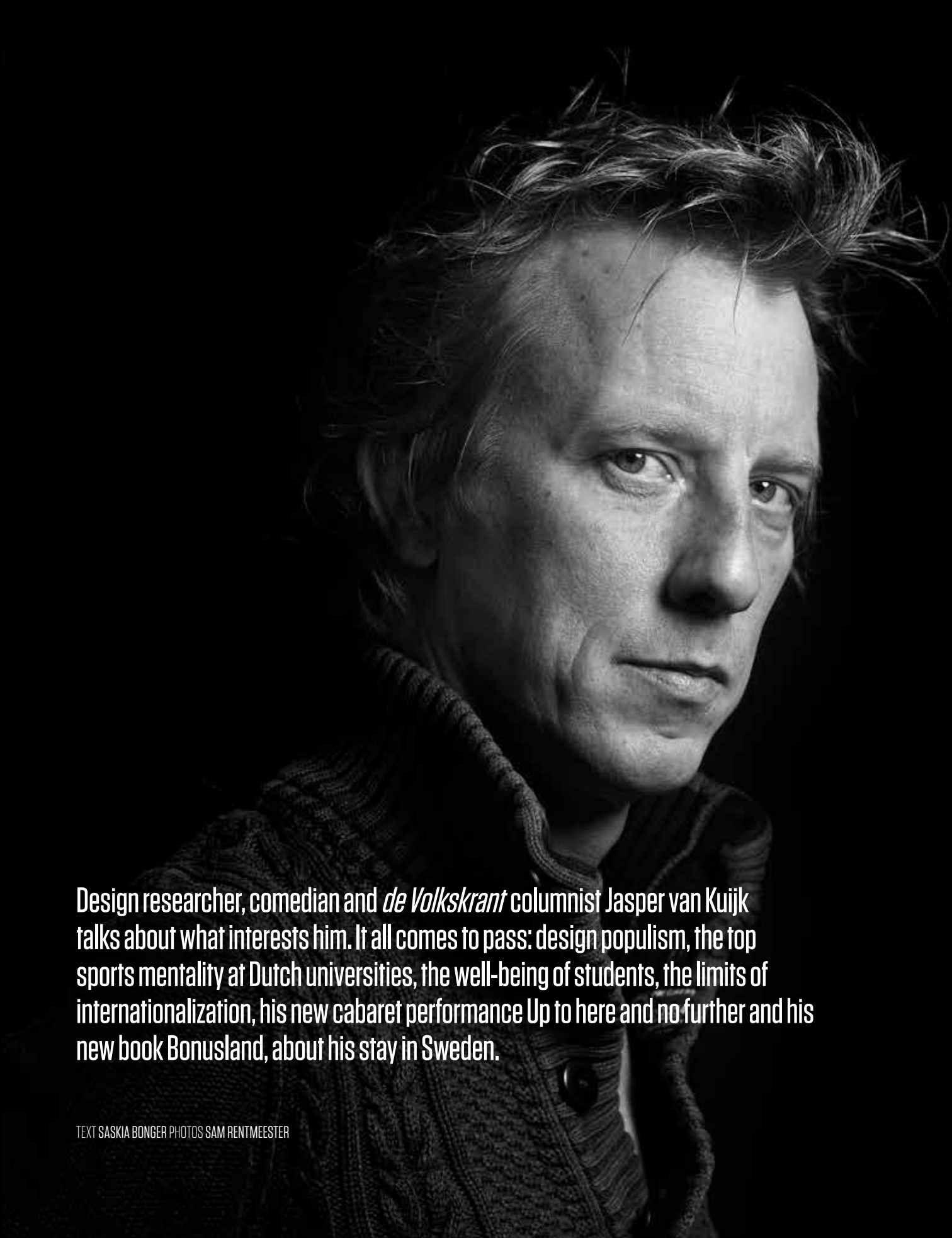
Having said that, we also need fuels and heat. It is possible to supply low-temperature heat, say up to 100 degrees or so, from geothermal sources or from solar sources. That can solve part of the heat and fuels requirement. But we also need fuels for high-temperature applications in industry and transportation. We basically have three important categories to supply these: bioenergy, fossil fuels with carbon capture and storage, and hydrogen or other new fuels. Hydrogen can be produced in two ways: green hydrogen from renewable electricity and blue hydrogen from fossil fuels in combination with carbon capture and storage. With hydrogen we can also produce various other substance like ammonia and ethylene.

Developments in fuel and heat are typically in a less advanced stage than the transition in the electricity sector. Green fuels are also typically more expensive. Where solar and wind have become quite affordable, most of these new fuels and resources are still substantially more expensive than their fossil alternatives. Overall, the challenge of the energy transition is huge because the world needs to accomplish this in a period of 20-30 years. That is a very short time to completely redevelop the energy system." JW

In the MOOC Designing a climate neutral world Professor Kornelis Blok will focus on designing a climate neutral world. Participants will learn about climate change strategies and are given basic tools used for evaluation alternative options for mitigating greenhouse gas emissions. See onlinelearning.tudelft.nl. via the QR-code.



‘A year abroad will do away with any preconceived notions’



Design researcher, comedian and *de Volkskrant* columnist Jasper van Kuijk talks about what interests him. It all comes to pass: design populism, the top sports mentality at Dutch universities, the well-being of students, the limits of internationalization, his new cabaret performance Up to here and no further and his new book Bonusland, about his stay in Sweden.

TEXT SASKIA BONGER PHOTOS SAM RENTMEESTER

Your book Bonusland was published this summer, a year after you returned to Delft. How was it received?
"The nicest thing that I heard was someone feeling surrogate homesickness. It seems as if people want us to go back to continue the story. I think that many of them would secretly like to do something similar."

What remains with you after that year in Sweden?
"A sort of undercurrent of homesickness. We immediately felt closed in when we returned to Delft. Before we left Delft it was natural to always have people around you. Now we miss the peace and quiet of the countryside. There is also a nagging doubt about what a good life is, how you create it and what you do. A year abroad will do away with any preconceived notions."

How do you reflect this in your new theatre show Until here and no further?
"Sweden is unavoidable. My director said that 'That experience is what makes your story unique and personal and gives you the chance to see the Netherlands from the outside'. The story starts with my being back from Sweden for a year, but that I have still not unpacked all my boxes. Why not?"

You came back to the Netherlands in the middle of the corona pandemic, just before the second wave. That probably didn't help in adjusting to being back.
"True. It was perfectly fine to coach groups of students online, but not being physically present on campus magnified the feeling of disconnection. The connection is now starting to come back."

