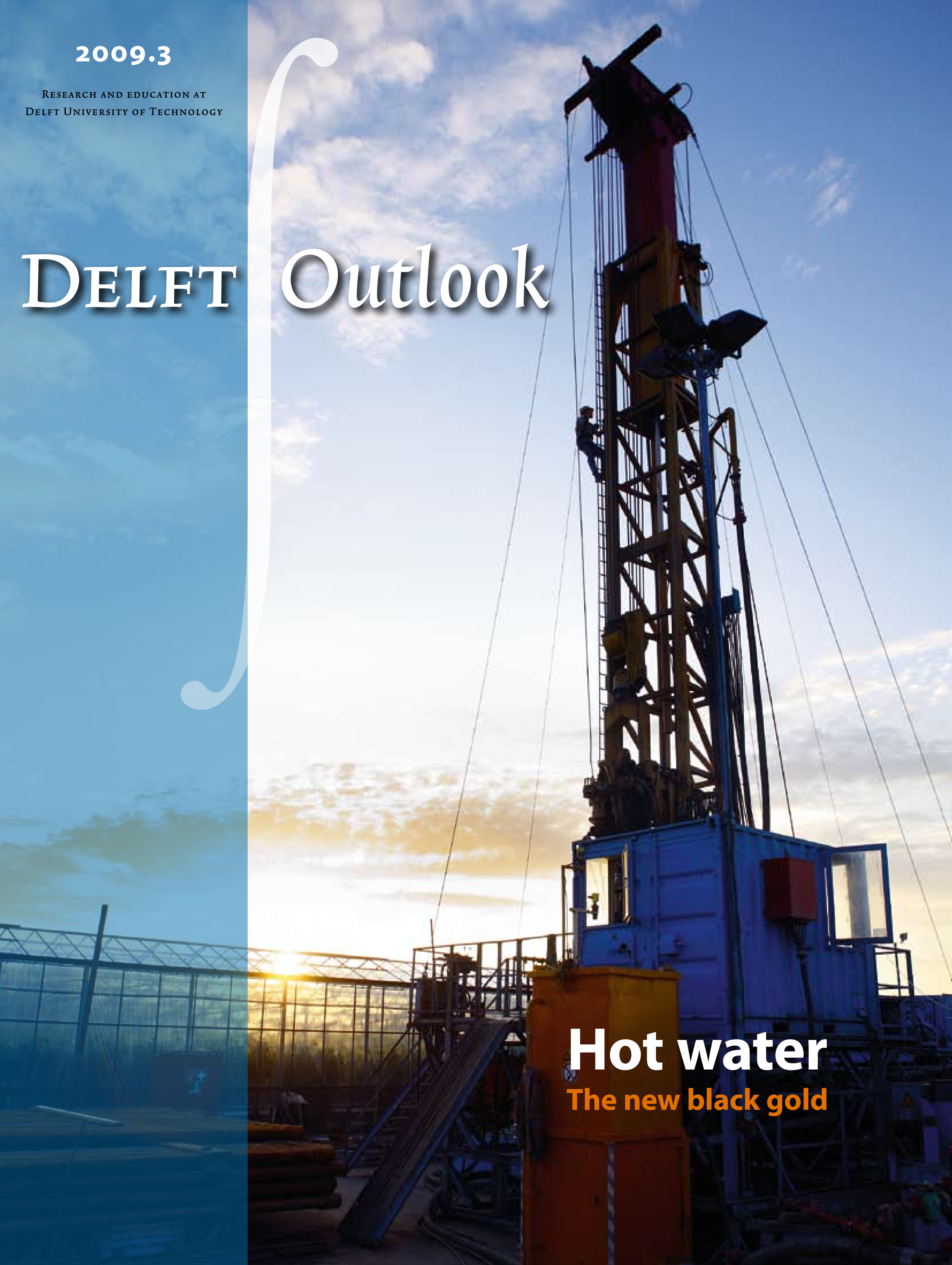
2009.3

Research and education at
Delft University of Technology

# Delft Outlook



## Hot water
### The new black gold

**Proton clinic** • **Sustainable buildings** • **Philosopher Jeroen van den Hoven**
Coach cat • Wooden bike • **Water on Mars** • Houdini bacteria

# Contents

# 2009.3

## DO



# Delft Outlook

## [Ed]DO

*Boys and their toys.* The men and women of TU Delft are always happy to have the latest technological 'toys' at their disposal, so that they can take their fields of research to the next level. Like a new, yet to be built, proton clinic, where certain types of tumours could be treated much more effectively than with radiotherapy. Or the Delft Aardwarmte Project, which in future will allow homes and buildings to be heated in environmentally friendly ways. The same goes for Silly Putty, which you're never too old to play with. Professor Stephen Picken is using Silly Putty in his research of self-healing materials. Meanwhile, professor of philosophy, Jeroen van den Hoven, warns that there is an urgent need for ethicists and engineers to join together to understand how great technologies will come to rule our lives. For researchers, such great inventions can ultimately lead to the summit of scientific fame: publication on the covers of the leading science journals Nature and Science. To become a cover star, nano-scientists use a primitive tool: psychology. Nothing human is alien to scientists.

Frank Nuijens
*Editor-in-chief / Delft Outlook*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# COLOPHON

**coverphoto**

Photo: Sam Rentmeester/fmax

*Volume 26, № 3*

Delft *Outlook* is published four times a year
by Delft University of Technology.
ISSN 0926-7212

**editorial staff**

Frank Nuijens (*editor-in-chief*),
Dorine van Gorp, Katja Wijnands (*editors*),
Tomas van Dijk, Erik Huisman, Maaike Muller,
Sam Rentmeester (*picture editor*),
Connie van Uffelen, Jos Wassink

**office**

P.O. Box 139
NL 2600 AC Delft
The Netherlands
T +31 (0)15 278 4848
F +31 (0)15 278 1855
www.delftintegraal.tudelft.nl
e-mail delftintegraal@tudelft.nl

**contributing writers**

Frans Godfroy, Joost Panhuysen, Angèle Steentjes,
Chrétien Verheijen, Robert Visscher

**translations**

Margareth Clegg, Marcus de Geus, David McMullin

**subscriptions**

Willy Abramsz-Witte
+31 (0)15 278 8598
w.m.s.abramsz-witte@tudelft.nl

**design & typesetting**

Cok Francken – MultiMedia Services, TU Delft

**photography**





**printing**

DeltaHage BV, Den Haag






# Nuna 5: now even lighter

**This year's car is lighter and more streamlined and efficient at converting sunlight. The TU Deft student team behind the solar-powered racing car Nuna 5 hopes to win the World Solar Challenge for the fifth consecutive time. The race will be held in Australia, in October. Forty teams are competing, including some big names in the car industry. The fully solar-powered cars must traverse the Australian continent in just five days.**

Photo: Tomas van Dijk

Minister Jacqueline Cramer (VROM) behind the wheel of the Nuna 5 on the TU Delft campus

The Nuna 5 has undergone three major improvements compared to last year's race-winning model. Nuna 5, which weighs just 160 kg, is 30 kg lighter than previous Nuna cars – a weight reduction that was achieved through changes in the manufacturing process, which allowed for more precise use of the construction resin. The new car also generates 30 percent less wind resistance, because it is lower to the ground and its sides more streamlined. The previous Nuna model had sharp sides. The Nuna 5's sides are rounded, meaning less air turbulence is created when driving. And last but not least, this car is powered by a very promising new type of solar battery that is currently being used in space missions, but which was specially adapted for this race, allowing it work within the earth's atmosphere.

More information:
www.nuonsolarteam.nl



# Fingerprint for capturing $CO_2$

**Dutch power company Nuon, and a PhD student in process and energy (3mE) are trying to 'capture' carbon dioxide as efficiently as possible at an experimental power station in Buggenum.**

"We're striving for a new approach to capturing carbon dioxide", says Kay Damen, of Nuon's carbon capture and storage department, which focuses on capturing and storing greenhouse gases.

This PhD research was triggered by a new thermodynamic model that can be used to specifically look for the detergent that is best suited to 'soak out' carbon dioxide from syngas, an intermediary product in power stations.

"The model produces a kind of fingerprint for the ideal detergent molecule," says Prof. Dr Joachim Gross, of TU Delft's process and energy laboratory. "With that fingerprint, you can pick the best detergent from the hundreds of thousands of existing solvents."

Klaas Steur (Applied Sciences), who developed the thermodynamic model for his MSc thesis, recently won the European Talent Award for Innovative Energy Systems 2009 for his groundbreaking work.

Photo: Sam Rentmeester/fmax

More information:
Prof. Dr Joachim Gross, j.gross@tudelft.nl

# Wooden bike

**Industrial design engineering student, Arno Scheepens, aims to develop a bicycle that's 100% sustainable. And he's not simply talking 'cradle to cradle': "That's not nearly ambitious enough."**

Scheepens only uses materials that are produced locally – in Friesland, which also happens to be his target market. The Cartesius Institute in Leeuwarden is supporting his research. The materials used to build the bike must be natural and renewable. No rubber for the tires, because there are no rubber trees in Friesland. And no steel for the ball bearings or brakes. "With the natural and renewable materials available locally, I can produce 70 percent of the bike," Scheepens says. "And there is more to come." Many people in Friesland will be happy to ride his bike, Scheepens predicts. A paid membership in his wooden bike cub will allow a member to 'borrow' a bike and ride it until it's worn out. "That process will take about five years," Scheepens estimates. The member will then be given a new bike, while the old one is dismantled and incinerated. Scheepens: "And the ashes will be given back to Mother Nature, for fertilizing other trees. My design is like an ecosystem that poops out and lends bicycles."

More information:
arnoscheepens@hotmail.com

Photo: Sam Rentmeester/FMAX

# Coach cat

**Patients are more inclined to stick to a healthier lifestyle when an animated cat closely watches over their actions, concluded Dr Olivier Blanson Henkemans in his PhD thesis.**

Blanson Henkemans asked 118 overweight people to keep a four-week long journal about their diets and physical exercise. Some of these people then received written comments on their journal entries, while others had an iCat appear on their computer screens. This little cat would make sad, happy or neutral faces, depending on the recent entries about the person's diet and exercise habits. The people who were confronted with an emotive cat lost more weight, more quickly. Blanson Henkemans' conclusion: a Personal Computer Assistant (PCA) can make a difference.

A PCA can help people to take their medication regularly and stick to their treatment regimes. But eHealth is not meant to replace personal physicians, Blanson Henkemans stresses: "But it does allow patients to gain more knowledge about their health, and consequently they probably won't need visit their doctors quite so much."

Blanson Henkemans conducted various experiments. At TNO, he put his test subjects in an 'experience lab', a home-like environment that encourages people to act naturally. "It turns out that older patients need a PCA that has a more cooperative manner," Blanson Henkemans concludes, "because they lack understanding and want to learn how it works. Young people prefer a PCA that gives clear, concise orders."

Photo: Olivier Blanson Henkemans

IN•BRIEF

# New Delft

The Mekelpark was officially opened on Friday, 5 June, following two years of intensive construction work. The new heart of the TU campus is named 'New Delft', an 832 meter long pedestrian boulevard made of cut granite, ringed by 1,500 metres of seating area capable of accommodating up to 3,000 students. "And we hope millions of conversations," says Francine Houben, the architect who designed the Mekelpark. The park features 13,700 m2 of natural stone, 90,000 m2 of lawns, 80 large boulders and 664 trees. Still to come are works of art in the form of applied engineering installations designed by TU Delft's students and staff.

Photo: Sam Rentmeester/FMAX

More information:
voorlichting@tudelft.nl

# Noisy trampoline

Photo: Walter Aprile

This interactive trampoline was designed to help autistic children work off their emotions, thus helping them to clear their minds and concentrate better. The trampoline, dubbed the 'Jumpillo', was designed by Marijke Verhoef, an industrial design engineering MSc student, and a team of fellow students - Jolijn Teunisse, Elsemieke van Rossum, Nicky Out, Gregor Ptok and Deger Ozkaramanli. Verhoef explains that the Jumpillo adds something extra to standard trampolines, which need only to be bouncy. "The Jumpillo also features noise and light and therefore is extra attractive for children with autism. Each bounce creates a drum beat, and jumping on each of the four differently coloured sections creates different sound effects, thus providing a variety of sounds." Verhoef and her team came up with the idea for the Jumpillo during a study assignment that called for using new interactive techniques in an innovative product. The student designers will now make further improvements to their prototype.

More information:
http://studiolab.io.tudelft.nl/vanderhelm

# Houdini-like bacteria

**Bacteria can squeeze through the smallest nano-slits, researchers at TU Delft's Kavli Institute of Nanoscience have discovered.**

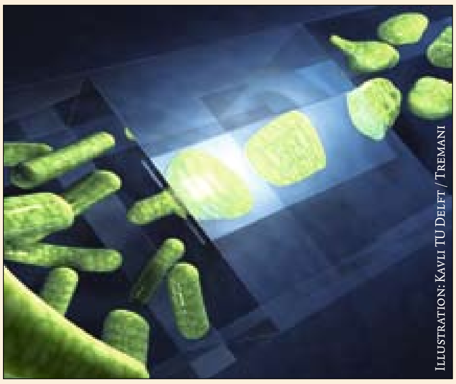
Illustration: Kavli TU Delft / Tremani

Biophysicist, Prof. Dr Cees Dekker, and evolutionary biologist, Dr Juan Keymer (Bionanoscience, Applied Sciences), allowed bacteria to move between tiny chambers on a silicon chip, via a narrow channel that measured 50 micrometres (one-thousandth of a millimetre) long and approximately 1 micrometer wide. By choosing narrower and narrower channels, the researcher forced the micro-organisms (E. coli and B. subtilis) to perform a kind of limbo-like dance, to which the bacteria responded to in a surprisingly Houdini-like way. The cigar-shaped bacteria still found room to swim when the width was 1.3 micrometres, even though the bacteria were one micrometre wide. The experiment became increasingly interesting as the channels narrowed - down to just half the diameter of the bacteria. At this point the bacteria can no longer swim, but that doesn't deter them. The bacteria become stuck at the beginning of the channel, but then they start dividing. After a bacterium divides ten to 15 times, it emerges at the other end of the channel. Remarkable was the way the bacteria changed shape inside the nano-slit: a cigar-shaped bacterium becomes flat like a pancake.

Apart from the importance of these findings for fundamental research of cell structures and cell divisions, this research also has practical implications for the membrane filters containing tiny pores that are used in water treatment, and for medical applications like pacemakers, for example, as it now appears that excluding bacteria from such vulnerable places is far more difficult than was previously thought. These research findings were published in the American scientific journal, Proceedings of the National Academy of Sciences, on August 17.

More information:
Prof. Dr Cees Dekker, c.dekker@tudelft.nl

# Quantum computer a step closer

Researchers at the Kavli Institute of Nanoscience have successfully managed to grip the environment of a quantum particle, allowing them to exert more control over a single electron. The research team, led by Prof. Dr Lieven Vandersypen, has thus brought the development of a superfast quantum computer another step closer. Until now, it was impossible to hold the magnetic 'spin' of a particle in a specific state for an extended period of time because the surrounding environment – also consisting of quantum particles – constantly disturbed that state. The team's research results will be published in Nature Physics.
In July, the research findings of fellow Kavli researchers, Prof. Leo Kouwenhoven, Prof. Herre van der Zant and Dr Gary Steele, were published in the prestigious journal, Science. The researchers succeeded in measuring the influence that one single electron has on a vibrating carbon nano-tube. The research is important for the development of ultra-small measuring instruments

More information:
Prof. Dr Lieven Vandersypen, l.m.k.vandersypen@tudelft.nl

# Liquid water on Mars

**It's highly probable that water flows on Mars, although not constantly. That is one finding of NASA's Phoenix robotic spacecraft, which conducted two months of research on Mars in 2008. Professor Urs Staufer (3mE) is one of the project's researchers.**

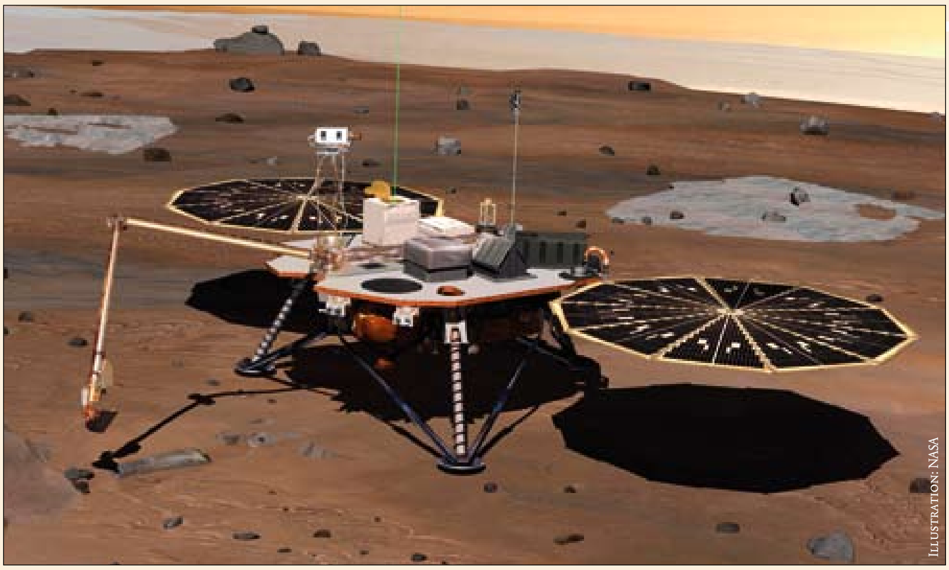
Illustration: NASA

Staufer and his colleagues discovered a hydrogen cycle on Mars. At night, very tiny snowflakes fall onto the planet's surface. Once on the ground, the ice is converted directly into gas without going through a process called sublimation, the NASA researchers reported in the July issue of Science. The researchers also conclude that it is highly likely that enormous amounts of subterranean ice on the poles of the planet contribute to this cycle and occasionally assume liquid form. "Due to the cold and the low atmospheric pressure, the water on Mars is always in two states: either frozen or vapour," Staufer explains. "But water molecules have however been known to precipitate in very fine sand. Tiny, wedge-shaped cracks between the grains of sand function as pipettes, which heightens the pressure."

