

VISION

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THE POTATO FIELD**

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SHOULD PROTECT US
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Dear reader,

When in April the 'hydrological summer' began, the six driest months of the year, it already became clear that we are not safe from a water crisis this year either. The dry summers of recent years caused that hardly any water reserves have been built up.

Flanders is one of the most water-scarce regions in Europe, as we have experienced several times in recent years. Hosepipe bans were announced, pumping restrictions were imposed on farmers and more and more companies and organisations had to deal with water shortages.

Concrete action is needed and we must put "the spade in the ground". As part of the Blue Deal, the Flemish government entrusted VITO with the coordination of Flanders WaterProof. In this ambitious and large-scale project, we will investigate in the coming years - through some well-chosen demonstration projects - how we can counter drought with smart water buffering. Hence, we assist in making Flanders an exemplary region for efficient water use. In this issue, you can read more about the unique 'system project' Flanders WaterProof.

This spring, the citizen science project 'CurieuzeNeuzen in de Tuin' has been launched. With help from citizens, the heat and drought in Flemish gardens and parks, as well as in playgrounds and business parks, will be mapped out. This second part of CurieuzeNeuzen is also a big success. The first CurieuzeNeuzen project enabled the air quality in Flanders to be studied on an unprecedented scale, thanks to the efforts of many volunteers. This second project includes a sub-project in which the impact of heat and drought on the cultivation of potatoes in Flanders is being studied. We will go more deeply into it in this issue.

You will also discover how our state-of-the-art test lab is keeping its finger on the pulse of the rapidly evolving and differentiating battery applications market. How we are using smart, AI-based recognition technology to solve bottlenecks in waste recycling and how we are driving sustainability in the construction sector with the creation of a brand new spin-off, Enperas.

Of course, corona is still around. The pandemic is not over yet, and the economic and social consequences will continue to affect us for a long time. Nevertheless, we are hoping for improvement and VITO, with the support of the Flemish government, will support the economy and the population of Flanders even better in the future.

The drastic switch last year to comply with the corona measures while allowing our researchers to continue their important work safely, went smoothly and had little impact on our results. The figures for 2020 show that, with continuing consideration for good project management and cost efficiency, we are ready for the challenges of the post-corona era.

Together, we will evolve into a sustainable society. Happy reading!

Dirk Fransaer
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VITO RANKS AGAIN IN TOP 10 OF BELGIAN PATENT APPLICANTS IN 2020

As in previous years, VITO strengthens the ranks of the top 10 Belgian organisations and companies that have applied for a patent at the European Patent Office (EPO) in 2020. A strategic selection of the geographic regions in which patent protection is sought, should enable an efficient cost control in function of valorisation planning.

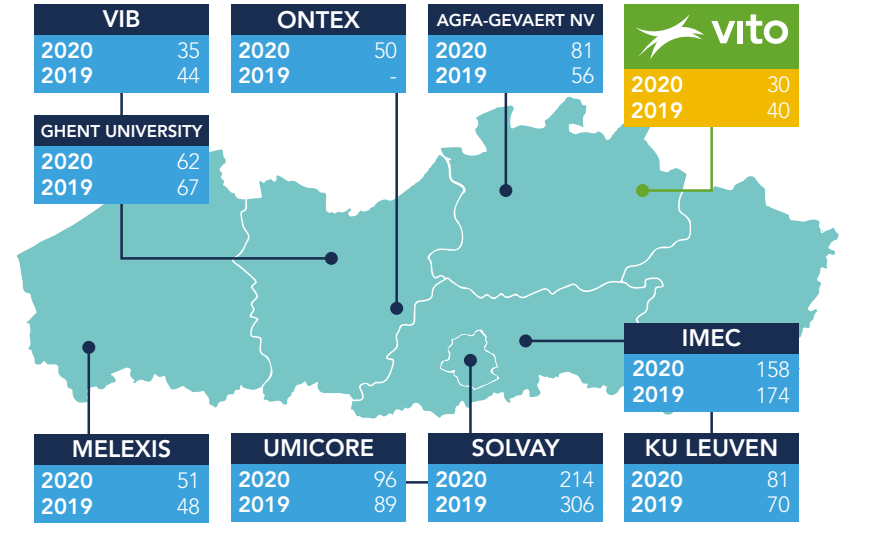
In 2018, 32 applications were filed by VITO, which grew to 40 in 2019, and evolved towards 30 in 2020. Solvay still leads the list with 214 applications in 2020 and imec stays second in rank. With 30 applications, VITO is again following closely its colleague VIB. All in all, the Belgian organisations and companies accounted for a total of 2,400 patent applications filed at the EPO in 2020, a slight decrease compared to the number of applications filed in 2019 (2 422). This is in line with the generally observed decrease in the total number of patent applications filed at the European Patent Office (- 0.7 %). The global pandemic that has been going on since the beginning of 2020 has everything to do with this.

65.9 % of Belgian applications originate from applicants located in Flanders (1 580), followed by the Walloon region (19.9 %) and the capital Region of Brussels (14.2 %). Flanders was number

eleven in the top twenty European regions for patent applications. According to EPO president António Campinos, it is innovation, research and science that will lead to a healthier world and a more solid and sustainable economy. Indeed, innovation supported by a strong IP system is the engine

of recovery, in every sense of the word. Medical technology was the big leader in terms of volume, while pharmaceuticals and biotechnology were the strongest growers.

NUMBER OF PATENTS FOR UNIVERSITIES, RESEARCH ORGANISATIONS AND INDUSTRIES IN BELGIUM IN 2020



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CHARACTERISATION TECHNOLOGY TURNS WASTE STREAMS VIRTUALLY INSIDE OUT

VITO is developing a unique, smart characterisation method for SUEZ, a well-known waste and raw materials company, which is able to fully analyse a seemingly homogeneous waste flow 'on the fly'. The technology, which is currently being scaled up to an industrial level, allows for the valorisation of the last remaining residues from bottom ashes.

'The problem with waste streams is that we often don't know what's in them,' says Karen De Boeck, Business Development Director at waste and resources company SUEZ Recycling & Recovery Belgium. 'And what we don't know about, we can't extract.' This is certainly the case with what are known as bottom ashes, visually homogeneous residues left behind after the incineration of all kinds of waste streams, including household, industrial and construction waste. Nonetheless, bottom ashes have been processed into aggregates for quite some time, in a process in which metals are recovered as much as possible. Originally, this was only done for the very coarse fraction of the metals, but today, valuable non-ferrous metals such as copper and aluminium are also being extracted from these bottom ashes with a grain size smaller than 20 millimetres.

There are other useful materials in fine bottom ashes too, such as precious minerals and metals. In recent years, SUEZ has developed a technology for the recovery of particles as small as one-tenth of a millimetre. But without knowledge of the exact content of these waste streams, waste processing essentially depends upon craftsmanship and

experience. De Boeck: 'We now process ultra-fine metal streams from bottom ashes without knowing their exact composition in advance. That means it takes a great deal of knowledge and expertise to make a usable raw material for an end user. In recent years, it has become clear that digital technologies can help us in this respect.'

The idea for a technology that could characterise a seemingly homogeneous (but in reality very heterogeneous) waste stream in its entirety and in real-time was born in 2014. Whilst the waste particles are passing on a conveyor belt in a processing plant, the characterisation would happen without any disturbance - 'on the fly' - in jargon. This is very different from the current approach, in which sample-taking and analysis takes a lot of time and money, and is also only a limited representation of the waste stream. The idea evolved into a project supported by Flemish funds (coming from the Environment and Energy Technology Innovation Platform MIP within VLAIO) and called Characterise-to-Sort (CtS). In the years that followed, it was further developed as a Proof of Concept (PoC) in collaboration with VITO, which has a wealth of relevant knowledge and expertise in the field of sustainable materials management.

Digital twin

Kris Broos, today a business developer at VITO, was involved in the project from day one. As (then) a team leader in waste recycling, he and Roeland Geurts, along with other VITO researchers, devised the core of the characterisation technology, which

can predict exactly what a waste flow contains. 'We wanted a technology that looks directly at the entire flow without disrupting it and identifying each individual particle,' Broos says. 'This allows to generate knowledge that's immediately available and therefore doesn't come too late, as with traditional sample collection.'