How do you think things are going for students at TU Delft?
"The education sector could have stood up for students more during the corona crisis. Why did we not erect tents so that they could get together when the restrictions started to be lifted gradually? They may have passed their modules and earned their credits, but how did they feel? I see my graduates getting stuck. They had to stay at home with their own projects, after their masters' had been online as well. We were always very concerned about their mental welfare and brought graduates together digitally, had them make vlogs and so on, but it was just too lonely. I now speak to my graduates every fortnight and sometimes every week. You did not do that before. But it's needed now otherwise their energy seeps away."

In *Bonusland* you talk about the value of the 'fika' culture (drinking coffee together) in Sweden. This was also a feature of the University of Karlstad where you were able to write your new book about the public understanding of design. You can introduce fika at TU Delft, can't you?
"I am only here two days a week. The disadvantage of working part-time is that you forget the 'social overhead' because you are so focused on what you need to get done in the little time you have. Fika worked for me. I sat alone in my room for a couple of hours getting things done as I knew that I would have to go and drink coffee again. There was a clear division between social time and quiet time.
I now share a room with two colleagues at TU Delft, while I used to sit in the StudioLab. That is a very lively place, without being very social.

'I can't stand design populism'

People often sit with their earplugs in and get coffee when they want. The atmosphere at Swedish universities is also more amiable because the funding system is different. There is a very competitive mentality in the Netherlands."

Why is that mentality bad and how can we get rid of it?
"Universities are run on doctoral candidates, postdocs and tenure trackers who have to do their work on temporary contracts, in different countries and with a lot of uncertainties. This system is supposedly so that we can get the best out of people and retain the best people. Consultants worked like this, with a lot of competition, for a long time and look what happened. Only the most churlish people remained, those who did not have a life and who usually just looked at themselves. I don't know the answer, but can we not do away with the big research grants that always go to the same people? Share them around. Some subjects can do a lot with smaller grants of EUR 100,000 a year.
The system, in which university funding is based on their market share, does not help students either. The only way that a university can maintain the same share in government funding is to attract more international students as demographically, the number of Dutch students is not increasing. Everyone knows this but nobody can step out of the system. This is sad to see."

CV

Jasper van Kuijk (1976) is assistant professor for user-centered design & innovation two days a week at the Faculty of Industrial Design Engineering, the faculty where he also studied and obtained his PhD. In de Volkskrant newspapaer he writes the weekly column How difficult can it be? about fallacies in contemporary design. He also reported on his experiences in Sweden in that newspaper and, based on these columns, the book Bonusland was published last spring. He also performs as a comedian. That career started during his studies at the TU with Delfts Blok, the group with which he won the Groninger Student Festival in 2001. In 2010, he won – two weeks before his PhD – both the jury and the audience prize of the Cameretten Festival. He is currently touring the country with his show Until here and no further. His previous show Janus can be seen on Netflix. Van Kuijk is married and has three children.

Should TU Delft accept fewer international students, which can't be done just like that?
"What do we want to be? What do we want to achieve? These are interesting questions. You can come up with answers, but you need to open up the discussion without accusing each other of xenophobia. Is bigger always better? What is the role of language? The Netherlands views America as an example, but what I miss in the discussion is that international students do not speak the language of the host country here. Universities have an obligation to the region and nationally, and internationals are unable to do projects which require Dutch. Can you actually specify 'spoken Dutch required' in certain projects?
Don't get me wrong, we should not stop internationalising. It is enriching and wonderful to see other knowledge, perspectives and backgrounds. Only, you should not sweep the language issue under the carpet. One question is whether bachelor degree programmes should continue being given in Dutch. Is it useful for children who do not have a strong language foundation, for whom Dutch is already shaky? And what about our connection to society? On the other hand, now that our masters are in English, this has attracted a flow of top international English-speaking colleagues. It would be crazy to not use them in bachelor programmes. This should be the subject of a discussion, shouldn't it? Teachers have dealt with this at the practical level, though the Board could have thought this through better in advance."

Like what, for example?
"Have the Board members thought about what a double inflow means? A new group of master students twice a year means that teachers do not know the order in which their master students take their modules. Talking about stress levels, the staff yet again have to deal with it."

Can you not raise this issue? As you are doing now?
"I don't know how popular I will be if I did. I sometimes hear at TU Delft that I am quite critical in my Volkskrant newspaper columns (on design faults, ed.) and that I should stand up more for the design sector. But what I really can't stand is when designers present things as solutions when it is abundantly clear that they are not. I have referred to this as 'design populism' as it fosters a response from the public of 'you see, why haven't companies put that on the market?', while it can't be done!
Take Phonebloks, telephones that are made of separate components. This idea was pushed through by the Dutch Design Week and was presented in the TV show 'De Wereld Draait Door'. It couldn't be done technically, but the suggestion was that companies were blocking it. I don't like that. It's below the belt. To my mind Phonebloks was not a solution but art. The project posed good questions about the throwaway society."

> 'There is a very competitive mentality in the Netherlands'

You are completely back to teaching and cabaret. Are you intending to move back to Sweden?
"After a year in Sweden I am not so sure about anything anymore. So I am not ruling out going back. I don't want to push things aside, so bring on the uncertainties. The context largely determines how you live. Before we went to Sweden my mind often wandered when I was at home. My wife said "In Sweden you were completely present". And now? No, not completely, but more than before. If you want to do the same things in a different context, it simply takes more energy."

IN PERSON

After skipping a year, the election of the Lecturer of the Year has been resumed. The winner for 2021 is Dr **Tom Burdyny**, "an acknowledged example of excellence". Burdyny has been lecturing at the Faculty of Applied Sciences for three years now: initially as a postdoc, and the past two years as Assistant Professor. He lectures on chemical reactors and transport phenomena. His passion for his discipline and for his students "makes following his lectures a pleasure", one of his students says.

A traffic accident in November resulted in the death of **Antonia Terzi**, who was one of the driving forces behind TU Delft's Superbus. Terzi was Associate Professor at Aerospace Engineering from 2005 to 2014 and chief vehicle designer of the Superbus. She spent many years working in Formula 1, with the then-invincible Ferrari and later Williams team. After Delft she worked at Bentley, and n 2020, she was appointed professor at the Australian National University.

TU Delft researchers Dr **Mohamed Abobeih** (QuTech), Dr **Maurice Krielaart** (Applied Sciences) and Dr **Sebastien Callens** (Mechanical, Maritime and Materials Engineering) have received Rubicon grants from research financier the Dutch Research Council (NWO) to use towards gaining experience abroad. Abobeih is going to Harvard where he will be studying how error-prone quantum computers are. Krielaart plans to spend his time at the Massachusetts Institute of Technology (MIT), answering the question whether light generated by a single electron has predictable and consistent properties. Callens will be going to Imperial College London to study the manipulation of bone tissue.