Staufer examines the soil structure in order to determine if such a temporary, intermediate liquid phase can indeed occur. An Atomic Force Microscope (AFM) that Staufer designed was used onboard the Phoenix to collect the 'nano high resolution' pictures of the grains of sand that are now being analyzed.

More information:
Prof. Dr Urs Staufer, u.staufer@tudelft.nl

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Photos: Sam Rentmeester/FMAX

The robotic arm of the frameless radiosurgery system, Cyberknife, contains a small linear particle accelerator that generates radiation. The arm can be manoeuvred into many more positions than conventional systems. Cyberknife utilises the pencil beam, a small radiation beam that scans the radiation area. Researchers are however not yet certain if the Cyberknife is also suitable for the Delft proton clinic.

# Fighting cancer with protons

**To help in the fight against cancer, researchers at TU Delft are lobbying for a proton clinic in Delft. Proton therapy is potentially far more effective than current treatment methods. Protons attack tumours with much greater precision, thus leaving the healthy tissue intact.**

Robert Visscher

Proton therapy is gaining favour. The health care insurance board recently gave the go-ahead for including proton therapy in basic insurance policies, thus bringing the establishment of a Dutch proton clinic that much closer. The Dutch cities of Groningen, Maastricht and Delft would all welcome a proton clinic within their municipalities. Delft however seems to be the frontrunner in acquiring such a clinic, thanks in part to the radiation expertise available at the university's Reactor Institute Delft (RID). TU Delft however would not be engaging in this venture alone: the university works in close collaboration with the Erasmus Medical Centre, Netherlands Cancer Institute, and Leiden University Medical Centre. A suitable location for HollandPTC – as the proton clinic would be called – has already been found next to the RID. The clinic, which could be operational by 2013, would accommodate 2,000 patients a year. A complete proton clinic, including equipment, has a price tag of 100 million euro attached to it. The treatment of a single patient would cost about 40,000 euro, which is approximately one and half times more expensive than the currently used x-ray radiotherapy.

## More effective

Clinics in the United States began offering proton treatment five decades ago. There are currently 28 proton clinics worldwide, including in countries such as Japan, the United Kingdom, Switzerland and Germany. Dozens of new clinics will be built in the United States in the coming years. The reason behind this growing interest in proton therapy is that tumours can be irradiated much more effectively using protons than by using photons. "In radiotherapy, a tumour is irradiated with photons from different directions in order to reduce the impact on the surrounding healthy tissue," says professor emeritus of radiation technology, Dr Carel van Eijk, of the Faculty of Applied Sciences. "The problem is that the radiation dose inside the body is relatively high before the tumour can be reached, and remains high after hitting the tumour. Consequently, much of the healthy tissue gets hit pretty badly too. Proton therapy however greatly reduces this problem, because it allows you to set the proton beam in such a way that it peaks when it strikes the tumour. This technique is known as the Bragg peak. Much more of the healthy surrounding tissue is spared than with radiotherapy." Professor van Eijk is a proponent of establishing a proton clinic in Delft, and should the plans materialise, he would be closely involved in proton research.

This improved accuracy makes proton therapy highly suitable for treating tumours located in sensitive areas, such as the eyes, Van Eijk explains. And there is also much to be gained in the treatment of cancer in children, because irradiating a tumour with photons causes a second tumour to develop in the place where the first irradiation struck healthy tissue. These secondary tumours often take 15 to 20 years to develop. Van Eijk: "Ten-year olds would see the second tumour appear in their late 20s, which is terrible. For them, proton therapy is very important." Children moreover are extra sensitive to radiation, because large numbers of cells in their bodies are still dividing.

The precision of proton therapy offers great benefits, but it also renders the treatment process more complex. Knowing exactly where a tumour is located is essential, which is why TU Delft researchers are trying to find out how they can obtain the most accurate images of tumours. Professor Freek Beekman, of the radiation detection and medical

*'At least another decade will pass before we manage to crack that nut'*

imaging department at the Faculty of Applied Sciences, intends to use 3-D technology to create artificial patients with realistic tumours. He and his team will then insert small dosimeters in the artificial patients, in order to see if the protons reach the tumours in the way they should.

But researchers also have other problems to cope with. The displacement of tumours within the body is particularly problematic. Adjacent organs can push tumours around. Or inside a lung, the tumour moves when the patient inhales and exhales. The motion of tumours also poses problems in radiotherapy, but the dose of photons does not ▸▸

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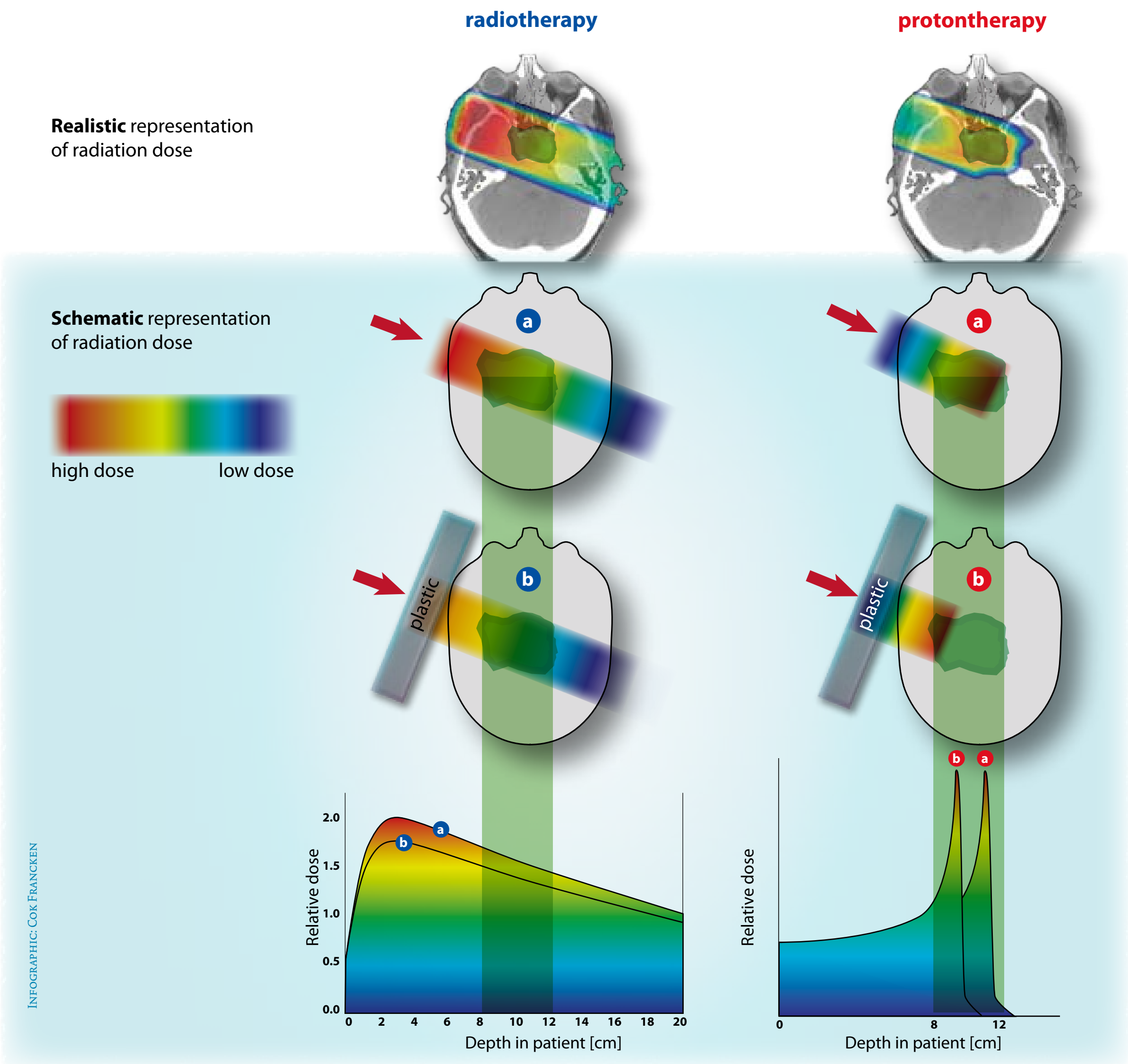
decrease as dramatically on its way through the body as it does with protons. Even though the tumour moves slightly, the beam still manages to hit it. In proton therapy, however, if the tumour moves the beam misses it, hitting instead the healthy tissue and leaving the tumour untreated. Beekman therefore intends to create a real-time tumour imaging system, and is currently engaged in developing such an ingenious device. “As we have patent applications pending, I can’t reveal too much about it,” he adds. But will this new system completely solve the tumours in motion problem? “Movement is the greatest problem,” Beekman emphasises. “At least another decade will pass before we manage to crack that nut. Without the proper imaging techniques, proton therapy fails to deliver on its promise and will only be useful in a very limited number of cases. However, if the proper imaging equipment does eventually become available and can be properly integrated within the treatment environment, proton therapy would be a much more effective method than photon therapy.”

To pinpoint the location of the tumour as accurately as possible, researchers are attempting to devise methods for modelling the movements of tumours, and many of these methods are currently being used in x-ray therapy, including MRI and CT scanning techniques. TU Delft researchers meanwhile are trying to determine the extent to which these techniques can also be used in proton therapy, albeit perhaps with some modifications. “I like to look for the shortest route to a good solution for the patient, which leaves little time for endless fundamental research,” Beekman frankly admits.
In addition to excellent imaging systems, the optimum beam configuration is also essential. Dr Mischa Hoogeman, a clinical physicist at Erasmus MC university medical centre, explains a technique known as the pencil beam: “Given some knowledge of the shape of the tumour gained from CT and MRI scans, you can use this information to scan exactly over the tumour and continuously set the appropriate depth of the Bragg peak.”
If the pencil beam is not an option, the shape of the




Infographic: Cok Francken

tumour is determined and then a cast of it made in bronze. The resulting collimator is then placed in the path of the beam, leaving the exact shape of the tumour for the radiation to pass through. Along the length of the beam, the Bragg Peak is spread out over the tumour using a rotating plastic wheel. This technique is known as scattering. “But it’s not as accurate as a pencil beam,” Hoogeman adds.

## Beam dosage

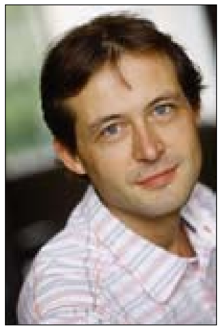
The proton beam must have exactly the right dosage to get the Bragg Peak in the right spot and at the correct depth. Tumours aren’t uniform in thickness, and bone slows down the beam. “If there’s a bone in your way, you could easily be off by two centimetres,” Van Eijk says.
Professor of radiochemistry, Dr Bert Wolterbeek, is conducting research on the optimum dosage of protons. “We test whether the beam is actually as accurate as we think it is,” he explains. “We do this by using special fluorescent gels. A container with the gel, in combination with UV lighting, reveals in 3-D where the proton beam ends up. This shows us the fractional volume and the shape of the beam.”
Wolterbeek’s aim is to be able to adjust the beam to have the greatest impact on the most malignant cells inside the tumour. “Suppose I have a solid tumour of a certain size in which I want to hit the cells that have the highest metabolic activity. I would have to differentiate between the cells to hit even within the tumour. Another option is to load the tumour with radio-sensitising material to render it even more susceptible to the therapy. It is even possible to aim for the blood vessels around a tumour, which would block the flow of nutrients to the tumour and kill it.”

## Carbon ions

The problems outlined above do not threaten the establishment of a proton clinic. Proton therapy can already be applied successfully, according to proponents of proton clinics, who like to point to the fact that there are currently 28 proton clinics worldwide. Improvements will ensure that proton treatment becomes even more effective. Van Eijk would like to see more research undertaken: “We must stop endlessly trying out things, because this is pointless. What we can do now, we should do now. That’s what brings the greatest benefit to patients today.”
In addition to the Netherlands, other countries are also thinking about setting up proton clinics. In Belgium, the value of such a clinic has been the subject of heated debate for years. The Federal Health Care Knowledge Centre, in Brussels, has however come out against the proposal, and consequently Belgium has shelved plans for a proton clinic of its own. “Nobody has yet demonstrated conclusively that protons are better than the existing types of treatment,” says Michel Huybrechts, a physician and knowledge economist at the Federal Health Care Knowledge Centre. “Since proton therapy is more expensive than x-ray treatment, we see no point in setting up a new clinic. Our calculations show that in the whole of Belgium only 50 to 60 patients a year would benefit from proton therapy. We would be much better off sending these patients to Switzerland. That‘s cheaper than building our own clinic. I think the Netherlands wants a clinic for the accompanying prestige.”
According to Huybrechts, carbon ions are a better investment. “Research in this field looks very promising. A carbon atom consists of six neutrons and six protons and weighs 12 times as much as a proton. It gives off much more energy and is more efficient. Also, carbon ions do not diverge as much, so the energy impacting the cell is even greater. The damage inflicted on tumours is considerable. In Japan they can treat an eye tumour in half a day. Isn’t that great? Lung cancer can also be treated very effectively,” the Belgian doctor states. “I say we wait a bit longer for developments with carbon ions before we start building a whole new clinic, which would not only require lots of doctors, but also physicists in particular.” In Heidelberg, Germany, patients are also being treated with carbon ions. Hoogeman agrees with Huybrechts that developments in the field of carbon ions are promising. “But much more research is needed,” Hoogeman says. “We don’t exactly know what the effects of carbon ions are. What will be the impact of the fragments of carbon that remain behind? There are still too many unanswered questions. Protons, on the other hand, can already be used for treating tumours. And that’s what counts.”
Any future design of a proton clinic in Delft would however take the carbon ion developments into account, and thus, with a few minor modifications, this method could also be used in the new clinic.
Hoogeman and his fellow researchers at TU Delft are hopeful that Delft will acquire a proton clinic. They are eager to start optimising their ideas and research methods for clinical use. “The proton clinic-related research is scientifically interesting,” Beekman concludes, “and what is also very stimulating is that as a physicist you’re solving problems that have such a major impact on people’s lives. If the clinic is set up close to TU Delft, many of our physicists will feel compelled to enthusiastically set about thinking up clever new things.”

*‘Improved accuracy makes proton therapy highly suitable for treating tumours in sensitive areas, like the eyes’*

Prof. Dr Carel van Eijk: “We must stop endlessly trying out things”.



Dr Mischa Hoogeman: “You can use the pencil beam to scan exactly over the tumour”.

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# Climate neutral with the air-conditioners on

**Supermarkets that transfer their heat to homes and indoor swimming pools that help heat office buildings. Thanks to this type of energy exchange, Rotterdam aims to render some of its neighbourhoods CO2 neutral. Easy to do, they say in the port city.**

Tomas van Dijk

FOCUS


Photos: Sam Rentmeester/FMAX

Those old, drafty homes built during the 1950s still dominate the streetscape of the neighbourhood situated around Rotterdam city hall, the former post office building and the World Trade Center. But if it is up to the city to decide, this neighbourhood will be $CO_2$ neutral by 2025. Achieving that feat will require more than just solar panels and better insulation, however.

In this area of the city, new homes, offices, a second shopping mall and supermarkets are all in the pipeline, and all these buildings will have their own heating and cooling needs and produce residual energy flows. Rotterdam wants to exchange these energy flows. Supermarkets for example must continually operate cooling systems, which produce huge amounts of heat that at present simply disappear into the atmosphere. Which is shame, since it is also possible to use heat pumps to transfer this residual heat to nearby homes and buildings.

