TO2MORROW

Magazine on results from the Open Innovation Network

2025

TO2 federatie
De samenwerkende organisaties in toegepast onderzoek

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TNO innovation for life

Deltares

WAGENINGEN UNIVERSITY & RESEARCH

MARIN
BETTER SHIPS, BLUE OCEANS

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Dear reader,

Innovations strengthen our economy. They are indispensable in seeking and finding solutions to the societal problems of today and tomorrow.

Before you lies the tenth edition of TO2MORROW. Every year since 2016, our TO2 institutions have presented a selection of projects they can rightfully be proud of. This anniversary issue is once again filled with impressive and diverse examples that show how the Netherlands benefits every day from the translation of scientific ideas into concrete solutions.

Read, for instance, about the Future Force Design team from the Royal Netherlands Aerospace Centre (NLR). This team aids the Ministry of Defence to strategically secure and utilize our airspace, thus contributing to our safety. Or the Netherlands Organisation for Applied Scientific Research (TNO), where they developed a new, accessible open-source SOAR tool (Security Orchestration, Automation, and Response) that allows organizations and researchers to develop and test advanced technology to automatically repel cyberattacks within one flexible system.

But innovation is not limited to the area of resilience alone. Wageningen University & Research (WUR) developed a digital application that enables food companies to produce healthier products faster and more cost-effectively. MARIN uses data to keep the river IJssel safe for both ships and local residents, while Deltares, in collaboration with TNO, is working on New Groundwater Reserves to ensure that the Netherlands never runs out of drinking water.

In short: our institutes for applied research and their work are indispensable. They make our country safer, healthier, and more sustainable. And we all reap the benefits.

I wish you an enjoyable read!

Vincent Karremans
Minister of Economic Affairs

In the overview below, each of the institutes, who are part of the T02 federation, summarise their most relevant areas of activity and the key technologies they develop and apply.

The T02 federation consists of:

Deltares

Deltares

Deltares is an independent knowledge institute for applied research. We believe in the power of in-depth knowledge, in innovative solutions, and software, to keep delta regions all over the world liveable.

Our mission *"Enabling Delta Life" focuses on the water and ground system. We focus on five supposed moonshots to create an impact with our knowledge: habitable deltas, flood control, healthy water and ground systems, greenhouse gas reduction, renewable energy, and resilient infrastructure.*

Our 900 qualified employees are curious and passionate. In co-creation, we work in conjunction with universities, research institutes, the business community, NGOs and public authorities domestically and abroad and share our knowledge with the world ("dare to share").

MARIN
BETTER SHIPS, BLUE OCEANS

MARIN

Maritime Research Institute Netherlands (MARIN) conducts research into hydrodynamics, maritime (zero-emission) technology and operations with simulations, model testing, true-size measurements and training. MARIN focuses on shipbuilding, shipping, the offshore industry and public authorities. To this end, MARIN pays attention to the following social themes in its mission-driven innovation policy: energy transition and sustainability; agriculture, water and food; and safety. Key technologies that receive special attention are artificial intelligence and autonomy & decision support.

nlr Accelerating the future of aerospace

NLR

The Royal Netherlands Aerospace Centre (NLR) connects the sciences, business community and public authorities in the Netherlands as well as internationally. This knowledge organisation conducts applied scientific research in the market segments: industry, civil aviation, aerospace and defence. NLR's work covers the full spectrum of "Research, Development, Testing & Evaluation" (RDT&E). Within its mission-driven innovation policy, NLR's research focuses on social themes: energy transition, sustainability, and safety. Examples of key technologies that receive special attention are artificial intelligence, augmented/virtual reality, digital twin and state-of-the-art materials (e.g. composites and 3D metal printing). ▶

Follow-up ▸

The T02 federation consists of:

TNO

The Netherlands Organisation for Applied Scientific Research (TNO) has a mission to connect people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. TNO believes in jointly creating value in economic as well as social terms and, together with partners, focuses on innovations in six domains: Mobility and the Built Environment, Energy and Materials Transition, Defence and Safety, Healthy Living and Work, High-tech Industry; ICT, Strategy and Policy.

Development and making key technologies functional for application, is one of TNO's core activities within these domains. These could include photonics, nano technology and quantum technology. But also new forms of production, materials and chemical technology. Key technologies are characterised by a wide field of applications or scope in innovations and sectors. They will radically change the way we live, learn, innovate, work and produce. Key technologies are essential in resolving social challenges, such as safety, energy and healthcare. Key technologies also enable ground-breaking innovations of processes, products and services, and provide a major contribution to the economy, to the emergence of new businesses and new markets, to increasing competitiveness, and to bolstering job creation.

WUR

Wageningen University & Research is a collaboration between Wageningen University and the Wageningen Research. Our more than 7,000 employees and 13,000 students from more than 100 countries, work and study in the domain of healthy food and living environment. Together, they contribute to solutions on societal issues, in cooperation with governments and industry.
The mission of Wageningen University & Research is “To explore the potential of nature to improve the quality of life”.
The strength of Wageningen University & Research’s lies in the ability to join the forces of specialised research institutes and the university. It also lies in the combined efforts of the various fields of natural, technological and social sciences. As a result, scientific breakthroughs can quickly be translated into practice and into education. Wageningen Research is part of the T02 federation and consists of several research institutes who are active with the topics Food & Biobased Research, Bioveterinary Research, Livestock Research, Marine Research, Social & Economic Research, Environmental Research, Plant Research and Food Safety Research. ■

New knowledge for old engineering structures

“We’re facing a monstrous task”, says Joost Breedeveld, researcher at Deltares, the knowledge institute in the field of water and subsurface. “In forthcoming years, more and more bridges, sluices, weirs, pumping stations and other sections of the waterways will reach the end of their lifespan, in any event, on paper.” ▶

Deltares, MARIN, TNO

Problem: many "hydraulic engineering structures", such as sluices, weirs, storm-surge barriers and quay walls, are reaching the end of their lifespan. As a consequence, the quality of the infrastructural networks that they form part of, could deteriorate.

T02 Solution: Deltares, MARIN and TNO are investigating which engineering structures should be demolished, which should be reconstructed, and when that should happen. They are also looking at which engineering structures require renovation and which of them can remain in use for the time being. Sometimes additional maintenance or partial renewal is necessary. At the same time, the parties are working on new measuring methods that support the research.

Impact: research provides the necessary knowledge and development of tools that give operating authorities an overview of the preservation requirement of hydraulic engineering structures, and action prospects. All this is collected and organised in a knowledge database that is accessible to everyone.

The Netherlands is a water-rich country, filled with thousands of "hydraulic engineering structures", as these constructions in our water infrastructure are called in technical terms. Many of them were built in the years before and just after World War II and, given their lifespan, are possibly "exhausted". In the meanwhile, transport, safety, agriculture, water supply and the economy are highly dependent on this water infrastructure. "Some engineering structures need to be replaced", says Breedeveld, "others can be renovated and sometimes the lifespan can be extended with more intensive maintenance. The costs of all these operations are considerable and capacity is limited, so we have to make choices. The question, however, is which choices are good."

Dick ten Hove, MARIN

"The KpNK must support the making of choices by operating authorities with knowledge and tools to assess the engineering structures."

Research into corrosion

Together with TNO, MARIN and Rijkswaterstaat, the operating authority of many large, complex engineering structures, Deltares is working on the Knowledge Programme of Hydraulic Engineering Structures (Kennisprogramma Natte Kunstwerken, KpNK). "The KpNK must support the making of these operating authority's choices with knowledge and tools to assess the engineering structures", says Dick ten Hove, a researcher at MARIN. Ten Hove, Breedeveld and their TNO colleague Ad van 't Zelfde were interviewed about the KpNK. "A good example is research into the corrosion of steel sheet piling, which have been constructed along canals, or as sections of sluices or weirs", says Breedeveld. "Due to corrosion – in real terms rust – the thickness reduces and therefore becomes less sturdy over time. Would there possibly be a smart way to measure how thick these steel sheet piles are?"

PECT technique

"Until now, a technique based on ultrasonic sound has been used for such thickness measurements", says Van 't Zelfde at TNO, the institute that developed this technique. "To do so, a diver must enter the water, because the surface must first be cleaned of fouling, the growth of algae, shells and other muck." However, deploying divers is expensive and entails risks. A new technique, the Pulsed Eddy Current Testing (PECT), measures thickness by detecting the response to electromagnetic pulses. "There is no need to wipe anything clean for this", says Van 't Zelfde, "so it can be done from the water's edge, or possibly with submersible robots." But before switching to another measuring technique, one needs to know if the techniques are equally reliable. "So we applied both techniques to a sluice that was to be demolished. Then we extracted the sheet piling and measured the thickness with an extremely precise laser measurement." This research validates the new PECT technique, which in future, will allow sheet piling to be measured faster, cheaper and more thoroughly. ▶

KpNK conducts research into corrosion of steel sheet piling.

Sheet piling

"In some cases it still looks quite good even after fifty or seventy years, in other cases there are corrosion spots everywhere", says Van 't Zelfde. If such measurements show that a longer lifespan is possible, then it can simply be maintained as usual, or more intensive maintenance can be undertaken to extend the lifespan further. "However, it may also be necessary to reinforce the sheet piling", says Breedeveld. "More extreme would be to extract the sheet piling completely and put a new one in its place. Or the choice might be made for an optimised construction with less steel, or made of timber. These are all options to be considered."

Collision risks

"Another aspect is identifying the risks of collision at bridges", says Ten Hove, an expert on ships at MARIN, "in seeking new methods to assess the likelihood of a collision and what the consequences would be." The scaling-up of shipping, with ever more and larger ships, as well as stronger engines, plays a major role in this. Ten Hove: "One always assumes the worst situation, i.e. the biggest ship, with the greatest speed. That means wanting to be on the conservative side with the dimensioning, but that leeway is not always available anymore. So, we need to look at how the actual risks

Joost Breedeveld, Deltares

"Imagine getting shipping to make a detour so that the ageing sluice gate does not need to be used at all, then that would make an enormous difference in costs."

can be ascertained better. It means, literally pushing the boundaries a bit more." "Such considerations explicitly include the role that the engineering structure plays in the waterways network", says Breedeveld of Deltares, "not every engineering structure is of equal importance. Imagine getting shipping to make a detour so that the ageing sluice gate is used less often or does not need to be used at all, then that would make an enormous difference in costs." Aside from shipping, factors such as water safety, the supply of drinking water and ecology are also included in such considerations. Another issue is preservation of the ageing weirs in the river Meuse, which regulate the water level in the Meuse for shipping. Breedeveld: "The mechanisms with which the weirs are being lowered and raised, are starting to show defects, and they no longer comply with the latest European machinery directives." A major renewal operation will have to be decided on in forthcoming years.

Climate change

In addition to the "maturing warranty" of the engineering structures, there are also other factors that make the task of renewal pressing. "Climate change is creating more extreme situations", says Breedeveld, "which means more and longer dry spells with water shortages and wetter periods with flooding." Given the history of the Netherlands, it has always been about the threat of high water levels. Van 't Zelfde: "But in 2018, we learned that drought and low water levels can be a problem too." This is so, not only for shipping and the supply of drinking water and sprinkler water, but also for engineering structures. "Corrosion of dried-up sections could increase, and there is less fresh water available to prevent the intrusion of saltwater from the sea."

Simulations

Facilitating simulations, e.g. an intrusion of the volume of salty seawater through a sea lock to the inland waterway when allowing ships to pass through, is also part of the KpNK programme. "The knowledge gained is systematically analysed", says Van 't Zelfde. "Drawings of older engineering structures are sometimes no longer available, but all kinds of data from various sources are available. If a hundred sluices are examined, how would you be able to compare these? And retrieving the essence from all that information, for example, to find where the problems mainly lie? The knowledge database plays a major role in such knowledge management questions." The knowledge database is a website that is accessible to everyone. "One can select by type of engineering structure, and perspectives specific to the subject", Breedeveld commends, "the nautical angle, the structural side, or the geotechnical side."

Ad van 't Zelfde. TNO

"Drawings of older engineering structures are sometimes no longer available, but all kinds of data from various sources are available."

Shared knowledge

All three KpNK researchers emphasized that hydraulic engineering structures are inherently interdisciplinary. The expertise at Deltares, TNO and MARIN is complementary. Breedeveld: "For a sluice gate, TNO has expertise of the steel and concrete, Deltares of the water and subsoil where it is constructed, and MARIN of the ships that make use of it." The shared knowledge is also collated in plans for practical research. Breedeveld: "If a sluice has been amortised in full and must be demolished, this could possibly be used as a kind of testing ground. How instructive would it be to get a ship – also amortised – to crash through the sluice gate under controlled conditions. Then the consequences could be studied very precisely for the entire structure. A great deal can be learned from that kind of research. This is one of the wilder ideas that is being considered to provide operating authorities with better knowledge and tools for their preservation requirements in future." ■

Hydraulic engineering structures of the future

Who: Deltares, MARIN, TNO, Rijkswaterstaat.

Budget: EUR 1 million.

Duration: cycles of four years since 2017, third cycle started in 2025.

Ingrid van der Meer, senior researcher and head of the Bioscience Department at WUR.

Water lentils: why this novel vegetable will end up on our plates

Within two years, according to WUR researcher Ingrid van der Meer, water lentils (duckweed) will find their way to restaurants and supermarkets as vegetables. These small water plants are healthy, can be cultivated sustainably and grow superfast. Public interest is significant; growers, restaurants, food producers, supermarkets as well as consumers are enthusiastic. ▶

WUR

Problem: we eat too many animal proteins. That is not good for the environment, the climate, our health and for global food security.

T02 Solution: Wageningen University & Research (WUR) is developing knowledge and technologies to accelerate the protein transition: shifting from sources of animal-based protein to plant-based protein. Among other things, WUR researches water lentils: a fast-growing, sustainable and healthy new vegetable. Ten years of research was needed to get this "Novel Food" approved for consumption in Europe.