Prof. **Marileen Dogterom**, professor of Bionanoscience at TU Delft and an internationally acclaimed researcher, will succeed Ineke Sluiter next year as president of the Royal Netherlands Academy of Arts and Sciences (KNAW), of which she is currently vice-president. Dogterom's appointment is for a period of three years, and she will combine the presidency with her scholarly work. She is one of the pioneers in the discipline of biomolecular and cellular physics. Her research concentrates on the cytoskeleton: the microtubules that give living cells their form and mechanical function.

Energy transition? Energy revolution!

TU Delft was born towards the end of the first industrial revolution. That was when people still moved around using horse and wagon, and when houses were lit with oil lamps and candles. By the time the first Ford Model T rolled off the assembly line, TU Delft was a venerable 66 years old! The second industrial revolution, which introduced electricity into our homes, was still a while away. Today, every household has more than one car on average, and we live surrounded by electricity-guzzling electronics. A power cut brings our normal life to an abrupt standstill. Admittedly, this doesn't happen that often, but if our energy grid is not adapted soon, this might start happening more often. The fact is that if we start using sustainable sources of energy at a large scale, the stability of our current energy system will be endangered. And that is just one of the enormous challenges the energy transition poses.

For that matter, it will not be the first time we make the transition to other sources of energy: coal, oil and gas were once very promising sources of energy too. We got a lot out of them, but they had undesirable side effects that we completely underestimated. And while this will not be the first time we transition to new sources of energy, the speed at which we need to make the transition is quite new. Past energy transitions were initiated by technological innovation and promoted by market demand once the technology, and therefore the source of energy, offered clear advantages in terms of cost and/or reliability.

In essence, these were energy evolutions; what we need now is a revolution.

Waiting for the market to do its thing is a luxury we do not have. If we want to limit climate change we must transition to CO_2-neutral sources of energy at an unprecedented rate, remove CO_2 from the atmosphere on enormous scale and find solutions that allow us to use less energy. In short, we need technological innovations to solve the problems we have created with our old technology. That is the irony of technological advancement in the energy sector. Please let us do things better this time around.

To achieve acceleration we must simultaneously work on technological breakthroughs, behavioural change and directive measures. There is no single technology or party that can solve the problem; we need a multidisciplinary approach to make a success of the energy transition. Our alumni play a crucial role in this: academia and the business community must join forces to bring about an acceleration together. We must bring about an energy revolution together.

I therefore invite you all to take part actively in the discussions, projects and events that will be organised during the 180 days of the anniversary. I will be there. Will I see you there?

Deborah Nas is part-time Professor of Strategic Design for Technology-based Innovation at the Faculty of Industrial Design Engineering.

THE FIRM

Alumnus Dieuwertje Drexhage wants to develop an affordable intubation tool with her start-up Layco Medical Devices.

More than ninety percent of all medical equipment is made in high-income countries. It is difficult for low-income countries to acquire affordable equipment. Dieuwertje Drexhage hopes that her start-up Layco will help to close this gap.

It was never Drexhage's plan to become an entrepreneur. "I never saw myself as a true entrepreneur, as I hate negotiating." Yet it crossed her path during her Master's programme in Biomechanical Design. "I did my internship in a hospital in Kenya. There I saw what a lack of affordable equipment means for the hospitals there."

The TU research programme Surgery for All was already working on an intubation tool that the doctors really needed, but was too expensive. A junior researcher who was leaving asked Drexhage to continue with the product. That resulted in the start-up that Drexhage is running together with her financial partner Thom Weustink.

'Ultimately, you just need to find that one person who is crazy enough to go for it'

Drexhage: We started out just trying to find our way, stalking everyone we vaguely knew who was working in Africa or in the medical world to ask them for tips. Thom still had a full-time job and we spent Fridays and Sunday evenings writing the business plan." Meanwhile they have landed a substantial grant and Weustink has been able to give up his job at Friesland Campina. Drexhage: "We are still in the R&D phase and haven't sold any product yet."

Dieuwertje Drexhage: "I never saw myself as a true entrepreneur."

Company:	Layco
Product:	Video laryngoscopes, 'the Goodscope'
Started in	2020
Degree programme:	Biomechanical Design
Number of employees:	5
Revenue:	None as yet (grants, tender)
Target group:	Hospitals in low-income countries
In five years' time:	Selling ten different medical devices, exponential growth, 8,000 Goodscopes sold.

The product is the video laryngoscope, "a horrible word", thinks Drexhage, which is why she has renamed it the Goodscope. Doctors use a laryngoscope to intubate a patient for mechanical ventilation during an operation.

A video camera helps to guide the tube between the vocal chords and into the airway. "There are already a lot of video laryngoscopes on the market, but they are very expensive and not really suited to the local context", explains Drexhage. "We have disconnected the screen, so the doctor can also use a smartphone or tablet. The product is fully reusable and works more intuitively, meaning less training is required."

Hospitals and knowledge institutions were and are happy to give Drexhage constructive input. "But once you start looking for a business partner to purchase parts or make agreements, you realise you are still very young", says Drexhage. Businesses find it tricky to invest. "Ultimately, you just need to find that one person who is crazy enough to go for it."

The dream is to expand Layco with many more products. "That can also be a pitfall, there are so many products awaiting development." The Goodscope should be ready in February 2022. Then it needs to go through the certification process. "We expect to be able to sell the first Goodscope in around a year's time." SvdP

PHOTO: SAM RENTMEESTER

TEXT: JOS WASSINK PHOTO: SAM RENTMEESTER

The risk of virus inhibitors

Virus inhibitors disrupt the production of new viruses by the host cell. But too low doses can cause resistance to develop. Prof. Nynke Dekker (AS) showed how this works.

