BE-Basic Foundation
Annual Report

2013

Colophon

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We thank all scientists and parties involved for their cooperation

BE-Basic Foundation Annual Report

2013

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Foreword

We are very pleased to present our 2013 Annual Report, which highlights all that has happened within the BE-Basic Foundation last year. It was an important year for the foundation. Our aim was to consolidate our complete range of activities – the original FES programme, the new programme set up as part of the Dutch Top Sector strategy and the associated package of European projects – into a coherent biobased R&D programme.

Translating science into business

One of the most important activities of the BE-Basic Foundation is to translate science into business. We have executed several activities to promote innovation over the undertaken year.

The first results are already being shared between the Flagships, within terms of intellectual property agreements. We have also emphasised the importance of activities which cut across different Flagships, as well as the horizontal programmes which bring industry and academy groups together. It is essential to work across a complete value chain, rather than just on your own inventions. For example, when developing a high-value biofuel process, you must also consider the logistics of harvesting, the quality of biomass and the impact on land use, nutrient and water recycling as well as adding value. This is critical for a truly sustainable development. BE-Basic therefore supports a number of scenario studies that give good insight into which integral scenarios work best.

These scenarios also demand further internationalisation. Think of the links between countries which grow large quantities of biomass and those which carry out research and refining. Biobased development is global and our industrial and academic partners act globally. So we are particularly pleased with our international alliances with Brazil and Vietnam, both of which took on concrete form in 2013. We are also involved with the Rapid Assessment Project devised by the SCOPE organisation (Scientific Committee of Problems of the Environment) that will analyse the status and impact of bioenergy and sustainable development. This alliance shows that BE-Basic has impact beyond its original, highly technical mandates and has become a public-private consortium that emphasises quality across its operations.

We also achieved concrete results in the Bioprocess Pilot Facility. This facility allows both small and large industry partners to observe their projects develop from a scientific idea and laboratory testing to technological development and demonstrable processes. Several projects made the move to a start-up status in 2013. Another important milestone is the acquisition of BIRD Engineering by Corbion/Purac to bring their FDCA-technology to the market.

Nevertheless, all this research can only lead to a successful biobased economy if society at large is prepared for it. Training scientists and educating students is of paramount importance. That is why we are extremely happy with our new ambitious educational programme which has the potential to reach tens of thousands of students worldwide. A number of other interest groups, such as environmental group *Natuur en Milieu* and the *Platform Bioenergie* have joined our EBD programme to work towards gaining acceptance for a biobased economy.

In 2014, we will have the tools to communicate these insights to the wider public, to governments and our politicians. 'Biobased' is a complex field, and experts from BE-Basic have a responsibility to help non-experts understand how 'biobased can be done right'.

Bram Brouwer and Luuk van der Wielen
Board of Directors BE-Basic Foundation

BE-Basic Foundation / Governance / IPRC

The BE-Basic Foundation was set up in October 2012. Becoming a foundation has made it easier for BE-Basic to take a flexible approach to current developments and opportunities in science and politics.

The Executive Board about BE-Basic governance

"Re-shaping BE-Basic as a foundation brought an important legal change, yet did not affect our programmes, the IP rights of our partners or other important issues. It has enabled us to acquire more resources to support our partners via their programmes and projects, and I trust we can continue in this way."

Luuk van der Wielen

"Many more people have recently joined forces with us. We started out focusing on the chemicals and energy industries but a merger with food biotechnologists means we now cover the entire spectrum of pertinent research. Starting up an investment programme of over €100m takes time and 2013 was the year in which it all came together. Now, the results are gradually beginning to come in."

Bram Brouwer

'Re-shaping BE-Basic as a foundation'

The Executive Board consists of Bram Brouwer (managing director) and Luuk van der Wielen (chairman). The Board's task is to ensure cohesion across the entire BE-Basic programme and to take care of day-to-day business including decisions about funding and the continuation of projects. The Board presents its decisions to the Supervisory Board for its recommendations. The Supervisory Board monitors the actions taken by the Executive Board and represents the interests of the BE-Basic partners. In addition, all partner organisations are represented in the Consortium Partners Assembly (CPA). The CPA offers important, non-binding advice to the Board.