This core consists of three different imaging techniques: a colour camera, a 3D camera and an X-ray sensor - to determine the colour, the shape and the internal chemical structure of each waste particle respectively. The particles are characterised by hundreds of different measured parameters, of which size, shape, chemical structure and mass are among the most important. The measurement results are immediately uploaded to a computer model that uses them to create a so-called digital twin of the waste stream. 'This virtual representation allows for virtual experimentation with the waste stream. In addition, we use AI techniques such as machine learning to make even better predictions,' says Roeland Geurts. The digital twin enables well-founded decisions. 'Hence, the processing procedure can be continuously and automatically adjusted and streamlined. Later on, based on the digital twin, the sorting will also be able to take place autonomously.'

With this kind of 'smart' waste processing, the outflow properties (the composition of the recovered materials, their quality, etc.) of the process can be continuously predicted. This can significantly improve the recycling of bottom ashes and their derived streams, as well

as the quality of any end products. 'This is actually about much more than a characterisation technology,' says Karen De Boeck. 'We're leading the recycling of bottom ashes 'out of the dark' as it were. Soon, we won't have to process blindly anymore and we'll be able to inform our customers thoroughly about the quality of the recovered materials.'

Fourfold benefit for the environment

'Six years ago, we could never have imagined that we'd end up doing this at the level of individual particles,' says Peter Segers, business development & innovation manager at SUEZ Belgium. 'Sensors for characterising waste have been used for a long time. But characterisation based on not one, not two, but three different scanning techniques is the future, especially if you can see straight through materials and even determine their chemistry.'

Segers sees the development of this characterisation technology as the result of two parties daring to look beyond their own company walls. 'By sitting around the table with us, VITO has gained new insights into the importance of knowing certain parameters in waste processing, for example. In turn, it's made us think about how we can adapt our operational processes and possibly even our commercial activities based on this new characterisation technology.'

Hence, the project is providing both sides of the collaboration a deepening of expertise and business opportunities. The initiative grew in recent years from a PoC into a lab-scale research project called INSTAnT, which just like CtS is being supported by the Flemish government (via VLAIO within the ERA-MIN2 framework).

Segers: 'At ValoMET, our centre of excellence in Ghent, we'll also be able to start applying the characterisation technology to other material flows.' For VITO, the further development of this technology could then potentially lead to market valorisation in the form of a spin-off.

But first and foremost, it is the environment that gains. 'By adding value to end-of-life waste streams, not only are valuable materials recovered and value created, but we're also reducing Europe's dependence on primary raw materials,' says Broos. 'If you're also aware that recovering aluminium, for example, requires 95 % less energy than primary production from bauxite, then every kilo is worthwhile,' adds Karen De Boeck. 'And on top of that, you can reduce the amount of landfilled materials. The environmental gain is therefore fourfold,' says Broos.



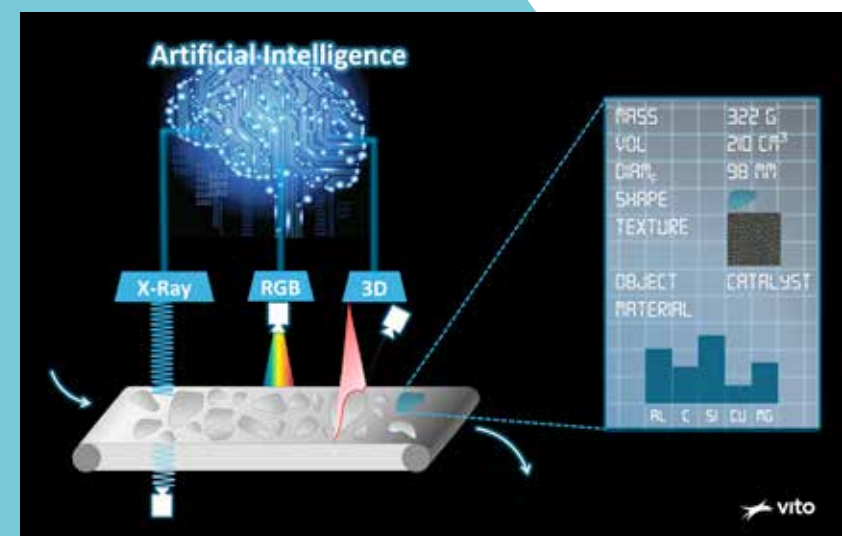
And now, scale up!

In recent years, SUEZ and VITO have proven that the characterisation technology for bottom ashes works. Now, the challenge is to scale it up to an industrial level. Or to stay in the world of waste management: from the level of the waste bin to that of the waste truck. 'The characterisation needs to take place on a conveyor belt that moves at a realistic, industrial speed,' says Liesbet Van den Abeele of VITO. 'So the sensors need to be able to measure fast enough and the software and algorithms need to be able to process all the measurements within a few seconds. Furthermore, the technology must be able to fit into an industrial process that runs non-stop and practically around the clock.'

The scale-up is part of a two-year project (called CHARAMBA), this time being supported by European funds from the KIC Raw Materials. This is part of the European innovation policy that helps technology bridge the dreaded valley of death. Van den Abeele: 'With this support mechanism, the KIC aims to support good ideas and innovations and bring them to market. In order to support only the most promising technologies, companies have to contribute a large part of the project funding themselves.'

In addition to SUEZ and VITO, Ghent University and materials and recycling company Umicore are also involved as partners in CHARAMBA.

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VITO SPIN-OFF DIGITALISES SUSTAINABILITY ASSESSMENT IN THE CONSTRUCTION SECTOR

Assessing the carbon footprint of construction products is usually time-consuming and difficult. Not so with the Enperas software, the newest digital solution from the spin-off programme through which VITO is making the Flemish economy stronger and more sustainable. With this digital sustainability assessment, which results from the activities of VITO/EnergyVille, companies can cover their entire product range in no time.

Sustainable construction starts with the use of sustainable materials, including raw materials. But how does an architect, contractor or builder know which construction products qualify? By consulting the EPD, an information sheet collecting all the data on the impact of construction products on the environment, the climate and human health. The EPD (environmental product declaration) is a standardised way to quantify and report on the ecological footprint of a construction product, process or system.

Public database

As early as 2014, the minimum requirements that EPDs must meet were set out in Belgian legislation. For example, they must be based on a thorough life cycle analysis (LCA). This includes the environmental impact of raw materials, water and energy consumption, CO₂ and other air pollution emissions, waste production, as well as the impact on human health (for construction workers as well as for building users) and the required transport. This last aspect is not unimportant: locally produced building products are preferable to products that have to be transported from the other side of the planet. The results of this analysis are compiled in an EPD and then validated by an independent third-party expert. Finally, the EPD is uploaded into a public database, managed in Belgium by the federal government.

Manufacturers of construction products therefore benefit greatly if they can demonstrate the (preferably limited) environmental impact of their products by means of an EPD. They can do this

through the brand new VITO spin-off Enperas. It develops software that allows companies to make their own LCA and calculate the environmental costs in practice. The results of the LCA form the basis of an EPD, through which companies can offer their customers accurate and certified information about the environmental impact of their products. 'Until now, the LCA and assessment of the ecological footprint of a product was very time-consuming,' says Luc Plancke, CEO of Enperas. 'By digitalising the entire process, we've gained a lot of time. As a result, companies can now quickly cover their entire product range.'

Making the entire chain more sustainable

The Enperas software also offers companies a powerful tool for better understanding the ecological footprint of their products. By altering parameters in simulations, they can discover how their business operations can be made more sustainable. This sustainability exercise is not limited to the company's own activities, but can span the entire life cycle. Plancke: 'In such an exercise, everyone in the company can get to work with our software: from the buyer who evaluates different suppliers against one another, to the product manager who makes sustainable adjustments to a product, to the person responsible for waste management.' In addition to software, Enperas can also advise companies on the sustainability of construction products.

In addition to European regulations, EPDs must comply with strict national legislation on sustainability certificates for construction products, which is different in each country. One of Enperas' strengths is that its software takes this into account and can easily convert this national test with a single



mouse click. For example, results for Belgium can be immediately converted to results for France, allowing the product in question to be described from the relevant market. The increasing market demand for these country-specific results is the main reason why the spin-off was launched. 'Our focus on this makes us absolutely unique and allows us to add value to a product's ecological footprint for our customers,' says Plancke.