Impact: fewer CO_2 emissions, reduced usage of water and pesticides, better public health, and expanding the supply of vegetables.

Water lentils, also known as duckweed, processed as vegetables in pasta sauce, a pizza base, vegetable soup or a smoothie. If it's up to Ingrid van der Meer, this will become reality within two years. Initially it will be on the menu in restaurants and later it will also be available in the freezer section and as fresh vegetables in supermarkets. "Growers can't wait for this product", says the senior researcher and head of the Bioscience department. "We have ten years' worth of experience and can offer them support: which species can be used, what is of importance when growing? We can help growers get in touch with customers."

Harvesting every week

In 2014, during a study for a pharmaceutical company, Van der Meer learned all about duckweed. "I noticed its exponential growth and thought it was an interesting plant." She explains: "The plant does not grow using seeds, but by splitting into two. As a consequence, it is possible to harvest every week." It was found to contain plenty of proteins, vitamins and minerals, and the vegetables can be cultivated sustainably: within a few square metres, with little water and nutrients, and without the use of pesticides. In Europe, water lentils were not simply allowed to be eaten, because they do not, by tradition, appear on the menu here. In Asian countries like Thailand that is allowed. This is why Van der Meer submitted a "novel food" application to the European Food Safety Authority, EFSA. Subsequently, she conducted research with her research group. For example, the researchers analysed the various types of water lentils, analysed all the nutrients, and conducted long-term research, which showed that the plant does not contain any toxic substances nor allergens, and is safe for human consumption.

Are consumers amenable to it?

What was also quite significant were the consumer surveys: would they like it? Van der Meer: "Otherwise, it would be pointless to continue with it." According to a questionnaire completed by a thousand respondents, people wanted to try it. Groups of volunteers were then offered dishes containing water lentils. The reactions were positive, so too from the participating cooks who prepared the dishes.

Ingrid van der Meer: "I noticed its exponential growth and thought it was an interesting plant."

Human guinea pigs

To obtain EU approval, researchers had to demonstrate, among other things, that water lentils digest easily. In a number of studies, they made human guinea pigs eat water lentils and subsequently took blood samples to see whether the proteins had ingested and if the food had any health effects. Other studies focused on the shelf life of water lentils in various packings, using it in a variety of products and dishes and the ideal growing conditions. Ten years later, finally the good news came in ▶

2024. The EU assessed that the two types of water lentils for which the application was submitted are safe for consumption, provided that the indoor growing conditions is well controlled and meets all EU requirements.

On the menu

Van der Meer keeps hearing the same stories from restaurants, supermarkets and food producers: "It is a nice vegetable, it has a good bite with a rather neutral taste and as a consequence, it blends in well with other ingredients." The senior researcher expects water lentils to initially be on restaurant menus. Basically, they can work with one grower, whereas supermarket chains and food producers need large quantities and therefore have to work with several growers. Many growers have already shown an interest. But, before they tackle it on a large scale and invest in growing this vegetable, growers want to be sure that there will be customers. "We are now working with a few growers to help them create the right growing conditions, with analyses of materials and to obtain subsidies. We are also having talks with the food industry and with restaurants."

Eat more plants

Van der Meer herself has been a vegetarian for a long time and thinks it is important that we make the transition from a diet with many animal proteins to a diet that has more plant-based products. "I like to contribute a little by ensuring that this new sustainable and healthy vegetable can be produced and eaten." Not only in the Netherlands, but worldwide too. A startup in Africa has shown an interest and small farmers in Indonesia now use water lentils as animal feed. ■

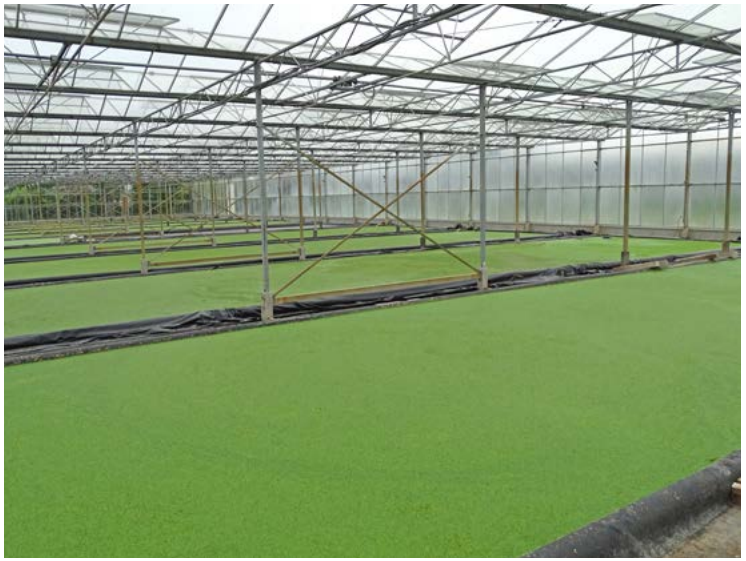
"It is a nice vegetable, it has a good bite with a rather neutral taste."

Who: WUR

Duration: 2014 – 2024.

Follow-up: WUR brings parties together and is working on new project proposals to bring water lentils to the marketplace – in supermarkets, restaurants and as animal feed.

Will we soon be eating water lentils?



Lentils are grown in a greenhouse.

Water lentils blend in well with other ingredients, such as this stew.

Tarts, cakes and biscuits with less sugar, thanks to a digital tool

Confectionery such as tarts and cakes are popular, but often contain a lot of sugar and are therefore not very healthy. Researchers at Wageningen University & Research developed a digital tool that enables bakers and food product manufacturers to make good products faster with less sugar. The available know-how has been converted into teaching materials for professional schooling courses (MBO and HBO). ▶

WUR

Problem: too much consumption of sugar leads to health problems, but sugar reduction is complicated and time-consuming for food manufacturers.

T02 Solution: Wageningen University & Research (WUR) developed a digital tool for food manufacturers to develop effective recipes quickly, and teaching materials for MBO and HBO courses. Information will be available via groenkennisnet.nl at the end of this year.

Impact: companies save time and costs in developing healthier products. Students and teaching staff at bakeries and cookery courses discover new opportunities, and public health benefits.

A group of MBO students at the baker's training school in Ede, recently visited the university in Wageningen. The manufacturer's assigned task: develop a tasty chocolate-flavoured shortbread cookie containing 30% less sugar or no sugar at all. Senior researchers Anke Janssen and Miriam Quataert (also an instructor at senior secondary vocational education institutes) helped the students get started and reported the following: "The students were given a few recipes from our digital tool, which they tested at school. Ultimately, the company was very satisfied with the cookie that was developed."

Too much sugar

The World Health Organisation (WHO) of the United Nations advises that no more than 10% of the daily intake of calories should be from "free sugars", preferably less than 5%. Free sugars are added sugars, as well as sugars naturally present in honey and fruit juices, for example. According to the researchers, most people consume significantly more sugar than recommended, which is not only harmful to the teeth, but also contributes to developing obesity and cardiovascular diseases. Sugar is contained in a variety of products, from cereals and fruit juices to off-the-shelf pizzas and soups. This research focuses specifically on tarts, cakes and pastries, because these products have a high sugar content, an average of 20 to 40 percent.

More than sweet

The researchers explain that using less sugar in products is not easy. "A small reduction still works, after which it becomes complex", says Quataert. "Sugar influences the taste, texture, colour and shelf life. It is a challenge to make a fluffy cake or brittle cookies without sugar." Yet blind tastings show that well-developed products with little or no sugar are barely distinguishable from the original. Janssen: "During a workshop with representatives from the baking industry, we had a tasting of muffins without sugar. Even experienced bakers barely noticed any difference in taste. The recipe was derived from our digital tool."

Tool for recipes

This expert tool developed by the researchers and their colleagues, helps food manufacturers to come up with good recipes quickly. Manufacturers often spend a lot of time and money developing new products. "We input the original recipe, together with the required percentage of sugar reduction and the substitutes we want to use", Quataert explains. This will produce a number of recipes. Beforehand, the researchers measured certain physical properties of the ingredients in the specific product, with which the tool calculates. Companies can then test the recipes and adapt them where necessary. "The feedback we get, for example, is that the product is too dry, the ▶

colour too dark, or that the texture during chewing is not ideal", says Janssen. "In that case, we formulate possible improvements together with the manufacturer." Several manufacturers have collaborated with WUR in this way.

"Even experienced bakers barely noticed any difference in taste. The recipe was derived from our digital tool."

Future bakers

Aside from the collaboration with companies, the project focuses on education. The researchers developed a curriculum on sugar substitution with thirteen MBO and two HBO education courses. It was instructive both for students and for the teaching staff. "I think we have inspired quite a few students", says Janssen. "The food specialists of the future are now more aware of the possibilities. In their work later in life, they can state with conviction that pastries or cakes with less sugar are certainly possible." The researchers also gave workshops on the possibilities of sugar reduction in the bakery and the aspects that should be taken into account. Trade organisations and their members were enthusiastic. Quataert: "We hope that there will be more tarts, cakes and pastries with less sugar in the shops in the coming years." ■

Who: Wageningen University & Research.

Duration: tailored know-how project; acceleration of sugar reduction in the bakery 2024 – 2025.

Follow-up: food product manufacturers who seek support in the development of products with a reduced sugar content should contact WUR. Several educational institutions are continuing their curriculum and collaboration with WUR.

groenken-nisnet

Water supply for a rainy day

In the Netherlands, water seems to be such an obvious thing. Yet, the pressure on our supply of drinking water is rising. The population is growing, our water consumption is increasing and climate change is causing longer dry spells. “It is necessary that we should already start thinking about how to get safe and clean drinking tap water in 2100”, says Geert-Jan Nijsten at Deltares. ▶

Deltares, TNO

Problem: the issue of drinking water continues to grow due to population growth, higher consumption, and climate change. Our current sources provide us with reliable drinking water, but in the event of major disasters they could come under pressure. That is why we are working on National Groundwater Reserves (NGRs).

TO2 Solution: TNO and Deltares explore mainly deep-lying freshwater and brackish water supplies that are uncontaminated and free of pollution. By using advanced 3D models, they map out the locations, quality and risks, and advise the State on restricting these areas and on strategies to protect these water supplies.

Impact: the Netherlands will have a robust, future-proof system of drinking water supplies, usable in the event of large-scale disasters as well as a possible structural supplement to existing supplies in the long term. In this way, future generations can count on having adequate drinking water.

Together with TNO, Deltares is mapping out the National Groundwater Reserves (NGR): often deeply situated, unspoiled freshwater resources, to be able to meet future drinking water shortages. Nowadays, the Netherlands extracts two thirds of its drinking water from groundwater. Today's resources are protected by stringent rules. The origin of the NGR's plan lies in the 2014 Drinking Water Policy Document. Provinces had to point out potential areas for expanding the drinking water supply by 2040 – which is known as supplementary strategic supplies (Aanvullende Strategische Voorraden, ASV). In addition, the State has demarcated the NGR. Geert-Jan Nijsten, groundwater expert at Deltares: "NGR is the final element of our drinking water supply. These are supplies that will not be needed for decades – or only if there is a national disaster. For example, an environmental disaster that prevents large communities from having access to safe drinking water."


Geert-Jan Nijsten (left) and Jan Gunnink

Fresh water supplies

TNO and Deltares are exploring resources of deeply situated freshwater supplies that are uncontaminated and free of pollutants, such as fertilizers or herbicides. Jan Gunnink, Researcher and Project Manager at TNO: "We demarcated where clean drinking water is available in the ground and wanted to establish the water's depth, it's volume, and what happens when it is extracted? If it is situated deep enough and is well protected, this could mean the space above or below it can be used for other purposes, e.g. in the context of renewable energy via geothermal energy." In this respect, three-dimensional maps and models are used. These not only define the location of supplies, but also the effects of extraction, such as a drop in groundwater levels or the risk of salinization. "In the case of structural extraction, nature must not suffer", Gunnink emphasises. "If groundwater is extracted, then the upper groundwater layer drops, risking consequential damage to nature. This should only be done in absolute emergencies, for example in the event of a major disaster. Then it is an emergency water supply in a literal sense."

Sounding board group

The quest to find new drinking water supplies is complex. Drinking water is valuable, but the substrate is also needed for geothermal energy. Nijsten: "Parties want to protect drinking water and keep the land usable for other purposes." TNO and Deltares complement each other: TNO maps out geological structure and modelling, Deltares researches the effects of extraction on water quality and nature. Knowledge institutes collaborate with water companies, provinces, water boards, trade organisations for ground energy and geothermal energy, the Ministry of Infrastructure and Water Management (IenW) and the Ministry of Climate Policy and Green Growth (formerly the Ministry of Economic Affairs and Climate Policy). "It is unique how broad the sounding board group is", says Gunnink. It involves parties from policy to practice – everyone is included.

Every region

Preliminary results have shown that the most promising water reserves are in the North and East of the Netherlands. In the west, the water is often too brackish because of salinity infiltration. Distribution across the land is important: in the event of a disaster, every region must have access to clean water. "It makes no sense if all the water reserves lie in the subsoil of the Veluwe; it does not help Limburg much", says Gunnink. The first survey in 2015 was merely a "pencil sketch". In the meanwhile, it has evolved into a major research programme. The Ministry of Infrastructure and Water Management is taking the recommendations into account in their Ground, Water and Subsoil programme. Nijsten: "We provide knowledge and maps, but the ultimate NGR restrictions and possible level of protection is a political-administrative decision." ■

Who: Deltares, TNO, in collaboration with water companies, provinces, water boards, umbrella organisations and the Ministry of Infrastructure and Water Management.

Duration: first survey in 2015, follow-up study 2020–present, current research phase started in 2023.

Budget: approximately EUR 1.6 million.

Follow-up: partly on the basis of research results, the State decides on formal restrictions of National Groundwater Reserves and further protection policies.