"This would allow also us to exchange heat between offices and homes," says Nico Tillie, of Rotterdam's city planning and housing department, which is responsible for successfully launching this project. On hot days, office air conditioning units roar into action. The heat that is blown into the air from these units could be stored at the bottom of WKO (Warm Cold Storage) installations and then used to help heat homes at night or during the winter months.

"Waste from the neighbourhood could also be collected to produce biogas," Tillie adds. The city also plans to generate residual demand for energy using available green technologies, such as solar panels.

The project is part of the Rotterdam Climate Initiative, which aims to halve the levels of $CO_2$ emissions in the city by 2025, as compared to 1990 levels. Certain areas, such as those around the former post building, must also become totally $CO_2$ neutral.

"According to our model, this easy to do," says Tillie, in reference to the REAP (Rotterdam Energy Approach and Planning) model, which Prof. Dr Andy van den Dobbelsteen, professor in climate design and sustainability at TU Delft's Faculty of Architecture, helped to develop.

"Until now, architects have followed three steps when building sustainable buildings," Van den Dobbelsteen explains. "Reduce the energy consumption, utilize sustainable energy and use fossil fuels as efficiently and cleanly as possible for the remaining needs. However, to date, this 'Trias Energetica' has not led to substantially more sustainable buildings. We have therefore added another step: reuse waste flows, such as waste water, household and agricultural waste, and residual heat. This method will ultimately render the use of fossil fuels unnecessary."

The REAP method allows urban planners to comb the city looking for opportunities to exchange energy. Van den Dobbelsteen: "If you can't solve your energy needs in a certain neighbourhood, then you have to look elsewhere. Perhaps a better balance could be achieved from exchanging heat with a neighbourhood that has fewer homes, but does have an indoor skating rink and swimming pool."

The researchers have applied the method to the Hart van Zuid, a new district in Rotterdam, whose urban planning blueprint calls for new homes to be built near the Zuidplein shopping centre that can use the residual heat generated by a local supermarket. The Ikazia Hospital, which is also located nearby and consumes huge amounts of energy, must especially be energy self-dependent and reclaim heat from its residual hot air and waste water,

*'This method will ultimately render the use of fossil fuels unnecessary'*

while also becoming much better insulated by means of an overarching climate facade, which resemble a huge greenhouse covered in vegetation.

For now, these adaptations have yet to come into effect. "We've opted to start applying this method in the neighbourhood situated around the former post office building, because this is an area where more project developers are active." Tillie says. "New buildings must be built, because otherwise you'd never recoup your investment."

*'New buildings must be built, because otherwise you'd never recoup your investment'*

Prof. Dr Andy van den Dobbelsteen

A REAP transformation does however require a substantial amount of infrastructural changes. Small buildings must be built to store and redistribute energy, and heat pumps and heat storage systems are needed for counterbalancing daily and seasonal temperature changes.

Logistics also present a challenge. Suppose a newly built residential complex in a $CO_2$-neutrale neighbourhood is completed earlier than the supermarket the residents depend on for their heat. "The project developer has stated that he is not prepared to wait," Tillie says. "Fortunately, the energy company, Eneco, is prepared to build an emergency generator."

The energy that becomes available after all these transformations must be sustainable energy. For Rotterdam, another sustainable energy source is the residual heat from surrounding industries, which can flow into the city through the pipes of the municipal heating system. But then again, what happens if these industries also become sustainable through accordance with the cradle-to-cradle principle, and these hot water flows suddenly dry up? Over time – about 20 years –we must find alternatives," says the ever-optimistic Van den Dobbelsteen. "We could then make the switch to geothermal energy."

*(See infographic on the following pages)*

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**Scale of optimisation essential**
At present, cities are collections of buildings in which each building individually optimises its own energy consumption. All residual energy released from the building is wasted, without first determining if anyone else in the area could use this energy. By exchanging (warm or cold) residual flows, the use of primary energy could be reduced by an estimated 50 percent.

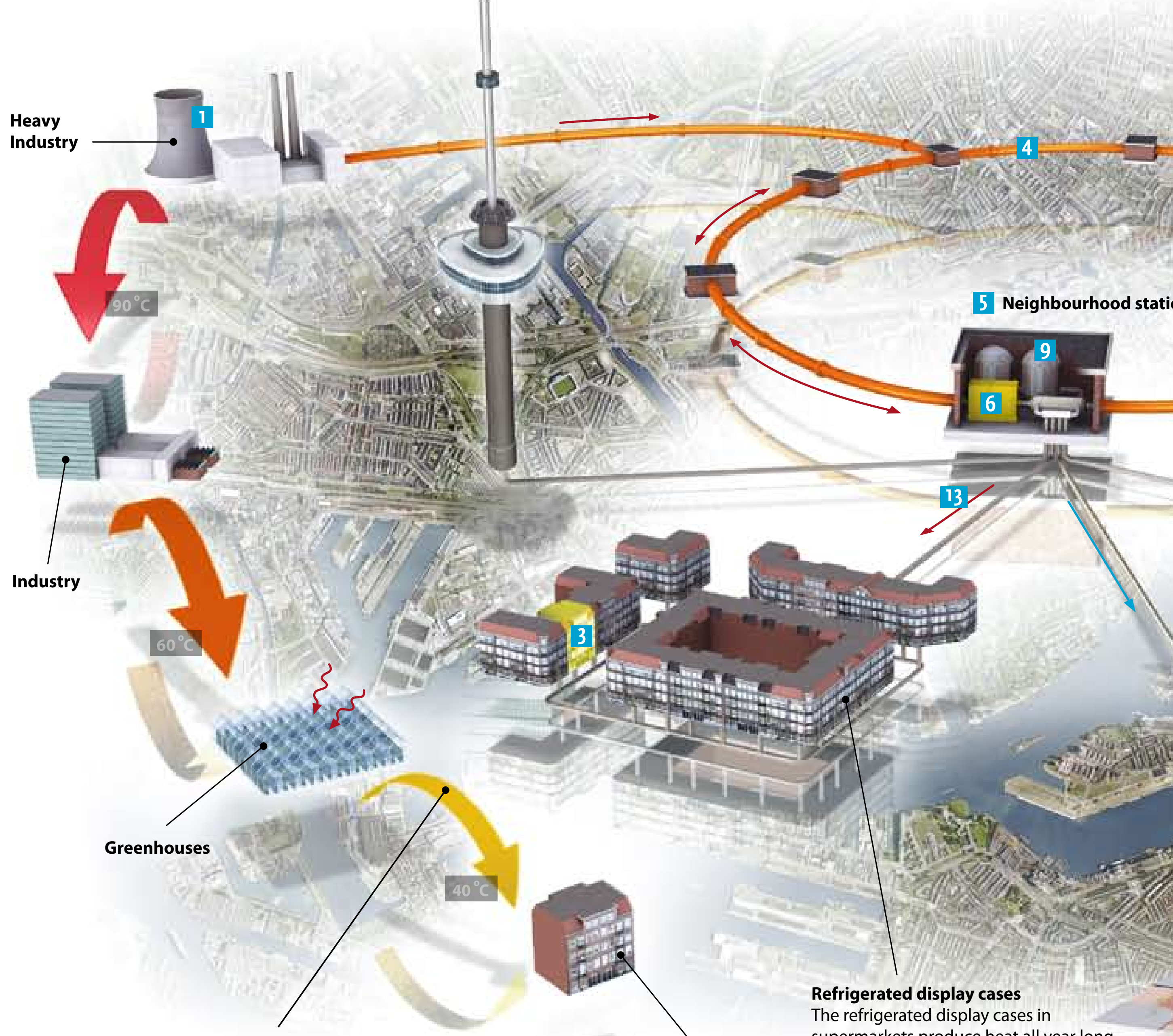
**Lots of lost energy**
Residual heat from power stations is sometimes used for district heating, but when there is no demand for this heat in the summer months, the heat is discarded by means of cooling towers 1 or discharge into surface water. The heat from air conditioning units 2 is also emitted into the atmosphere, and at waste installations, trash is often incinerated without utilizing the generated heat.

# REAP

REAP (Rotterdam Energy Approach and Planning) links homes, offices, shops, sports centres, schools and other operations in the neighbourhood and city to each other, in order to allow for the sharing of each other's residual heat and cold.

## 1 Reduce energy consumption

Building regulations (insulation, for example) must minimize the energy consumption in each building 3.




**Refrigerated display cases**
The refrigerated display cases in supermarkets produce heat all year long, and at present this heat simply disappears into the atmosphere. This residual heat could be used to heat homes: 1 m² of supermarket can heat 7 m² of a home.

ALTERNATIVE TO RE-USE

## 2* Cascading energy

The cascade system allows all residual heat to be passed on to the next user in the energy chain who can use heat of lower temperatures. It is a waste of energy to use 1500 °C gas to heat homes. Primary energy should only be used for high-grade industrial processes (heavy industry) that require such high temperatures. The residual heat is stored in a reservoir or used for heating greenhouses. By designing homes in new and clever ways, the residual heat of greenhouses (25 to 40 °C) could be used to heat such homes and offices up to a temperature of 20 °C.

RE-USE OF ENERGY FLOWS

## 2C Energy exchanges

If a neighbourhood contains buildings that have various supply and demand patterns, energy could be exchanged between buildings. One example is the heating of indoor swimming pools and homes with the heat released from the cooling systems of skating rinks 7 or supermarkets. If a neighbourhood is still running a deficit on its energy balance sheet, this problem could be solved at a higher level (district, city, region). New buildings can also be added to the neighbourhood to improve this balance.

**Heat network**
The transfer of energy can occur by connecting all the buildings to a network of water pipes 4. Neighbourhood stations 5 can regulate supply and demand by collecting and redistributing the heat. Heat pumps 6 and heat exchangers could be deployed to extract heat from lukewarm water or to further heat up warm water or to cool down lukewarm water (converting residual heat into cold).

RE-USING RESIDUAL FLOWS

## 2A Accounting for the energy balance

Each building (hospital, skating rink, swimming pool, concert hall) has its own individual use of heat, cold and electricity. By accounting for the consumption and the surplus of heat and cold in each building in a city district, it becomes clear which supply and demand patterns are most suited to each other.

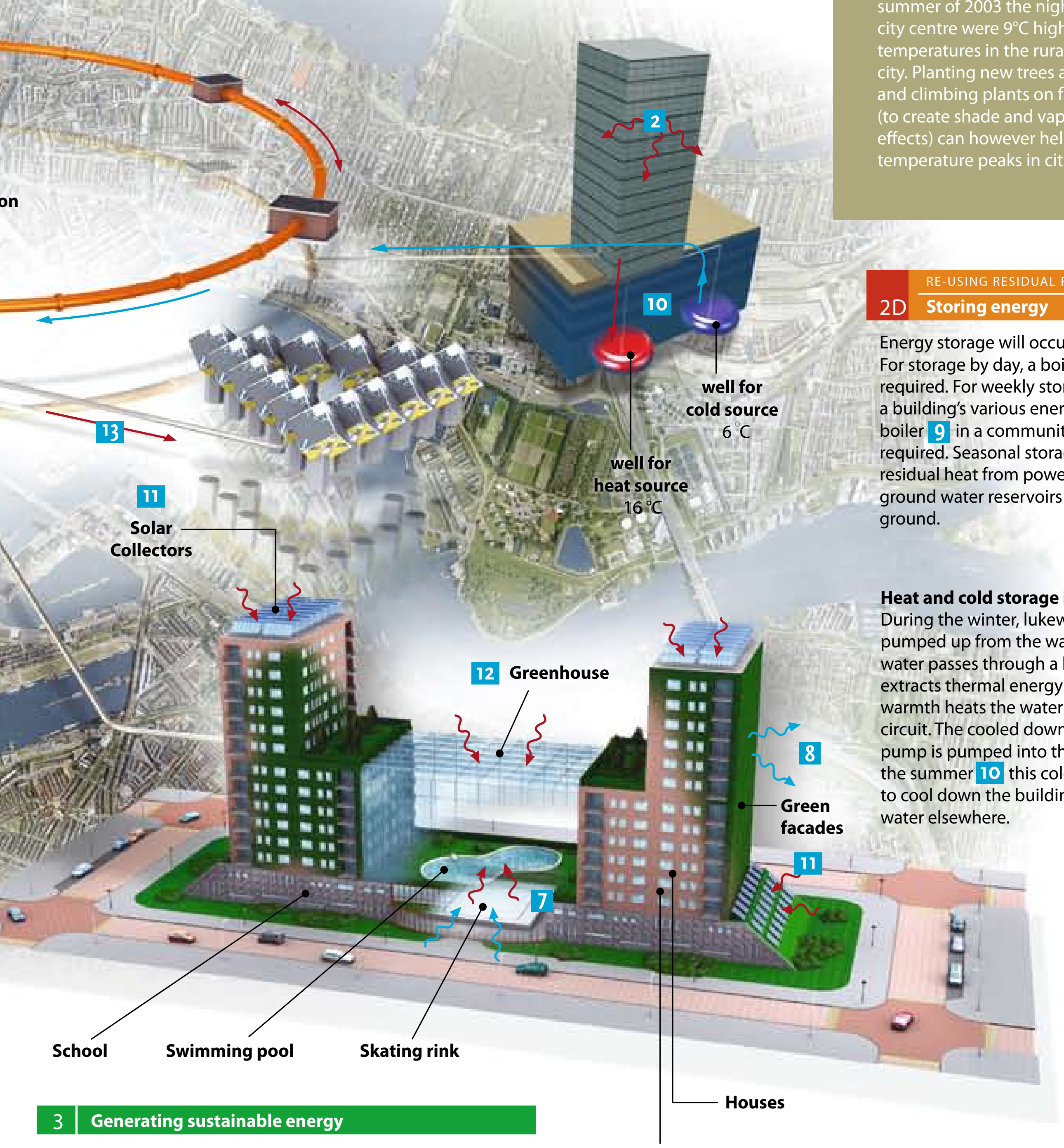
RE-USING RESIDUAL FLOWS

## 2B Residual flows in the building

First, the residual heat at the level of a single building must be utilized, for example, by reclaiming heat from ventilated air or shower water.

## Urban heat islands

Extracting residual heat is essential for preserving a comfortable living environment. Large stone surfaces store heat, a lack of water and plants means there is insufficient vaporisation (and subsequently cooling), and the wind does not offer sufficient cooling either, because densely built-up urban areas restrict wind speeds. The use of air-conditioning units creates higher temperatures, and hence a vicious circle is created.
The Greater London Authority commissioned a study of the so-called 'urban heat islands', which revealed that during a heat wave in the summer of 2003 the night temperatures in the city centre were 9°C higher than the night temperatures in the rural areas south of the city. Planting new trees and growing plants and climbing plants on facades 8 and roofs (to create shade and vaporising cooling effects) can however help limit extreme local temperature peaks in cities.




RE-USING RESIDUAL FLOWS

## 2D Storing energy

Energy storage will occur on different levels. For storage by day, a boiler in every home is required. For weekly storage (making use of a building's various energy patterns), a large boiler 9 in a community building is required. Seasonal storage (for example, residual heat from power stations) occurs in ground water reservoirs 10 located in the ground.

**Heat and cold storage in the ground**
During the winter, lukewarm ground water is pumped up from the warm source well. The water passes through a heat pump that extracts thermal energy from the water. This warmth heats the water in the central heating circuit. The cooled down water from the heat pump is pumped into the cold reservoir. In the summer 10 this cold water is pumped up to cool down the building or to use the cold water elsewhere.

FOCUS

## 3 Generating sustainable energy

The remaining energy demand has now been reduced to such an extent that it can be met with sustainable energy sources. Some of the possibilities are: generating energy via solar panels/foil 11 on the roofs and facades of the houses; windmills; a greenhouse 12; asphalt collectors located in road surfaces; installations to extract biogas from waste/water; composting waste.

**Heat exchange**
In modern offices, cooling begins as soon as the indoor temperature rises above 12°C. The subsequent residual heat 13 can be used to heat homes.

Photos: Nout Steenkamp/FMAX

# ‘Is this going to make our lives better?’

**During the early developmental stages of a new technology, ethicists and engineers are still able to influence how that technology will ultimately affect our lives, says professor of philosophy, Jeroen van den Hoven, of the Faculty of Technology, Policy and Management.**

*As the scientific director of the 3TU Centre for Ethics and Technology, you also work together with researchers from the other 3TU centres of excellence, including bio-nano applications, intelligent mechatronics systems, and sustainable energy technologies. Do you notice any reluctance on their part?*

“Always. It’ll be a while yet until good relationships between ethicists and engineers become commonplace. Right now people are still a bit wary, testing the waters. But let’s not forget that we’re still in the pilot project stage.

“As soon as researchers realise that you’ve really studied their work, the reserve often disappears. It helps that many of our researchers have dual backgrounds in philosophy and technology. I think that’s necessary, because you must be a credible partner in the debate.”