LCA and sustainability methods for innovative research and development for and with companies and governments. Important innovations can be expected about circularity and sustainability aspects of building stock, energy technology and systems such as batteries and power to molecules, in close cooperation with the technological R&D on sustainable energy, materials and chemistry from VITO/EnergyVille.

The decision to create this spin-off from VITO/EnergyVille's activities was already taken in September 2019. Last year, the structure was put in place and investors were attracted. 'You need that time to get off to a good start,' says Bart Swaelens of VITO. Since Enperas became independent, VITO remains a shareholder of the company, which now has four employees.



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Tech transfer strengthens Flemish economy and makes it more sustainable

With the recent creation of the spin-off Enperas (which offers software for sustainability assessments of construction products) and the imminent launch of Mona (a spin-off that will develop eye scans to detect for example diabetes), VITO is doing what it should: adding value to the expertise and technology it has developed by transferring it to industry. The two spin-offs are the latest in a growing list of companies that have emerged from within VITO – about ten in the past five years.

This 'tech transfer' can take place in two ways: through the sale of a licence to an existing company, or through the creation of a spin-off. In most cases, this strengthens the Flemish economy, which is at the core of VITO's mission. By doing so, VITO is injecting sustainability into Flemish industry.

For the creation of a spin-off, the first step is to detect opportunities for adding value within VITO. 'We have specific programmes for this,' says Bart Swaelens Head of Tech Transfer and Venture Development at VITO. 'Take for example 'accelerate your business idea' or AYOUBI, an initiative through which we encourage our employees to come up with interesting business ideas.' Once such an opportunity has been identified, the key is to allow it to mature. 'We then build a team around it. The quality of that team makes or breaks the success of a spin-off. A good balance between VITO expertise and external entrepreneurship is important. That's why we've specifically engaged Luc Plancke for Enperas.'



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Then a business plan and a financial plan are drawn up, and it is crucial to find external investors. Once these have been found, the spin-off can be launched.

CURIEUZE NEUZEN IN THE POTATO FIELD

Our farmers are among those involved in the unique large-scale citizen survey 'CurieuzeNeuzen in de Tuin'. With five hundred soil sensors spread across potato fields throughout Flanders, the impact of heat and drought on the cultivation of this typically Belgian crop will be investigated.

As you might have noticed, in recent years, fries have become a little shorter on average. This is a result of the increased summer drought. Because potatoes grow shallow, hot and dry weather soon has an impact on the tubers and thus on the size and quality of the potato harvest. If drought is not sufficiently compensated for by irrigation, this results in smaller potatoes and therefore shorter fries.

Micro-climate in the field

The exact impact of heat and drought on the cultivation of potatoes in all its aspects, from the role played by soil type, through the development of pests and diseases, to the effectiveness of crop protection products, is not yet well known. This is why 'CurieuzeNeuzen in de Tuin', which will map the heat and drought throughout Flanders for six months with 5,000 soil sensors, offers a unique opportunity for potato cultivators to investigate that impact on their fields. Using 500 field sensors spread across various potato fields, information is gathered about their micro-climate.

The participating fields are spread all across Flanders and were selected in consultation with the Institute for Agricultural, Fisheries and Food Research (ILVO), the inter-provincial Potato Production Research Centre (PCA), INAGRO, the Hooibeekhoeve, Agristo and Clarebout. Unlike the sensors in gardens, parks, schools and businesses that were placed in early April 2021, the smart soil sensors will be put into the field as of late May, early June 2021.

The sensors will accurately measure and record both temperature and soil moisture every 15 minutes – the temperature is determined below as well as above ground. The measurements are automatically uploaded into the WatchITgrow platform via Orange's Internet of Things channel and forwarded to the University of Antwerp, which

is responsible for the scientific coordination and processing of the field measurements along with VITO.

'In fact, we're studying the micro-climate on the smallest agricultural scale, that of individual potato plants,' says Bart Deronde of VITO. 'This gives us a picture, as it were, of how the plants are feeling and how they're handling the sometimes extreme environmental conditions.' A look at some recent meteorological tables shows that those conditions are quite considerable. In April 2020, the average temperature in Belgium was no less than 3 degrees higher than normal, there was barely 40 percent of the normal amount of precipitation and the humidity was also abnormally low. And May 2020 was even warmer and even drier.

This endangers Belgian potato growing, because the crops cannot withstand prolonged drought or the combination of humidity and heat. Climate change is thus threatening the survival of a crop that has always done very well, especially in Flanders (thanks to the optimum soil and climate conditions).

The yields from recent years illustrate how serious the impact of heat and drought could be on potato cultivation. 'In 2018, we had 30 to 40 percent lower yields,' says Jean-Pierre Van Puymbrouck, Chair of Belpotato, the trade association for the entire Belgian potato chain. 'In 2019, there was a 5 to 10 percent loss, and last year we lost another 20 percent.' Moreover, the quality of the potatoes is also compromised. 'We've seen a greater variation in quality in recent years, as well as a higher black spot sensitivity.'



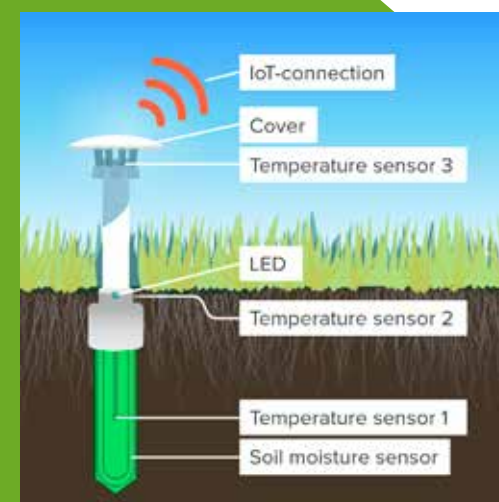
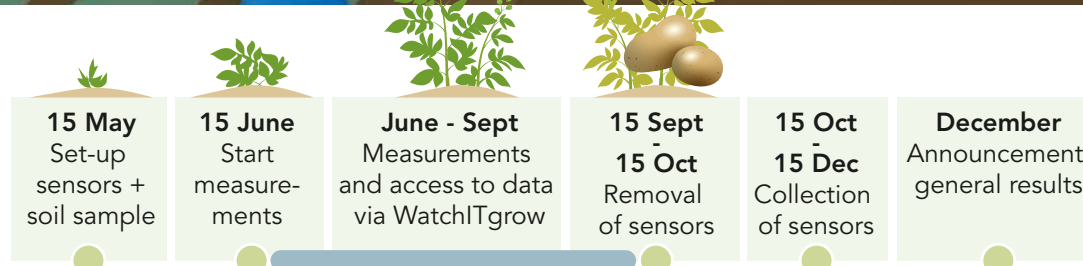
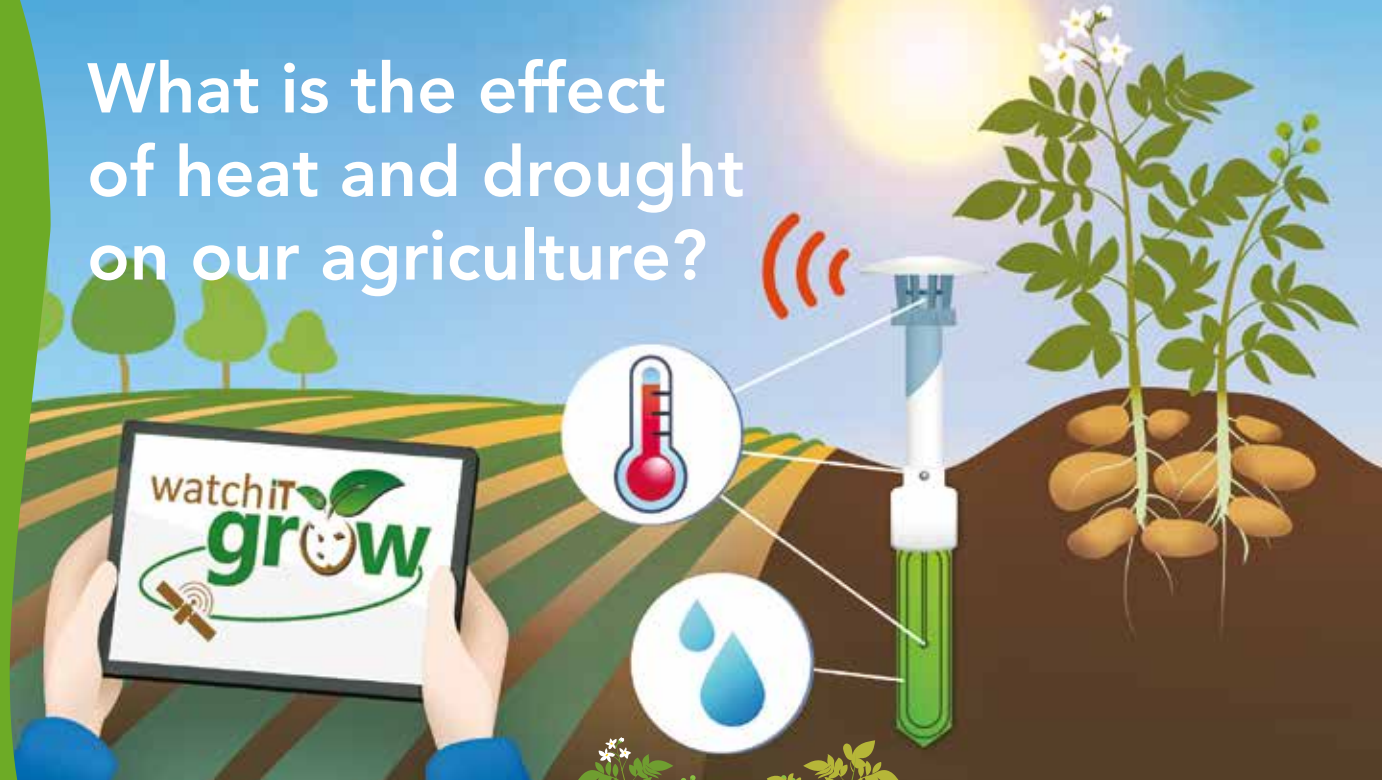
Another problem that has cropped up quite often in recent years is the abnormal formation of shoots and tubers. 'This is a type of overgrowth that occurs in some varieties, such as the bintje,' explains Van Puymbrouck. 'Heat and drought stop growth, after which heavy rainfall (also something that's become more frequent in recent years) causes growth to resume. As a result, new tubers appear and suck the first tubers dry. The resulting potatoes are characterised by a low underwater weight.' That weight is a measure of the starch and dry matter content, and thus of quality.