The actual research takes place in Flagships, each of which focuses on a specific aspect of the biobased economy – from technology development to public acceptance. (see pages 8 to 23). In total, about 70 projects are ongoing under the auspices of the Flagships. In addition, the BE-Basic Innovation Centre stimulates innovative start-ups and entrepreneurship in the field of the biobased economy (see page 30-31). Progress in Flagships and BE-BIC is monitored by the Management Team, in which all Flagship Managers and the Board, are represented.

BE-Basic also hosts the Dutch EBD (Economy, Policy and Sustainability) programme of TKI-BBE - the Top Consortium for Knowledge and Innovation, Biobased Economy, which is supported by the industry and academic parties as well as the government. The EBD programme focuses on developing policy to stimulate support for the biobased economy among stakeholders and the general public and is closely related to Flagship 9.

Accountability

BE-Basic accounts for its results and research to several different bodies.

Financial

BE-Basic's programmes are funded through industrial and academic partners, and partially stem from the Dutch government's FES funding as well as other resources (TKI-BBE, European). The Netherlands Enterprise Agency monitors research progress and financial accountability on the basis of deliverables and key performance indicators (such as published papers, the implementation of new methodology by industry and patent applications).

Within BE-Basic

All partners in the consortium can submit research proposals. The latest call for these was finalised in December 2013. The proposals are submitted with the permission of the Flagship Manager and discussed within the Management Team. Selected projects are then sent to international scientists for review. Projects that meet the quality criteria are listed and the Board, together with the Supervisory Board decides which projects should be funded and incorporated into the BE-Basic Flagships.

Review and evaluation

The BE Basic programme is also reviewed on an annual basis by the International Peer Review Committee (IPRC), an independent body of external, distinguished specialists from academe and industrial leaders in the field from the Netherlands and abroad. They discuss progress in all projects with the Flagship leaders and draw up a confidential evaluation report.

To stimulate innovation from within the consortium, the Innovation Evaluation Committee reviews all papers prior to their publication. Moreover, each Flagship has a Party Panel representing partner organisations that invest in that particular Flagship. This panel proposes bottom-up new projects and programmes to the Flagship Management, and thereby to BE-Basic. It is a formal mechanism for partner organisations to influence the programming.

Future

The new BE-Basic structure has also initiated discussion within the organisation about future directions, scale and scope in terms of budget, partners, and for instance the degree of internationalisation. BE-Basic plans to facilitate this discussion, including a road-mapping process, because the outcome will guide the BE-Basic Foundation towards the desired future.

Second Generation Carbon-based compounds

Itaconic acid is a promising biobased building block for the chemical industry. It has many different industrial uses and acts as an eco-friendly replacement for oil-based products. Flagship 1 'Second Generation Carbon-based compounds' has shown itaconic acid can be produced by transferring parts of the genetic code of an itaconic acid-producing fungus into Aspergillus niger, a fungus capable of degrading plant residues.

*The Flagship **Second Generation Carbon-based compounds** aims to develop clean, efficient and otherwise sustainable industrial processes for carbon-based chemical building blocks mainly for the chemicals, materials and fuels industries. The research focuses on the conversion of lignocellulosic materials (first & second generation) and other biobased feedstocks (glycerol, alcohols, acids and furanics) including their contaminants into relevant products.*

'Three birds with one stone'

"This research has killed three rather than two birds with one stone," says Leo de Graaff, Associate Professor Systems and Synthetic Biology at Wageningen University. "Firstly, agricultural plant waste which currently has no value can be turned into economically-important products like pharmaceuticals, plastics, food, food additives and preservatives. Secondly, the results of this research will make us less dependent on oil products. This is not only interesting from an economic point of view but has other benefits as well, namely in terms of the environment and nature. So thirdly, using less fossil fuel means less damaging emissions, such as carbon dioxide."

It works, but why?