*Do the working relationships vary between the centres of excellence?*

“In some centres, where the researchers have already endured a degree of public criticism, the collaboration is very practical in nature; these researchers are well aware of the fact that you cannot simply do whatever you want, because if you do, you will face resistance: less funding, political turmoil, and so forth.”

*That sounds like a defensive strategy.*

“It is. When the corporate sector first started talking about socially responsible entrepreneurship some 30 years ago, there was also a defensive ring to it. ‘Why do we do this?’ ‘Because the customers are asking for it’. But these days, this has become part and parcel of how they think, especially in the larger companies.”

*In July you travelled to New York City to receive the World Technology Award, in the ethics category. The candidates for these awards are nominated by the previous award winners – including Peter Singer and Al Gore. Apparently the research at the 3TU Centre caught their attention. Were you surprised?*

**Jeroen van den Hoven**

The scientific director of the *3TU Centre for Ethics and Technology* is sometimes referred to as an ICT philosopher. Even though Professor Jeroen van den Hoven (Rotterdam, 1957) received his doctorate for his work on information technology and moral philosophy, and although as a researcher and political consultant he is still engaged in the ethics of ICT, the label appears to be somewhat restrictive now.
In 2004, Van den Hoven became a professor at TU Delft’s Faculty of Technology, Policy and Management, where he now also serves as the deputy dean. He studied philosophy at Erasmus University Rotterdam, where in 1998 he was appointed endowed professor of information and communication technology.
Van den Hoven was the architect of the socially responsible entrepreneurship programme of the Netherlands Organisation for Scientific Research (NWO), which is a major funder of the research conducted at the 3TU Centre. As a researcher, Van den Hoven has published on such subjects as value-conscious design, the downside of the internet, and the possible effects of nanotechnology (radio frequency identification tags) on our privacy.
Van den Hoven, together with prominent liberal politician Frits Bolkestein and others, compiled the recently published collection ‘The politics of things’ (‘*De politiek der dingen*’), in which researchers from the 3TU Centre detail the ‘moral and political significance’ of ‘technological artefacts’. Van den Hoven is married and has two children.

“Not entirely. The 3TU Centre employs about 50 researchers, and they are often told at international conferences and congresses how marvellous it is to have such a unique institute with such a high concentration of leading researchers in the field of technology and ethics.

“Another confidence-booster is that the James Martin 21st Century School in Oxford wants to work with us. James Martin is one of the gurus of the information age. He gave Oxford 150 million pounds to fund a scientific institute where scientists could study the technologies that will define the next century. Yale and the Royal Institute of Engineering in Stockholm are also partners in our research. And there is also a 3TU initiative in place to establish an international graduate school for technology and ethics.”

*Why is your research so popular?*

“Because it’s multi-disciplinary: we not only work together with engineers, but also with social and behavioural scientists. These are also disciplines rich with empirical knowledge. We don’t just shout out the first thing that comes into our heads. Proper research methodology is crucial when considering ethical issues. You must also look at the problems proactively, at the moment when moral considerations are still relevant. Traditionally ethicists were accustomed to waiting until the negative effects of a new technology emerged, but by then it’s too late.”

*In the introduction to the publication ‘The politics of things’ (De politiek der dingen), you quote the social scientist and historian of technology, Thomas Hughes. To paraphrase Hughes, when technology is still in its infancy, it’s still possible to control its application and scope. But once a technology has gained a foothold, it mostly becomes a case of that technology influencing us, rather than the other way around.*

“One must try to get involved in the early stages. But then you are also confronted by Collingridge’s dilemma, which boils down to this: at the moment when you’re still capable of controlling the technology, you have too little information to know how best to do it. And by the time that information becomes available, there is little left to control.

“So you need to pick exactly the right moment, which means you must keep up with the new technological developments. You must also have a keen eye for the problems that ▸▸

INTERVIEW

*'We're now heading for a world in which we'll find it virtually impossible to do anything undesirable, especially in certain places'*

can crop up. Being alert starts with realising that new technology creates new opportunities, but yet also always closes off other avenues. You can compare this to building a wall to hang a picture on. The wall also has limitations. Anyone designing technology will also be consciously or unconsciously shaping other people's scope for action."

*And since technology influences our lives in this way, an ethicist must think about the positive and negative effects at the appropriate time?*

"Yes. The first question you must ask yourself is: will the technology improve our way of life? That is always what the makers say, but can they really make it happen?"

*What are the criteria for assessing whether a certain technology improves our way of life?*

"That's a tricky question, a 'can of worms' as it were, but as a researcher you're obliged to try and answer that question."

*In 'The politics of things', the idea arises that we might need to use technology to express moral values; for example, a car that won't start if the driver is drunk. In future, will people really have to weigh the ethics of their actions much less often?*

"We're already heading in that direction. I often say that we come from a world in which it was possible to do things that were not desirable. You could for instance simply stand up and punch one of the people in this hotel lobby in the head. Of course such an action is not only undesirable, but also morally reprehensible and against the law, but you could do it if you wanted. We're now heading for a world in which we'll find it virtually impossible to do anything undesirable, especially in certain places.

"We already have buildings where you cannot enter a room or an information system unless you have the proper authorisation. The technology of individually traceable RFID [radio frequency identification, ed.] tags offers a wealth of possibilities in that respect.

"If we continue along the same lines, we can assume that anything that isn't allowed will soon become impossible. And then people will no longer have to think for themselves. What's more, they'll start to think that anything they *can* do is therefore allowed: 'I was able to gain access to this information, so how was I supposed to know I was doing something wrong?' We haven't got to that point yet however."

*Technology to protect you from 'your evil side' – isn't that rather paternalistic?*

"Cass Sunstein, a professor at Harvard Law School and currently one of Barack Obama's regulatory czars, published a much-discussed book on soft paternalism this year, entitled *Nudge – Improving Decisions About Health, Wealth, and Happiness*. Soft paternalism means nobody is forced to make the right choices. People are simply nudged in the right direction. As an example Sunstein describes a self-serve restaurant where the vegetables and fruit are placed in easy reach, while the fried food has been pushed to the back. He calls this 'choice architecture'. Another example is car seatbelts, which start beeping if people don't fasten them.

"Of course, the right choice isn't always obvious. And people could also simply have bad intentions, in which case soft paternalism and choice architecture won't get you very far."

*The 3TU Centre conducts research into the use of robots in a variety of guises: as an (overly) obedient soldier of the future, or as a home carer who makes sure Mrs Smith takes her medication every day.*

"There is something to be said for 'carebots'; they're a smart solution to a real problem, i.e. the ageing of the population and spiralling health care costs. But society could also decide that it simply refuses to leave its elderly parents to the care of robots.

"Experiences with this in Japan do not seem so negative, however. The elderly there say that they don't mind the carebots at all – perhaps because of the privacy and anonymity they offer. The elderly are also relieved that they no longer have to ask their families for help, because the carebot is always there to help them.

"There is however another side to this argument. Japanese senior citizens may be reacting positively to the carebots because the technology has been made available to them and hence everyone expects them to use it. That is the social pressure of not being a burden on others, which is also sometimes encountered in the issues surrounding euthanasia."

*Can ethicists and engineers prepare for the possibility that technology will end up in the wrong hands?*

"I think they can. Perhaps the design for a central database should include a 'dead man's switch', which could be used to make the database disappear – and with it all the collected personal information about citizens – if there were a real danger of abuse by a dictator."

*Moral values can be expressed in new technology. But does this also works the other way round? Does technology affect our ethics?*

"Yes. It's not a case of one-way traffic. Take Facebook for example. The younger generations don't care so much about privacy; they post all kinds of stuff on the internet, which they sometimes come to regret later, but nevertheless, the familiarity with a new technology makes us less anxious about certain things. But there is certainly also a flip side to the internet.

"Technology also offers possibilities of gaining experiences that in turn can determine your identity. Just driving a car once gives you a feeling of freedom and independence, and once you've experienced this for a while, you attach great value to it."

*And thus we can never persuade people to stop using their cars. Should an ethicist consider these psychological effects when assessing new technologies?*

"Yes. And we can ask ourselves whether we want people to eventually consider themselves satisfied consumers of this new technology. If not, is it then ethical to develop that technology?"

*Can you imagine ethicists ever recommending that engineers stop developing a certain technology?*

"I don't think that would happen easily, but it's not entirely inconceivable. After all, the development of super-fast swimsuits was recently stopped at the request of the sport's governing body. Perhaps we will also one day ask engineers to stop developing human enhancement applications designed to turn people into ever more intelligent cyborgs. Or a technology that can slow down the ageing process: our planet could never handle all those lively 200-year olds.

"This begs the question: should issues like these be debated in a democratic context? And if so, what kind of political institutions would we need to do this? Parliament isn't really up to it, I think. And a lack of expertise is not the only reason. Over the past decades, liberalism has been the dominant political philosophy, and this means that the government has deliberately not interfered in questions about how certain types of technology relate to a good lifestyle. Liberalism regards these issues as primarily private matters. This view is no longer tenable, however. In the 21st century, it's impossible for technology policy to be neutral, because technology isn't morally neutral either."

*In 'The Politics of Things' you state that terms like sustainability and good management are empty concepts unless one can demonstrate how they can be incorporated into the design of new technology.*

"Indeed, and it isn't enough to simply start shouting that privacy is also important. You must be able to show in detail exactly how privacy affects a design, otherwise it is simply gratuitous.

"The field of applied ethics once had an eye for concrete problems. The next step could be for us to start linking applied ethics to design problems, so that we can actually solve them. In addition to designing new technologies, this would also mean establishing new laws, procedures, institutions....

"Thomas Pogge, a fellow philosopher at Yale University, came up the idea for a Health Impact Fund, which is a smart system that, for example, creates incentives for large pharmaceutical companies to make medication available at cost price to large groups of people in developing countries who would otherwise never have access to those drugs. An ethicist should never shy away from devising such practical design solutions. This is far better than expending all your energy on endlessly repeating theoretical principles and their implications and spouting moral outrage."

◂◂

**They got a big shock at Rijkswaterstaat, the governmental agency charged with overseeing public works. Research conducted on concrete samples revealed that the concrete in countless old bridges had unexpectedly low tensile strengths and was thus much more prone to cracking. Rijkswaterstaat has therefore commissioned TU Delft researchers to study the crack behaviour of the concrete bridge sections. In the laboratory of the structural and building section (CEG), researchers use hydraulic jackhammers to destroy concrete beams in a step-by-step process. After each hammer strike, the researchers trace the new cracks with a stylus, and the resulting animated film provides insights into the concrete's crack behaviour. The red stickers are the reference points that reveal the movements occurring in the concrete.**

More information: Prof. Dr Joost Walraven, j.c.walraven@tudelft.nl

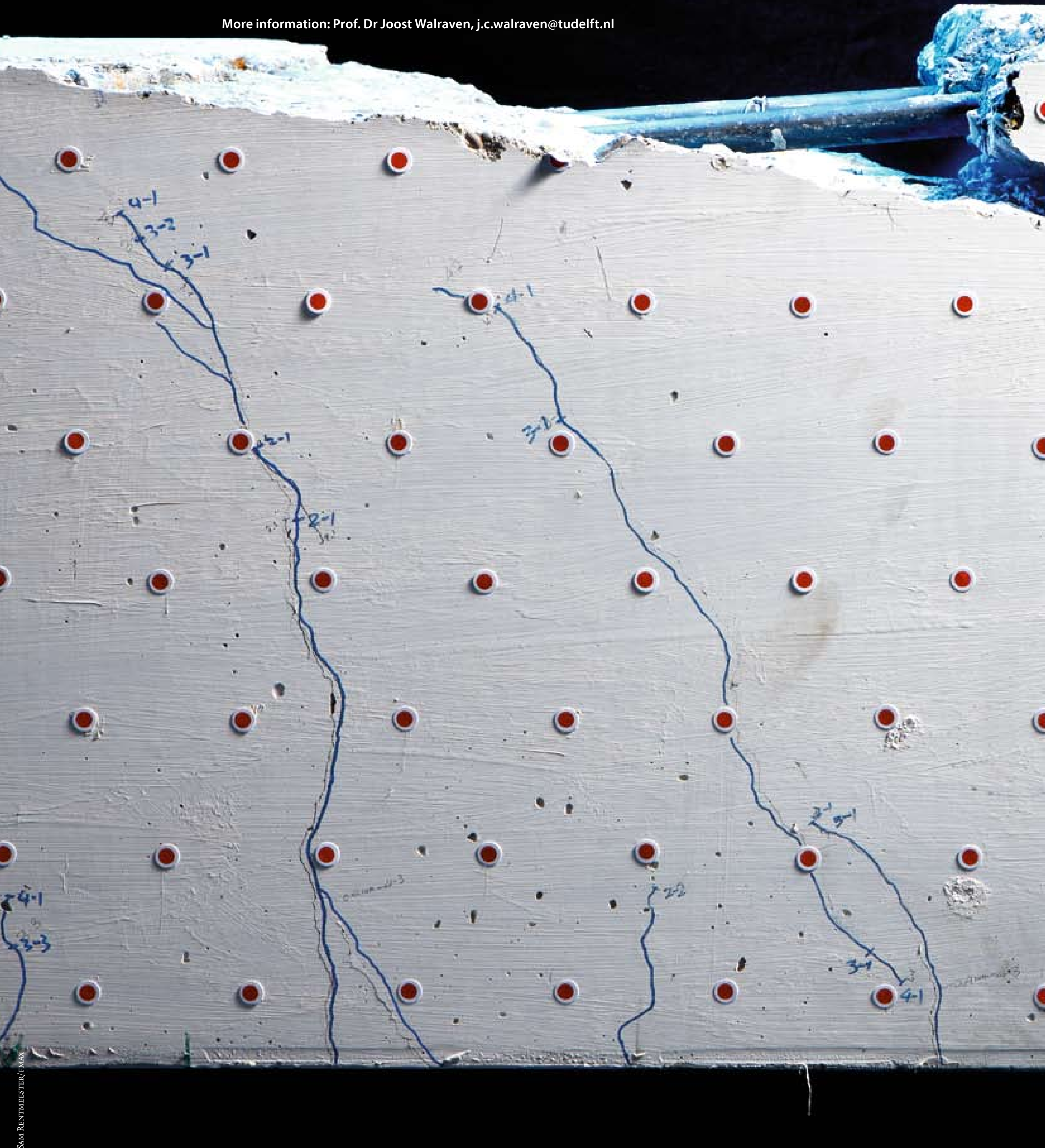
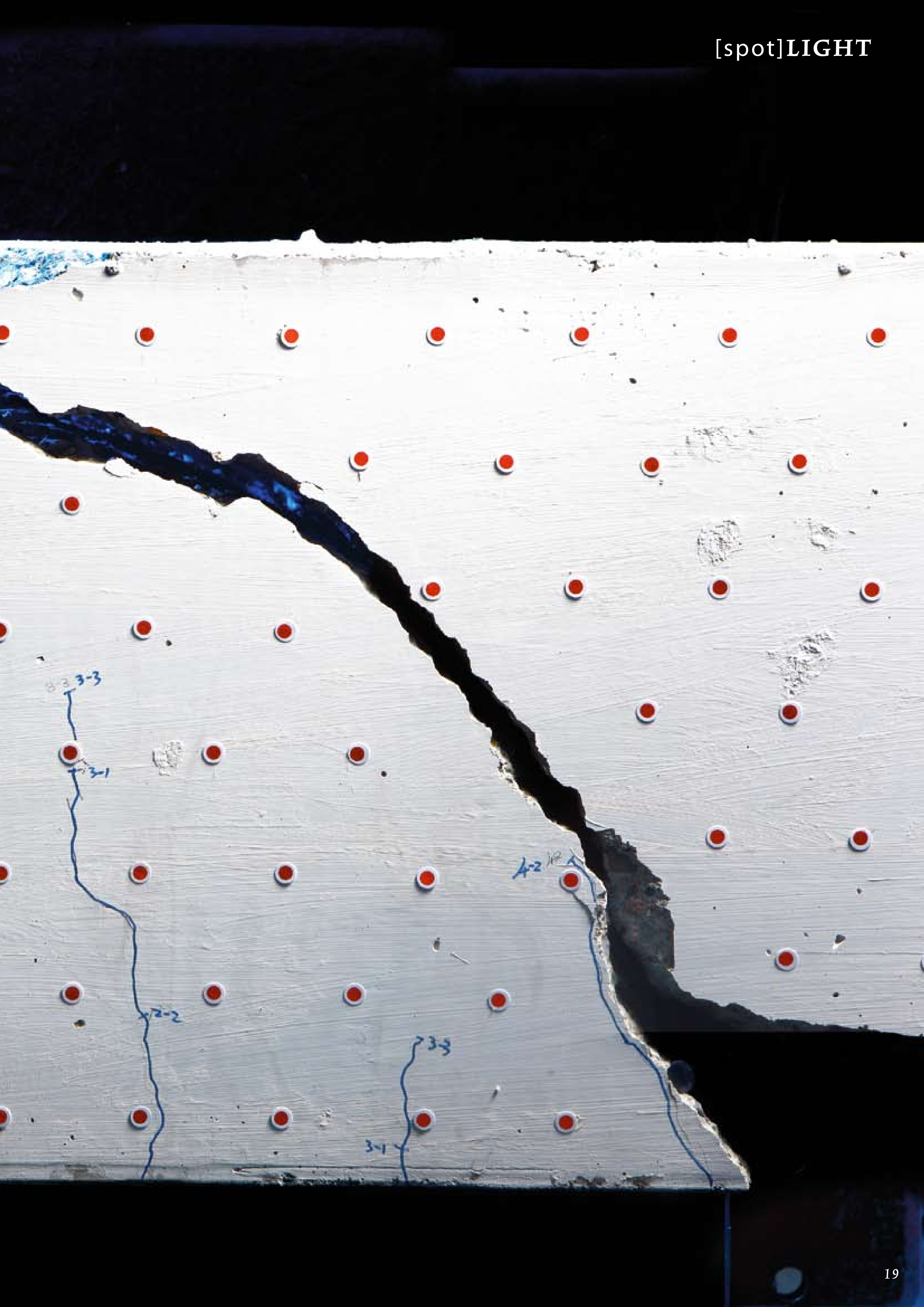


PHOTO: SAM RENTMEESTER/FMAX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# The new black gold

**Geothermal energy is rapidly gaining in popularity, thanks in part to ambitious climate goals and steep gas prices. TU Delft plans to pump up hot geothermal water from deep in the ground to heat the university's buildings.**

Tomas van Dijk

It is almost like a kaleidoscope: grains of sand in changing shades of white and grey light up and continuously create new colour patterns. To create this play of colours, mining engineering student, Douglas Gilding, has placed a wafer-thin layer of sandstone under a light microscope and simply changes the polarisation direction of the light source.