More information, higher yield

The measurement results from the five hundred sensors will be used for basic research in the first instance. Which potato fields suffer most from drought and heat? And why? What role do the soil characteristics (sand, loam or clay) play in this? 'We want to answer these type of questions,' says Anne Gobin of VITO. Belgian potato growers are very interested because they are hoping to achieve higher yields through better information gathering. Gobin: 'With this research, we can look at how they can better adapt their crops to a warmer and drier future.'

'CurieuzeNeuzen in de Tuin' is an initiative from the University of Antwerp and De Standaard in close collaboration with Rabobank, Orange, VITO, the VMM, the Department of the Economy, Science and Innovation, the Department of the Environment, Bio-Planet, DPD and Aquafin.

What is the effect of heat and drought on our agriculture?



STEM lesson packages

Projects like 'CurieuzeNeuzen in de Tuin' lend themselves perfectly to the educational curriculum. In collaboration with trainee teachers from the Thomas More University of Applied Sciences, De Helix and MOS (the Environment Department's educational operation) and Klimaatlink, a project from the Global Change Ecology Centre and the University of Antwerp, lesson packages were developed for the first, second and third years of primary education, and for the first and third years of secondary education. They focus on the importance of gardens, parks and other green spaces and the ecosystem services they can provide. These lesson packages are available from the CurieuzeNeuzen website.

In collaboration with its educational partner GoodPlanet, VITO is also launching its own STEM teaching module entirely devoted to remote sensing. In this module, third-year secondary school students can discover how VITO translates remote sensing data into information that is useful in various sectors. This module can be taken on-site at VITO in Mol, given online as a teaching assignment or worked through in class under the guidance of a GoodPlanet coach.

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A UNIQUE 'SYSTEM PROJECT' FLANDERS WATERPROOF SHOULD PROTECT US AGAINST DROUGHT



'The spade must be put in the ground', but not ill-considered – by introducing balanced water solutions, Flanders aims to evolve, in order to become a model region for water management. As part of the Blue Deal, VITO coordinates the ambitious Flanders WaterProof project, the aim of which is to investigate drought mitigation through smart buffering in the form of three large-scale demonstration projects. The systematic vision behind the project transcends the local nature of the three areas to be used for demonstration: the gained innovative or revised knowledge and experiences obtained from this project will be applied on a Flanders-wide scale in the future. This will be the start of a 'water redistribution project' that will make our region waterproof.

In the coming years, specific actions will be taken at three locations in Flanders to achieve a more resilient water supply by means of combining smart spatial planning, intelligent management of buffers and optimised circular water networks. 'These regional demo areas must deliver new knowledge and expertise on how to make Flanders more resilient to drought and to the effects of global warming', says Flemish Minister for Environment Zuhair Demir. In this way, Flanders WaterProof makes a significant contribution to the Blue Deal, which sets out to combat drought and water scarcity by implementing a broad package of structural measures.

Hilde Crevits, Flemish Minister for Economy, Science and Innovation, responsible for VITO and co-project lead, is pleased that VITO will launch Flanders WaterProof. 'It is clear that drought and water scarcity are important challenges for Flanders. That's why it is good that VITO, with its extensive expertise in this domain, will take on a coordinating role, and will work together with other players in the field. The project benefits from the strengths of Flanders to contribute to the Blue Deal. Through research and innovation we will provide circular water use and better buffering capacity. This will not only contribute to better water management, nature conservation and smart water use in business parks, but also to a more efficient agriculture and horticulture.'

Companies, sand quarries and fruit orchards

Under the 'WaterArchitect' project, a business park in Tielt (West Flanders) will be equipped with a local and smart water network, a kind of smart water grid with built-in flexibility that allows a maximum degree of coordination between supply and demand. This brings about a decentralised collective water cycle. As a local partner, POM West-Flanders is closely involved in this demo, which forms part of the overarching 'Business Park of the Future' programme.

The 'KlimaatPlassen' (Climate Lakes) project focuses on buffering water during wetter periods, in order to improve water availability during drier times. In the wider region around the city of Mol (in the province of Antwerp), a well-considered system of water management is to be implemented in former white sand lakes and quarries. This will be achieved in close cooperation with the services of the Governor of the Province of Antwerp, the Flemish Environment Agency and the sand extraction company Sibelco.

Finally, the 'WaterGemeenschap' (Water Community) project involves creating an efficient system of water and soil management in the fruit-growing area surrounding the town of Sint-Truiden and in the Hageland region (in the provinces of Limburg and Flemish Brabant). In concrete

terms, this will involve the local buffering, infiltration and reuse of rainwater, both on an individual and on a collective scale. This demo is being carried out in collaboration with pcfruit (Proefcentrum Fruitteelt).

In each of these three demos, VITO will integrate its broad knowledge and experience in the field of water, climate and spatial planning at system level. An innovative monitoring and data infrastructure will also be set up in the demo areas to provide an insight into the operation and the effects of the buffer measures and to permanently monitor them.

'Within the Flanders WaterProof project, very close cooperation is taking place in a regional context', says Inge Genné from VITO. 'But ultimately, it's not just about the local picture in the three individual demo areas, or the technological innovations being put into practice there. If we look at the wider picture, this is the first practical phase of a dynamic learning process that is in line with the Flemish government's ambition in the context of the Blue Deal. In the future, the knowledge and expertise that result from that process will be applied on a Flanders-wide scale and will include the water system in the region as a whole. That is what makes this project absolutely unique.'