National Groundwater Reserves

Towards safe and energy-secure armed forces

The Ministry of Defence wants to be strong in future not only on land, at sea and in the air, but also in the area of energy. TNO, NLR and MARIN are working on solutions: from solar panels at encampments to sustainable kerosene for fighter jets and clean fuels for naval vessels. This is how we can make our armed forces more self-sufficient and less vulnerable in times of crisis. ▶

NLR, TNO, MARIN

Problem: the Ministry of Defence is highly dependent on fossil fuels, often derived from politically unstable regions. This results in missions being vulnerable and logistically complex.

T2 Solution: TNO is working in cooperation with NLR and MARIN on the deployment of sustainable fuels, electric and hybrid means of propulsion, simulations to replace physical training, and local energy generation for encampments.

Impact: by way of solutions proposed by research organisations, the armed forces run fewer logistics risks, are less dependent on fuels from abroad, and emit reduced volumes of carbon dioxide. And that is not a luxury, but a necessity – both for our security as well as for the climate.

TNO works closely with NLR and MARIN for this. Each institute focuses on a domain – TNO on the army, NLR on the air force, and MARIN on the navy – but insights are shared to strengthen the armed forces as a whole. Yvonne van Delft, senior project manager at TNO, is researching energy consumption of vehicles, encampments and the military itself (who are getting more and more weapons and other equipment that use a lot of energy). In this respect, measuring methods, measures, and alternatives to diesel, such as electric propulsion and self-generation with solar panels, are being studied. "In Afghanistan, generators at encampments were running on diesel, and it was precisely those fuel convoys that were most vulnerable to attacks. The safety aspect increases enormously if you generate your own electricity and use, for example, an electric motor or electric air conditioning instead of a diesel generator."


Elisabeth van der Sman.

Elisabeth van der Sman, NLR

"In the short term, SAF can ensure a sustainability impact within the department of Defence."

Logistics chain

Prior to a mission, first an inventory is drawn up of the goal, the number of people going along, and all the necessary supplies to keep the camp operational. Until now, this has mainly meant diesel for generators and vehicles. Van Delft: "But, what if we switch to dual-fuel, batteries or solar panels? Then the whole logistics chain changes and we make models for that." This knowledge is not only relevant for the Ministry of Defence. An encampment resembles a district or village in terms of energy supply. "This also makes it feasible for use in self-sufficient communities or even festivals, where facilities without fixed connections are organised on a temporary basis." The knowledge institutes also work together on cost-benefit analyses. "TNO develops the method, which is then applied in all situations", says Van Delft. "For the army, models are developed that predict energy consumption in tents, whether that is in the north's icy conditions or in the heat of the desert." The recently completed EDF INDY project (Energy Independent and Efficient Deployable Military Camps) shows that encampments can become 35 to 55 percent self-sufficient, with up to 45 percent fewer logistics, 15 to 28 percent lower costs and 40 to 80 percent fewer carbon emissions.

Demand for energy is increasing

"Sustainability can strengthen the air force's position", says Elisabeth van der Sman, senior consultant sustainable aviation at Royal Netherlands Aerospace Centre (NLR). "In view of current geopolitical developments, it is important that the Ministry of Defence becomes more autonomous and therefore less vulnerable. At the same time, we want the air force to reduce emissions and to contribute to a broader sustainability of society," says Van der Sman. Within the Energy Transition Operational Materiel programme, NLR is investigating how the Ministry of Defence can meet its energy needs until 2050. NLR identifies energy consumption, how it can be monitored better, and which technologies make its use more efficient. "The high level of threat will only escalate the demand for energy", says Van der Sman. "Defence therefore needs to train and fly more to stay prepared, and that simply requires more energy." In doing so, various technologies can help. For example, certain parts of training can be replaced with simulations. ▶

"If a fighter aircraft's pilot is going to train, he goes into the air. But the enemy with which the pilot trains does not necessarily have to be real. This can be replaced with a simulation," Van der Sman explains.

Yvonne van Delft, TNO

"If you can generate electricity yourself with an electric motor, safety increases enormously."

More sustainable kerosene

The use of aircraft can also be more sustainable, even in the short term. The use of renewable fuels reduces emissions when compared to fossil kerosene. It is for this reason that NLR has conducted research within Defence into the use of Sustainable Aviation Fuel (SAF), biokerosene and synthetic kerosene. Van der Sman: "The advantage of SAF is that it is suitable for present-day aircraft, no adjustments are necessary." In the short term, SAF can ensure a sustainability impact within the department of Defence. According to current fuel standards, it is already possible to mix the new fuel with fossil fuel – up to fifty percent. "At the air base in Leeuwarden, pilots have already been conducted with the use of biokerosene and the results so far are promising", says Van der Sman. In the long term, NLR also wants to research whether it is possible to use more than fifty percent SAF. This means that many test runs have to be repeated, for example by examining how the engines respond to higher SAF percentages.

Naval vessels

Frans Hendrik Lafeber, senior project manager of Powering & Signatures at MARIN, and his team are researching which alternative fuels and means of propulsion are suitable for naval vessels. The focus is mainly on, e.g. methanol, biodiesel, and hybrid

systems. An example of a research method that MARIN uses is the digital twin: a digital model of a naval ship. "With this, we test run in scenarios how the ship performs with different means of propulsion, what that means for its capacity, and how we can switch to dual-fuel step by step", he explains. The logistical processes are also important. Fossil fuels are widely available, but that is not the case yet for alternatives such as methanol. Also, non-fossil energy carriers often have a lower energy density, which means that the ship has a shorter range. More frequent bunkering may be needed, or the ship could be modified with larger fuel tanks or a fuel tanker ship could be dispatched more often. Alternative fuels will therefore be needed in other places in different quantities than what we are used to with fossil fuels. Aside from sound technology, international cooperation is paramount. Ships and aircraft must remain deployable to operate in a coalition. "If use is made of methanol, for example, ensure that bunkering services are available at international ports", says Lafeber. "That calls for coordination with other countries."

Frans Hendrik Lafeber, MARIN

"The challenge not only lies in technology, but also in international cooperation."

Greatest contenders

The initial results of the Energy Transition Operational Materiel programme are already practically applicable within Defence. "The construction programme of the new hydrographic support vessels is studying a dual-fuel methanol-diesel solution. The various options are also studied in detail in the replacement programmes. Hence, the know-how at MARIN is used straightaway when considering the options." Methanol is currently one of the greatest contenders in the navy, Lafeber expects. "For ships with a limited range like harbour tugs, batteries could be a good alternative. For larger vessels, HVO (Hydrotreated Vegetable Oil) is an sustainable short-term solution, which can later be substituted by methanol or another sustainable synthetic energy carrier. In this way, new fuels and technologies can be put in place step by step, while seeking the solution each time that best suits the type of ship and the mission."


Frans Hendrik Lafeber.


Yvonne van Delft.

Combat effectiveness

The ultimate goal is clear: a military force that is self-sufficient in energy, generates fewer carbon emissions, and simultaneously maintains and even preferably improves its combat effectiveness. The initial phase of the programme focused on exploring different technologies; the second half focuses on integration and interpretation. Ultimately, the researchers combine their findings in a joint report for the department of Defence, which encompasses all armed forces. "That calls for close cooperation and courage to actually deploy new technologies", says Van der Sman. ■

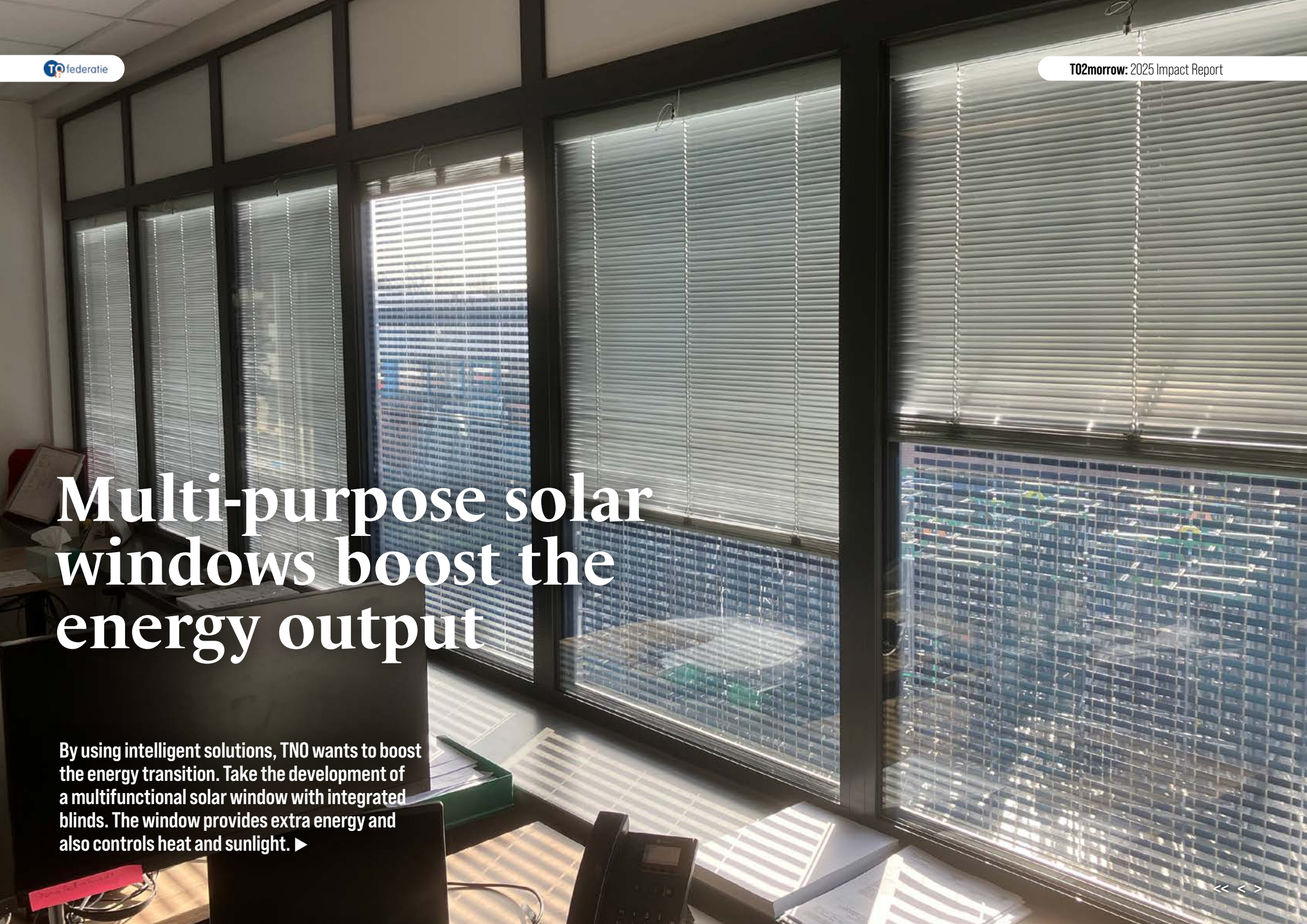
More about the EDF INDY project:

Who: Royal Netherlands Aerospace Centre (NLR), TNO and MARIN, in consultation with the Ministry of Defence.

Duration: the initial phase was about exploring technologies, the second about implementation and application.

Budget: part of wider defence innovation programmes co-financed by European projects such as EDF (European Defence Fund).

Follow-up: further implementation of sustainable fuels and propulsion systems, scaling up simulations, developing logistics models for the energy transition.



Multi-purpose solar windows boost the energy output

By using intelligent solutions, TNO wants to boost the energy transition. Take the development of a multifunctional solar window with integrated blinds. The window provides extra energy and also controls heat and sunlight. ▶

TNO

Problem: the energy transition is progressing slowly in the Netherlands. There are too few solutions that generate not only energy, but are also useful for other things.

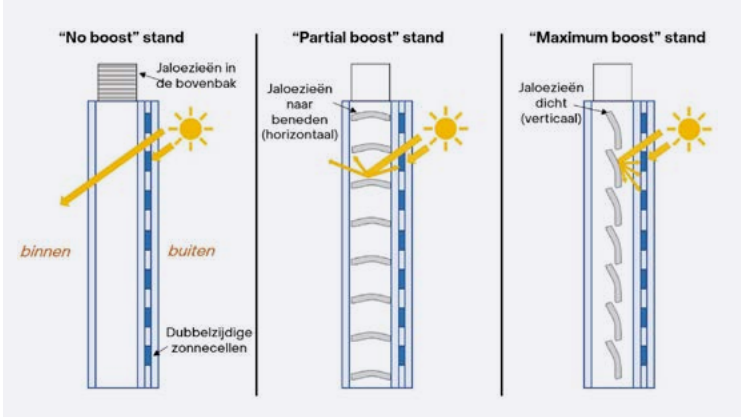
T02 Solution: TNO is developing such a multifunctional energy solution together with it partners: ZIEZO, a solar window that generates electricity and simultaneously regulates heat and light. This allows office buildings to reduce their carbon footprint by up to twenty percent. The window can be prefabricated for both existing as well as new office buildings.

Impact: solar windows particularly help make the urban environment more sustainable and that makes the Netherlands less dependent on conventional energy sources. Besides, the initiative strengthens the position of the Netherlands as a leader in sustainable technology.

The energy transition in the Netherlands is in full swing. Miles of solar panels along motorways and on rooftops of buildings colour the landscape. However, where we have exchanged fossil fuels for more sustainable solar energy, another problem has arisen: an overstretched electricity grid. "The Netherlands is a champion in grid congestion", says solar energy expert Roland Valckenborg of TNO. He works on solutions that not only deliver energy where it is needed, but which are also multifunctional and suitable for large-scale usage.