Back in 1953, this small piece of sandstone was brought up from a depth of two kilometres below the surface at a location near the fire department station on the Krakeelpolderweg in Delft. At the time, a Dutch gas joint venture (called the Nederlandse Aardolie Maatschappij (NAM)) was drilling at this site to determine if any oil or gas was present.

"This stone seems promising," Gilding says. "It has a porosity of 25 to 45 percent. Under the ground, all those holes in the stone were filled with water." He then places a piece of stone from a well dug near Moerkapelle (12 kilometres east of Delft) under the microscope: "Here and there you can see some traces of oil, which is a bit of a shame."

## Delft Aardwarmte Project

Not oil or gas, but rather hot water – that is the mineral increasing numbers of mining engineers and geologists are now searching for. As is Gilding. Two years ago, he and some fellow students devised a plan to determine if the hot geothermal water beneath the TU campus could be exploited to heat buildings. The students presented their plan, called the Delft Aardwarmte Project (DAP – or Delft Geothermal Heat Project), during the 115th anniversary of the Delft Mining Engineers Association. "We wanted to come up with something other than the usual building of a tower made of beer crates," recalls Gilding, who is now the secretary of the DAP Foundation. "We wanted to pull off a feat that would help make TU Delft more environmentally friendly."

Twenty mining engineering students have since devoted their graduation projects to the development of a feasibility study, and thanks to their collective research efforts TU Delft recently obtained an exploration permit from the Ministry of Economic Affairs. The university now has the right to search for geothermal heat in a 61 square kilometre area in the municipalities of Delft and Pijnacker-Nootdorp.

TU Delft's Rector, Professor Jacob Fokkema, a geophysicist himself, has embraced the project: "It's a wonderful showcase for sustainable energy right on our own campus." The students are working together with local commercial gardeners and produce growers that want to use the hot water to heat their greenhouses, and it is these companies that are the main driving force behind the current surge in interest in geothermal energy, or geothermics. Since mid July 2009, the Ministry of Economic Affairs has received around 50 applications for drilling permits, with many of these requests coming from commercial gardeners and produce growers in the Zuid-Holland region. This stands in sharp contrast to the preceding years, when the ministry received only a few such applications.

These local commercial gardeners were inspired by tomato grower, Rik van den Bosch, from Bleiswijk, who was fed up with the high and sharply flucuating prices of gas. In 2008, he was the first commercial grower in the Netherlands to extract geothermal energy. Van den Bosch had two wells drilled, each to a depth of nearly 1800 metres. One well is used to pump up 60 °C water, the other to drain off the water after it has cooled down to 30 °C. Pumping back the water is necessary to prevent subterranean friction in the stone layers.

*'DAP wants to experiment with a new drilling technology that uses tubes made of carbon composite instead of steel'*

Today, 150 litres of hot ground water is now flowing through the approximately seven hectares of greenhouses where Van den Bosch grows 18 million kilos of tomatoes each year. Thanks to these wells, he saves five million cubic metres of natural ▸▸


Photo: Nout Steenkamp/fmax

[Back]GROUND

gas a year, which accounts for 90 percent of his annual energy consumption. Van den Bosch expects to recover his 6 million euro cost of investment in five years.
TU Delft is also envisioning similar figures from its plans to pump up hot geothermal ground water. The university would thus be following an example set by a handful of geothermal housing projects started in the Netherlands in recent years. Elsewhere, other municipalities and housing corporations in the Netherlands are also keen on

*'We wanted to pull off a feat that would help make TU Delft more environmentally friendly'*

using geothermal heat. In October 2008, Heerlen, a city in the southeastern Netherlands, began pumping up hot water from abandoned mineshafts to heat newly built houses. And in The Hague, housing corporations and energy companies want to heat 4,000 new buildings and homes with the geothermal heat contained in a layer of sandstone.
The geothermology of heating homes and buildings is however more complex than for heating greenhouses. In countries like the Netherlands, where ground water temperatures are lower than 100 °C, generating electricity is too costly. For homes and buildings, the energy tapped from ground water must flow through an expensive installation equipped with heat exchangers.
'The main argument for heating buildings in the Netherlands with geothermal heat is environmental," says a press officer from Eneco, one of the energy companies involved in the geothermal water project in The Hague. "Drilling is expensive, and constructing the network is also expensive, because the tubes must be thicker than the gas pipes. Therefore, from a strictly financial perspective, you shouldn't do it. But the main advantage of geothermal heat is that no $CO_2$ is released during the entire process, except for a tiny amount that comes from powering the pump."
An important condition is that there must be purchasers in the vicinity of the hot geothermal water well. There must also be a power station nearby for the combined production of electricity and heat, as well as a network of pipes. In this respect, the TU Delft students seem to have had a stroke of luck: there will indeed be plenty of local consumers of geothermal energy in the near future.

The municipality wants to use an extensive network of pipes to heat newly built homes with the residual heat of nearby factories. "That hot water can be nicely supplemented with geothermally heated water," Guilding says. According to DAP's plan, a two-kilometre deep well will be dug close to TU Delft's cogeneration station on the Leeghwaterstraat, from where water with an expected temperature of nearly 80 °C will be pumped up. To make all this a reality, however, a partner must be found that is willing to exploit this energy source and cover the investment costs.
Eneco has expressed interest. "We're very enthusiastic," says Eneco's director of general affairs, Pieter Jan Witvliet, who hopes the project can be set up and executed in the coming year. Although Witvliet does not offer any firm commitment on Eneco's part, he does say that he's convinced "the project will take off."
Eneco is especially interested in DAP's plan to experiment with a new drilling technology, which involves using tubes made of carbon composite instead of steel, with the idea behind this being that since carbon composite is lighter than steel, drilling with carbon composite tubes will require a smaller drilling platform. "Drilling with steel requires a whopper of a drilling platform, and in crowded urban areas we often don't have the space to accommodate such platforms," Witvliet explains.

## Underground flows

TU Delft and DAP also want to study the underground hot water flows. Gilding: "We want to put lots of sensors in the well to measure the pressure and temperature and to map the water and heat flows."
TU Delft expects the Ministry of Economic Affairs to green light the planned geothermal explorations this autumn, after which drilling for hot water can commence. If the amounts of hot water prove to be as large as anticipated, a second well needed for exploitation could be drilled immediately afterwards.
The ministry's authorization for the exploration of the geothermal energy (granted this summer) was initially delayed because there turned out to be rivals in the field. The municipality of Pijnacker-Nootdorp had also requested permission to search for hot water sources, and a number of commercial gardeners in the area also have advanced plans in place for drilling. In July, however, the municipality of Pijnacker-Nootdorp decided to collaborate with TU Delft and DAP.
On his computer, Gilding studies a 3D image of subterranean Delft and its environs. Colored lines indicate the wells, although their exact locations remain uncertain. "That depends on the geological model we're developing of the substrata," Gilding explains. "To ensure we don't get in each other's

Photo: Sam Rentmeester/FMAX

way, we must predict exactly how the water will flow once it has cooled down and is being pumped back into the ground. And we must also map the pressures in the ground caused by the circulation of water."

Drilling in the wrong locations should, obviously, be avoided. The Delft sandstone – thusly named because the ground under the city is so rich with it – was deposited here by the rivers some 150 million years ago. River sandstone is however notoriously treacherous, because the continually meandering rivers often take 'bites' out of thier own, older sedimentation.

*'The geothermology of heating homes and buildings is however more complex than for heating greenhouses'*

"We must grasp the full complexities of the rivers," Gilding notes. "And that's why we're studying under the microscope the grains of sand that NAM had collected in this area. If the grains of sand are round, the river has probably transported them a long way. If they're angular, they've travelled shorter distances. Using this kind of data, we're trying to trace the history of the area."

The stones form a fantastic subterranean landscape. Tectonic plate shifts, as well as meandering rivers, have helped create subterranean mountains. The African continent, for example, collided with Europe before once again retreating. Such shifts have caused many ruptures in the ground.

"You're never 100 percent certain that you're drilling in the right layer of sandstone," says Jan de Coo, from Pan Terra, a geological exploration company. Pan Terra has analysed the underground for the two commercial gardeners in Pijnacker-Nootdorp, and for the tomato grower in Bleiswijk. His company is also supporting the DAP Foundation's investigations. De Coo: "In Bleiswijk, the nearest test well – the spot from which we can therefore know with certainty the stratification of the ground – was four kilometres away. Based on the data from that well and on seismic data, we make an educated guess about the situation underground.

"Many blunderers simply draw straight lines between the layers of stone detected during test drillings in the area," De Coo continues. "And that's dead wrong," adds his colleague, Wiebe van Driel. "To be able to determine the exact stone patterns, you must know during which sedimentation period the ruptures occurred."

The commercial gardeners, energy companies and geologists have nothing to complain about in this regard, the two researchers maintain. "Nowhere else in Europe is there so ▸▸

much information available about the condition underground," Van Driel says. "And that's due to the thousands of oil and gas drillings and test drillings that were done here in decades following the second world war."

Analysing drilling cores is part of Pan Terra's work. Oil companies are obliged to submit a representative selection of their excavated materials to TNO, an independent Dutch research institute. In a warehouse in Zeist, TNO has amassed more than 100 kilometres of drill cores, a TNO employee reveals.

## Cold fronts

DAP's geological model not only shows the different layers of stone, but also how the underground cold fronts will spread very rapidly once the wells become active. After a few decades, the cold water that was pumped back into the ground will once again have reached the suction points. Pan Terra says that by that time the water will be hot again. "It's generally assumed that after more than 30 years, and at a depth of 2000 metres and a distance of 1500 metres between the pumping up and pumping back locations, the cold water will have long since been reheated," De Coo states.

Gilding disagrees. "The water will not even be close to being reheated after 30 years. The calculations aren't yet finished, but that it will take more than 100 years is already certain."

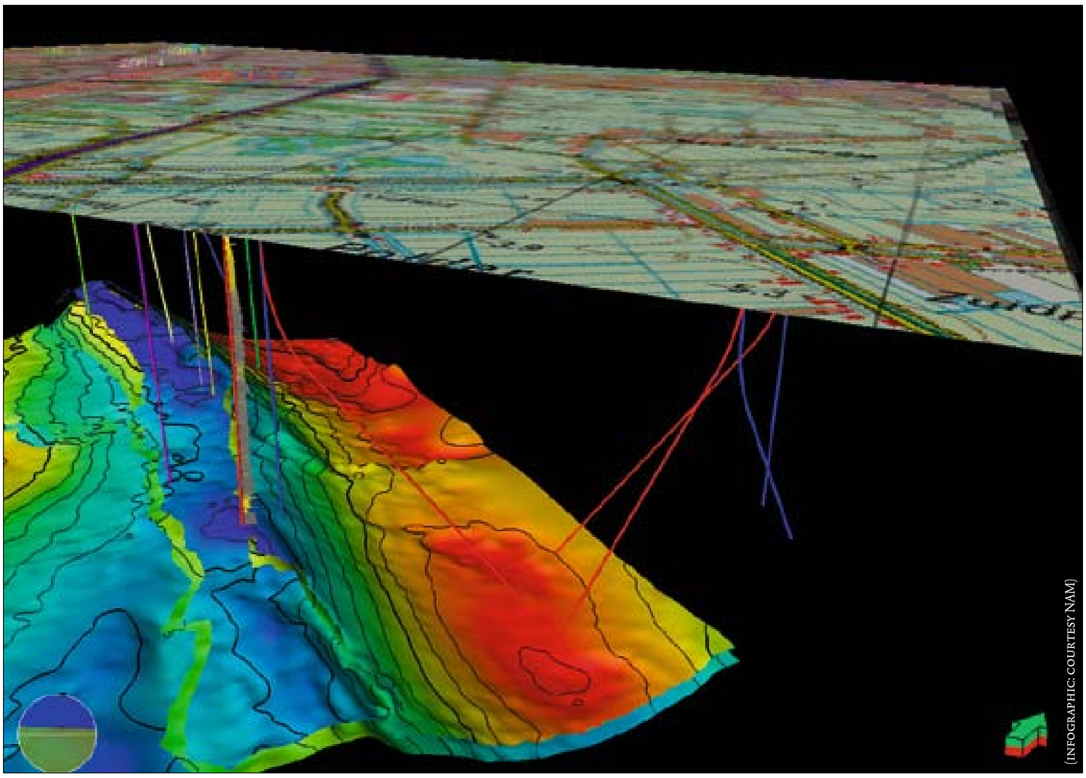
"In a sense, the geothermal heat we tap will not be an inexhaustible source of energy," Gilding says. "In 30 years time the TU will have to have ensured that it can also heat its buildings with 60 °C water."

Such scientific disagreements are however of no concern to the local commercial gardeners in the area; they'll be more than happy if they are able to pump up hot water for a few decades, Gilding and the researchers from Pan Terra maintain.

Leon Ammerlaan, a grower of tropical plants in Pijnacker-Nootdorp, confirms this. The Ministry of Agriculture has already granted Ammerlaan a 2 million euro subsidy to drill for geothermal water. "In ten years time, the land my business is on will probably be covered with newly built homes," he says. "At least that's what the municipality's development plan calls for." Long before then, however, Ammerlaan hopes to have recouped the roughly 4 million euro of his own money he has invested in the project.

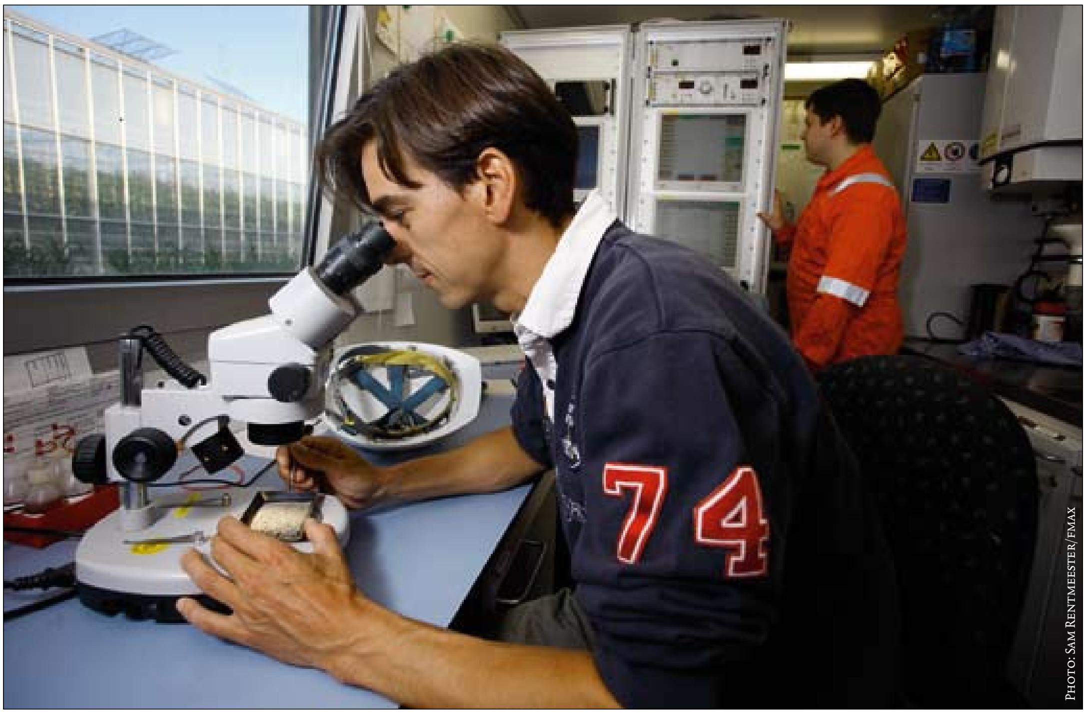
But for now, Ammerlaan is biding his time. He wants more financial security. He hopes that a Guarantee Fund, which the government promised to the commercial gardeners, will be expanded. The arrangement, which has yet to be approved by Brussels, takes as its starting point the so called P90. This is the amount of energy that – with a 90 percent degree of certainty – can be generated at a particular location. Pan Terra meanwhile has calculated that there is indeed a 90 percent chance that Ammerlaan's wells will deliver at least 60,000 litres of hot water per hour.