According to Aquafin, which is involved in the three demo areas, Flanders WaterProof will help make sure that 'every drop of water is in the right place'. 'Our aim is to assure that as much wastewater as possible ends up in our sewage treatment plants,' says Katrien Moubax, hydraulic engineer at Aquafin. 'We also try to keep rainwater on site as much as possible by maximizing our focus on reuse and infiltration. With innovative and smart solutions to these water challenges, we are endeavouring to create a living environment that exists in harmony with water.'

The system-based approach used by VITO in the context of the Flanders WaterProof project is also playing a key role within the horizontal action lines of the project. Inge Genné continues: 'By carrying out system analyses, we want to further map the most important cause-and-effect relationships within the Flemish water system, including interactions that take place with other systems such as energy, mobility, food and health.' This approach is necessary so that a type of water reallocation project can ultimately be achieved for the whole of Flanders, which will make our region truly waterproof. This systematic approach is based on the so-called PESTEL principles – the political, economic, socio-cultural, technological, environmental and legal aspects of innovation must be considered in relation to each other, in order to achieve maximum impact.

Building on the basis of ongoing reflections

VITO and the Flanders WaterProof partners are in a position to build on the ongoing co-creation process in the Water Arena H2050 (www.h2050.be). The purpose of this is to develop a systematic, long-term vision for water in Flanders. 'A great deal of thinking has already been done,' says Yves De Weerd from the VITO Transition Platform (VTP). 'Our current understanding of the system can now be expanded by applying this knowledge in the development of the demo projects.' The initiative was taken by Aquafin, De Watergroep and VITO/Vlakwa. Vlakwa (the Flemish Water Knowledge Center) and the VTP had the privilege to set up and facilitate this track with innovators. This is resulting in a cross-pollination between Arena H2050 and Flanders WaterProof. 'In order to achieve that, a process of systematic thinking that has already been developed is being used as a means of modelling the demonstration areas, while those very areas offer an ideal opportunity

to test out in practice what benefits this systematic vision may actually have on water policy in Flanders.' Once that systematic vision has been developed, it will provide input into the Flemish research and innovation agenda, which Vlakwa is working on as part of its role to link different players together. 'Ultimately, we always set out to reinforce policy and prevent ideas from being insufficiently implemented in practice,' says Bastiaan Notebaert of Vlakwa. The Blue Deal makes it clear that from now on, things 'have to be done differently'. The combination of an action and learning-oriented innovation process and in-depth water expertise has the potential to enable Flanders to become a leader in water management.

Exactly what will become of the three demo areas in early 2025, when the Flanders WaterProof project will end, is still uncertain. That was a conscious decision, because during the implementation of the project, maximum synergy is being sought with local stakeholders, who are playing their part in formulating the central question, thereby ensuring that support for the project is in place right from the start. 'We will work with all of the stakeholders to examine what needs to happen on these three sites in specific terms', says Genné. 'During co-creation sessions, one of the topics we will discuss concerns the possibilities of large-scale water buffering, the concept of 'water citizenship' which should make users more responsible but also more autonomous, and the socio-economic value of so-called ecosystem services (for example, the transportation of water by farmers or buffering in nature reserves).' Ultimately, when determining 'the value of water' and who is entitled to use it, it will be a case of reconciling the various interests involved, including within the three very different contexts of the demo areas. 'This will most definitely become an issue of ensuring the common good.'



**WATER
PROOF**

 **Vlaanderen**
verbeelding werkt

 **Blue Deal**
De strijd tegen droogte en waterschaarste



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OPTIMISATION OF CO₂ CONVERSION UNDER HIGH-PRESSURE

Industrial point sources of CO₂ are well suited for carbon capture & utilisation applications, or CCU. The conversion of greenhouse gases into added value (base) chemicals can take place in biological processes. With a brand new, unique high-pressure fermenter, VITO is researching how these processes can be optimised.

The custom-made bioreactor or 'fermenter', which was installed a year ago, looks impressive. The installation is equipped with steam, gas, compressed air piping, sensors, valves, sampling systems, etc. In short, it is equipped with all relevant peripheral equipment to be able to measure and control what is happening inside the reactor. This is where pure biochemistry takes place: gases such as CO₂ and hydrogen, as well as oxygen, methane or syngas are the raw materials of a fermentation process carried out by specialised bacteria. This results in products suitable for use in the chemical industry – where they provide an alternative to fossil chemicals from oil and natural gas.

The microbiological conversion takes place in the liquid phase, while the reagents are injected in a gaseous state. 'The gases we use are typically poorly soluble, which makes the transfer from gas to liquid phase difficult,' says Heleen De Wever of VITO. 'As a result, the conversion by bacteria is also very slow.' This is not only a chemical-technical problem, but also an economic one, because the fermentation of CO₂ or other gaseous reagents has to be done efficiently enough to be deployed as a feasible climate-friendly alternative in industry.'

Unique high-pressure fermenter

Therefore, the process engineers at VITO increase the pressure in the bioreactor, allowing the gases to dissolve more easily and speeding up the fermentation process. In more traditional (glass) lab fermenters, the maximum pressure is severely limited. This is one of the reasons why VITO commissioned a unique high-pressure

fermenter, based on its own design. The funding was provided by the European project BioRECO₂VER*, which investigates the technical feasibility of energy-efficient and sustainable biochemical conversion of CO₂ to chemical building blocks.

With the new installation, VITO can extensively research the influence of various parameters such as pressure, temperature and composition and dosage of the gas phase on fermentation. With an online gas chromatograph, samples of the gas phase can be analysed almost continuously, and the gas composition can then be adjusted immediately if required. Many other measurements are also performed online. 'The maximum pressure in the bio-reactor is 10 bar, which allows an incredible



flexibility in experimental conditions,' says Wouter Van Hecke of VITO. 'Hence, we can investigate the fermentation in a lot of circumstances. We can also apply a wide variety of gas mixtures supplied by companies.' Furthermore, the high-pressure fermenter also has membrane filters to retain the micro-organisms in the reactor. 'This is important for speeding up the process and making it more efficient.'

VITO wants to gain a better understanding of the effect of pressure on fermentation. De Wever: 'At the moment, gas fermentations are still too often characterised by low productivity and low product concentrations. By increasing the pressure and therefore the mass transfer from gas to liquid, we hope to improve these parameters.' On the other hand, the pressure should not be too high either, as this may reduce performance of the bacteria. 'Does the fermentation speed up ten times if you increase the pressure by a factor of ten? That's not certain at all. The answer may very much depend on other test conditions, as well as on the metabolism of the bacteria used.'

High-tech research platform

The high-pressure fermenter is far beyond the lab scale. 'It is a prototype that can address several research questions prior to scale-up to an industrial level,' says Van Hecke. 'Its size and complexity are required as our research largely aims to answer fundamental questions: we study processes in detail and try to optimise them on the basis of the gathered insights. To that end, we want to have as many online measurements and steering capabilities as possible.' Pressure fermenters are logically more expensive to purchase than conventional fermenters. The trade-off between increased mass transfer and higher investment costs is one of the research questions that VITO wants to answer in the coming months and years. 'But due to its fundamental nature, our installation can also provide answers about processes that take place in other types of reactors featuring gas conversions.' Therefore, VITO has a unique high-tech research platform from which other researchers and companies in Flanders (and beyond) can benefit.

Companies with an 'emission problem' can approach VITO to see if and how their emitted gases can be valorized. 'As part of the BioRECO₂VER project, we are now mainly working with CO₂ and hydrogen, but in fact a wide range of production gases and processes can be investigated, whenever gas supply is a constraint for a particular conversion process,' says De Wever. This could range from dosing oxygen to the conversion of methane or syngas. 'We comply with all safety regulations, including ATEX certification for explosion safety.'