Solar panel and sun protection

Take ZIEZO: A sun protection including an electricity-generating solar window (Zonwering Inclusief Elektriciteitsopwekkend Zonneraam). The window generates electricity while simultaneously regulating heat and light. It consists of double glazing with double-sided solar cells and adjustable blinds in-between. In the lowered position, the blinds regulate sunlight and heat and reflect sunlight onto the back of the solar cells (see illustration). When the blinds are in a vertical position, the energy output is optimal. This system reduces the risk of overheating. "The window also replaces conventional sun shades, which often does not last more than about fifteen years", says Valckenborg. On sunny days, the solar window provides up to 25 percent more electricity than standard solutions




The ZIEZO window generates electricity while simultaneously regulating heat and light.

with single-sided solar cells without blinds. On average, the energy gain is thirteen percent over a year. Whereas a classic solar panel generates a 200 Watt-peak per square metre (Wp/m²*), the solar window achieves 100 to 120 Wp/m². When used in a reference building (e.g. a concept with which energy performance can be compared), Valckenborg expects a carbon emission reduction of about twenty percent, but this must be studied in more detail in the project.

Energy boost

What's quite unique according to Valckenborg is that this system responds to the need for heat and natural light combined with an optimal energy output. "The lowered and vertical position of the blinds bring about an optimal energy boost, but with less light and heat. But, some people specifically want light and solar heat." During working hours, users can operate the blinds themselves. After office hours, the computer regulates an optimal balance between the electricity output of the solar cells and lower air conditioning costs. ▶

* The amount of electricity that a solar panel can generate per square metre under what is termed as standard test conditions (STC).

"The lowered and vertical position of the blinds bring about an optimal energy boost."

Intelligent integrated components

"The solar windows are not available in the marketplace as yet", says Valckenborg. TNO is developing this concept together with the Pilkington Glass Company, TU Eindhoven (TU/e) and W/E Adviseurs. In 2018, Pilkington patented the energy boost idea, by combining the blinds with the double-sided solar cell strips in glass. Among other things, TU/e examines light and heat regulation and develops the algorithm for its control. W/E focuses on building standards and sustainability calculations. TNO coordinates the collaboration so that the product is suitable for office buildings.
The window is less-suited for homes, because the solar cell strips look like stripes in the glass. "That is not an obstacle for office work", Valckenborg expects. He particularly sees potential in the integration of these types of intelligent integrated components in prefabricated construction. "When façades are prepared in the factory, then all the electronic elements are already integrated."

Solar cell technology

The researchers are currently testing twelve prototypes on a rooftop at the SolarBEAT research institute in Eindhoven and 8 windows of 2 m² at Pilkington in Enschede. The variants differ in their solar cell width and solar cell technology. The tests show, among other things, that the reflection of sunlight is difficult to model, because there is no uniform reflection of sunlight from the solar cells.
A point of concern is the funding. Expenditure cuts in the National Growth Fund's solar programmes renders any follow-up as uncertain. "That's a shame", says Valckenborg. "We would prefer to have the double-sided PV cell stripes (strips with solar cells) made in the Netherlands, but this might have to become China, due to the lower costs." ■

Who: Pilkington Glass Company, University of Technology Eindhoven, W/E Adviseurs and TNO.

Duration: Basic project ZIEZO: mid-2022 to end-2024. A European follow-up project is pending: 2026 to 2028.

Budget: EUR 1 million for the basic ZIEZO project and EUR 3 to 4 million for the follow-on project (pending).

Follow-up: there is a proposal for the further development of this type of solar strips, among other things, as well as experiments with "shutters" instead of blinds (for a greater boost), and with fully transparent glass.

From left to right: Mario de Rooij, Sylvie Poels and Misja Steinmetz of TNO.

Tool for building industry against the nitrogen problem

Anyone can try TNO's emission tool for the building industry, which enables one to estimate in advance what emissions a building project will cause. "I would just use it a couple of times, to get a good idea of how it works", says TNO researcher Misja Steinmetz. ▶

TNO

Problem: the building industry contributes significantly to emissions of carbon dioxide, nitrogen and particulate matter, which has a negative impact on the environment, climate and health.

T02 Solution: TNO has developed an innovative emission tool for the building industry that can estimate and monitor the emissions (CO_2, NO_x, NH_3 and particulate matter) of construction projects, but also provides guidance on how to reduce them. The online tool starts with standard profiles for activities such as construction transports, construction activities and deployment of personnel, the data of which can be adjusted manually. The tool thus helps to find emission-reduction measures, such as the use of a construction hub, electrical equipment or prefabricated solutions, which in some cases are also cheaper and more efficient.

Impact: the tool will help the building industry (contractors, subcontractors, planners and possibly architects) to reduce harmful emissions, and to support policies (of municipalities and policy makers) for a more sustainable building industry and a better environment.

And indeed, just after a few clicks, a high-rise project created on the spot on a computer screen, containing 80 homes each with 80 square metres of floor space, is found to yield 151.6 tons of carbon dioxide, 18 kg of particulate matter, 344.2 kg of nitrogen dioxide (NO_x) and 16.6 kg of ammonia (NH_3). The last two compounds are covered under the umbrella term "nitrogen", which has become a restrictive factor in the Dutch building industry. The emissions are estimates based on standard profiles for materials, tools/machines and staff deployment, which can be tailored to requirements.

Zero-emission construction

"The tool has been derived from the Zero-Emission Construction programme that ran from 2021 to 2023, aimed at fast solutions for the nitrogen problem on building sites", explains Mario de Rooij, programme manager at Clean and Zero-Emission Construction at TNO. "The first projects had already been completed more than two years before", he says, "when we noticed that a number of things had not yet been properly organised, such as calculating emissions. Everyone did it in a different way – taking emission measurements – using a method based on an LCA (Life Cycle Analysis) or using another method. This makes it very cumbersome to compare things." So, TNO decided to investigate whether a single standardised calculation model could be set up for emissions on site and in connection with transport to the site. Via a precursor, "Brains for Nitrogen" which only included nitrogen, that led to the present tool. "There was a need to calculate the volume of reduced emissions", says Sylvie Poels, project manager of the tool. "So too for passing knowledge on to contractors, subcontractors and clients about what they could work on to reduce these emissions."

Profiles

A major viability step, other than the expansion of only nitrogen to four types of emissions, was to introduce the profiles. Poels: "For certain housing concepts, e.g. a low-rise development, we are already well aware of the approximate number of truck movements involved." These default values are default inputs as soon as the option "low-rise development" is selected. This gives an indication of the emissions, but the input data can also be adjusted to improve the calculation.


Mario de Rooij.

"The tool itself provides recommendations on how to reduce emissions."


Sylvie Poels.


Misja Steinmetz.

Measuring programme

"The profiles are based on a TNO measuring programme, and are updated every year", says De Rooij. This measuring programme, which has been running for decades, measures emissions emitted by vehicles and equipment at construction sites. "It is based on scientific ▶

research and validated, and we try to be as transparent as possible about the methodology and the underlying data. That is the only way to know that calculated emission reductions make sense." This enable users to ascertain emission reductions, e.g. by making use of electric vehicles, or using prefabricated building components, where a large part of the work has already been produced in a factory. The tool itself provides recommendations on how to reduce emissions. An emission-reducing measure can be a "construction hub", a central location for the storage of materials and equipment. This is often beneficial for transport logistics, because fewer transport movements result in reduced emissions.

Enthusiastic users

That first version of the emission tool for the building industry was promptly put into service in April 2024. "Many people started using it", says a satisfied Misja Steinmetz, the researcher responsible for the software. "We have seen 250 to 300 sessions per month. We are able to see what kind of projects are being implemented and, as the creators, we get a lot of queries and requests." Sometimes they come from users for whom the tool was not really intended. "We also get queries from municipalities, who wonder whether they would be able to use it to monitor building projects."

Contractors

Contractors may also find it useful to keep track of emission fluctuations during the project if changes – often unavoidably – occur during construction. Steinmetz: "The tool becomes more user-friendly if it can use an account that is able to assume data that already was entered." This, and other types of user-friendliness, are being developed nowadays, similar to expanding the number of profiles, e.g. also for innovative and circular construction methods or renovations. Steinmetz: "We also make decisions on new features based on user feedback."

Civil and hydraulic engineering

A new field of application is to calculate the effects of civil and hydraulic engineering projects, such as the construction or maintenance of bridges, roads and viaducts. "For this purpose, there are no routinely completed lists of materials and transports." In future, the tool could also be deployed for enforcement, thus being able to check whether a contractor, who has been granted a permit based on the use of an electric crane, also deploys such a durable crane.

Innovative policy

In due course, the tool may play a role in innovative policies. "At present, the nitrogen policy strongly focuses on depositions. That means what comes down in a certain area", says programme manager De Rooij. AERIUS is a computer model known in the building industry that performs such deposition calculations based on emissions and things like wind direction, temperatures and precipitation. "An interface is currently being developed between AERIUS and the emission tool for the building industry", says Steinmetz. "That would be a nice intermediate solution." However, instead of depositions, emissions would be a more useful starting point. "They are easier to calculate, influence and this also means control", De Rooij argues. Policy, for example, should rather be focused more on emissions, which is then followed by the depositions with what is known as an area-focused approach. Aside from nitrogen and carbon dioxide, other parameters, such as water quality, will also play a role. De Rooij: "The question is how best to organise the Netherlands locally and how we can come to agreements on this. The tool could play a role in setting up an area-focused approach, focusing on emissions. We have noticed an increasing interest in this, so too from Europe." ■

"The tool could play a role in setting up an area-focused approach, focusing on emissions."

More details about this project? Visit the website

View the video here

Who: TNO, for the Jungle Minds website version.

Duration: started in 2023, launched online on 1 April 2024, development is still an ongoing process.

Budget: EUR 600,000.

Follow-up: continued development and expansion of features, building methodologies and user-friendliness.

Printed electronics: practical nowadays, but soon to be circular

Printed electronics offer many new opportunities, but also challenges us in terms of sustainability. Together with partners, TNO is developing technologies to repair, recycle and ultimately apply printed electronics in circular production chains. ▶

TNO

Problem: printed electronics are flexible and offer many design options. The downside: there is no good way to recycle them, because circuits are rarely separable from their encapsulating plastic. Without reliable recycling technology, electronics waste grows and precious raw materials are lost.

T02 solution: the Holst Centre (a collaboration between TNO and the Belgian firm Imec) is working with industrial partners to develop methods to separate printed electronics from the thermoplastic polymer in which they are encapsulated. For example, by using an 'ablation layer' which evaporates when exposed to a powerful light pulse. Or a heat-sensitive coating that disengages with directed heating.

Impact: these methods make it possible to repair printed electronics and to recycle them in their entirety. This leads to less waste, the recovery of precious raw materials and the possibility of establishing circular production chains.

Electronic circuits have not been confined to printed circuit boards anymore. Of course you remember them, those greenish little circuit boards, covered with a maze of shiny metal lines, microchips and LED lamps. Silver or copper-coloured digital ink circuits are increasingly being printed on thin, flexible materials. This offers all kinds of advantages, such as a comfortable and easy usage of "wearables" i.e. carried devices, e.g. for medical applications. In addition, the integrated printed electronics fit perfectly into a variety of applications, such as a modern vehicle dashboard that seamlessly eliminates all buttons, displays and lighting. This offers unprecedented design freedom.

Durable light cords

Yet the integration of electronics with plastics makes recycling complicated. The circuits and the plastic are fused in such a way that separation is no longer possible. This means that the shredder or incinerator is the only option at the end of their life cycle. That would lead to carbon emissions and a loss of precious raw materials. It is estimated that global electronic waste will increase to 74.7 million tons by 2030 and to 110 million tons by 2050, if we do nothing. "That is why now is the right time to come up with a sustainable solution for printed electronics", says TNO researcher Stephan Harkema, "before it goes into mass production." To bring this solution closer to practical usage, the Holst Centre – a collaboration between TNO and the Belgian firm Imec – is working with industrial partners on new technologies. Researchers have developed a durable and flexible variant of a light fitting by the lighting manufacturer Signify. This was done in the context of Ecotron, a European research project that aims to make electronic devices more sustainable. Stephan: "We created the cord from recycled PET plastic and printed the circuits with recovered copper. In-between, we inserted an 'ablation layer' which evaporates when exposed to a powerful light pulse. This makes all materials easy to separate and recycle afterwards. In terms of carbon reduction and circular production, this enables us to progress in huge steps."

In-mold electronics

Holst Centre also partnered with the Finnish firm TactoTek, a market-leader in the development of printed electronics for the automotive industry. In this Unicorn project, the researchers tested a heat-sensitive coating for what is known as In-Mold Electronics (IMEs), electronics that are encapsulated in thermoplastic polymer during an injection moulding process. For example, the lights and control elements in a vehicle dashboard or door panels. "Normally, these elements cannot be separated afterwards, but with our coating the electronics and the plastic can be separated after directed heating. While testing, we showed that recycling is possible in this way. Plus: it is the first time that IME components can be repaired, as shown in the EU project CIRC-UITS." This is better for the environment than replacing and disposing of defective components in their entirety, which is now the practice.

"Now is the right time to come up with a sustainable solution for printed electronics"

White goods

It is not coincidental that the automotive industry is interested in this technology: thanks to legislation, this industry is bound by sustainability objectives. In this way, the lessons learnt in the Unicorn project will soon be further developed in new projects. "But, it is more difficult to progressively take steps in the white goods sector, for example. The margins are minimal, and competition is purely on price", says Harkema. It is for this reason that he hopes the pricing of carbon emissions will be established for the industry. "That is the nudge that many electronics manufacturers need to make efforts in achieving greening and recycling." The Unicorn and Ecotron projects have shown the environmental benefits that can be achieved when it comes to printed electronics. "What works on a small scale will – hopefully – be done on a large scale later." ■

Holst Centre, durable electronics with minimal environmental impact

Who: Holst Centre and Tactotek® (Unicorn project), Holst Centre and Signify (Ecotron project)

Duration: 2022 – 2025 (both projects)

Budget: EUR 5 million (both projects)

Follow-up: Various follow-up projects, including a B2B project together with TactoTek®.