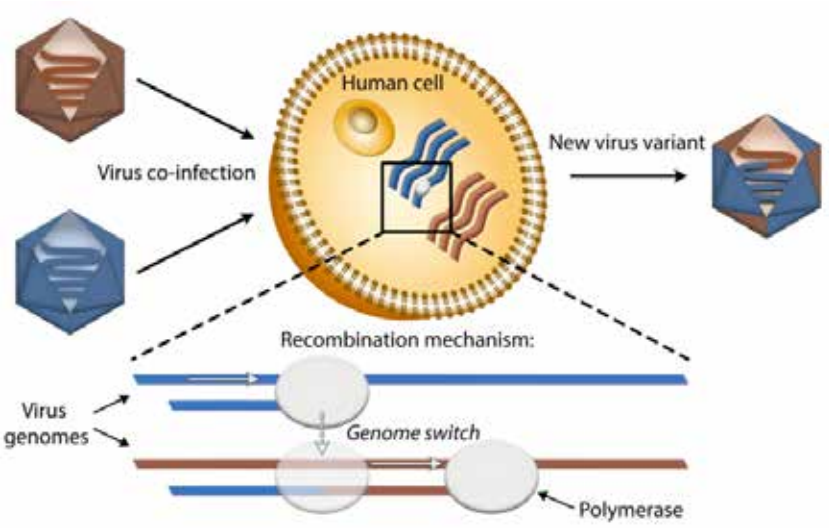
Prof. Nynke Dekker's (Faculty of Applied Sciences) research group has unravelled the molecular origin of recombination in viruses, in other words, how new virus variants can arise. The fact that virus variants can have disastrous consequences The fact that virus variants can have disastrous consequences is cuurently clear.
They disrupted the molecular copying machine (polymerase) that makes a copy of the RNA of a virus. Polymerase reads the building blocks of RNA chains (there are four types) and places the next building block in the right place in the copy. This is how viruses multiply. Or rather, it has itself multiplied by the genetic machinery of the infected host cell.
The sabotage comes from a molecule that closely resembles one of the building blocks, but does not fit in nicely. As a result, the copying process gets stuck and the progress of the virus is halted. At least, that is one of the possible outcomes of the antiviral drug that Dekker tested.
Other possibilities are that the copying process starts again, but makes false copies (more about this process at the end of the article). Incorrect copies will usually result in defective viruses. But by chance, a better virus may emerge that is resistant and/or more

Prof. Nynke Dekker: "We have now shown for the first time how an antiviral drug causes a polymerase to cause jumps in the RNA."

infectious than the original. This is, at least in theory, a potential risk of antiviral drugs.

Resistance

Does it happen in practice? Prof. Louis Kroes is Head of the Department of Medical Microbiology at the Leiden University Medical Centre. "We treat people with viral infections here and use antiviral drugs," says Kroes. "This is a very different world from the molecular research that Nynke Dekker's group is doing on substances that might one day be used to fight viruses."
He knows some examples of mutations resulting from treatment with antiviral drugs. "Lamivudine was the first agent used against Hepatitis B infection, but it was actually an anti-HIV agent. Resistance then quickly developed due to mutations in the virus."
In Kroes' experience, starting therapy too late, using non-specific



Viral recombination is a major evolutionary mechanism in RNA viruses that drives adaptation and genetic diversity,. Recombination occurs when at least two virus subspecies co-infect the same (human) host cell and exchange genetic segments. The study revealed the underlying molecular mechanism and triggers of polymerase switching between different parental virus genomes during RNA replication that can result in recombination and attendant novel genetic combinations. Image credit: University of North Carolina/TU Delft

> For this reason, the WHO advises against using the drug for Covid-19

agents and not achieving complete inhibition increase the risk of resistance.
Resistance is the result of beneficial mutations. "We have now shown for the first time how an antiviral drug causes a polymerase to cause jumps in the RNA," says Dekker enthusiastically. "As far as I know, medicines are not screened for the fact that they encourage recombination in this way."
According to Kroes, pharmaceuticals are well aware of the risk of mutants. For example, when combating corona with Remdesivir, the manufacturer pays for the genetic analyses of the virus during treatment to keep track of mutations. As far as Kroes has seen, there was little genetic variation in the coronavirus. Is that good news? "I deduce that the virus is not under very much pressure from the drug," he says. For this reason, the WHO advises against using the drug for Covid-19, regardless of the severity of the disease, reports Dr Richard Janissen, fellow researcher of Nynke Dekker and first author of the publication.

Magnetic tweezers

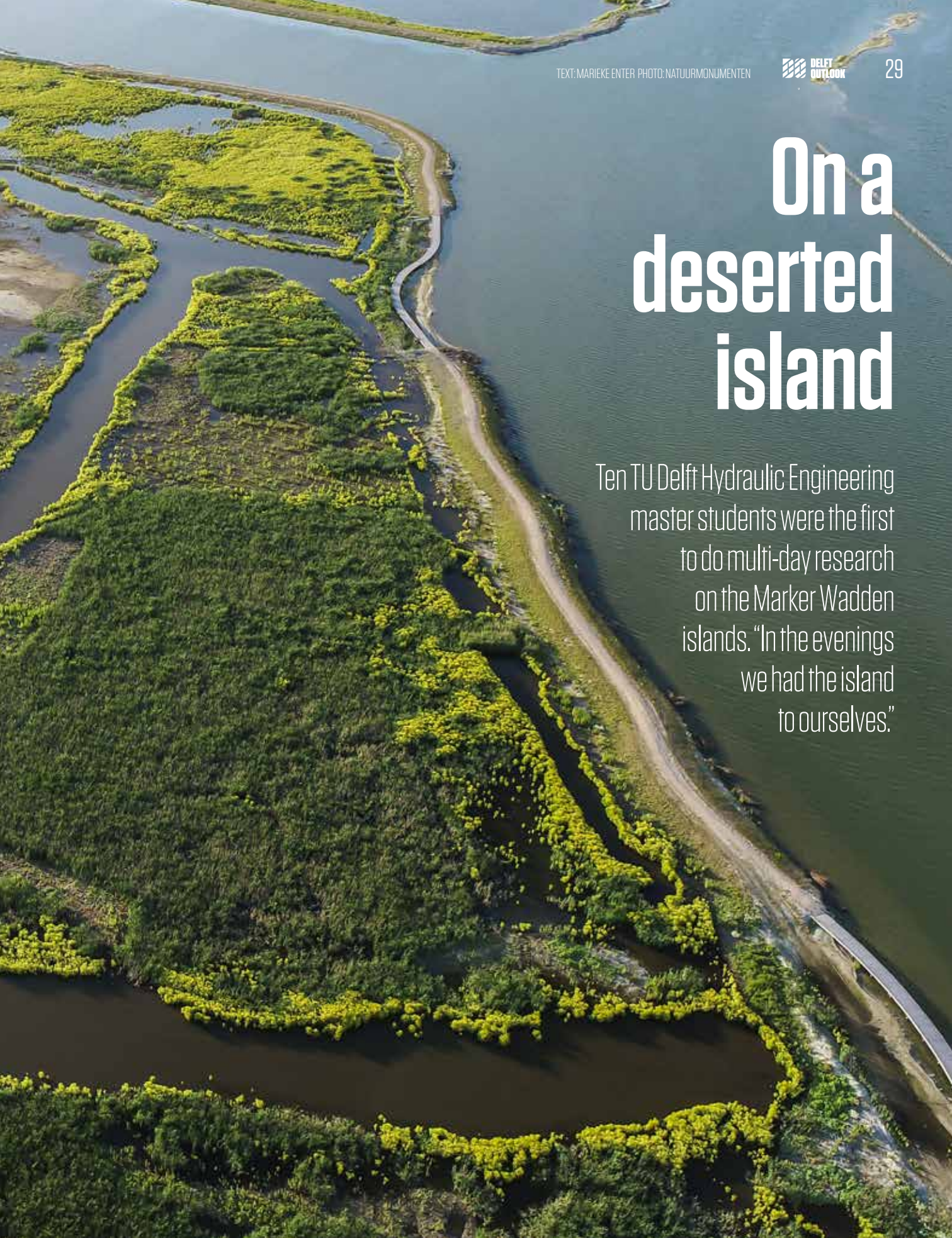
Researchers in the Nynke Dekker Lab have built a set-up with which they can closely follow a single RNA copying process. Using 'magnetic tweezers', they can feel exactly what happens during the genetic copying process, even when it is disrupted by a virus inhibitor. They published this in the journal Molecular Cell.
In collaboration with the University of North Carolina (USA) and Chang Gung University (Taiwan), TU Delft researchers showed that recombination can increase under pressure from viral inhibitors. Cells were infected with the virus and the amount of recombined virus RNA measured. A virus inhibitor that disrupted the RNA copying process was administered to some of the cells. Analysis showed more recombined RNA here, exactly as the molecular measurements at TU Delft had predicted. In a wider sense, this could mean that one should be wary of doses of virus inhibitors that are too low and that increase recombination but do not kill enough viruses.
Dekker emphasises that there is now more basic knowledge of these processes. "We started with molecular mechanics. Then we saw the same process in living cells. That was very interesting to experience."