One of the industrial partners in the BioRECO₂VER project is Arkema, a French producer of high-quality chemicals. 'It is not sufficient to reduce our fossil energy consumption, we also need to look at strategies to consume CO₂ in our processes. The major change which is happening is the availability of hydrogen (from electrolysis or pyrolysis which is not coproducing CO₂) and carbon-free electricity. Microbial gas fermentation using the right combination of feedstocks and technologies can lead to molecules that are not accessible

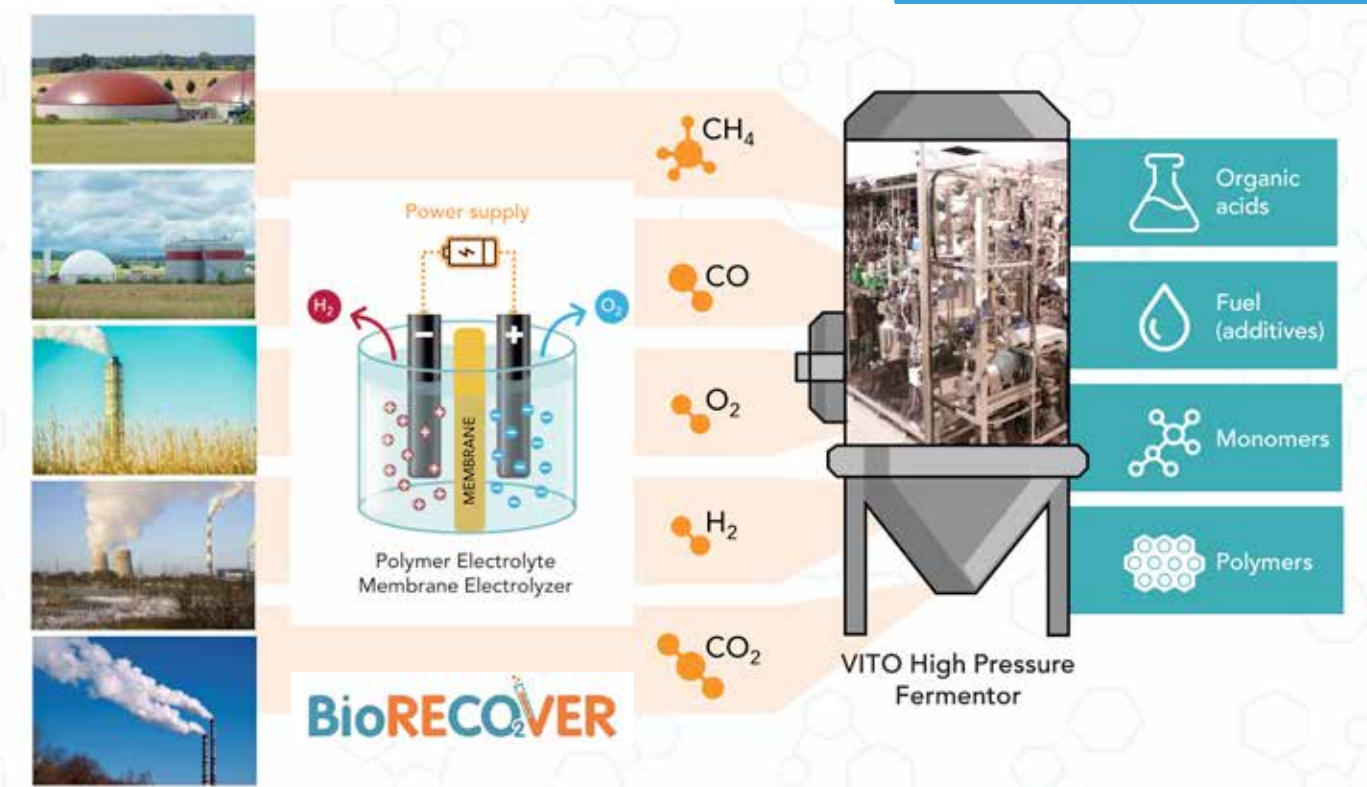
in a single step by chemical processes. It is then important to investigate the opportunities and challenges of this technology', says Jean-Luc Dubois, Arkema's Scientific Director.

The high-pressure installation is also interesting for companies that enlarge the assets of the micro-organisms by genetic research. 'Ultimately, that's where it begins: the type of bacteria determines which gases you can valorize, and which end product is ultimately produced,' says Van Hecke. The VITO researchers are therefore eager to test new bacterial strains.

*Horizon 2020, Grant Agreement 760431



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SPEARHEADING BIOMONITORING RESEARCH FOR TWENTY YEARS

VITO plays a prominent role in the new large-scale European PARC programme (Partnership for the Assessment of Risks from Chemicals), which is currently being set up to start next year. VITO owes this to its impressive track record in Flanders and in Europe.

Through the European Human Biomonitoring Initiative HBM4EU, which finishes at the end of this year, the exposure of the European population to chemicals has been measured and assessed since 2017. This should provide a better understanding of the health effects of such exposures and thus improve chemical risk assessment. VITO and its Health unit are co-coordinators of the initiative, which can be seen as the culmination of more than twenty years of progressive environmental and health research.

VITO itself was still young when it began to develop specialist expertise on biomonitoring at the late 1990s. 'Initially, it was mainly research into the effects of chemical substances on the environment,' says Greet Schoeters of VITO. 'So that's ecotoxicology, looking at the impact on plants and animals.' At the start of this century, the study of effects on human health was added. 'A very broad programme was set up around it, and from the outset we focused strongly on the multi-disciplinary nature of the research – which was reflected in the composition of our teams. The research helped Flanders to develop evidence-based environmental and health policies with an important role for the effects of environmental stress on humans.'

Highly policy-oriented

But good policy needs more than evidence-based information alone – it also needs solutions for addressing

the exposed problems. 'As a follow-up to our various measurement programmes, so-called phase plans were rolled out locally, consisting of policy-oriented solutions,' says Rudi Torfs of VITO. 'At a European level, that was quite unique; we were in the forefront.'

Also progressive was VITO's use of new technology in its biomonitoring campaigns and research. 'Very early on, we switched from old-fashioned animal testing to techniques such as in-vitro research, which enabled us to study the effects on individual tissues and cells,' adds Schoeters. 'That research was more than just descriptive; we also explored the biological mechanisms behind the effects of chemical substances.'

Today, biomonitoring research is far broader than it was twenty years ago. 'We no longer only focus on the harmfulness of substances, but also attach importance to aspects that contribute positively to our health and to a clean living environment,' says Torfs. 'How do we lay out that environment? How do we make maximum use of space? How can we reduce health inequalities? These are some excellent themes that we have to approach in a very multi-disciplinary way.'

Biomonitoring is therefore not just about pointing the finger when a substance has been detected that does not really belong in the environment or in the human body. Today, companies are also encouraged to determine the toxicity of their products or systems at the design stage, so they can intervene on time – known as the sustainability by design principle. This also requires the use of advanced technology, which demonstrates again that good biomonitoring research is strongly technology-driven.

Proven track record

Hence, VITO participated from the outset of the Flemish biomonitoring programme, and thus in fact of the Flemish environment and health policy. Schoeters: 'Central to our approach was that we never lost sight of the fact that results and data should always be usable by policy-makers. Not just random measurements, but always with a focus on policy translation.' VITO also found an international response with its approach. In Europe, it therefore became part of the foundation for a similar system that was also based on technology, multi-disciplinarity and policy translation, and later to the HBM4EU. 'In other European countries, biomonitoring had been much more classically inspired for a long time. It's nice to see that the way we brought technological innovation to Flanders has also found its way to the European level.'

And VITO's innovations in the field of biomonitoring are continuing to find their way into Europe. As a successor to HBM4EU, PARC will soon be rolled out, which is part of the Horizon Europe programme and will run from 2022 to 2028. 'Because of the corona pandemic, the importance of health is greater than ever,' says Schoeters. 'That makes it very important to be strongly represented in such a large programme (PARC has no less than 400 million euros in funding). This gives us a seat at the table where European regulations are being worked out as part of the EU ambition to reduce pollution to zero and create an environment free of toxic substances – as described in the Green Deal.'

Thanks to its excellent reputation and because it is, among other things, jointly responsible for distributing and implementing the work packages within PARC,



VITO holds an important voice and a strong Flemish voice in the upcoming European initiative. 'Our proven track record and good relations with the European Environment Agency and the Directorate-General for the Environment (of the European Commission), among others, outweigh us,' says Schoeters, who also participated eight years in the European Environment Agency's scientific advisory committee.

One important task for PARC is to provide access to environmental and health data at a European level. VITO has a lot of experience with this and will therefore submit a proposal for a separate work package on data. 'Today, too little attention is paid to the correct handling and integration of data,' says Torfs. 'We have 27 different research cultures in the EU, which will need to be harmonised in one way or another.' The data must be accessible in accordance with the

FAIR principles: findable, accessible, interoperable and reusable. 'One of VITO's goals is to start blending European environmental with health data.'