Climate change makes the river IJssel more difficult to navigate

The IJssel river in the province of Gelderland is becoming more difficult to navigate due to climate change and a fluctuating water supply. At low tide, ships risk getting stuck or are unable to pass each other, whereas the navigation channel has changed due to sediment transport. With the help of skippers in a simulator, MARIN is mapping out the bottlenecks and offers guidance to Rijkswaterstaat, such as customised signage, dredging or a different distribution of the water supply. ▶

Nicole van Spronsen, project manager at MARIN

MARIN

Problem: due to climate change, there are greater fluctuations in the water supply and levels of water of the IJssel in the province of Gelderland. This makes it more difficult for inland vessels to navigate.

T02 Solution: MARIN is mapping out problem areas with riverbed data, AIS data on vessel movements, and with the help of skippers who virtually navigate the IJssel in a simulator.

Impact: the study provides a guidance for Rijkswaterstaat's measures, from changing the customised signage or dredging the navigation channel, to a different distribution of the water supply to the river, which improves the navigability and safety of the river IJssel.

In the Netherlands, with its straight canals and stretched out rivers, the IJssel is an exception, as a meandering old river. From the point where it branches off into a tributary of the Lower Rhine between Arnhem and Westervoort, it meanders with sweeping curves towards the IJsselmeer. This creates beautiful landscapes and rich nature conservation areas. All the IJssel's floodplains together, make up a large Natura 2000 area. But, it also makes the river more difficult to navigate for commercial shipping. "Undoubtedly, now that drought spells last longer due to climate change", says Nicole van Spronsen, project manager at MARIN. "During low-water conditions, when the upper Rhine lacks rainfall for a long time, the IJssel is not only lower than in the past, but also for longer periods. This puts the reliability of inland shipping under pressure", says the researcher. In 2022, for example, there was a time when, at Lobith – where the Rhine enters the country – only 700 m³/sec. of water flowed, whereas in normal periods, it was between 2,000 and 5,000 m³/sec.

Mapped out riverbed

At the request of Rijkswaterstaat, Van Spronsen and her colleagues investigated the navigability of the IJssel in the province of Gelderland between Westervoort and Zutphen-North in various scenarios: one scenario with a normal water discharge, one scenario with a low-flow discharge, and one with an extremely low-flow discharge. The research question was: what would be the maximum allowable vessel dimensions without compromising the free-flow and safety of the waterway? Van Spronsen explains that "free-flow simply means that you can sail from point A to point B at a normal rate." The study begins by mapping out the riverbed. "Sediment is carried along the river, which means that the location and the level of the bed changes. The navigation channel therefore constantly changes its shape in relation to the 'design channel', as intended by water authorities and dredgers. Measurements done in 2002 and 2018 clearly show this. As Van Spronsen points out on a map she says, "look, here you can see that the position of the riverbed has really changed significantly. Red sections mean that it is shallower than 1,50 metres."

The skipper's perspective during a simulation.

"During low-water conditions, the IJssel is not only lower than in the past, but also for longer periods."

Oncoming vessels and bends

This means that navigability is also more difficult. In the event of low-flow discharge, there are spots in the navigation channel where the available waterway's width narrows from 40 metres to 25 or even 20 metres. Inland vessels have a maximum length of 110 metres and width of 11.4 metres, with a draft of up to 3.5 metres. Not only must this fit through the navigation channel, but ships must also be able to pass oncoming vessels at various places. Bends in the meandering river also have restrictions: the ship itself does not bend. "We first mapped out the situation, and from that we derived the theoretical space available for various vessel classes", says Van Spronsen.

Tracking system

However, vessel dimensions in conjunction with the valley profile of the river, don't tell the whole story. So, the actual routes of ships were examined based on AIS data. AIS (Automatic Identification ▶

System) is a tracking system that continuously tracks the position and sometimes other data of vessels. "We get recorded AIS data from Rijkswaterstaat, which allows the actual navigation characteristics of vessels to be studied. The pursued course can be seen, and also where they passed each other or overtook during low-water conditions." On her computer, she showed a specific example of two (unidentifiable) inland vessels. "Here, it is evident that the vessels encountered one another on 4 January 2022, in very low-water conditions at Doetinchem. The space is rather confined, but they do pass each other safely. This shows that they veer away from the starboard bank, but that they jointly agree to specifically pass on the port side, because that fits better. This is called 'blue sign navigation', because the skippers display a blue sign on deck as a sign of the arrangement."

Seven Oceans Simulator centre

To get an even better understanding of problem areas, six inland waterway skippers were invited to virtually navigate the IJssel in MARIN's Seven Oceans Simulator Centre, where a simulator is housed with a spherical screen measuring thirteen metres and a tiltable bridge. "We have a fixed pool of inland waterway skippers who do this from time to time. They generally think it's fun." For example, problem areas in the river have been simulated for almost fifty different scenarios. Two skippers encounter one another on such a route and need to pass each other. They subsequently spoke to our human factors specialists: "How did that go, did you think there was enough space here, or were you scared?"

Passing ban

The conclusions: during extreme low-water conditions, the IJssel navigation channel is not wide enough in many places to sail safely and smoothly at the same time. "Passing safely is now very dependent on the experience and the good mutual agreements between skippers", says Van Spronsen. Although collisions are extremely rare, improvements are needed to keep the IJssel navigable. "Our conclusions support Rijkswaterstaat's policy choices." Such a measure could be, for example, a local passing ban, but also a deepening of the navigation channel by way of dredging, or an alteration to the distribution of water discharge between the Waal, the Lower Rhine and the IJssel with the help of weirs. "Of course the most unwanted measure would be that the largest vessels can no longer sail there."

Image of the IJssel's floodplains, with a few inland vessels.

Weighing up the interests

Choosing such measures is a puzzle, in which the MARIN study and the navigability problem areas are just merely some of the pieces. Other challenges for the shipping industry – from the energy transition to an increasing shortage of personnel – also play a role, and measures must also fit in with the integrated river management programme, the programme of the State, provinces, water boards and municipalities for a future-proof management of the Meuse and the Rhine. Van Spronsen: "The river is not only for sailing, but water is also needed as drinking water, for irrigating crops and for the environment. Rijkswaterstaat must weigh up all these interests. This research helps." ■

"Our conclusions support Rijkswaterstaat's policy choices."

Who: MARIN, Rijkswaterstaat, four inland waterway skippers.

Duration: 2023 – 2024.

Budget: EUR 250,000

NLR

Self-scan satellite navigation helps identify risks quickly

Satellite navigation – like GPS and Galileo – is indispensable in traffic, agriculture and critical infrastructure. But, interference or cyberattacks can disrupt positioning and timing. The Positioning, Navigation and Timing (PNT) portal offers a solution. By using the free toolkit, users can ascertain where their systems are vulnerable via a self-scan and get practical advice on how to improve resilience. NLR provides knowledge on satellite navigation, it tests scenarios such as 'spoofing' and 'jamming', and validates solutions both in labs and in practice.
Together with CGI, NLR and S&T, the portal was developed by the EGNSS Centre of Excellence under the supervision of ESA and the Ministry of Infrastructure and Water Management. This helps users to make their navigation and time systems safer and more reliable.

PNTPortal

Introduction Positioning Timing and Navigation services

MARIN, NLR

Smart composite propeller tested on board

MARIN successfully tested a new carbon fibre propeller on board the Royal Netherlands Navy's diving vessel, Nautilus. This propeller is full of smart sensors that measure how the material behaves while sailing. It is a key step in the SHM Composite Blades project, in which MARIN is collaborating with NLR, Jules Dock and Solico on techniques to monitor the condition of ship propellers and helicopter blades.
The sensors transmit their measuring data to the ship in real time, using an innovative combination of inductive power supply and microwave technology, jointly developed with Krona Subsea. All the electronics are cleverly concealed in the propeller hub. The smart propeller offers an insight into the condition of composite blades during use and provides key data to improve future designs. Besides, it also forms the basis for future on-board advisory systems. An important step towards better-performing marine propellers and helicopter rotors.

A future for biodiversity in a changing climate

In the rounded off EU project FutureMARES (2020–2024), coordinated by NIOZ, Deltares and Wageningen University & Research partnered on nature-based solutions for the preservation of biodiversity and ecosystem services. Their study focused on the potential effects of low-trophic aquaculture (seaweed and shellfish) on the marine ecosystem under different climatic scenarios, and on the recovery of shellfish beds, both in coastal areas, as well as the opportunities for recovery of the flat oyster offshore. The combined results provide actual suggestions for the recovery of shellfish beds, as well as policy recommendations for the sustainable management of coastal and marine ecosystems. In this way, the partnership provides a scientific basis for future nature and climate policy.

FutureMARES

TNO

TNO launched an open source cyber security tool

Cyberattacks are becoming smarter and more frequent. SOAR tools (Security Orchestration, Automation and Response) help by automatically detecting vulnerabilities and taking immediate action via a “security playbook”, a roadmap that describes how to automatically respond to a particular security threat or incident. Many existing tools are not open source and are difficult to interface with other systems. TNO has resolved this with the new SOARCA tool: fully open source and based on the latest international standards.

The tool is for organisations that want to experiment with Open Source standards, such as knowledge institutes, universities and colleges. Commercial companies can use it too. Consider, cyber security automation in the energy sector, to protect wind farms or solar parks. This improves the resilience, protects sensitive data and reduces the impact of incidents. By using SOARCA, TNO is taking an important step towards more accessible and future-proof cyber security.

TNO

GPT-NL

GPT-NL for safe and responsible AI

The Netherlands wants to exploit the opportunities of artificial intelligence (AI), but also wants to manage the risks and ethical questions. So, TNO developed GPT-NL: an advanced AI language model, specifically geared for the Dutch language and context. The model uses the latest technology in machine learning and natural language processing and is employable in sectors such as healthcare, education, as well as trade and industry.
With GPT-NL, TNO not only wants to stimulate innovation and efficiency, but also to ensure a responsible application of AI. Regulations and collaborations with experts should help to employ AI safely and ethically. The model offers a local alternative to international solutions, reducing the Netherlands' dependence on foreign technology. The model is only trained with data that has been lawfully acquired and right from the start, the legal frameworks of GDPR, copyright and the EU AI Act have been taken into account. GPT-NL is intended for professional and commercial use, such as for public authorities and companies.

Deltares, MARIN

Towards a future-proof inland shipping

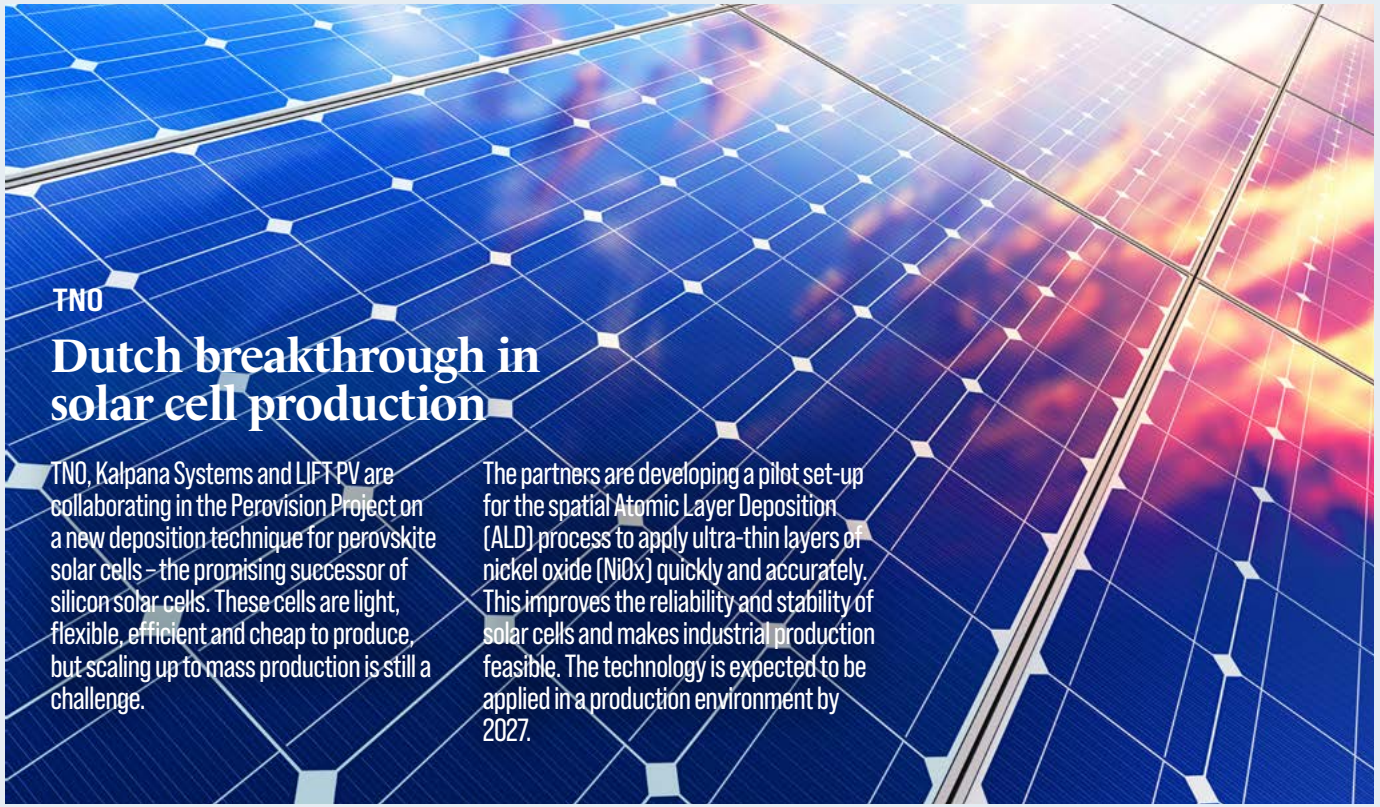
Dry summers and low river levels are an increasing challenge for inland shipping. How can we keep transports via the major rivers to the hinterland reliable and sustainable? Within the research project TRANS2, Deltares, MARIN and thirteen other parties joined forces to consider solutions. Two tracks were considered: the long and short term, for which *tooling* has been developed. Which solutions are most effective for operating more cost-effectively at low-water levels in future – consider lighter vessels with shallower draft. Which solutions look potentially promising to be explored further by the sector, such as the use of medium-term water level expectations or an adapted deployment of the fleet with an intermediate transshipment. If skippers and planners – supported by decision-making systems – can intelligently adapt their routes and loads, this could help to reduce any economic damage.