Researching the morphological development of beach and dunes on a new man-made group of islands (see box on page 30) is special in itself. What makes it even more special is that nobody lives there and you may stay there a week. Ten TU Delft Hydraulic Engineering master students and their supervisors even wrote a little bit of history. In the young life of the Marker Wadden, they were the first group of students to carry out research from the field station and the group accommodation. They were there for the Hydraulic Engineering fieldwork module.

Social experiment

Florine Speth is one of the students. "I really wanted to do it, but did see some parallels with social experiments: 'Go to a deserted island for one week with 10 students who you barely know'. But it was wonderful, especially at the end of the afternoon when the last ferry with visitors left and we had the island to ourselves. The peace and quiet, the deep darkness at night. It was amazing and we could go stargazing.

Read more on page 30



On a deserted island

Ten TU Delft Hydraulic Engineering master students were the first to do multi-day research on the Marker Wadden islands. "In the evenings we had the island to ourselves."

The installation of jet poles. The acoustic doppler velocimeter will be placed on the poles to accurately determine the flow speed and wave direction in the surf. (Photos supplied by Anne Ton)

I was also pleased that the island nature reserve staff and the visitors were interested in what we were doing. They regularly asked us about our measurements. That really underlined how special it is to be able to do research here."

Bubble

That the students were able to learn the intricacies of fieldwork was in part thanks to the contacts that researcher Anne Ton has with the island's owner, Natuurmonumenten (an organisation that protects the Netherlands' natural heritage). She had been there about 10 times for her PhD project (in Dutch) and knew that Natuurmonumenten were pleased to welcome researchers there (in Dutch). "I had been there when the islands were just a sandy bulge.

Man-made nature

The Marker Wadden are a group of five uninhabited islands made of dredged up sand, clay, sludge and peat. Only the main island permits limited numbers of people. The islands were created to restore the ecology of the Markermeer Lake. This last Zuiderzee polder was to have been created here and the Enkhuizen-Lelystad dyke has been here since 1976. But the land reclamation project was cancelled and the Markermeer Lake turned into a dead basin of sludge filled water. The creation of the Marker Wadden islands in 2016 was intended to change this.

This project, unique in the world, has had positive ecological results so far. The sludge is sinking and the flora and fauna are recovering fast. Two new islands dedicated to nature are currently being created (in Dutch). The Marker Wadden fall under the Nieuw Land National Park (in Dutch), designated as a national park in 2018, an important resting site for migratory birds between Scandinavia and Africa.

I have really seen them develop." Now, together with the students and commissioned by the Nieuw Land National Park, she charted the developments on and around the sandy edges of the Marker Wadden. Despite her familiarity with the Marker Wadden, Ton had never spent a night there. "I wondered if I were over-romanticising the idea of staying there. But I didn't. You really are in a sort of bubble if you spend a week on a deserted island. In the evenings especially I had the feeling that I was cut off from the world, while in fact we were not far at all from civilisation. We could clearly see the lights of Lelystad and Almere from the island."

No quick visit to the lab

Fieldwork in a special place needs special preparation, says student Koen van Asselt. "One of the big challenges was to bring all the things we needed with us, both food and research equipment," he says. "You also really need to think hard about what you will need. You can't just whip to the lab or the hardware shop to get something. This taught us to improvise on the spot."

The students put in long days. From 09:00 to 19:00 they paired up to do all sorts of measurements on land, in the water and even in the air. Led by lecturers Matthieu de Schipper and Sander Vos, they learned to work with the Acoustic Doppler Velocimeter to accurately ascertain the speed of the current and the wave direction in the surf. Or with stereovision, where two cameras set at a fixed distance from each other make recordings in a particular sequence, creating a 3D image of the newly formed land. The students also took along a drone, which they used to learn how to make recordings by which ground elevations can be determined.

With cameras on the screw piles, a 3D image is made of the dune using stereo vision.

Researcher Ton: "All these data together tell us a lot about the hydrodynamics and morphology on and around the Marker Wadden: where do the wind and water erode what soil particles and where are they deposited?"

Van Asselt was relieved to be busy outdoors the whole day. "And that while working closely with others. The contrast with the corona distancing of last year could not be bigger," he says. He also praises the group dynamics among the 14 students and supervisors. "Everyone was completely committed to the fieldwork and making it successful. The short debriefing sessions in the evening were rarely short. We usually talked for a long time about interesting observations. I have no more doubts – put a few coastal engineers on a deserted island and they will automatically become subject fanatics."

Valuable data

The week on the island did more than just teach the students fieldwork skills. Researcher Ton says that "To protect the Marker Wadden islands it is hugely important to understand their behaviour. The data from the students' measurements are very valuable in this."

TEXT: ROBERT VISSCHER PHOTO: FRANK AUPERLÉ

Shelf-stocking robot working independently

A robot that helps store employees by moving independently through the supermarket and shelving products in their proper place. According to researcher Carlos Hernández Corbato of the Department of Cognitive Robotics, this may be possible in the future. But the robot must be able to adapt to the dynamic and challenging conditions in a supermarket.