The process of breaking plant residues down into sugars using chemicals and then enzymes is the focus of another Flagship 1- project (Process development for the production of C3-Acids from lignocellulosic feedstocks). The Flagship 1- project 'Novel economic and eco-efficient processes for the production of itaconic and fumaric acid' is charged with developing new micro-organisms which turn these sugars into polymer building blocks. The research focuses primarily on the production of itaconic acid. The researchers are using Aspergillus niger, a filamentous fungus and an efficient natural citric acid producer which is also capable of degrading plant material. Since the start of the project three years ago, five researchers at Wageningen University and Delft University of Technology have succeeded in developing a new fungus which is capable of making itaconic acid. Levels are not yet on a par with the citric acid produced by Aspergillus niger itself. Nevertheless, De Graaff is very satisfied with the results so far. "We have made great progress. The challenge for the next few years is to optimise production and properly understand the process," he says. "At the moment all we can say is: 'it works', but we don't know how."

Cheaper and more efficient

Until now the research has focused on sugars available in the laboratory but in 2014 the focus will be on actual raw materials such as sugar cane bagasse and the sugar beet pulp left over after the refining process. The life and materials sciences company DSM, which has a direct interest in the results, is responsible for the development of the biotechnical production process together with the TU Delft. "Itaconic acid is produced worldwide on a significant scale, but we hope to show it can be done more cheaply and efficiently," says Sybe Hartmans, Principal Scientist Fermentation, who is involved in the project on behalf of DSM. "Itaconic acid is an important raw material for our products and we are a major buyer. At the moment, it is largely produced from corn starch in China. But if we can produce itaconic acid from plant residues using Aspergillus niger for a similar price, we would be very interested. In the long term, DSM wants to produce more eco-friendly products."