Deltares

PFAS study into clean water and soil

PFAS – persistent, barely degradable substances – are found more frequently in the ground, dredging and surface water. Deltares is exploring how these substances distribute through water and ground systems. Together with Wageningen University & Research (Food) and RIVM (Risks), the knowledge institute is developing measuring methods to detect PFAS more accurately; it models the distribution in rivers and groundwater; and tests innovative purification and remediation techniques, such as advanced filtration and applications for clay soils. Deltares is also studying solutions for removing PFAS from groundwater at polluted sites, for example with natural solutions such as plants and trees. This knowledge helps public authorities, water boards and companies to take effective measures. Deltares thus works step by step towards clean surface and groundwater based on its ambition for healthy water and ground systems.

PFAS research
Deltares



TNO

Dutch breakthrough in solar cell production

TNO, Kalpana Systems and LIFT PV are collaborating in the Perovision Project on a new deposition technique for perovskite solar cells – the promising successor of silicon solar cells. These cells are light, flexible, efficient and cheap to produce, but scaling up to mass production is still a challenge.

The partners are developing a pilot set-up for the spatial Atomic Layer Deposition (ALD) process to apply ultra-thin layers of nickel oxide (NiOx) quickly and accurately. This improves the reliability and stability of solar cells and makes industrial production feasible. The technology is expected to be applied in a production environment by 2027.

WUR

An outbreak of infectious animal diseases, what now?

At an outbreak of an infectious animal disease in the Netherlands, such as bird flu or bluetongue disease, staff at Wageningen University & Research (WUR) immediately jump into action. Suspect samples are tested day and night in Lelystad, resulting in a reliable diagnosis within 48 hours.

WUR also provides support in policy making and risk assessment. Among other things, the researchers collaborate with the Netherlands Food and Consumer Product Safety Authority (NVWA) and the Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN). That forms the golden triangle for crisis situations.

Depending on the disease, thousands of suspect samples are processed every day, in addition to regular diagnostic assessments that are ongoing throughout times of crisis. As a result of permanent preparedness, state-of-the-art laboratories, and intensive collaborations, WUR is able to switch quickly and effectively. Similar to the fire brigade's role; always being ready, acting quickly and competently in crisis situations, as well as working on prevention and control.

WUR

Locally produced cotton

Wageningen University & Research (WUR), Dutch Cotton BV and G Star have jointly developed a pair of denim jeans produced from cotton cultivated in Dutch greenhouses. This growth method creates five to twenty-three times higher yields, it uses 95 percent less water thanks to the reuse of rainwater, and the process happens without any chemical crop protection products. In the greenhouse at Bleiswijk, WUR researched the quality, fibre structure and yield of this 'Dutch cotton' for a whole year. It also studied the environmental benefits and the opportunities to launch it into the marketplace. Although production costs are still quite a challenge at present, the research collaboration has shown promising opportunities for the development of a new standard in sustainable clothing production. In addition, it has provided valuable insights that could contribute to more efficient and environmentally-friendly cotton production worldwide. Grodan and Innogrowers are affiliated in the follow-up study.

Luca Bordes (left) of WUR and Bart Keijser of TNO.

Fast, affordable and frequent testing in the next pandemic

Nobody wants a new pandemic, but we'd best be prepared for one. Wageningen University & Research have developed a testing system that is fast, affordable and reliable, and can help prevent the further spread of a virus. ▶

WUR

Problem: a new pandemic can always happen, but the Netherlands does not have an affordable and rapidly scalable testing system at the moment.

T02 solution: WUR has developed a self-sampling testing system that can be deployed on a large scale within a few weeks, using robots for fast and cost-effective analysis.

Impact: rapid testing of large groups of the population makes it possible to better control the spread of infectious diseases. This will help to detect infections sooner and to prevent further spread. The low costs also ensure that the system can be applied in less prosperous countries.

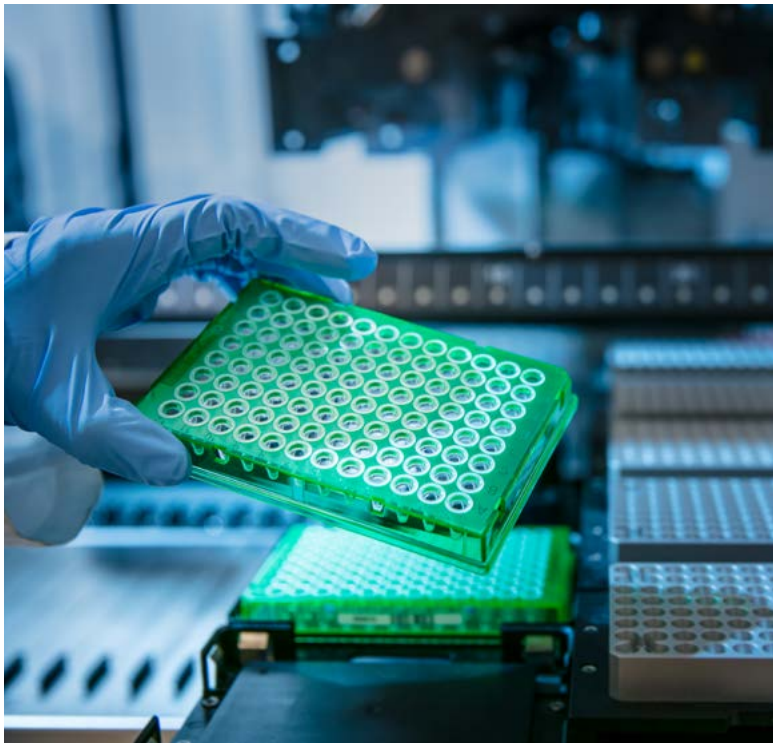
As was the case for the corona self-tests, use is made of a cotton swab to extract some mucus from the nose or throat. This test sample is then placed in a tube with a barcode and QR code and is then sent by post or taken to a collection point. In the laboratory, robots process and analyse the samples. "It will not be necessary to make an appointment, the test can be carried out at any time and the results will be available via an app within 24 hours", says Luca Bordes, project manager in molecular virology at Wageningen University & Research.

Keeping track of the spread

Bordes is contributing to the design of a large-scale testing system that should allow mass testing – within two to four weeks – in the event of an outbreak of a contagious virus. The aim: to process tens of thousands to even hundreds of thousands of samples a day. "Although nobody wants to think about a future pandemic, it is important to quickly get a picture of the spread of such a virus by testing", says Bart Keijser, principal scientist at TNO. "We are an innovative country, and yet it took months for test centres to be widely accessible. Crucial information was mainly derived from local research, for example, among healthcare personnel in Brabant. This showed that the virus had already spread much further than had previously been thought, which led to intrusive measures. This is what we want to prevent happening in the next pandemic." During the corona pandemic, Bordes worked on his doctoral research and saw how people in laboratories worked around the clock to process the enormous volumes of test samples. The fact that it nonetheless took a long time for all those who wanted it, to have themselves tested, motivated him to contribute to a better-working system.

Lower costs

The new testing system should cost no more than ten euros per test, preferably less. Low costs are not only important to enable testing for low-income countries, but also to reduce the high costs for the Netherlands during a pandemic. "One corona test via the Municipal Health Services (GGD) cost an average of 65 euro", says Keijser. "At a given point, we carried out 100,000 tests a day." The lower costs of this test system are achieved by three factors: self-sampling, automation



The new testing system should cost no more than ten euros per test.

and the use of more efficient technology. Robots, in the form of a box measuring about 1x2 m, scan the codes on the test tubes and automatically carry out all the laboratory steps. The knowledge for this robotisation process derives from Radboudumc.

Fewer scarce resources

Many laboratories already have the necessary robotic systems available. They are now being used for other purposes, but can simply be adapted. Multiple test boxes can be added for increased test requirements. "Similar to lego blocks", says Keijser. "This is a quick way to scale up,

even in several locations at the same time." The system uses CRISPR-Cas technology to detect genetic material. Scope Biosciences, a spin-off from WUR, focuses on applying this technology, as this was developed by WUR and Scope Bioscieces. When the virus is detected, the system emits a fluorescent signal indicating the presence of an infection. In contrast to PCR tests used during the corona period, this method requires less complex equipment and fewer scarce materials, such as specific plastics which are mainly produced in China.

Test app

In contrast to corona self-tests, where the results were shown right away, the analysis in this system takes place in a laboratory. This testing method is more sensitive: it can determine whether a person has been infected both sooner and after a while. However, says Bordes: "One of the lessons learnt during the corona period was that having the test easily accessible was at least as important as the quality of the test." So, researchers wanted to develop an app that guides users step by step through the testing process. "The app should explain how the test works, what happens to the data, and how to get the results", says Bordes. "So that everyone can get tested as soon as possible and protect themselves as well as others."

"During a crisis, it is difficult to innovate, because everyone is mainly concerned with keeping the situation under control."

Other applications

Researchers are currently working on the set-up of the robots. The system should be operational by the end of 2026. "We hope to carry out the initial tests with real samples at the end of this year", says Keijser. The researchers stress the importance of using the system on a continuous basis, not only when a pandemic genuinely breaks out. "Otherwise, it would be outdated when it is really needed", says Bordes. "That is why we are also considering other applications, such as the monitoring of animal diseases including avian flu, flu research among the population, and for the detection of plant diseases." Keijser adds: "In this way, we can use the system for broader societal challenges and thus contribute to innovations in infection control, sustainable diagnostics, and public health." In conclusion, he says: "During a crisis, it is difficult to innovate, because everyone is mainly concerned with keeping the situation under control. This means that we must act now, because we now have the time and space to do so." ■

Who: Wageningen University & Research (WUR), TNO and Radboudumc.

Duration: 2024 – 2026.

Follow-up: researchers are aspiring to collaborate with companies to keep the testing system operational. Additionally, they want to make healthcare more future-proof, with less dependence on countries abroad, making the Netherlands less vulnerable to international instability.

Faster liver disease treatment

Greater numbers of the population are facing liver problems due to their unhealthy lifestyles and associated overweight. TNO has developed a method that can predict the risk of liver fibrosis sooner and easier. ▶

Roeland Hanemaaijer (left) and Lars Verschuren, researchers at TNO.

TNO

Problem: changing lifestyle and its associated overweight can cause fatty liver i.e. metabolic dysfunction-associated steatotic liver disease (MASLD) and scarring in the liver (fibrosis). Currently, a diagnosis is done in a hospital by way of a liver biopsy, which is intrusive and with that in mind, it does not happen until there is a serious risk of fibrosis of the liver. As a result, the diagnosis comes late in most cases when the damage to the liver is already irreversible.

T02 solution: by using a mouse model that accurately mimics disease progression in humans, TNO and its partners AUMC and LUMC have jointly identified a set of biomarkers that show the degree of fibrosis of the liver in a tube of blood. What's more, these biomarkers can predict fibrosis of the liver at an early stage, i.e. before symptoms occur.

Impact: the new testing method can lead to a simple diagnosis so that more effective therapy and/or lifestyle intervention can be put in place for patients at an early stage (pre-symptomatic).

One-third of the Dutch population has a fatty liver. Although this is not dangerous in itself, some people develop severe conditions over time, such as inflammation or fibrosis of the liver. Fibrosis is scarring that can occur in the liver due to prolonged overburdening. Those who suffer from it, often only notice that years later and then there is usually a lot of damage in the liver. The diagnosis nowadays requires an invasive biopsy, in which the doctor at the hospital uses a hollow needle to extract and diagnose a piece of liver. "Then, in fact, it's already too late", says Roeland Hanemaaijer, senior scientist at TNO. "An intervention is far more effective if this is done before irreparable damage occurs."

Molecular changes

TNO is working together with hospitals and international research partners on a new strategy. They developed a "mouse model" that closely resembles the course of the disease in humans. "We noticed that the initial disruptions in the liver are already visible at a molecular level, before there is any visible damage," says Lars Verschuren, senior scientist at TNO. The team used this model to identify hundreds of liver proteins involved in the disease process. Eventually, there appeared to be twelve biomarkers that predict the development of fibrosis of the liver in humans. These were subsequently tested in large-scale international studies. "In one of the studies, we used these biomarkers to be able to predict which participants would develop fibrosis of the liver six years later", says Verschuren.

40,000 euro

The blood test also has major advantages in clinical trials when testing new drugs in patients. "In a study in the USA, 2,000 people had to be screened using biopsies to find 1,000 suitable patients", says Hanemaaijer. "Our test enabled a far better selection in advance as to 'who is at risk'. As a consequence, trials can be faster, cheaper and more effective." The biomarkers also make it possible to sooner assess whether a medical treatment is effective. "The current remedy for treatment of fibrosis of the liver is only effective in a third of the patients, costing EUR 40,000 per year, and a result would only be known a year later", says Hanemaaijer. "Our method offers a better understanding of the disease process. In this way, treatment can be stopped if it does not work and the focus then only lies on those who really benefit from it." TNO's strategy may possibly be useful for other diseases involving fibrosis too, such as pulmonary fibrosis. "We are exploring whether an adapted biomarker panel makes early diagnosis possible for that too", says Verschuren. The strategy remains the same: researchers examine the molecular early stage of the disease.

"An intervention is far more effective if this is done before irreparable damage occurs."