Hence, VITO is continuing to stand out in the field of biomonitoring, both in Flanders and in Europe.



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STATE-OF-THE-ART TESTING TECHNOLOGY FOR BATTERIES



Things are moving fast in the world of batteries and the countless applications they power. In order to provide the best possible answers to specific questions from manufacturers, VITO/EnergyVille offers a particularly wide and varied range of battery tests and corresponding expert advice. 'In recent years, we have seen a strong differentiation in the market, and we take that into account.'

Companies that develop products or systems powered by batteries can contact VITO/EnergyVille for performance and lifetime tests. It has advanced testing equipment that meets all customer needs. This equipment was recently expanded with several state-of-the-art test instruments: a new battery tester, a larger temperature chamber and an ARC device that is unique in Belgium.

Tests tailored to the customer

The new battery tester was developed by manufacturer PEC and is only the second tester of this type to be put into service worldwide. 'Thanks to the new tester, we can now get to a voltage of up to 150V per module,' says Filip Leemans of VITO/EnergyVille. The higher testing range is important because the 'density' of cells in modules, which is often higher nowadays, means the modules have higher voltages.

The VITO/EnergyVille testers measure the decrease in battery capacity and the increase in resistance, while also monitoring things like heat development. 'This allows us to find the optimum

balance between the lifespan of a battery and its performance,' says Leemans.

Some of the battery tests take place in a temperature chamber, where the influence of highly variable and changing weather conditions on battery performance can be examined. In order to test these conditions even more effectively, VITO/EnergyVille not only purchased the new battery tester, but also an expanded temperature chamber – larger both in size and temperature range. 'This way, we can also test complete car batteries,' says Leemans.

Typical customers are companies who want to find out which battery is most suitable for their application, or who want to test already purchased batteries. Whether it is for a car manufacturer, renewable energy storage, medical devices (e.g. Philips) or even for household appliances (e.g. the KOBi garden robot), the tests are custom-designed to investigate the customer's specific requirements. The VITO/EnergyVille testing lab also offers a wide range of services, from data sheet verification to lifespan assessment

under various conditions of use.

The quality of the testing services is highly important to VITO/EnergyVille. The battery tests are carried out according to own defined ISO quality procedures and in compliance with ISO 9001/ISO 14001/OHSAS 18001. VITO/EnergyVille has its battery testers calibrated every year by the manufacturer PEC in order to guarantee qualitative and quantitative measurement values. These procedures prompted Jabil Circuit Belgium NV to call on VITO/EnergyVille in 2019 for a battery testing campaign within the framework of an accredited test report (ISO 17045).

Explosion-resistant safety tests

In response to growing concerns about the safe use of batteries, the lab has recently been equipped with a new 'accelerated rate calorimeter', or ARC. This ARC is suitable for testing small amounts of powder to measure the release of energy in chemical reactions, for example, as well as for investigating the thermal behaviour of cells and modules. The ARC also functions as an explosion-resistant chamber for safety tests. An

installation with these characteristics is unique in Belgium.

With the purchase and installation of state-of-the-art testing technologies, VITO/EnergyVille is keeping its finger on the pulse of the market and the needs of the industry. 'In recent years, the types of tests that companies request from us have started to vary greatly. That indicates a differentiation in the market, so we're taking that into account,' says Leemans.

In the coming years, the demand for batteries, and therefore for specific battery tests, will only increase. With the expected growth in demand from companies and authorities for these kinds of battery tests, the capacity of the multi-disciplinary battery test lab in Genk is likely to double soon. This is how VITO/EnergyVille is positioning itself as the leading battery testing laboratory in Belgium and one of the best testing facilities in Europe.



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Sabatair project: safe battery transport by air

In recent years, there have been several incidents of uncontrolled fires during flights, caused by lithium batteries. This was why the International Civil Aviation Organisation (ICAO) banned the separate transport of lithium batteries (without further equipment) as cargo on passenger flights in 2016.

To study these problems VITO/EnergyVille co-ordinated the Sabatair project (November 2017 to November 2020) on behalf of the European Commission and the European Aviation Safety Agency (EASA).

The main goal of this project was to evaluate new and existing potential measures for improving the safe transport of both lithium-metal and lithium-ion cells and batteries as cargo on both passenger and cargo flights.

An important outcome was the creation of a safety and risk assessment guide for air transport operators in using the identified solutions and measures in their daily operations.

Thanks to the success of the Sabatair project and the good collaboration between Airbus, DLR and VITO/EnergyVille, a follow-up research project – AirPED – will soon be launched for the European Commission, under the supervision of EASA. This project will investigate fire hazards related to the transport of portable electronic devices in checked-in baggage on aeroplanes.

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GSASGATE – A DIGITAL PLATFORM THAT ASSESSES SUSTAINABILITY OF CONSTRUCTION PROJECTS IN QATAR

Commissioned by the Qatar-based GORD, VITO/EnergyVille developed a software platform for GORD's green building and infrastructure certification framework called GSAS, which collects evidence for the sustainability credentials of projects during design, construction and operations phases. VITO/EnergyVille has fully digitalized GSAS through an online platform called GSASgate that proactively keeps all project stakeholders informed.

In 2015, a delegation from the Gulf Organisation for Research & Development (GORD), a non-profit organization from Qatar with a very strong focus on sustainability, travelled to VITO/EnergyVille in Belgium with a concrete desire: the development of a software platform to fully digitalize GORD's green building framework called the Global Sustainability Assessment System (GSAS) that determines the sustainability of construction projects objectively, accurately and efficiently – from the planning phase prior to construction up to the use of the building. GSAS is MENA's (Middle East and North

Africa) first performance-based green building certification system that adopts an integrated lifecycle approach to evaluate the sustainability of building and infrastructure projects. Representing green building regulations within Qatar Construction Specifications, GSAS is aimed at improving the design, construction and operations of buildings while also identifying sustainability challenges specific to MENA's built environment. Based on technical audits investigating the green building features of projects, GORD awards certificates to projects. Essentially, GSAS is intended to encourage building owners and project developers, as well as architects, contractors and suppliers, to work as sustainably as possible in the MENA region.

From energy consumption to solar reflection

GORD's GSAS framework encompasses a very broad scope as it is not just applied to individual homes and buildings, but to entire neighbourhoods and city districts too. Moreover, the tool assesses all the aspects that are remotely related to sustainability; from the

most obvious aspects, such as efficient energy consumption, share of renewable sources, minimal water consumption, waste management and greenhouse gas emissions (including during construction), through more environment-related aspects such as biodiversity and light (and air) pollution, to health aspects such as indoor air quality and thermal comfort. Even the minimum solar reflection in the street scene is taken into account – although in sun-drenched Qatar, that may not be an unnecessary aspect. Understandably, digitalizing a framework as comprehensive as GSAS was no simple task.

'We started from a blank sheet, with the data that we had at the time and that we received from GORD,' says Karel Styns from VITO. 'Over the past few years, the scope has broadened and our digital platform – which fully supports GSAS tools – has become increasingly sophisticated.' In 2020, after about five years of development, that assessment platform was ready and completely transferred to GORD's servers in Qatar. This completes the project, as the organisation now manages the platform itself. 'GORD has its own team of IT people, who we have co-trained.'

The strength of the GSAS assessment method optimised by its digital platform – which differs from other, more European 'competitors' such as BREEAM – is that the assessment takes place simultaneously with the evolution of a building project, from basic design to completion. 'During design, planning and construction, all those involved can upload the required documentation to demonstrate a particular sustainability aspect (an invoice, a certificate, a life cycle analysis, etc.) to the platform,' says Pieter Van Den Steen of VITO/EnergyVille. The platform facilitates and even stimulates this collection of information. 'It brings everyone together and ensures co-ordinated and streamlined communication. That saves a lot of e-mail traffic.' A virtual dashboard continuously monitors the progress of the collection of sustainability data, thus keeping all those involved in the loop. 'The process flow is clearly synchronised, with notifications, reminders, overviews ... In short, everyone knows what data to upload and when to do so.'