If these wells should turn out to be less profitable than expected, the government will pay Ammerlaan the amount of money he would then have had



(INFOGRAPHIC: COURTESY NAM)

Countless numbers of tubes currently extend into the ground under Delft. Most of these drilling tube-wells were made by NAM, as it searched for oil and gas reserves in the decades following the second world war. But it will soon become a lot more crowded underground. The red lines and blue lines on the far left show the possible configuration of TU Delft's tube system. On the right are the possible positions of those from local commercial gardeners in Pijnacker. The red tubes will pump up hot water from a sandstone layer located 2.2 kilometres underground. The blue tubes will pump the cooled water back to a depth of 2 kilometres.




Geologist Julien Smeulders: "I encounter the strangest things"

to spend on natural gas. But Ammerlaan does have to assume 15 percent as personal risk and he must also pay a premium. "It boils down to this: I could potentially incur a loss of 660,000 euro," he concludes. "I don't have that kind of money in my back pocket. With such a guarantee in place, no one will be willing to drill."

## Fossils

Tomato grower Van den Bosch isn't waiting around for a guarantee fund. He has acquired a taste for drilling for hot water. At his second nursery in Berkel en Rodenrijs, a 15 metre high drilling platform towers above a sea of greenhouses. Hundreds of drilling pipes are neatly stacked up next to a small path leading to the construction site, where workers from a German drilling company are busy preparing for the last major phase in the drilling process.

The well they have drilled so far extends downwards some 930 metres to a sandstone layer dating from the Cretaceous period, and they have only about one more kilometre to drill, but this will be through a few notoriously sticky layers of clay dating from the time when the western Netherlands was one huge swamp. Only then will they have hit the jackpot: a thick layer of Rijswijk sandstone containing 70 °C water.

"This sandstone came into existence when this area was just sea and sandy shorelines," says TU alumnus Julien Smeulders, who works as a geologist for Petrogas Minerals International, the company supervising the drilling. "It's much more equally distributed than the Delft sandstone, which reduces the chances of drilling in the wrong place. This layer does however lie a couple of hundred metres higher, so it's also not as hot, but still, 70 °C is more than enough for the greenhouses."

During the drilling, Smeulders lives in a mobile home next to the drilling platform. "The drill makes a quiet humming sound when it's going through easily penetrable earth layers. With that noise in the background, I sleep well. But as soon as the drill shudders, I'm wide awake. We then bring up samples to see what kind of layer we're drilling in and what exactly is going on below."

Although Smeulders is foremostly a mineral

*'In a sense, the geothermal heat we tap will not be an inexhaustible source of energy'*

researcher, all the other natural history information brought to light during the drilling does make his heart beat faster.

"I encounter the strangest things," the earth scientist says. "I've found fossils of foraminifera, small sea creatures that were never before known to be found in those stone layers. It's fantastic. You learn so much about these small creatures and the climate here at that time."

"Ultimately, we'll drill in dozens of locations in this area," Smeulders continues enthusiastically, "and later perhaps also in other parts of the Netherlands. In the eastern part of the country there are locations where you can drill into stone dating from the Carboniferous period, which began almost 300 million years ago. And in Assen we might even be able to pump up water from layers dating from the 450 million year old Ordovician period. We also know very little about these layers in the Netherlands."

# The cover stars of Nature and Science


**For the nano-scientists at the Faculty of Applied Sciences, having their articles published in prestigious journals like *Nature* and *Science* is no longer all that special these days. The TU Delft physicists have been publishing virtually non-stop in what are regarded as the best science journals in their field. Landing a cover story however remains an honour that merits some extra effort.**

Frans Godfroy

How times have changed. Twenty years ago the ultimate accolade for any physicist was to be published in *Physical Review Letters*. Up until the early 1990s, *Nature* and *Science* were deemed irrelevant. Dr Nynke Dekker, professor of single-molecule nanoscale at TU Delft's Faculty of Applied *Sciences*, cites as an example the publication history of Professor Hans Mooij, who forged his career during the 1980s and early '90s. The highly productive Mooij is regarded as an important predecessor of the faculty's current generation of nano-scientists. Yet his name is attached to no more than three articles published in *Science* and four in *Nature*. By the time his first article appeared in *Nature* in 1994, Mooij had already published more than 100 influential articles elsewhere. Dekker: "Of course he would have had even more publications in *Science* and *Nature* if those journals had been considered important at the time." *Science* and *Nature* used to focus mainly on subjects in the field of biology. Dekker recalls that in 1994, when she was a student, the University of Leiden's laser physics group had an article published in *Nature*, yet the journal wasn't even listed on the physics faculty's official list of publications.

## Tips & tricks

To get articles published in *Nature* or *Science*, authors need to overcome two major hurdles: the editors and the reviewers. The first hurdle already sets the bar fairly high, since the number of articles submitted for publication far exceeds the number that reviewers can cope with. Scientific quality offers no guarantee. The editor who must accept or reject the submissions spends an average of 15 minutes on each article. He just looks at the title, the accompanying graphics and reads the summary. That's it. Based on this summary review, the editor then decides to send or not to send an article on to the reviewers.

Generally, editors have only have a vague idea of an article's scientific merit, but they do sharply assess whether the article's subject is sufficiently trendy and the accompanying images sufficiently eye-catching. Editors must also weigh the variation in subject matter, and this is the point on which three out of every four articles get rejected.

It is exceedingly easy for authors to trip over the first hurdle. Professor Dr Leo Kouwenhoven, of the Faculty of Applied Sciences, is one of the faculty's leading authors. He says a certain deftness is required in the approach: "If you submit a badly written article, whatever its scientific merits it won't get past the editor." When a group at the Applied *Sciences* faculty tries to get published, Kouwenhoven is often the one who writes the final text in '*Nature*-speak'. "There won't be a single sentence left intact, and the final text will often be much shorter," he explains. "The text will have also become much more general, less aimed at fellow professionals and more focused on the underlying concept rather than on the exact technology."

Kouwenhoven has no problem with the idea of using tricks to increase one's chances of getting past the editor. "You can insert some remarks into the story that trigger the editor," he continues. "Even if the reviewers subsequently say that you cannot make such claims, it makes little difference. The reviewers will focus on the content."

If an editor decides not to send an article on to the reviewers, lodging an appeal may help, as it did for Nynke Dekker, who, in 2007, refused to accept a *Nature* editor's rejection of an article written by her research group on the development of tumour-inhibiting drugs. The editors agreed to take another look at the article - a process that took two months. When the article then got the green light and was passed on for review, within a week the reviewers reported that they loved it. In July 2007 the article was published in *Nature* as a cover story.

Whereas editors can still be coaxed, reviewers tend to see through such tricks, Kouwenhoven notes. He believes there is very little chance of sneaking a weak article past the reviewers, and consequently this happens rarely.

## Distorted view

The opposite however happens more often. Much top-level scientific research never makes it into the pages of *Science* and *Nature* for any number of reasons. Chief among them is that a particular subject does not appeal to a wider readership. Nano-research is a hot item these days. But if you're working in an applied science like civil engineering or design theory, you're out of luck. However, like nanotechnology, applied life sciences and medical research are also always well received.

Another trigger for rejection is if an article's content is too abstract; consequently, theoretical physics are rarely given space in these journals. Moreover, the spirit of the times may also work against a researcher. The fawning interest editors showed in the 1980s for subjects like nuclear physics and geology (oil) has somewhat abated today.

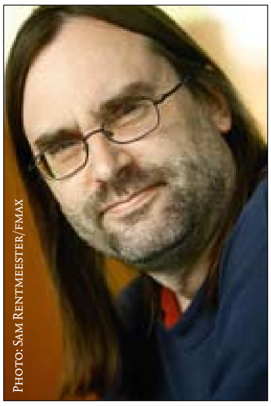
Some scientific breakthroughs do not make it into print in *Science* or *Nature* because the researchers themselves are indifferent. As an example, Nynke Dekker cites the renowned physicist, Michael Berry. "He always published in the *Proceedings of the Royal Society of London*. He couldn't have cared less. But then he was good enough that everyone read his articles anyway."

Once you make it into the upper echelons of leading authors, things suddenly become much easier. Kouwenhoven: "If a famous scientist submits ▸▸


Prof. Dr Nynke Dekker

[looking]BACK

Prof. Dr Leo Kouwenhoven




Dr Bert Vermeersen

an article, the editors benefit from publishing it, because that issue of the journal will have much more impact. These famous people are often invited speakers at conferences, they're more prominent. Other people read their articles more closely and will also refer to them more often because they're regarded as having a higher status. And so the rich grow richer and the poor poorer." According to Kouwenhoven, who himself has now joined the ranks of 'the rich', this results in a biased view: "Just suppose that articles were submitted anonymously. If that were the case, the process of selecting articles would certainly be different."

He is however somewhat reassured by the fact that these selection mechanisms do also come under discussion in the journals themselves, and this provides some level of reassurance that the editors cannot easily stretch the standards too far. Kouwenhoven: "If it became generally known that they were fiddling with the ethics of publishing, they would dig their own graves."

## Cover stars

The real fun starts when an article is chosen as a cover story, which happens a couple times a year at TU Delft and is always celebrated with cake for all one's colleagues. Sometimes the articles involve others, the primary authors, with whom TU Delft researchers have collaborated. This is how Dr Bert Vermeersen and Dr Riccardo Riva of the Faculty of Aerospace Engineering hit the bull's-eye last May; they had helped two British earth scientists with satellite observations that served as the basis for revised conclusions about the effect that melting Antarctic ice caps will have on global sea levels. The cover of *Science* presented its readers with a view from space of the research area in western Antarctica, in which different colours were used to visualise the various sea level effects.

Vermeersen regularly publishes in specialist publications, such as *Geophysical Journal International* and *Geophysical Research Letters*. He had submitted articles to *Science* and *Nature* in the past, but they never made it into print. Needless to say, he is "hugely delighted" to have made it this time around, although he is quick to put his success into perspective: this certainly wasn't his best story ever. Vermeersen: "This was a peripheral avenue of our research that we had worked on for a couple of weeks, and which isn't all that new. So making the cover was a real bonus for us, because we didn't actively try to. The proposal came from the editors of *Science*."

At the Faculty of Applied Sciences though, researchers do actively seek to publish cover stories. For a cover submission, Kouwenhoven and his staff first spread back issues of *Nature* across a table, in order to get an impression of what a cover should be like. Sometimes they will submit one of their own photographs of actual observations, to which attractive colours have been added, and at other times they will hire a graphic design company to produce a cover image. The designers, who charge 1,000 euro for such cover design jobs, use shadowing and other special effects to spruce up the image. Kouwenhoven: "In economic terms, one thousand euro is next to nothing if it gets you onto the cover of *Nature*."

Inside information can also give authors an edge


Prof.dr. Cees Dekker

### Publicity machines

The broadening of the scope of *Science* and *Nature* in the early 1990s to include physics was nothing short of revolutionary, as it has also proven to be for the nano-scientists at TU Delft's Faculty of Applied Sciences, who started publishing articles in those two leading journals in 1994 and haven't stopped since. *Science* and *Nature* offered the advantage of guaranteeing a larger readership and wider scope than the old familiar journals. Both publications, one commercial (*Nature*), and the other non-profit (*Science*), knew exactly how to utilise the increasing importance of public relations and marketing in the world of science. They also gave priority to image editing, which went well with the trend towards advanced optical research and the ever-increasing availability of technical means of visualising unobserved phenomena. The two publications were thus able to evolve into the most influential publicity machines for physics and the life sciences.

*Science* is published by the American Association for the Advancement of Science (AAAS), with every association member automatically becoming a subscriber, which explains why *Science* has a much larger circulation than *Nature*. The AAAS estimates the number of *Science* readers at one million. The Nature Publishing Group (NPG) is an American publishing company that focuses on roughly the same international readership as *Science*. NPG has followed a clever strategy, launching dozens of subsidiary titles that over the past 20 years have enabled the company to add specialist readers in separate scientific fields to the more broadly interested readers they were already serving. The NPG currently publishes about 85 scientific journals, including 35 that carry the *Nature* name and an added subtitle on the cover. Researchers at TU Delft primarily publish in *Nature Nanotechnology, Nature Materials, Nature Physics, Nature Biotechnology*, and *Nature Genetics*.

The fact that a single commercial publisher controls so many titles could be interpreted as an undesirable monopoly, but in actual fact it benefits the authors. Sometimes an article – despite its positive reviews – simply cannot be fitted into the main publication. When this happen, the article in question may then be sent to the editors of one of the subsidiary publications, in which case there is no need to find new reviewers, meaning the authors therefore have a much better chance of getting published than if they had to find another publication and go through the entire submission-review process again.

when battling the competition, and Kouwenhoven remembers how he once used this to good effect: "About ten years ago I knew some people working at the journal, and so I knew something about how they selected their covers. The cover submissions are all laid out on a big table, then the cover editor – usually a woman who knows a good thing when she sees it – comes in, looks them all over, and says, 'This one!' I was sufficiently up on the latest office gossip to hear in advance who would be doing the selecting and to learn that she loved the colour turquoise. So we changed everything to turquoise. And that was the one they picked."
It's not all about artistic quality though; impact is at least as important. Kouwenhoven: "We also had an article in the *Nature* issue that had the Mars rover on its cover. There was no way our cover was going to compete with that."