SME partners

The trial is currently still in the research phase, but is already being tested on patient groups in various hospitals. Diagnostics companies and SME partners are also involved, to further develop the trial into a practical toolkit for clinics. In September, a partnership started between two hospitals and four companies for further validation and product development. "Ultimately, this should lead to a simple test that is suitable for application across a wide range, so that healthcare is only given to those who really need it", says Hanemaaijer. ■

Who: TNO, hospitals like AUMC and LUMC, and SMEs.

Duration: 2019 – present.

Budget: various projects are funded by Top consortium for Knowledge and Innovation (TKI) and by the Netherlands Organisation for Health Research and Development (ZonMW). The current programme is funded by TNO's Early Research Programme BioAlert.

Follow-up: for fibrosis of the liver, the follow-up is to validate and optimise the test so that it can rapidly be put in place for screening purposes. Furthermore, research provides a sufficient basis for early, innovative diagnostics: tracking down patients without symptoms, but who have an active disease process.

TNO researchers revealed a newly discovered method in a Nature Communications publication, which describes that the measuring of three specific proteins is enough to determine the severity of fibrosis of the liver.

Looking ahead to be prepared

Not only aircraft and missiles pose a threat in conflicts, but cyberattacks and GPS disruptions are increasingly being used too. Actions in the air are changing and that requires a new approach. To prepare the Netherlands in this respect, the Ministry of Defence works closely with NLR's Future Force Design team. ▶

Antoine de Reus of NLR.

NLR

Problem: the threat environment is changing rapidly. Our security is threatened not only by kinetic means such as missiles and drones, but also by cyberattacks, electronic disruptions and disinformation campaigns.

TO2 Solution: NLR's Future Force Design team supports the Ministry of Defence in developing future scenarios and formulating strategic choices to secure and exploit the airspace.

Impact: the team will improve preparedness against new threats, more effective use of resources, and intensify collaboration between knowledge institutes and the Ministry of Defence, focusing on long-term security and deterrence. This will keep the Netherlands resilient.

"The time when war only involved firing rockets, is a thing of the past", says Antoine de Reus, NLR's team leader, responsible for development of the Future Force Design operations. "We have noticed a shift towards non-kinetic means: cyberattacks, the hijacking of communication satellites, or influencing public opinion via social media." A good example is the war in Ukraine, where digital attacks and the mass deployment of drones are at least as important as conventional weapons.

Looking ahead

In order to be prepared for future threats, the Ministry of Defence is working together with the Royal Netherlands Aerospace Centre (NLR) and the Netherlands Organisation for Applied Scientific Research (TNO) on Strategy and Armed Forces Development (SKMO). In this process, scenarios describe what the world would look like in five or ten years' time and which threats would then be topical. The Future Force Design team supports this by identifying trends, changes in trends, and technological innovations. "Concurrently, the geopolitical context is changing: dependency on American military support is under pressure. Europe must become more independent, using its own intelligence, observations and command", says De Reus.

Capabilities

The Future Force Design team not only thinks about trends, but also translates them into "capabilities". These include 24/7 airspace monitoring, effective drone control, and the use of artificial intelligence to make faster and better operational decisions. "We are thinking about what the air force's operational environment – the environment in which the military operate – could look like. The deployment of drones has obviously taken a huge leap. What does that mean for daily airspace operations? How does one counter an attack of five hundred drones? It is not only a defensive plan that is required. Attacks must also be prevented, for example by deterrence."

New technology

Technological innovations like quantum technology or AI also play a role. These can result in faster and more informed decision-making, e.g. during an operation in which GPS disruptions are deployed. At the same time, this technology could also pose a threat to the security of encrypted communications in future. The team explores both sides: exploiting opportunities as well as managing risks.

"Europe must become more independent, using its own intelligence, observations and command."

Broad-based view

What makes the Future Force Design team so special, is the way they act together. NLR experts work intensively with Defence and TNO staff and are present at the air force site several days a week. In forthcoming years, the team will be expanded with experts in military strategy, geopolitics, and political science. "This will enable us to keep a broad-based view on what is to come, so that we stay ahead of threats in the air and space", says De Reus. ■

Who: NLR's Future Force Design team in collaboration with the Ministry of Defence and TNO, which also focuses on land operations and maritime affairs in the SKMO process.

Duration: started in February 2025, with preparatory activities since 2021. The partnership is open-ended.

Budget: NLR and the Ministry of Defence employs own means to invest in capacity, training and reconnaissance.

Follow-up: the team will be expanded with experts on geopolitics and military strategy. Beyond that, NLR continues to work on new and better methodologies, as well as intensifying collaborations.

Shorter waiting times for new and better medicines

Patients often have to wait a long time for better and cheaper medicinal products. A technique developed at TNO can shorten the development time by ten months to two years. ▶

Wouter Vaes (right) and Steven Erpelinck of Peregrion.

TNO

Problem: developing new medicinal products takes long and is very costly. Healthcare costs continue to rise and patients wait a long time for better treatments.

T02 Solution: Peregrion, a corporate spin-off of TNO, helps pharmaceutical companies to develop medicines faster and cheaper. By using advanced technologies like AMS in combination with data analysis, it accelerates the phase of clinical trials. The latter usually happens with laboratory animals and humans, mostly men. Peregrion deploys the AMS to measure how the body handles administered investigational medicines. Peregrion can do this directly with humans.

Impact: this helps patients get better treatment and reduces the cost of drug development. Laboratory animals are no longer needed in this part of the clinical trial phase and there is greater potential for trials with children, women and the elderly.

The development of medicines is a time-consuming, labour-intensive, costly and uncertain process. This could take up to ten to fifteen years, which means that pharmaceutical companies have to recoup their invested billions in a short space of time. Patent rights, after all, are valid for twenty years, including development time. Researchers at TNO have found that this can be done much faster, shortening the time with no less than ten months to two years, thanks to a new method developed by TNO. Peregrion, a corporate spin-off of TNO, now offers this method to pharmaceutical companies. The Peregrion laboratories at Leiden Bio Science Park have about thirty employees conducting tissue research for almost all major pharmaceutical companies. There is one other global competitor who offers similar services. TNO is the full proprietor of this spin-off, whose development began fifteen years ago. Wouter Vaes and Steven Erpelinck run the company, in addition to their work at TNO.

Toxic

Erpelinck manages Peregrion's commercial activities and is the chief business developer at TNO. He travels the world with Vaes to promote Peregrion. Vaes heads the research section. The toxicologist has already been working at TNO for 26 years, mainly as a specialist in ADME research (absorption, distribution, metabolism and excretion). These are standard in clinical trials of drug research. These trials study how the body deals with any administered candidate drugs (medicines that are being developed or in an investigational phase), e.g. whether and how long they remain in the blood. These are then traced in the body, such as in blood and faeces. Peregrion has accelerated this part of drug research thanks to the new method for what is known as microdosing and microtracing studies. Vaes: "The body is created in such a way that it removes all foreign substances. Or, as Paracelsus (fifteenth-century physician and alchemist, ed.) said: 'It is not the substance that determines whether something is toxic, it is the dose that determines how toxic something is'. So, you can administer such a tiny bit of substance to humans that it is not toxic. Then it can be traced how it moves in the body and how quickly it is removed." This is called microdosing. "By merely using ▶

In the Peregrion laboratories at Leiden Bio Science Park, thirty researchers are examining tissue for all major pharmaceutical companies.

"Women and children also benefit from our accelerated method of drug research, but this is still in its infancy."

conventional methods, these extremely low concentrations cannot be measured", says Vaes.

Minimal radioactivity

Such measurements can be done using what is known as Accelerator Mass Spectrometry (AMS). It works as follows: The AMS measures carbon-14. This carbon is some kind of marker. This is administered into the medicinal substance and is traced back in the body's breakdown products, such as faeces. Vaes: "Then it can be referred to as being related to the medicinal product, and followed-up with other technology in further research." However, the radioactivity of carbon-14 can be harmful. Vaes: "Our AMS system makes it possible to reduce the required dose of radioactivity, namely by a factor of one hundred. This allows us to use the marker safely. We can also work with fewer quantities of substance in the trial drug."

From one week down to eight minutes

The benefits of this technique are innumerable. TNO's method automates and shortens the labour-intensive and manual preparation of a study sample of blood or faeces. Vaes: "This normally took a week for a batch of sixty samples. Nowadays, we do this in eight minutes." AMS works like this: an AMS only accepts the substance graphite, the black stuff of a pencil. So, the faeces or blood must be made into graphite. Vaes: "This requires strange actions, such as drying, burning and turning gas back into a solid substance. Not an easy task. Our system automates this process while simultaneously analysing the samples. TNO has developed an interface between existing devices. Due to the complexity of the method, customers such as AstraZeneca and Pfizer have now commissioned Peregrion to conduct these types of research (photo).

"Faster drug development of alternatives, makes extremely expensive treatments possible for more people."

Non-animal testing phase

Another benefit, the extra low dose of radioactivity allows for much earlier testing in humans for ADME research. Laboratory animals are no longer needed for that. Companies like Pfizer already use this "human first, human only strategy" in ADME research. However, Vaes expects that laboratory-animal research will always be necessary before human research. "But if humans are used, then ADME research no longer needs a single laboratory animal anymore."

Women and children

The new TNO method also benefits the elderly, women and children. Vaes: "In the *guideline for drug research Human* usually means a man aged between 18 and 65. Women and children are almost always excluded." For example, together with Nijmegen Radboud UMC, Peregrion is currently studying microtracing in ADME research on young children. Vaes and Erpelinck gave lectures on this research at the American Food and Drug Administration (FDA). The technology is now included in a new FDA guideline for research in newborn children. Nevertheless, pharmaceutical companies are not yet rushing to Peregrion for this type of research in children. Presumably out of fear of negative publicity. Vaes: "However, the dose is so low that a child is exposed to far more radiation in an aeroplane between Amsterdam and London than in participating in this type of research."
By tradition, participation by women is also lagging behind. In 87 percent of Peregrion's research only men have been involved. "We even researched a drug for women in which the metabolism study had been carried out on men", says Vaes. Drug research for women is considered complex due to hormone fluctuations and feared effects of radioactivity on fertility. "For women too, this is no longer an issue with our extremely low dose", says Vaes. Participation by women and children in these studies is still in its infancy. "There is still much to do in conveying our message to reach the masses."

Market opportunities

By launching Peregrion, TNO is accelerating the use of the new AMS methodology. Peregrion can focus on additional studies and the commercial message, which is significant according to Erpelinck: "Company patents on a medicinal product lasts about twenty years, which includes the development time. As a result, companies have about seven to twelve years to recoup the investment. During this time, they enjoy market exclusivity. If they use our AMS technology, they will gain ten to twelve months of recuperation time due to previous registration. Moreover, ninety percent of all drugs in development do not reach the final stage, so investors sooner want certainty regarding any further investments."

"Faster drug development of alternatives, makes extremely expensive treatments possible for more people."

Expensive treatments

There is more. "TNO's research techniques can also accelerate the development of cheaper, patent-free alternatives for expensive biologicals in, for example, immunotherapy and cancer therapies", says Erpelinck. These biosimilars are copies of natural proteins such as antibodies. These much cheaper biosimilars can then replace the original biologicals as soon as the patent expires. Erpelinck: "An immensely hot topic, because it makes extremely expensive treatments possible for more people." At present, TNO is also developing a concept that can demonstrate the effectiveness of these types of medicines far sooner. "We have terrific synergy between TNO and Peregrion and are on the brink of developing high-quality applications that advance medical science." ■

Who: TNO and various hospitals

Duration: 5 years.

Follow-up at TNO: development of faster efficacy research of cheaper, patent-free alternatives to expensive biological drugs, known as biosimilars.

WASP is forging ahead

For thousands of years, sails were the most efficient way to steer ships, until a century ago, when the ship's engine combined with a propeller took over the helm. But sails are making a hyper-modern comeback. A growing fleet of cruisers and cargo ships use the wind for propulsion. ▶

Large Motion Simulator, interior with wind propulsion system.

MARIN

Problem: sailing and other techniques for Wind Assisted Ship Propulsion (WASP) promise reductions in carbon emissions and in fuel consumption, and thus in the costs of ocean shipping. Its introduction requires a user-friendly interface to operate the sails, standardisation of performance, and regulation.

TO2 Solution: MARIN is researching user experiences and interfaces for the on-board workforce, and raising the WASP's Technology Readiness Level (TRL).

Impact: WASP technologies are increasingly being deployed and result in carbon emission reductions. Follow-up research focuses more on taking measurements and gaining an understanding on board of sailing ships that improves safety on board.

Instructor and Observation Room, Large Motion Simulator.

This new technology is called Wind Assisted Ship Propulsion (WASP), which is actually a whole range of techniques where the wind saves about five to fifteen percent of fuel, although, in certain conditions, the engine could be shut down completely. Within the European Horizon research project Optiwise, Niklas van Duinen, researcher and project manager of Human Factors at MARIN, investigated the Solid Sail system. "It consists of flexible panels that catch the wind", says Van Duinen. The French shipyard Chantiers d'Atlantique, one of the project's participants, developed the system. Each unit consists of a mast and two sails, on an underframe that can rotate 360 degrees. It can also tilt, allowing the ship to sail under a bridge.

Cruise ship

Three such units will be installed on the Orient Express cruise ship that offers trips in the Mediterranean, for example. Van Duinen: "For its design, we investigated the effect of adding the system for operational changes on board. These include aspects such as safety, training, procedures, effectiveness of the system, decision-making processes, situational awareness and the level of automation." To gain practical experience, two captains "sailed" in MARIN's Seven Oceans Simulator Centre. Here, they sailed the Large Motion Simulator (LMS), a large simulator with tiltable bridge. "At the start, sailing was a bit uneasy. They first went at full throttle from A to B as fast as possible. But, gradually they got more feeling for the sails, and planned the routes in such a way that it yielded more fuel savings. During simulations, we used observations and 'eye-tracking' to ▶

"With the help of a people-oriented design methodology, we investigated what information is really important to the operator."

analyse interactions with the systems. In this way we were able to understand what information the operators used to make choices."