Dr. Yousef Alhorr, Founding Chairman of GORD: 'Organizations across the world are leveraging latest technologies to achieve their existing and emerging business goals. As an entity driving sustainability in the MENA region, GORD needed a state-of-the-art solution to support advanced tools prescribed within GSAS. To this end, we are pleased to have worked with VITO/EnergyVille in developing the GSASgate platform that provides an all-in-one project management software for all concerned parties working on various green building projects targeting GSAS certifications.'

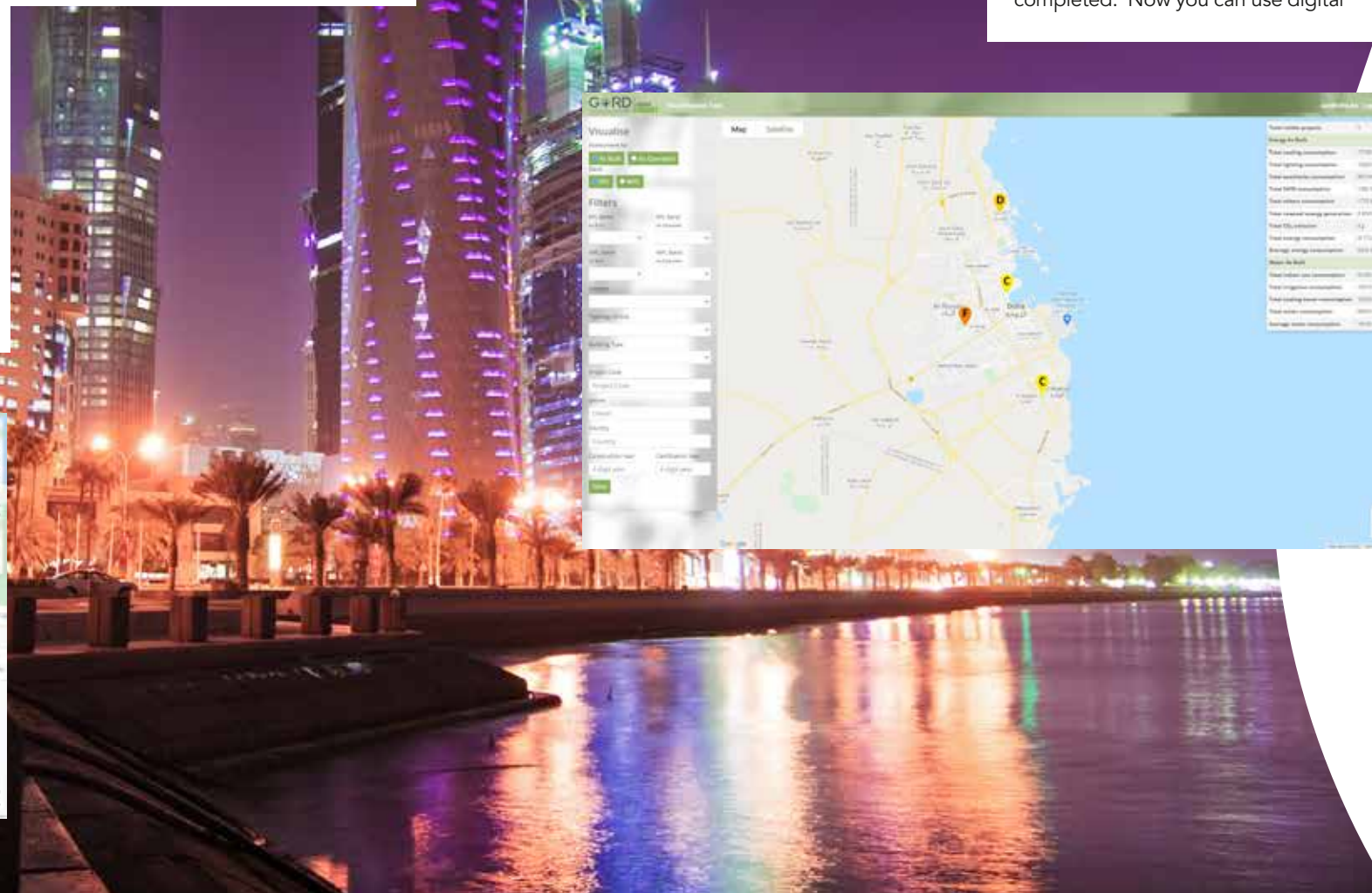
No administrative delay

The fact that the assessment is carried out simultaneously with the development of the construction project also ensures that it is finalised by the time of completion. This eliminates the long administrative tailback that delays the final assessment by months or even years – a shortcoming other assessment methods suffer from.

The fully digital ('paperless') platform also lends itself perfectly to clarifying visualisations of projects whose assessment has already been completed. 'Now you can use digital

interactive maps of the region to see how well a lot of buildings and neighbourhoods score in terms of sustainability,' says Van den Steen. And there are many of those, even though the digital platform has only been up and running recently. 'GORD has already assessed more than a thousand projects this way. So the method is being used very intensively.' The Qatari research organisation soon plans to offer the assessment platform in neighbouring countries and other states in the Gulf.

Due to GORD's broad approach and the high demands placed on the platform by the Qatari authorities, in recent years VITO has been able to significantly expand its knowledge and expertise in the field of assessment and certification methods for buildings. 'In the case of GSAS, it was much broader than in many European assessment methods, which often focus on the energy aspect,' says Styns. 'We think this can be done much more widely here too. That would allow different assessments and certifications to be merged. In any case, we now have the people and the resources to develop such future assessment methods and platforms.'



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VITO EMPLOYEE IN THE SPOTLIGHT

By the end of 2021, Anubhav Ratha will present his PhD thesis at the Technical University of Denmark (DTU) in Copenhagen. Ratha is part of the PhD programme at VITO/EnergyVille. He performs research on sustainable energy system models from the perspective of the free market, combining theory and practice, the two specific strengths of DTU and VITO/EnergyVille.

Before you started your PhD in Copenhagen, you had already followed quite a trajectory.

'I grew up in east India where I did my Bachelor studies. Then I studied at ETH Zürich (a top Swiss university) where I obtained my Master as an electrical engineer. I was already interested then in electricity markets and how they are modelled and designed theoretically.

After my studies, I set up a start-up in demand-response technology with a friend, but this was not very successful. So, I ended up back in India where I started working for General Electric. But I was still very much attracted to research. In 2018, when I saw an announcement for a PhD at DTU and VITO/EnergyVille on LinkedIn, I was excited to apply.'

What attracted you to the energy and electricity domain?

'The correlation of energy networks and markets, in all their complexity has fascinated me for years. Especially the theoretical aspects appeal to me, let's say the modelling work that is done behind a computer. My DTU promoters are very known for their expertise in energy market and analytics.

At the same time, the energy transition is now strongly evolving, so the relevance of practical research cannot be underestimated. This aspect is more present in VITO/EnergyVille, where the focus is more on scientifically-based policy advice, so closer to implementation and decision-making. My VITO team is involved in multiple EU projects on energy markets and flexibility integration with various industrial and academic partners.'

What exactly is your PhD about?

'For a successful energy transition, it is crucial to integrate vast amounts of unpredictable fluctuating renewable electricity sources like sun and wind energy. This demands higher flexibility from the whole system, for example, the integration of storage from batteries. But I have a holistic approach, looking at it from a multi-carrier energy system point of view.

It implies harvesting flexibility from sources beyond just electricity, i.e. from coordination with other energy systems such as natural gas or district heating or future green energy carriers like hydrogen.'

And you do this from a market perspective?

'The challenge is to adapt the energy markets so that various actors have the right economic incentives to coordinate towards reaching a decarbonized energy system. The closer the cooperation among the actors, the more flexibility that can be achieved, which then leads to a larger share of renewables in the system.'

And you do all this from behind your computer?

'Sometimes it may seem as if I am designing a computer game simulating markets, and then we change the economic rules afterwards to see what happens. But we do work with real-world data. And, even more importantly, our conclusions are relevant for the European Commission and governments in creating an energy market vision for a zero-carbon economy.'

Were you able to visit VITO/EnergyVille during the corona pandemic?

'No, the last time I was there was in 2019. But for me, that has not been a big issue, as our remote collaboration works well. On the contrary, since video meetings have now become the standard, I was able to attend many more meetings and events than in normal times.'

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