> *'Then in comes the cover editor – usually a woman who knows a good thing when she sees it – and she says, 'this one!"*

Nynke Dekker warns against overconfidence: "As a scientist, you can only go so far. If you give the impression that you keep sending in cover articles that don't have the solid science to back them up, that can be dangerous. You'll very quickly gain a reputation as someone who can make pretty pictures but is actually selling hot air. You can expect people to react accordingly. If your article then proves to have some weaknesses in it, you really have a problem."
In 2003, Professor Cees Dekker learned firsthand how easily a cover can open one up to criticism. In a letter to *Nature*, Julio Ottino, an American professor, reproached Dekker for having published an overly artistic representation of a nano-circuit on the cover of a previous issue: the atoms of gold that interact with the nanotubes shown on the cover were missing from the picture. Dekker however managed to adequately defend himself against the criticism, for the question still remains as to how those gold atoms should be drawn. "You cannot simply draw little gold balls," Dekker explains. "Electrons in gold and nanotubes are spread out over many atoms, so you end up with a more or less smooth surface. So, in this case, the illustration showed a schematic representation of the nanotubes as smooth tubes with a hexagonal structure - which itself is made up of atoms - and gold with a smooth surface." All of which is why, in fact, Dekker had included 'artist's conception' in the controversial picture's caption.
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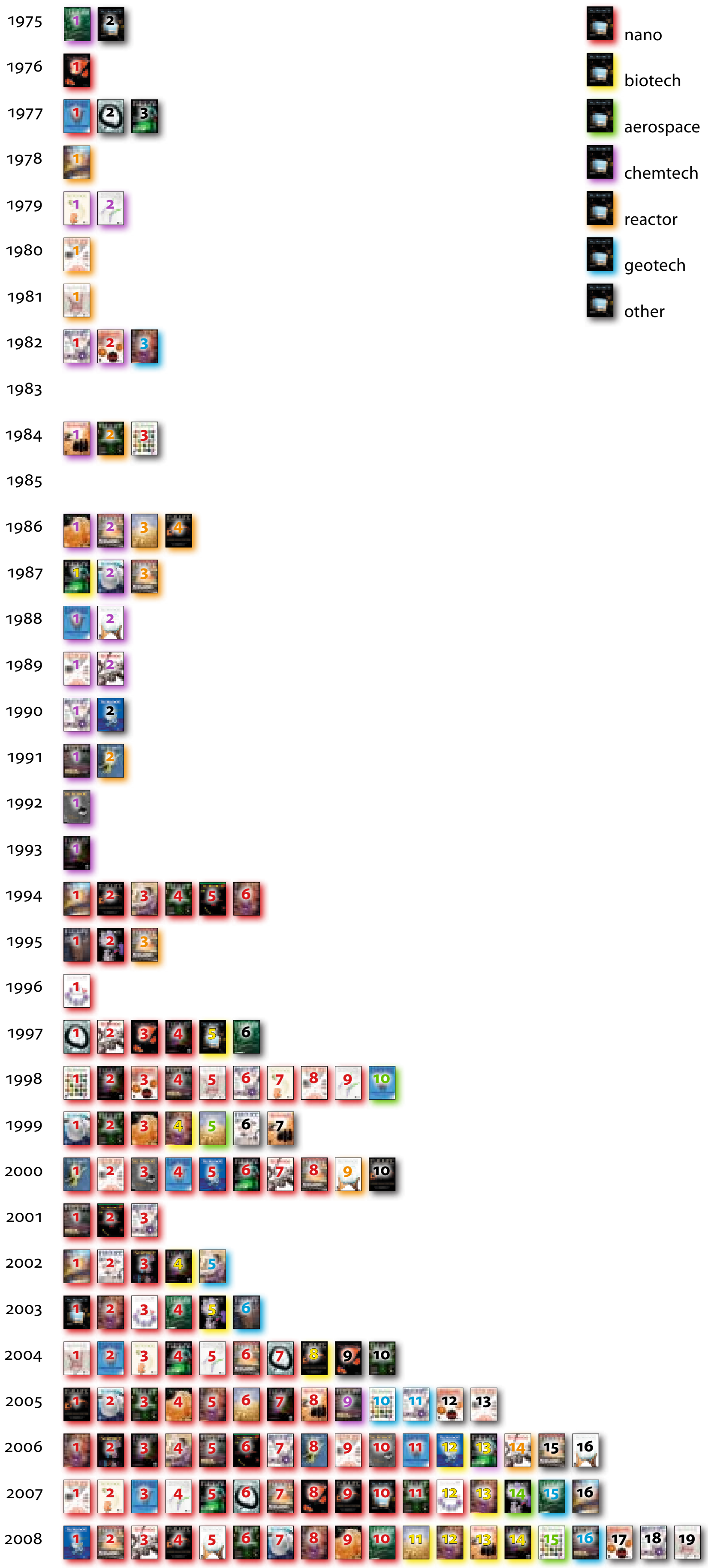
**TU Delft articles published in *Science* and *Nature* (including subsidiary journals) since 1975**



Photos: Sam Rentmeester/FMAX

# Prof. Dr Urs Staufer

*'I always want to know more. No longer about everything, but indeed more'*

# Dedicated

Prof. Dr Urs Staufer was born in Basel (Switzerland) on 3 July 1960. From 1967 to 1979, he completed his primary and secondary school education. In 1980 - after completing a year of military service - he began his undergraduate studies in physics, mathematics and philosophy at the University of Basel. Staufer graduated in 1986, with a specialism in the experimental physics of solid matter. In 1990, he received a PhD degree from the University of Basel for his research in the building of nanostructures with the aid of a scanning tunnelling microscope. From 1990 to 1997, he conducted research in miniaturisation of the electron microscope for IBM in Yorktown Height (USA) and the University of Basel, and in Basel on the production of electronic components for microscopic research. During the subsequent ten years, he developed a tool at the University of Neuchâtel for conducting research on the nanoscale.He has been a professor of micro and nano engineering at TU Delft's 3mE faculty since 2007.

Erik Huisman

In the **Mastermind** series a professor and a (former) student each answer the same questions to create a double portrait.

### How would you describe your research in layman's terms?

Staufer: "When you're dealing with matter, effects occur on the very small scale that do not occur on the large scale. The surface-area ratio differs, and hence also the stability of the structures. An apt comparison for this would be the difference between the legs of a mosquito and those of an elephant. We study the scale effects."
Heuck: "We're building a microscope that differs from the standard atomic force microscope (AFM). An AFM scans surface areas on a nano-level, like a blind man uses a stick to feel his way through his surroundings. For our microscope, we're developing a hollow, stick-like nanotool or probe."

### How is this useful?

Staufer: "When you're dealing with scale effects, you can discover new solutions to technological problems or medical challenges."
Heuck: "Using this hollow stick, we're able to spread liquid in a way that, for example, opens a 'door' in a cell membrane, allowing for interaction to occur between the cells or matter."

### How would you characterise the other person?

Staufer: "Friedjof is very sharp, positive, inquisitive, and extremely self-motivated."
Heuck: "Urs has a broad range of interests, both professionally and personally. He's extremely dedicated. If you ask him something, he always carefully considers the question before giving you not only an answer to your question, but also insights into other related issues. As a supervisor, he's committed to your personal development."

### What is distinctive about the other person?

Staufer: "His level of intelligence is very high indeed. I regard him as an equal partner in discussions. He's also completely fascinated by science, yet also flexible, and he has interests outside of science."
Heuck: "Urs always has time for you, even when he doesn't. He also gives you a great degree of freedom, while also ensuring that we have more than just a nice place to work. He's also an uncomplicated person. When I first arrived in Delft and hadn't yet found an apartment, he said: "No problem, you can stay at my place."

### Name two things you have learned from the other person?

Staufer: "There's a twinkle in his eyes when a new path forward opens up. His ability to enjoy his many sporting activities. I admire that. And it's not something that's easy to learn or to start doing yourself, although I'm trying my best."
Heuck: "Patience, which I'm still working to develop. First, take your time, then take a step back in order to study the issue more comprehensively and in greater

# Friedjof Heuck (MEng)

*'I'd be a terrible snowboard instructor'*

# SHARP

Friedjof Heuck (MEng) was born in Munich, Germany, on 30 November 1980. From 1986 to 2000 he completed his primary and secondary school education. He completed his mandatory social service from October 2000 to August 2001. In October 2001 he embarked on his undergraduate studies in microsystems engineering at the University of Freiburg (Germany), graduating in April 2006. From September 2006 to December 2007, he conducted doctoral research at the University of Neuchatel (Switzerland). In January 2008, he continued his research at TU Delft. He hopes to receive his PhD degree in June 2010.

depth, and then take your decision. And also giving people the freedom to find their own way. I'm too quick to say that if you take this step, you'll reach your goal. Urs, on the other hand, says: this is where you are, this is where you want to go, now go search for the way to get there."

### What is the essence of a good teacher-student relationship?

STAUFER: "There are three stages. In the first stage, you introduce the student to the subject, preferably by posing a problem that needs to be solved. The student uses the available knowledge to do this, but will also ask questions when he doesn't know the answers. This is how a teacher elevates the student to the same level of knowledge of a particular subject. Then stage two begins: the scientific discussions. The student proposes solutions and ways to achieve them, while the teacher offers insights based on his broader range of knowledge. This enables the student to devise solutions independently. And then comes the third and final stage, when the student is now more knowledgeable about the particular subject than the teacher."

HEUCK: "Having a teacher who gives you freedom, and whom you can ask for help when you're stuck – at such times his door is always open. A student must approach the field of research like an inquisitive child, with an open mind and spirit. Of course you'll make mistakes, but not the same ones twice. A PhD is not about achieving results, but rather about the learning process; this is a time when - in addition to your specialist subject - you must also learn as much as possible about other issues and processes.

### Is that the case for you two? Or do you sometimes have conflicts?

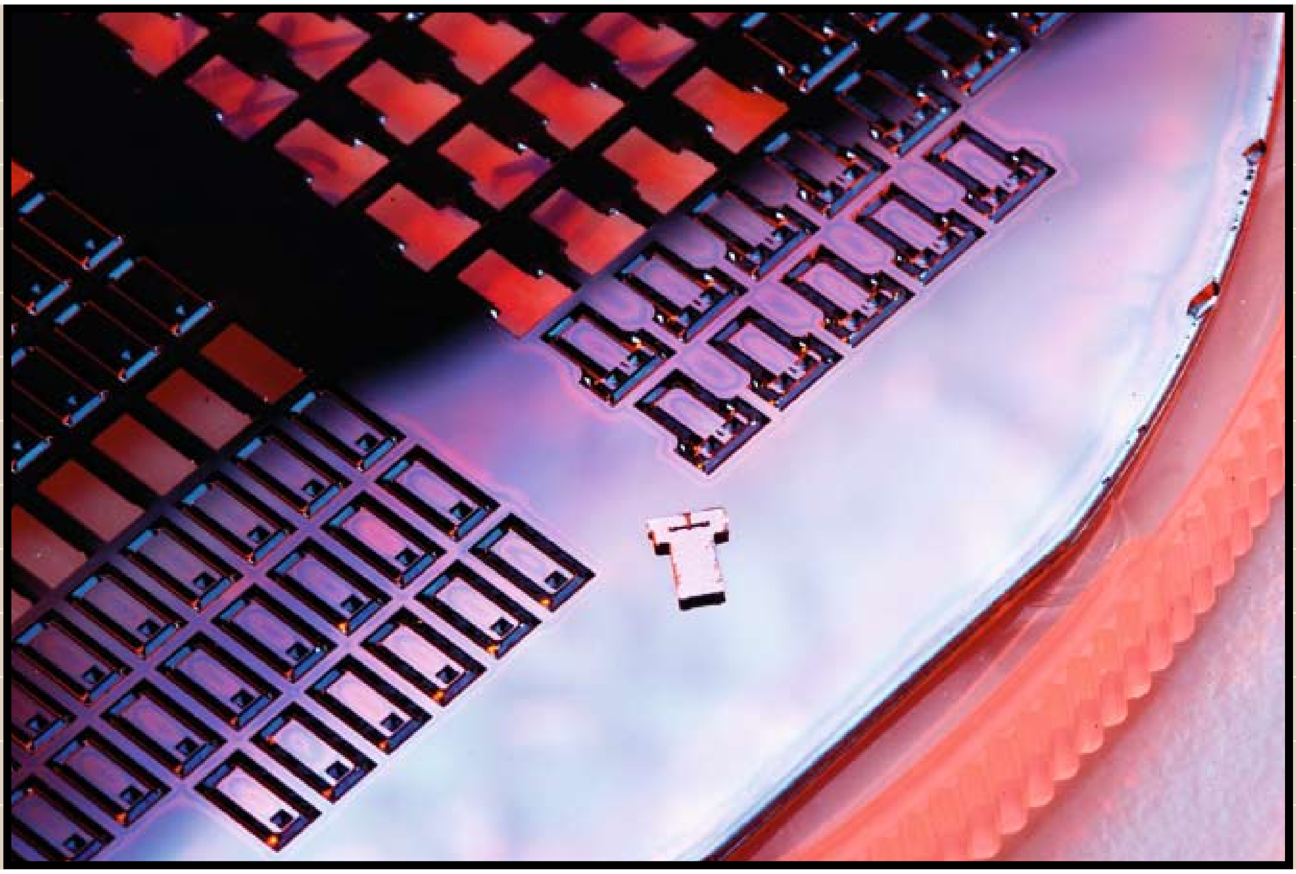
STAUFER: "With Friedjof, there is never conflict. That's not to say we have the same solutions for everything, but when we don't, we discuss the matter. As the teacher, I sometimes must hold myself back, because even if a particular problem was my baby, I gave it to him, and therefore I must also give his ideas a chance to provide the solution."

HEUCK: "Our biggest problem is expectations, when you expect something from him that he doesn't know. Real sparks never fly: he is after all the teacher. If we're having a discussion and I think I'm right, I'm never offensive or aggressive, but rather reconsider the issue and then explain my position again."

### Do you have a father-son type relationship?

STAUFER: "Yes, if you look at it in terms of nurturing and educating. The development from not-knowing to knowing, which I went through myself, is extremely gratifying. It's great to be able to contribute to this process in another person. And I of course then go through the process again myself."

HEUCK: "I don't know him well enough on a personal level to say if that is an accurate comparison. He is my mentor though, and I do benefit greatly from his scientific knowledge and know-how, and from how he leads his section, which I compare to other mentors." ▸▸



*Marital status*
Staufer: Married
Heuck: Engaged

*Favourite book*
Staufer: *Small world* by Martin Suter.
Heuck: *Brighter than a thousand suns: A personal history of the atomic scientists* by Robert Jungk.

*Most impressive book*
Staufer: *The Nature of Technology: What it is and how it evolves* by W. Brian Arthur.
Heuck: *The Forty Days of Musa Dagh* by Franz Werfel.

*Favourite newspaper and magazine*
Staufer: *NRC Next*
Heuck: *Die Zeit*

*In which historical period would you have liked to have lived*
Staufer: The present.
Heuck: In the age of the Greek philosophers.

**Can you recall a particular stroke of good or bad luck?**
STAUFER: "That all my teachers were good teachers. And what's more, that they all had positive attitudes. That is good luck."
HEUCK: "In my private life, I was once in the Mt Everest region and it rained for days. Just before the weather cleared, we caught our flight back home. If not, we would've had to climb for three more days. Professionally, I once accidently left air in a tube, and that turned out to be the solution for getting two silver electrodes on each end of the tube. And this was indeed a lucky break, because I had previously been focusing on using a method involving light."

**What is the other person's best characteristic?**
STAUFER: "He knows exactly what he can and cannot do, and in the latter case he isn't afraid to ask for help. This makes him extremely reliable: know what still needs to be done, how long it will take, and if he can provide what you ask for."
HEUCK: "His ability to listen."

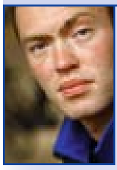
**And the worst?**
STAUFER: "That he finds it difficult to say no when colleagues ask him for something. He always wants to help, and I also think he feels obligated to."
HEUCK: "I think he doesn't make enough time for himself".

**What is something peculiar about the other person? And about you?**
STAUFER: "For Friedjof, it's the incredible enjoyment he gets from physical activities, like canoeing, mountain climbing or skating. He's totally into it. For me, it's that I always become further immersed when I concentrate on something. I want to be best, and it's difficult to feel satisfied. I always want to know more. No longer about everything, but indeed more.'
HEUCK: "Urs always eats carrots. And for me, it's that I lose myself when I'm inline skating or snowboarding. I leave everything behind me and become engrossed in the speed, the power, in attacking corners and falling to the ground. I'd be a terrible snowboard instructor."

**What contributions has the other made to your research area?**
STAUFER: "If Friedjof succeeds, he will have developed an instrument that we can use to conduct important biological research on cells. Over time, he can make many more contributions as well, thanks to his inquisitiveness and knowledge of micro fabrication and physics."
HEUCK: "No longer having to steer an AFM to Mars. Urs was fortunate enough to have co-steered the AFM, it landed, Urs could control it and he got results."

**What can we still expect from your research area?**
STAUFER: "To the general public's increasing frustration, too few of the promised developments in nanotechnology have thus far emerged. This field of science is still in its early stages. We're developing a new technology. We're taking steps in right direction, but it will still be quite some time before the promises can be delivered."
HEUCK: "I hope to have been able to develop a practical method for spreading liquids via the AFM. This would allow us to change surfaces on the nanoscale, and to monitor this. An example would be repairing breaks in a connection."

An overview of the most important awards, appointments and other remarkable personal milestones at TU Delft



On May 20, civil engineering student **Erik Ravenstijn** became the youngest Dutchman ever to reach the summit of Mount Everest, a feat he achieved after three years of intense preparations. Last year however his historic climb was put in jeopardy. Ravenstijn and his team of fellow climbers had planned to scale the mountain from the Tibetan side, but when riots broke out in Tibet the Chinese authorities denied them access.

**Prof. Dr Luuk van der Wielen** and his Dutch and international colleagues have launched the Global Biorenewable Research Society (GBR Society). The GBR Society aspires to become an authoritative, international network organisation, similar to the International Panel on Climate Change. The GBR society will focus on biofuels and other renewable materials, including bioplastics. Van der Wielen was appointed chairman of this new independent advisory body, which will provide governments with requested and unrequested advice. Among the 13 institutions participating in this network are the Netherlands' Kluyver Centre and B-Basic, the US's Energy Biosciences Institute, and the UK's Imperial College and University of Cambridge.

**Prof. Dr Joost Walraven,** of the Faculty of Civil Engineering and Geosciences, has been awarded an honorary doctorate from the University of Kassel in Germany. Walraven received the honorary doctorate for his many years of research and extensive knowledge in the field of concrete structures. According to the University of Kassel, Walraven's excellent scientific research and involvement in international commissions have made important contributions towards the recognition of concrete as one of today's most innovative and successful building materials.