Human Factors

One of the aspects that our Human Factors specialist Van Duinen focused on, was the user interface with which the crew can operate the sails and make choices between automatic and manual settings, for example. "The original interface was highly technical, and provided a lot of information, which does not make it very clear or intuitive to operate. With the help of a people-oriented design methodology, we investigated what information is really important to the operator, and how best to present such information. We developed a simplified version, emphasising the most important information. In doing so, the question is always: what information does the crew really need?" One conclusion was that wind propulsion radically changes the way of sailing: from journey preparations and wind-guided route adjustments for fuel savings, to clear procedures to ensure safety and efficiency. Wind propulsion requires automation with manual options so the crew maintains its control.

Gaining experience

The Optiwise research project also tested the Ocean Wings design by the eponymous French company, a system of dual vertical panels that catch the wind, as well as the Flettner rotor by the British firm Anemoi. This is a rotating vertical tube that produces propulsion transverse to the wind direction thanks to the aerodynamic Magnus effect. The International Maritime Organisation's (IMO) climate targets require net emissions from shipping to be reduced to zero by 2050. Working towards this goal not only requires better interfaces, but also other supporting measures, from adapted route planners to amendments in rules and regulations. On busy seas like the North Sea, ships operate in a traffic separation system, similar to the lanes on a highway. Van Duinen: "Can this also be used while sailing? Then how?" Answers to such questions are necessary now that WASP is forging ahead. ■

"The original interface was highly technical, which does not make it very clear or intuitive to operate."

Large Motion Simulator.

Optiwise

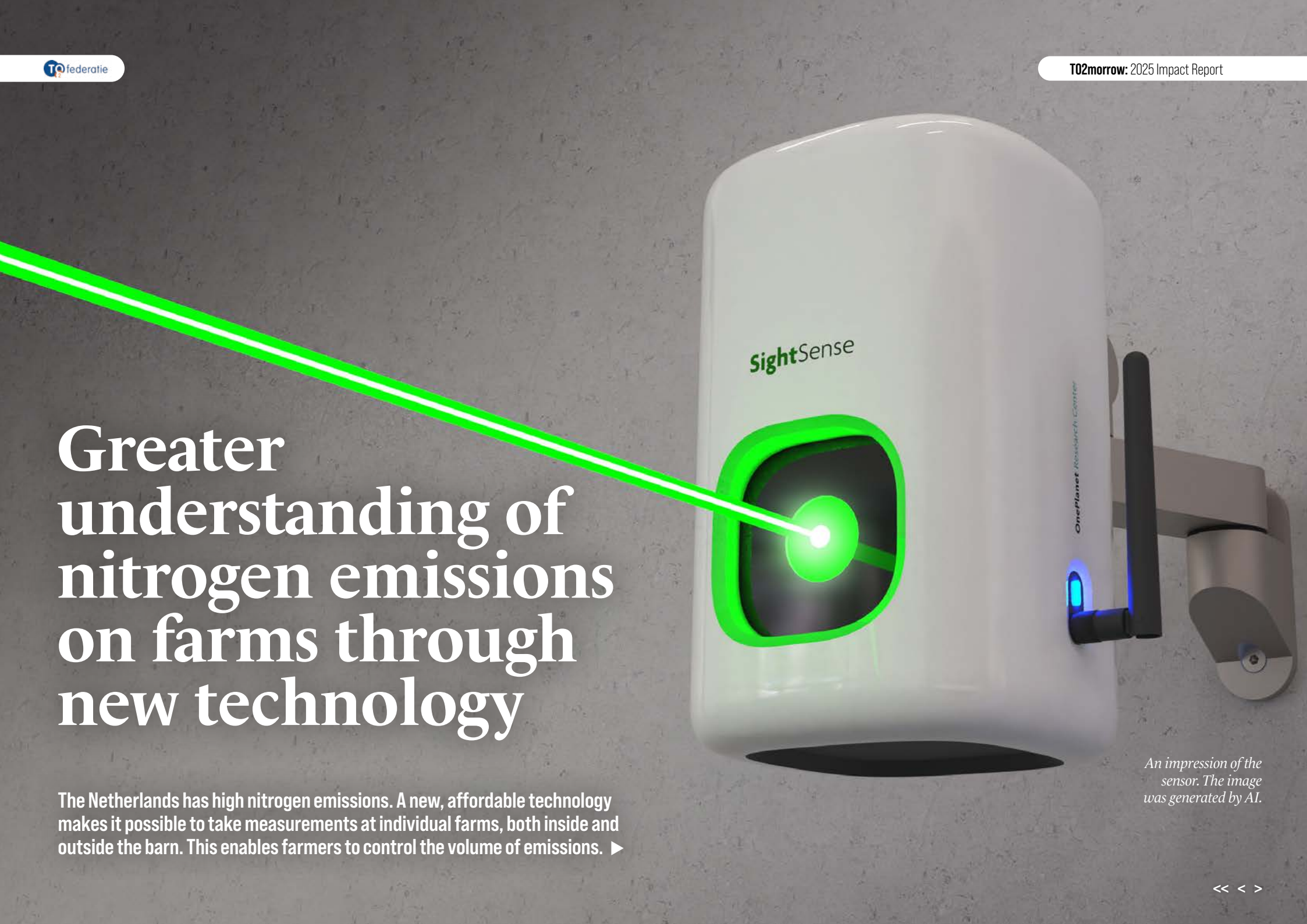
Who: MARIN, Anemoi, Flikkema Innovation Management & Consultancy, Core Innovation Centre, Ocean Wings, Wärtsilä, Research Institutes of Sweden, Chantiers de l'Atlantique, Università di Genova, Euronav.

Duration: 2022 – 2025.

Budget: EUR 5.1 million.
Follow-up: there will be research into how the systems are actually used on board.

Greater understanding of nitrogen emissions on farms through new technology

The Netherlands has high nitrogen emissions. A new, affordable technology makes it possible to take measurements at individual farms, both inside and outside the barn. This enables farmers to control the volume of emissions. ▶



An impression of the sensor. The image was generated by AI.

WUR

Problem: the Netherlands has long been emitting too much nitrogen. As a result, we do not comply with European commitments to protect Natura 2000 areas. Ammonia emissions are mainly released in agriculture. There is no proper system as yet for measuring emissions for individual farms.

T02 solution: development of a new measuring system based on photonic chip technology. This ensures that nitrogen concentrations are measured continuously, reliably and affordably and made transparent.

Impact: farmers gain an understanding into their farm's nitrogen emissions, allowing them to steer more towards reduction. This enables a reduction of overall emissions and creates prospects for agriculture and nature recovery.

Last year, sensors were installed inside the barn at De Marke's agro-innovation centre, a high-tech dairy farm for scientific agricultural research at Wageningen University & Research in the Achterhoek, a region of the Netherlands. A laser reflects a beam of light through the barn via a mirror, and measures the concentration of gas molecules in that beam of light. "Farmers will be able to read the data easily, similar to a speedometer", says Remco Suer, programme manager at OnePlanet Research Center. A dashboard, continuously displays the concentration of ammonia in the barn.

Taking measurements at individual farms

The National Institute for Public Health and the Environment (RIVM) determines the permitted nitrogen emissions for the whole of the Netherlands. But, to reduce emissions at individual farms it is useful to know exactly what the emissions are for each farm. At De Marke, researchers have been measuring nitrogen concentrations for six years already. This happens via a combination of sensors that take measurements at the top and sides of the barn. "It is a complex and difficult system and this measuring method actually only works well indoors", says Suer. "Even indoors it is difficult, and we also have to look what is happening outdoors, because fifty percent of the emissions occur outside the barn." The new sensors currently being tested at De Marke make use of photonics, i.e. light technology. Today's large, expensive research equipment also uses light-based measuring techniques, and OnePlanet Research Center makes use of Imec's photonic chips to develop a cheaper miniature version. "The installation is simpler and the technique is more precise than the current combined measuring method", says Suer. These sensors should be about 50-70% cheaper than the current combined systems, which cost about EUR 15,000.

Measure what works

The environmental permits of farms specifies how many animals can be kept in a given barn system so that nitrogen emissions remain within the norm. Nowadays this is based on averages, without taking into account management measures taken by farmers to further reduce emissions. Consider for example, feed with less proteins, spraying water over the manure, and sweeping

Farmers will easily be able to read the data in the barn.

About De Marke

Agro-innovation centre De Marke is a high-tech dairy farm for scientific agricultural research. Together with farmers and other partners, they work on circular agriculture, nature-inclusive agriculture, climate-robust agriculture and precision farming. De Marke is part of Wageningen University & Research.

Sensors can detect several substances at once, not only inside the barn but outdoors too.

the manure off the floor more frequently. The government prescribes such measures, but since no individual farms are measured as yet, the actual effect on each farm is unclear. For target management, a method being considered by the government, farmers will use their own discretion to stay below a maximum target emission. Suer: "Then it helps if farmers can measure exactly what works." In the long term, this could also help to take measurements outside the barn.

"Farmers will easily be able to read the data, similar to a speedometer."

Industry and construction

Researchers are currently working on chips that not only measure nitrogen, but also other substances, such as carbon dioxide, methane and nitrous oxide. "Every substance absorbs light in a specific wavelength", Suer explains. "One sensor can detect several substances at once, not only inside the barn but outdoors too. This new measuring system can therefore be used in sectors such as industry and construction. ■

Who: OnePlanet Research Center, a collaboration between Wageningen University & Research (WUR), chip innovation and research centre Imec, Radboud University (RU) and Radboudumc, supported by the Province of Gelderland.

Duration: OnePlanet started in 2019. This technology has been developed for two years now, and it will take about two more years to achieve a large-scale product.

Follow-up: this technology not only measures ammonia (nitrogen compound) but other substances too, such as carbon dioxide, methane and, at a later stage, nitrous oxide and even odours. In addition to agriculture, the method can also be applied in sectors such as industry and construction.

Co-pilot for urban planning

“We sometimes jokingly call it SimCity for professionals”, says Jeroen Borst, CEO of Scenexus, a TNO start-up that offers “digital twin” urban planning in the form of Software-as-a-Service (SaaS). ▶

TNO

Problem: given the growing complexity of urban areas, there is an urgent need for efficient and accurate urban planning solutions.

T02 Solution: TNO established Scenexus, a spin-off company specialising in virtual solutions for urban planning. Scenexus offers fast Software-as-a-Service solutions that calculate scenarios and modifications in real time. Decision makers, planners and engineers can assess the exact impact of their ideas and changes in only a few minutes.

Impact: the introduction of Scenexus' technology significantly improves the speed and accuracy of urban planning, leading to better decision-making, greater flexibility, and the sustainable development of cities and regions.

A digital twin is a software solution that is a digital copy of a physical structure, process or system in a virtual environment to enable real-time understanding, simulation and optimisation. The digital twin at Scenexus, promptly simulates spatial planning scenarios, such as traffic flows, noise nuisance, or air quality. What makes it unique is that this virtually happens in real time. Changes are factored in, "within the time it takes to drink a cup of coffee", says Borst.

GIS tools

"Scenexus came about as a pure necessity", says Borst. "As early as the 1990s, I worked at TNO with traditional GIS tools to simulate the environmental pressures of traffic, for example. I discovered that speed had to be much higher." Such a model spent at least 24 hours calculating the consequences of a road closure. "The calculation of noise pollution or air quality took ten days", says Borst. When I presented my report to a municipality they would then say: "great, but we have made some changes in the meantime, could you calculate those implications too? It's expected to be on the alderman's desk by next week."

Gaming hardware

Being both inspired and frustrated by these experiences, Borst began in 2005 to develop an interactive model that would virtually be able to calculate the implications immediately. A meeting with Scenexus' current CTO Walter Lohman, led to the understanding that this required a distributed application that divides the calculations among a large number of CPUs. Borst: "Then we decided to do so on NVIDIA's gaming hardware, the graphics processors that also enables 3D graphic games." The interactive software led to commissions for cities in the Netherlands, Europe, China, India, Singapore and the USA. Borst: "Scenexus is web-based, but our demo room in The Hague can also be visited. Everybody stands around a planning table, it looks similar to a very large iPad."

Municipality of Amsterdam

The municipality of Amsterdam uses the tool for urban strategy planning, for example when calculating the consequences of a speed reduction to 30 kilometres per hour, or for planning the renovation of bridges and quays in the city centre. Borst: "If this is not done, unforeseen situations occur, where people take unexpected shortcuts, or people are unable to leave their neighbourhood due to closures, for example".

Impact

Scenexus was established on 1 January 2025, with a first-round capital injection totalling EUR 1.6 million by TNO and financier LUMO Labs. "TNO conducts applied research, in which innovations must make an impact", explains Mark Courage, director of Smart Industry at TNO and specialises in digital twinning for the manufacturing industry. "If this is successful, and innovation is ▶

TNO

"In the long run, we must become a kind of co-pilot for urban planning."

repeatedly applied, it becomes a product: innovation becomes relatively less important, but the impact increasingly becomes greater. That is the moment to assess how best to market the innovation." In the meanwhile, the nine employees are working on expanding the options, e.g. with economic aspects such as housing prices, or providing information for emergency services. It is also possible to link up with other digital twins, e.g. for disaster scenarios.

Co-pilot

A deployment of AI is being worked on: not for the calculations themselves, as those must remain predictable and explicable, says Borst. But, it could guide selecting alternative scenarios. "In the long run, we must become a kind of co-pilot for urban planning." There are also tremendous aspirations to grow commercially. Borst: "In five years' time, if left up to us, we will have at least a hundred cities as customers. Scenexus will then offer 'state-of-the-art' urban planning." ■

Who: Scenexus, TNO, Lumo Labs.

Duration: started on 1 January 2025.

Budget: EUR 1.6 million.

Follow-up: expansion of technical capabilities and assignment portfolio.

scenexus

Credits

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