Carlos Hernández Corbato develops robots that can adapt to the circumstances.

Carlos Hernández Corbato investigates the dynamics of robots at the Department cognitive robotics at the Faculty of Mechanical Faculty of Mechanical, Maritime and Materials Engineering. "My research focuses on using artificial intelligence to make machines smarter and more reliable by teaching them symbolic knowledge. The goal is to develop robotic "brains" for intelligent robots that can be trusted to work alongside people, because it can explain their decisions." A supermarket is typically a place where unexpected things happen all the time. Not only are there thousands of products with different shapes and looks, there are also people walking in and out. How can an independently operating machine handle this safely, efficiently and intelligently? By activating symbolic knowledge that we humans also use, says Hernández. "We recognize a tray with four legs underneath as a symbol: "table". We don't need a photo for it. When we encode such 'symbol language' and make it suitable for robots, they can perform more complex tasks." One look with its camera eyes and the robot knows it is facing an object on which plates and cups can be placed. Based on this, it can decide what to do. The acceleration that this produces, should enable robots to perform multiple actions at the same time: navigate, pick up and move objects, and ultimately communicate with people.

Symbolic knowledge

For Hernández, the AI for Retail Lab research program of supermarket chain Ahold Delhaize brings together everything that fascinates him about artificial intelligence. Retail requires robots to use a broad diversity of skills: to perceive the environment,

navigate around it, manipulate objects or collaborate with humans. For him, it's all about the question of which algorithms are needed to make a machine respond just as intelligently as a human brain. As a specialist in software for autonomously operating robots, he already won the Amazon Picking Challenge in 2016 with a team from TU Delft. At this occasion a robotic arm placed products from a container in their place on a shelf.
The "supermarket robot" is even more challenging. It requires the leap from a static factory environment to the dynamics of a store. The traditional way, in which robots learn from the data they collect, is too cumbersome for that. The robot would already get stuck in stock management.
Programming a customized robot treatment for every orange, bottle, soup can, milk carton or cucumber

'We need to endow robots with self-awareness so that we can trust them'

would be too much work. "We want to inject symbolic knowledge into the robot's operating system all at once," says Hernández. "If that knowledge is available, the robot can continuously adapt to his changing environment. For example, by downloading a different hand movement."
The robot must be able to independently choose a different algorithm if it encounters a problem along the way. So that he can pick up a can that falls from his hands, or change the grip of his hand slightly when picking up an unknown object. The technicians have already set up a test shop where robot 'Tiago' can practice with it. In about five years' time, it should deliver a machine with a mobile base, two arms and two camera eyes, which independently refills supermarket shelves 24 hours a day. And it must be able to do that under all circumstances, day and night.

Enable to reason

The latter does not only apply to the supermarket robot. In fact, every robot should have a next generation operating system to better cope with changing circumstances. Hernández Corbato: "Beyond integrating different robot skills, cognitive skills for robots need to enable them to reason about those skills, to understand how they can use them, and what are the consequences of their own actions. In sum, we need to endow robots (or any intelligent autonomous system build) with self-awareness so that we can trust them."
Beyond integrating different robot skills, cognitive skills for robots need to enable them to reason about those skills, to understand how they can use them, and what are the consequences of their own actions. In sum, we need to endow robots (or any intelligent autonomous system build) with self-awareness so that we can trust them.
It is the core idea behind the European project Metacontrol for ROS2 systems (MROS) that the Cognitive Robotics department recently completed. The AI technique that Hernández used for this is called the metacontrol method. It describes the properties and skills of the robot in a structured way, so that the robot can use the knowledge to adapt and overcome problems.

Prototypes

As part of this research, he developed multiple prototypes of these next generation robots together with Bosch Corporate Research, Universidad Rey Juan Carlos, Universidad Politecnica de Madrid and IT University in Copenhagen.
Does it perform better than traditional robots? "Yes, he navigated more safely and, thanks to its symbolic knowledge, was able to adapt to the circumstances. When one sensor broke, it switched to another independently," says Hernández enthusiastically. "That is where we want to go to: a robot with sufficient intelligence to deal with failures."

From technology to people

The focus in robot development is normally on the technology, or speeding up production processes. TU Delft focuses on people, especially on professionals in physical professions. In the new TU Delft Vision Team Robotics, researchers work together with social scientists and humanities, but also with people from society. "There is no shortage of people, but of good jobs, and technology can help improve the jobs," says David Abbink, professor of Haptic Human-Robot Interaction and representative of this Vision Team. "A lot of work in physical professions should become healthier, safer, more meaningful or more challenging than it is now."

TEXT: ELLA DONGSTRA PHOTOS: TU DELFT

Best graduates of 2021

Zhuo-Ming Shia has been elected TU Delft's best graduate of 2021. Like the seven other nominees, he was awarded top marks by the Board of Examiners. Shia designed a socially responsible process for large-scale housing design.

Zhuo-Ming Shia: "Social architecture has a lot to do with asking the right questions."

The TU Delft Best Graduate Award ceremony, organised by the Delft University Fund, was broadcast live from the Aula Building this year. The eight best graduates from the respective faculties presented their Bachelor's theses and shared the personal background to their study. Who are they, and what makes their work special?

Zhuo-Ming Shia

(ARCHITECTURE AND THE BUILT ENVIRONMENT)

The worldwide shortage of homes prompted Zhuo-Ming Shia to develop a process for large-scale housing with the individual in mind. His design process involves the users/residents at a very early stage. "Architecture is amazing, but as architects we do have to attend to the most urgent problems in society", he says. "Architecture can never merely revolve around lucrative projects that say something about the architect in question." The method he proposes is intended to be used for mass housing, but leaves room for customisation. His own experience in Beijing is that increased demand for homes has resulted in new apartment buildings increasingly being located outside the city. "People have to move further away from where their social ties are, and that greatly affects their standard of living."

Eduardo Gutiérrez Prieto

(MECHANICAL, MARITIME & MATERIALS ENGINEERING)

The cilia in our body are important to our health. They help us transport fluids, such as mucous from the lungs. Eduardo discovered how cilia are activated – an insight that could help the medical world solve health problems. Gutiérrez Prieto: "Until now we suspected that cilia were activated by a protein in our body. The truth is far simpler: cilia vibrate of their own accord. My research has led to simplified modelling, allowing us to better predict and influence the behaviour of cilia."