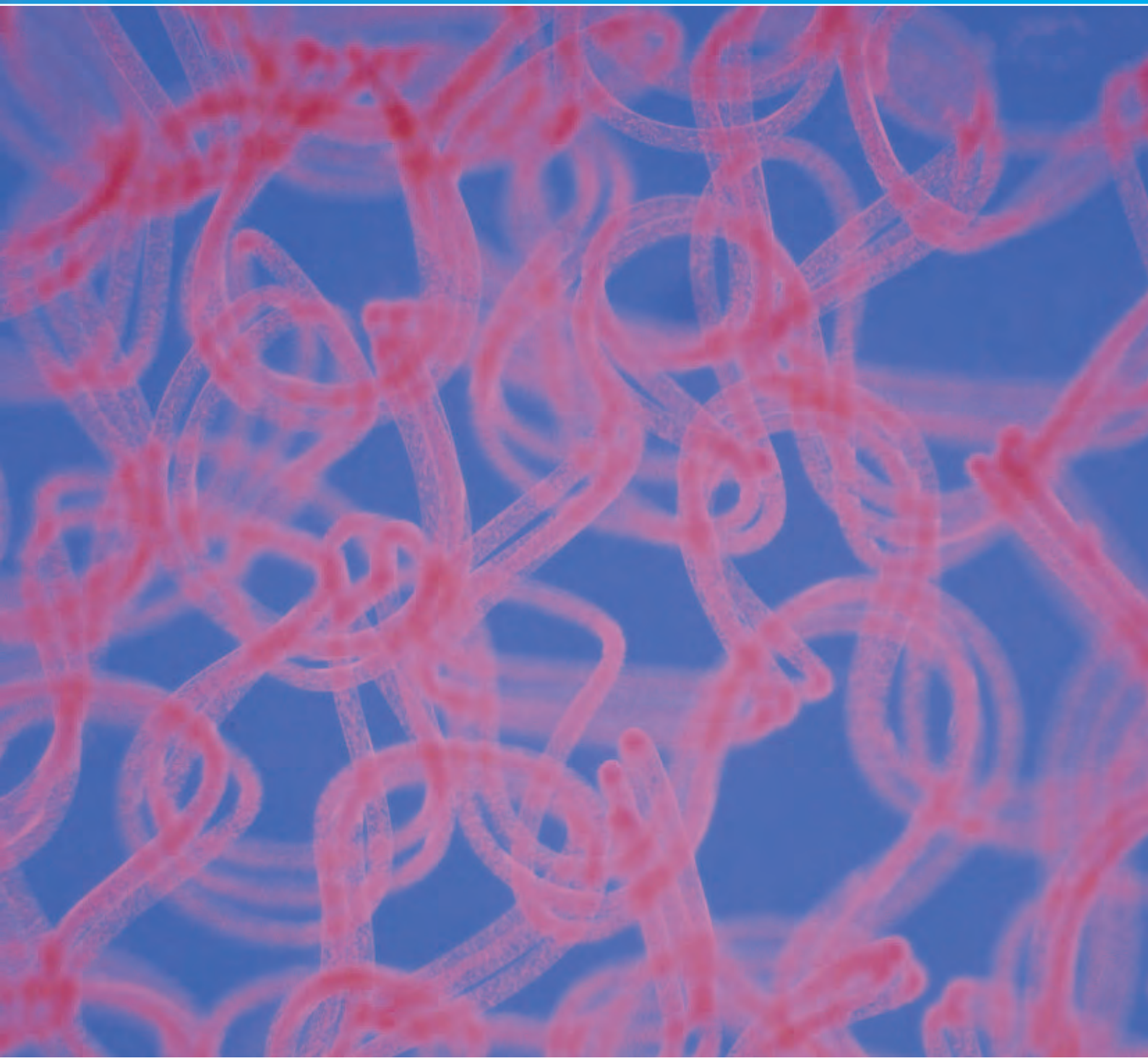
Forecasting results

The systems and synthetic biology used in the research has undergone major developments over the past few years, improving the performance of the industrial micro-organisms by designing and introducing new functionalities. "We want to develop a range of models so that in the future new processes are more effective. It is a very labour-intensive process but the efforts are now beginning to pay off," says De Graaff. "We can be more focused, switch more quickly and try out new variants. Applying systems and synthetic biology may well be the biggest success we have had so far."

The research project Biobased Itaconic and Fumaric Acid Production, will run until 2017. Delft University of Technology, Wageningen University and DSM are collaborating in this project together with Corbion.

Nitrogen-based specialties

"The Flagship 2-projects aim to find better biotechnological ways to produce plastics and pharmaceuticals," says Dick Janssen of Groningen University. A biological pathway for producing antibiotics has already been identified. Another project is developing new biosynthetic pathways to produce caprolactam, one of the building blocks of nylon. "In 2013 we were able to confirm proof of principle of a route developed by DSM," Janssen says. "We now know it is possible to establish an alternative pathway."



FS2

*The Flagship **Nitrogen-based Specialties** develops novel technologies for the production of nitrogen-containing compounds from renewable feedstocks through the use of advanced engineering of micro-organisms. Research within this flagship is focused on the design and optimisation of pathways for the production of unnatural compounds that can be used as pharmaceuticals or as building blocks for materials. In addition, this flagship includes high throughput bio-pharmaceutical process development toward the optimisation of protein production.*

'A new way of producing the building blocks for nylon'

Flagship 2 involves developing new technologies to produce nitrogen-containing compounds. The BioCap project focuses on caprolactam, which is used for the production of nylon. Nylon itself has a wide variety of applications, from clothing and packaging to electronics and the automotive industry. "That is why this area is so interesting," says Janssen. "There is such an enormous range of applications. If we develop a process which is more environmentally responsible, it will also mean an important step forward in increasing sustainability." The project is, Janssen adds, a high-risk endeavour and there are many challenges ahead. "To develop new pathways to produce caprolactam we need to identify enzymes. Sometimes we have to adapt the way they function and that is a long process. This is being supported by computational and screening techniques explored in FS7. Caprolactam is not produced in nature and that provides a major challenge for biochemists. In addition, industry demands a cheap production process because of the wide variety of applications in consumer products."

Proof of principle

Major advances were made within the BioCap project in 2013. "We came to understand more about a number of issues which we had been wrestling with," Janssen says. "We've shown one pathway will not generate the desired results and have stopped it. It is regrettable, but it is also an important result because it prevents us entering a dead-end. In addition, one of our partners, Wageningen University, has found one of the building blocks for caprolactam production in plants. We are now working with cells that are already showing some production. So it appears to be possible to synthesise caprolactam biologically." This research is contributing to the development of a biobased economy, he says. "We are exploring a technology portfolio consisting of new methods which will advance science that supports the biobased economy. In addition, we are specifically targeting improved enzymes for caprolactam production and thus working toward a less polluting process."