Are there ways to prevent cars that merge onto roadways from causing traffic jams? For the next two years, **Victor Knoop**, from the Faculty of Civil Engineering and Geosciences, will study this question at the University of Lyon, in France. He is one of 34 promising young researchers who recently received a Rubicon grant from the Netherlands Organisation for Scientific Research (NWO). A Rubicon grant offers researchers who have recently received their PhDs an opportunity to gain up to two years of experience at a renowned international institute. Mathematical engineer, **Jan Maas**, from the Faculty of Electrical Engineering, Mathematics and Computer Science, also received a Rubicon grant. He will head to Germany's Hausdorff Center for Mathematics, where he will study how diffusions can be described mathematically.

In July, MSc student **Kartik Kumar** received a grant from NWO's Mosaic Programme for young talented graduates of non-Dutch origin. This 200,000 euro grant will enable him to pursue a four-year PhD programme. In 2006, a mysterious blue ring and a moon following a strange orbit around Uranus were discovered. Kumar intends to model the interaction between the ring's tiny ice particles and the moon. In December 2008 he received an award from the Netherlands Association of Aeronautical Engineers for his thesis, titled 'Weak Capture and the Weak Stability Boundary'.

For the NS, the national Dutch railway, **Frank Pijnenborg** and **Robbert Weijers** proved to be a major headache. Last summer the two students from the Faculty of Technology, Policy and Management built a website - nstrakteert.nl - that tracks every NS train delay, making it easier for customers to request refunds, even if those customers had not been passengers on the delayed trains and entitled to refunds. Pijnenborg and Weijers won first prize in the competition, 'Are you better than Microsoft?', organized by Tam Tam, an internet company. However, after the NS threatened legal action, the students adjusted their website.

**Adriaan Beukers**, professor of composite materials and structures at the Faculty of Aerospace Engineering, was awarded the 2009 UFD-Leermeesterprijs during a ceremony to mark the official opening of the new academic year. This prize is awarded annually to a TU Delft staff member who excels in teaching, conducting leading research, and valorising his/her knowledge and expertise. Beukers' prize included 15,000 euro and two plane tickets for a sabbatical abroad.

In June, a committee headed by TU Delft president, **Dirk Jan van den Berg,** presented its plan for an Institute for Global Justice, to be located in The Hague. This new institute, which will work closely with Leiden University and have a scientific staff of around 25 researchers, aspires to become a world leader in the area of justice, peace and international security. Former US Secretary of State, Madeleine Albright, will be a member of institute's international supervisory board. In his position as committee chairman, Van den Berg was not representing TU Delft.

**Prof. Karel Luyben** has been appointed the new Rector Magnificus of TU Delft, effective as of January 1, 2010. Luyben has served as the dean of TU Delft's Faculty of Applied Sciences since April 2008. On September 1, 2009, Prof. Dr Raoul Bino was appointed to replace Luyben as the dean of the Applied Sciences faculty. Luyben will succeed Prof. Dr Jacob Fokkema, who has served as TU Delft's Rector Magnificus since January 2002. Luyben studied chemical technology at Eindhoven University of Technology, before moving on to conduct research at Wageningen University. He later worked briefly as a contract researcher with Bayer in Germany and Cehave in the Netherlands. In 1983 he was appointed professor of biokinetics at TU Delft, where, in 1988, he was appointed professor of bioprocess technology. In 1984, Luyben was appointed chairman of the TU Delft-Leiden University joint venture in biotechnology, and, from 1993 to 1999, served as the scientific director of the Delft-Leiden Biotechnological Sciences Graduate School resulting from this joint venture.

[PEOPLE]

HORA•EST

# Propositions

It is more difficult to predict the global economic crisis than to predict the message in a Chinese fortune cookie.
*Hao Li*
Biotechnologist

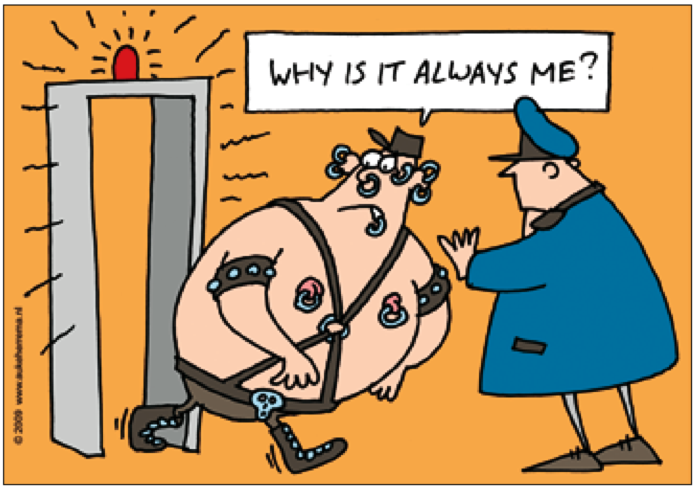
The number of emergency debates (in Dutch 'spoeddebatten') requested by a politician is a good measure of how much he/she values his/her ego above the content of his/her job.
*Dirk van Amelsfort*
Civil engineer

In our world where knowledge is praised, admitting not to know is undervalued.
*Kris van der Zee*
Mathematical engineer

The policy to stimulate women choosing a career in science should focus more on changing the current male culture than on changing the women themselves.
*Enide A.I. Bogers*
SEPAM engineer

The fact that a Ph.D. research involves time pressure and the need to produce publishable results prevents the Ph.D. candidate from making attempts that are out of the ordinary, thus significantly reducing the chance of a breakthrough.
*Bas Cornelissen*
Computer science engineer

Scientific research is like mining; it requires digging deeper into a harder ground.
*Nghiem Tien Lam*
Maritime engineer




The process of selecting certain passengers for extra searches at airport customs is based on a classification of stereotypes.
*Clark Borst.*
Aerospace engineer

## [Sound]BITES

"There is a 1 in 200,000 chance of an accident happening in the Netherlands that involves a freight train carrying toxic materials."
*Professor in safety science and disaster abatement, Prof. Dr Ben Ale, in the AD.*

"When driving at a speed of 100 km/h, the average passenger car quickly amasses a wind resistance of approximately 30 kilograms. In Australia, the Nuna5 will be powered solely by solar energy. If our car would race using a petrol engine instead, it would use 1 litre of fuel per 133 kilometres. Thus, the car would need only 23 litres of petrol to complete the entire 3000 kilometre race."
*Nuna5 team captain, Rein van den Eijnde, in Het Parool.*

"For a commercial aircraft with full fuel tanks, approximately one-third of the total weight of the plane is also fuel. Granted, you can fly further with a commercial airplane, but still, no one would say that the reason for flying them is to transport kerosene."
*Joris Melkert, of the Faculty of Aerospace Engineering, answering critics in De Volkskrant who say that one-third of the weight of a battery-powered aircraft is accounted for by the batteries.*

"Measured in ton-kilometres, a ship uses less fuel than a truck. The bigger the ship, the more efficiently it sails."
*Researcher, Robert Hekkenberg, specialist on inland waterways, in Trouw.*

Photo: Sam Rentmeester/FMAX

Proposition
The development of fast computer code benefits from working on slow computers.

Defence
"This proposition seems paradoxical, but it's not entirely. In 1990, I calculated flows using a 286 computer. Nowadays, you can hardly imagine how slow those things were. We certainly had to programme them cleverly. The programmes contained nothing superfluous. In those days we worked with hundreds of calculation points. With today's powerful computers, we can calculate flows using millions of calculation points. Memory is no longer a limitation. But a consequence of this is that younger PhDs therefore have much less of an eye for clever programmes. Older engineers, like me - I'm 45 - find it a shame to save a calculation in the memory if there is absolutely no need for it. But perhaps this is also something of a strange preoccupation of ours."

*Robert Jan Labeur*
Civil engineer

**An alumnus of TU Delft writes a column and then passes the pen on to another alumnus of his or her choosing.**

Driven as I was by an innate and lifelong passion for everything occurring in the universe, astronomy might have been an all too obvious choice for a university career. So I opted instead for aerospace engineering, believing that it would greatly improve my employment opportunities, as well as teaching me how to build a rocket that might propel me out into the universe. That's how I arrived in Delft as a wide-eyed boy of 18.

Looking back on my student years in Delft, the real significance of those years has now become clear to me. I went through a process of major change in practically every regard. I changed my focus, from studying to organising; I changed my interests, from technology to mankind and organisations; and I changed my motivation, from living my life according to other people's expectations, to my living my life in accordance with my own dreams and aspirations.

When I had graduated, I met my first guide in life, an éminence grise who got me into strategic human resources management, which in the 1990s had become a new theme in business circles.

And just like every process of change naturally leads to new worlds and opportunities, so my process of change at TU Delft opened up the world of company rationalisation, mergers, and management and organisation development. More recently this has also led to me providing change support for organisations and for people dealing with personal issues.

In 2007 I met another guide in life, who helped me cross the threshold into the world of entrepreneurship, which until then had remained shrouded in mystery. In an unexpected way it thus became clear to me what TU Delft had taught me: whether you're about to set up your own change support company, like [im]brace, or tackle an integration issue or support managers in their development as leaders, the application of models contributes to a clear analysis of the problem and helps you to consider all the various dimensions of a problem. You also learn how nature 'designed' the world around us. Models aren't the be-all and end-all, but they do make for good tools.

For example, I use models from astronomy and pretty pictures of change processes in the universe as metaphors, and in my day-to-day working practices at [im]brace I notice that this helps people and organisations to become aware of the universal laws of change processes in their own environments. This enables them to find solutions to their problems, based on the concept that awareness is the first step on the road to making your own dreams and aspirations come true.

This brings me full circle. In my passion for astronomy I rediscovered my motivation, and the process of change I went through has helped me discover my business focus.

In spite of, or thanks to my background of rational, technical training, I can only conclude that my destiny really was written in the stars.

Chrétien Verheijen studied aerospace engineering at TU Delft. He is the founder and owner of [im]brace, an agency that provides change support to organisations and individuals. Chrétien passes on the baton to Ben-Jaap Pielage, who studied mechanical engineering at TU Delft.



# *Serious silly putty*

OTO: SAM RENTMEESTER/FMAX

TOMAS VAN DIJK

It is still a great toy, that soft, kneadable stuff called Silly Putty. And Prof. Dr Stephen Picken just can't get enough of it. A ball of this silicon polymer lies on his desk, slowly collapsing. In an hour's time it will have become a small puddle. But Picken, a professor at the Faculty of Applied Sciences, won't let that happen. He slowly twists the ball into a tail-like shape and then, with a firm tug, pulls it apart. The tail breaks as if it were a piece of chalk.

How Silly Putty behaves – as a liquid or solid – depends on how much pressure is exerted on this soft, rubbery material. Picken is fascinated by it. A few years ago he bought a case of Silly Putty from a toy store. And every year he lets his students play with it.

As a toy or plaything, Silly Putty is excellent, and until now that was what it was primarily used for. Picken however has discovered that you can do much more with this material, such as for example making knee and elbow protectors or motorcycle clothing. "But to do that you need to add nano-particles," Picken explains. "The polymer then becomes much harder." Compared to other materials, the great advantage of this hard, silicon polymer is its ability to reform itself. If you leave the material alone for a while, the small holes and cracks in the material will seal themselves up again. Over time, the material will also increasingly form itself to the individual shape of a person's knees or elbows. "This makes it more comfortable to wear," says Picken, who patented his invention last summer.

In fact the material heals itself. Picken prefers using the term 'physical self-healing' to describe this process, and also as a means of stressing that his polymer differs significantly from the materials that many of his colleagues are developing based on a chemical healing process. Such materials often incorporate small balls of glue; if a crack appears in the material, the glue is released and the material is once again stuck back together.

The disadvantage of those types of materials is that they can only repair themselves once," Picken says, "while the physical self-healing capacity of the Silly Putty-like materials is endless."

So how exactly does this work? "Silly Putty is an example of a reversible supramolecular polymer," the professor explains. "It consists of small molecules with end groups that transversely bond (for example, hydrogen bridges) with each other at room temperature. These bonds can become momentarily unstuck and then later bond back together again. Whether the material behaves like a liquid or solid depends on how long pressure is applied to it."

With the support of TU Delft's Valorisation Centre, which is responsible for valorising inventions, Picken now intends to comprehensively map the possible applications of this material. "Perhaps we can appoint a PhD for this research," Picken says hopefully.

More information: Prof. Dr Stephen Picken, s.j.picken@tudelft.nl

# WHO & WHERE

DELFT UNIVERSITY OF TECHNOLOGY *has eight faculties, each of which is engaged in education and research in one or more disciplines. The University was founded in 1842 by King William II. With 13,000 students, 2,800 scientific staff members and 2,000 technical and administrative employees, it is the largest university of technology in The Netherlands.*

**TU Delft**
**P.O. Box 139**
**2600 AC Delft**
**The Netherlands**
**telephone +31-15 278 9111**
**telefax +31-15 278 6522**

## Disciplines

AEROSPACE ENGINEERING
Kluyverweg 1
NL-2629 HS Delft
Telephone +31 15 278 2058

APPLIED EARTH SCIENCES
Mijnbouwst raat 120
NL-2628 RX Delft
Telephone +31 15 278 1423

APPLIED PHYSICS
Lorentzweg 1
NL-2628 CJ Delft
Telephone +31 15 278 7774

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Berlageweg 1
NL-2628 CR Delft
Telephone +31 15 278 4184

CHEMICAL TECHNOLOGY & BIOPROCESS TECHNOLOGY
Julianalaan 136
NL-2628 BL Delft
Telephone +31 15 278 2667

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Stevinweg 1
NL-2628 CN Delft
Telephone +31 15 278 5440

ELECTRICAL ENGINEERING
Mekelweg 4
NL- 2628 CD Delft
Telephone +31 15 278 4568

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Kluyverweg 1
NL-2629 HS Delft
Telephone +31 15 278 3289

INDUSTRIAL DESIGN ENGINEERING
Landbergstraat 15
NL–2628 CE Delft
Telephone +31 15 278 4750

LIFE SCIENCE & TECHNOLOGY
Julianalaan 67
2628 BC Delft
Telephone +31 15 278 8271

MARINE TECHNOLOGY
Mekelweg 2
NL-2628 CD Delft
Telephone +31 15 278 6666

MATERIALS SCIENCE
Mekelweg 2
NL-2628 CD Delft
Telephone +31 15 278 6666

MECHANICAL ENGINEERING
Mekelweg 2
NL-2628 CD Delft
Telephone +31 15 278 6666

COMPUTER SCIENCE
Mekelweg 4
NL- 2628 CD Delft
Telephone +31 15 278 4568

APPLIED MATHEMATICS
Mekelweg 4
NL- 2628 CD Delft
Telephone +31 15 278 4568

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Jaffalaan 5
NL-2628 BX Delft
Telephone +31 15 278 7100

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NL-2629 HS Delft
Telephone +31 15 278 5353

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Julianalaan 67
NL-2628 BC Delft
Telephone +31 15 278 5140/2342

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Mekelweg 2
NL-2628 CD Delft
Telephone +31 15 278 3612

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Stevinweg 1
NL-2628 CN Delft
Telephone +31 15 278 6634

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Telephone +31 15 278 7884

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NL-2629 HS Delft
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NL-2628 CD Delft
Telephone +31 15 278 2535
Fax +31 15 278 2591

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NL-2629 HS Delft
Telephone +31 15 278 5170

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NL-2629 JB Delft
Telephone +31 15 278 5052

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NL-2628 BX Delft
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Berlageweg 1
NL-2628 CR Delft
Telephone +31 15 278 5400

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NL-2628 CT Delft
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INTERDUCT DELFT UNIVERSITY CLEAN TECHNOLOGY INSTITUTE
Rotterdamseweg 145
NL-2628 AL Delft
Telephone +31 15 278 7233

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NL-2628 CD Delft
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NETHERLANDS SCHOOLS FOR ADVANCED STUDIES IN CONSTRUCTION
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Telephone +31 15 278 3332

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NL-2628 CD Delft
Telephone +31 15 278 8032

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Kluyverweg 4
p.o. box 5017
NL- 2629 HT Delft
Telephone +31 15 278 6046

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Telephone +31 15 278 5678

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Telephone +31 15 278 5404

*Information on facilities for foreign students:*
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Jaffalaan 9a
NL-2628 BX Delft
Telephone +31 15 278 4670

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LIAISON OFFICE
Mekelweg 2
NL-2628 BX Delft
Telephone +31 15 278 1500

*Information on research fellowships:*
Mrs. M.Y.M. Spiekerman-Middelplaats
Stevinweg 1
NL-2628 CN Delft
Telephone +31 15 278 3773

*General information on university education in the Netherlands:*
MIN. OF EDUCATION, SCIENCE & CULTURE
CENTRAL INFORMATION DPT.
p.o. box 16375
NL-2500 BJ Den Haag
Telephone +31 70 412 3456

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NL–2600 AP Delft
Telephone +31 15 278 8019
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www.delft-toptech.nl

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Julianalaan 67
NL-2628 BC Delft
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NL-2628 BZ Delft
Telephone +31 15 278 4124