Friederike Nintzel

(APPLIED SCIENCES)

Friederike Nintzel wants to help make the pharmaceutical and chemical industries greener by making medicine production more sustainable. "Using enzymes could be an important game changer in this endeavour", she says. "Enzymes are natural proteins that you can use as a catalyst to accelerate chemical reactions. Scarce raw materials are currently used as catalysts. The downside of using enzymes is that they do not always react exactly the way we had in mind, and their water footprint is large." Packaging the enzymes in a coating of water-based jelly was the solution to both these problems. "The enzymes worked three times better than they did without this coating."

Riel Bessai

(INDUSTRIAL DESIGN ENGINEERING)

A modular chair made of blocks that store CO_2 which you can convert into other furniture. “My Unito chair makes the global CO_2 problem tangible; I hope it will get people to look at our consumer society through a different lens”, Bessai says. The Unito blocks are made of bio high-density polyethylene: a bioplastic in which you can capture CO_2. Each block holds approximately one kilogram of CO_2 , which therefore does not end up in the atmosphere. “The blocks will last at least a hundred years, which makes them a sustainable form of CO_2 capture.”

Rico Herzog

(TECHNOLOGY, POLICY AND MANAGEMENT)

Urbanisation presents considerable challenges in terms of spatial planning. Rico Herzog mapped out conflicts of values within cities and developed a model for dealing with these conflicts. Conflicting values of residents and policymakers mean that it can take many years for a project, such as the construction of an airport or housing, to get off the ground. Herzog: “This has less to do with inefficient decision-making and more to do with the fact that policymakers and urban planners don’t have a clear picture of what values are in conflict and how to resolve this.” Using Rico’s model, urban planners can make better choices when it comes to planning public spaces.

Sarah Hanos

(CIVIL ENGINEERING AND GEOSCIENCES)

Rising temperatures are leading to snow and ice masses melting faster, resulting in significantly increased drainage of rivers in certain periods. Hanos investigated the change in water drainage in six river basins in the Austrian Alps. She conceived, designed and developed a new hydraulic model for predicting future drainage patterns of rainwater and melt water. “The diversity of the data and the amounts of data I wanted to include made this model very complex. Coding my own model was the best and the worst part of my thesis. I was quite euphoric when I finally got it to work.”

From left to right: Marianne Schaaphok, Friederike Nintzel, Rico Herzog, Zhuo-Ming Shia, Riel Bessai, Sarah Hanus en Eduardo Gutierrez Prieto. Bart Duisterhof is not in the picture.

Marianne Schaaphok

(ELECTRICAL ENGINEERING, MATHEMATICS & COMPUTER SCIENCE)

Twenty minutes under lukewarm running water: that’s first aid for burns. Mathematics can play an important role in determining which treatment to choose next. But for that to work, the models used to assess skin recovery must be fast. Marianne used neural networks to arrive at models that are more than a million times faster. Schaaphok: “Neural networks are known for their use in image and speech recognition especially. Interest in using them to achieve this kind of acceleration is a recent phenomenon.” Besides her proof of concept, Schaaphok also delivered two case studies regarding medical applicability, as well as an app that determines the structure of the skin based on age, skin colour, wound size and location.

Bart Duisterhof

(AEROSPACE ENGINEERING)

Developing drones that are smaller and lighter than normal drones but still capable of performing the same tasks – Bart Duisterhof did just this. For his Master’s thesis, he developed smart, inexpensive mini drones that can independently detect gas leaks. “Spaces like these are often inaccessible or poorly accessible and involve the danger of explosion”, Duisterhof says. That’s a problem for emergency services, but also for large, expensive drones. He is keen to emphasise that the technology can also be used for other purposes. “Greenhouses, for example, where mini-drones can detect weeds or rot among the plants.”

Each year, Delft University Fund organises the TU Delft Best Graduate Award Ceremony. TU Delft’s eight faculties nominate their Best Graduate. Read the full stories of all the 8 nominees by scanning the QR-code.

TEXT: AGAATH DIEMEL PHOTO: FRANK AUPERLÉ

‘We have just one interest, and that is society’s interest’

Mike ten Wolde: “The energy transition is viable financially – it will take just a few percent of our gross domestic product – and it is feasible technically.”

The Fukushima disaster prompted alumnus Mike ten Wolde to start working in sustainable energy. He is in now in the right place at TenneT. The company is working hard on the challenges of the energy transition.

Ten Wolde is completely at home at TenneT. The combination of technology and finance has been his area of interest for a long time. During his Mechanical Engineering bachelor he did a minor in finance, after which he looked for a master’s which would feed his passion for engineering and finance. He found Transport, Infrastructure and Logistics, the joint degree programme of three faculties: Mechanical, Maritime and Materials Engineering (3mE); Civil Engineering and Geosciences (CEG); and, Technology, Policy and Management (TPM). “I filled my free time with master’s subjects on financial

mathematics," he explains. He also studied at the ETH Zurich for six months that, jointly with the University of Zurich, offered a quantitative finance programme. "Among the subjects I took at the ETH Zurich were modules on energy economics which looked at the financial impact of energy. I learned the term 'Dutch Disease' there. It was called the Dutch Disease because in the 1960s, the value of the guilder rose and rose because of the gas fields that were discovered and the sale of part of them abroad. The effect was to worsen the competitive position of industry."

The start of the energy transition

Ten Wolde was studying at ETH Zurich when the Fukushima nuclear disaster happened in 2011. "Things happened far away, but also closer to home. Japan quickly shut its nuclear power plants and started importing more coal. This increased CO_2 emissions. Germany followed suit

'Scientists should take a standpoint more often'

and started burning more lignite," he explains. "Ever since then I have been announcing to all my friends that we need to move to sustainable energy. But people overlook the most important thing: the infrastructure that you need to do so." This is what he is now working on at TenneT. Last year, after years of working on mergers and acquisitions as a consultant, and a year at an investment company, he asked himself the question 'what do I want to commit to?'. "Just then I came across the vacancy at TenneT. Now I can turn my interests into my work." As a business development advisor at TenneT, he finds himself at the very heart of the energy transition. Over the next nine years, TenneT will invest five to six billion euros every year in the infrastructure, new technology and digitisation needed for the energy transition. While the challenges are great, Ten Wolde is confident. "We know where we are going. If we all make an effort it should work. It is viable financially – it will take just a few percent of our gross domestic product – and feasible technically. We do need to make more haste in terms of policymaking, though. Of the eight to ten years that TenneT needs for infrastructure projects, six or seven are spent obtaining permits. If we want to speed up the energy transition, we will have to make the permit application procedure shorter."

Bicycle maker

His overriding memory of TU Delft was as a place where you could do so much if you studied hard. And this is what he did. "My group of graduates got the highest grade of that year for our final bachelor's project, which is a great memory." To do justice to the nickname *fietsenmakers* (bicycle makers), they designed a method to model and test bicycle designs. "We worked with the bicycle manufacturer Batavus to make an adjustable frame so that you could size the bike to certain specifications. We looked at things like what would happen if you put a child's seat in front. We obtained data from all sorts of sensors to see if it would work as well as in our models. We then had test persons ride a trail and fill in a questionnaire on their experiences. One of the things that emerged in that period is that you need to steer a little to the right to make a left hand turn. You swing out a bit. We saw this in our data. Our research was also published at the time."

Engineer for life

He has always stayed in contact with his alma mater. He has been a member of the alumni panel for years. "We try to help the alumni team by giving the right care to alumni. To my mind you always need each other, throughout your life. You are an engineer for life. How can universities keep their

'You are an engineer for life'

students loyal? We have actually reached that goal thanks to the current alumni team that is doing great work. If all the conditions are right, that loyalty will follow."
If he could change anything at TU Delft, it would be the participation in the societal debate. "Scientists should take a standpoint more often. Some TU Delft professors do so. TU Delft has an enormous amount of knowledge and the best experts in all sorts of subjects. Let them share their knowledge with the politicians that make policy. I always say, including to my colleagues at TenneT, 'We have just one interest, and that is society's interest'."

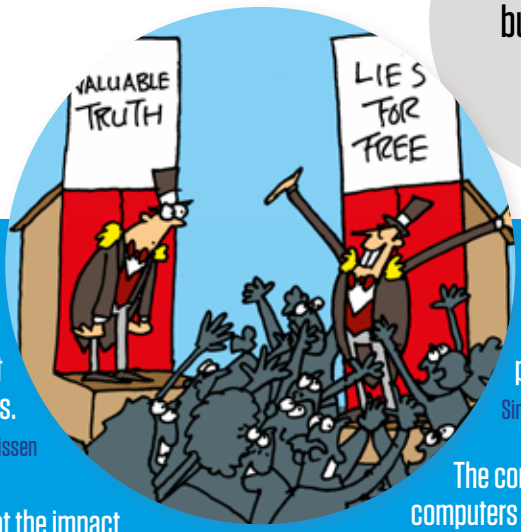
Get in touch

Questions, comments or ideas?
Email: alumnirelations@tudelft.nl
Website: alumni.tudelft.nl
Community: tudelftforlife.nl

'TU Delft for Life' is the online community for all TU Delft alumni. Expand your network, meet your old university peers and stay up to date on the latest news and events. Sign up on **tudelftforlife.nl**. You can also change your contact details and communication preferences there.

HORA EST

Truth is expensive, but lies are free.
Daniël Bouman



We are surrounded by enough good ideas to solve our scientific problems, but lack the right direction to find the right solutions.
Paul Johan Denissen

The covid-19 pandemic has shown that the impact of conspiracy theories on social media can be as great as that of articles in scientific journals.
Paul Oosterlo

Winter sports are a self-destructive industry.
Joeri Frederik

Miniaturisation pushes technological barriers and always leads to new physical insights and discoveries.
Maurice Krielaart

Urban mobility by air and the associated development of eVTOL vehicles is the best way to attract investment and develop technology needed to make the entire aviation sector more sustainable.
Tom Stokkermans

In scientific research, it is necessary to maintain a balance between persistence in a particular point of view and a willingness to compromise with alternative perspectives.
Wenting Ma

Rather than being a catalyst for change, anonymity is your biggest problem with social networks.
Sining Pan

The convenience and availability of computers today has a negative impact on average productivity.
Daniel Kraak

User-friendly interfaces are not the solution for complex models.
Bas des Tombe

For PhD research there should be more emphasis on collaborations rather than individual performance.
Michelle van der Helm

Personalised online advertisements are a threat to the open society.
Leon van der Graaff

Society has a bad memory and every now and then requires disaster as a reminder of what its priorities are.
Daniël Bouman

Diseases come in the mouth, disasters come out of the mouth.
Ziuhan Chen

Tech for Energy

Speeding up the energy transition

Twenty percent of the demand for energy in the Netherlands comes from the houses, neighbourhoods and districts in which we all live. If we can succeed in making that energy demand CO_2 neutral, we will achieve a major advance in the energy transition. That is why our 24/7 Energy Lab project is developing a local, autonomous and CO_2-free energy system for the built environment. To achieve that, we are making use of the knowledge and innovations of TU Delft and other partners. We combine and test existing and new technology in the unique living lab 'The Green Village'. While doing so, we will also look explicitly at affordability, acceptance and regulations.

Living lab The Green Village

Part of the answer will involve adapting the power supply of households in the built environment. Just imagine every neighbourhood having its own local energy system, with no CO_2 emissions and without putting pressure on the national energy network. That would be a real sustainable solution! At TU Delft, we have already started developing that system. We are building an installation that generates green electrons from solar and wind, featuring energy storage in batteries and in hydrogen and the conversion of hydrogen into electrons.

This is all set to happen in 'The Green Village' living lab on TU Delft campus. In this living lab with real homes and real residents and consumers, we are combining, testing and optimising existing knowledge and the latest innovations being developed at our university. The aim is to achieve CO2-free, autonomous energy provision, carefully calibrated to match energy demand and supply, at acceptable costs and in keeping with the existing living environments. This project will soon be scalable from The Green Village, to a neighbourhood and a whole district.

"This project is my way of **contributing**. To make an **impact** locally and **inspire** others to do the same. So that I can say to my grandchildren: **I did what I could**."

Prof.dr. John Schmitz

Will you join us?

With a donation to the Delft University Fund, you are enabling this project to be expanded and doing your bit to accelerate the energy transition. Scan the QR code on this page or visit **tudelft.nl/technologyforenergy** to find out more.

TU Delft | University Fund

ALL IN THE FAMILY

From landlady to house party

Some families have several generations who all study at TU Delft. In this series, parents and grandparents discuss their student days with their children and grandchildren.

Unlike today, the landlady played an important role in the life of a student. Grandpa Cees Distelbrink (Electrical Engineering 1958-1965) started out in a room on Spoorsingel, at the front of the house, where a train roared by every fifteen minutes. He then spent a year sharing a room with his younger brother in a house run by an 'old granny'. "It was rather a dirty house. Our landlady kept chickens, which were allowed to roam free. If you wanted to fry an egg, first you had to sweep the chickens off the kitchen worktop."

Granddaughter Anne Jacobs is a Master's student in strategic product design and spent over six years living in the same student hall, which she shared with seven other students and no landlady. "It was always a lot of fun; we could pretty well do anything we wanted. For example, every year we held a house party." Grandpa Cees and grandma Manon raise their eyebrows. A house party? No chance of that in their student days! MvdV

PHOTO: JOOST VAN PRENTMEESTER