Focus on increased production

Now the research team has tangible systems to improve caprolactam biosynthesis, they are looking at ways of increasing production. "We are now going to focus on the space time yield," says Janssen. "If we can complete this successfully, it will be a question of increasing the scale and the market introduction. But it is still too early to talk about a breakthrough in the production process. And if you ask how long this is likely to take, I have to say it is more likely to happen after 10 years rather than within two."

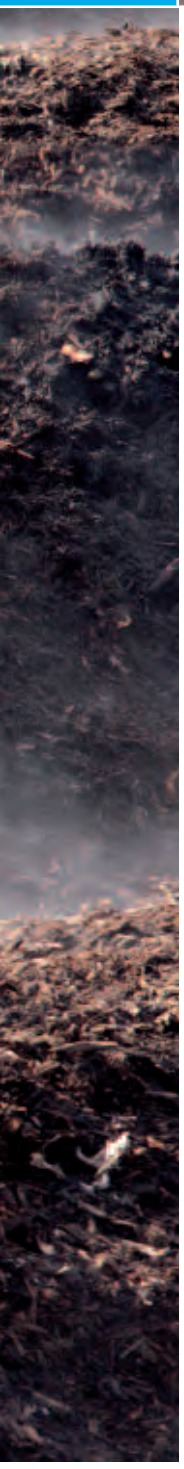
Partners

The BioCap project involves close cooperation with a number of partners, including Wageningen University and American and German scientists. DSM is closely involved on the industry side and provided essential background knowledge and engineered cells that gave proof-of-concept for the desired production. The company produces large quantities of nylon and wants to develop improved systems from an environmental perspective in order to further reduce its ecological footprint. Eventually, the hope is that DSM will produce nylon developed through biosynthetic technology.

Sustainable soil management and upstream processing

Aad Termorshuizen and his team are developing a tool to match organic residues with the needs of agricultural soil in terms of nutrients, soil structure improvement and disease suppression. The first year of research (2013) was spent primarily on defining the organic residues themselves.

*The Flagship **Sustainable Soil management and upstream processing** focuses on developing and testing scenarios for waste management from the perspective of closing cycles and prevention of negative side effects of a biobased economy (spilling=spoiling).*



'First year of research focused on defining residues'

The task which faced Aad Termorshuizen, Senior Agronomic Soil Scientist at BLGG Research, and his team in 2013 was to make an inventory of the waste residues left over during production processes in a biobased economy, including their analysis and quantification. "But before you can begin the inventory process, you need to define what counts as waste and what does not. That caused quite a few headaches," says Termorshuizen. "It all boils down to what perspective you take. Most people think old paper is something for the waste bin but it is also the primary raw material for the paper processing industry." To make the discussion even more complicated, waste has many different applications that may compete with each other. "Fresh organic matter like crop stubble is quite useful in the biobased economy for generating heat or methane," he says, "but the alternative, leaving this organic matter behind in the field, is positive for soil quality."

Mapping out the advantages and negative side effects

A biobased economy has many advantages but this first research year for Flagship 3 also involved studying the negative side effects. "The removal of agricultural residues from the land affects soil quality negatively," says Termorshuizen. "The question then is, how much of the residues can be taken away without having a detrimental effect on the soil? Or, how can residue removal be replaced by other sources of organic matter, including organic residues originating from the biobased industry?" Using such residues clearly has its own risks. "The more you process the residues, the more polluted they may become, making them less suitable for agriculture," says Termorshuizen.

In the meantime, the team has come to grips with defining the residue sources. The next part of the project is to research the make-up of different types of residue and their impact on agriculture. The team will also look at variations in the composition of fermented manure and the consequences for crop-growing. "Residues are only used for agricultural purposes after they have been mixed with other sources of waste by a composting company," Termorshuizen says. "For example, some of the waste material which remains when palm oil is processed into shampoo can be used in agriculture. But what about the waste matter as a whole? Can that also be used for agriculture?"

Developing a division support tool

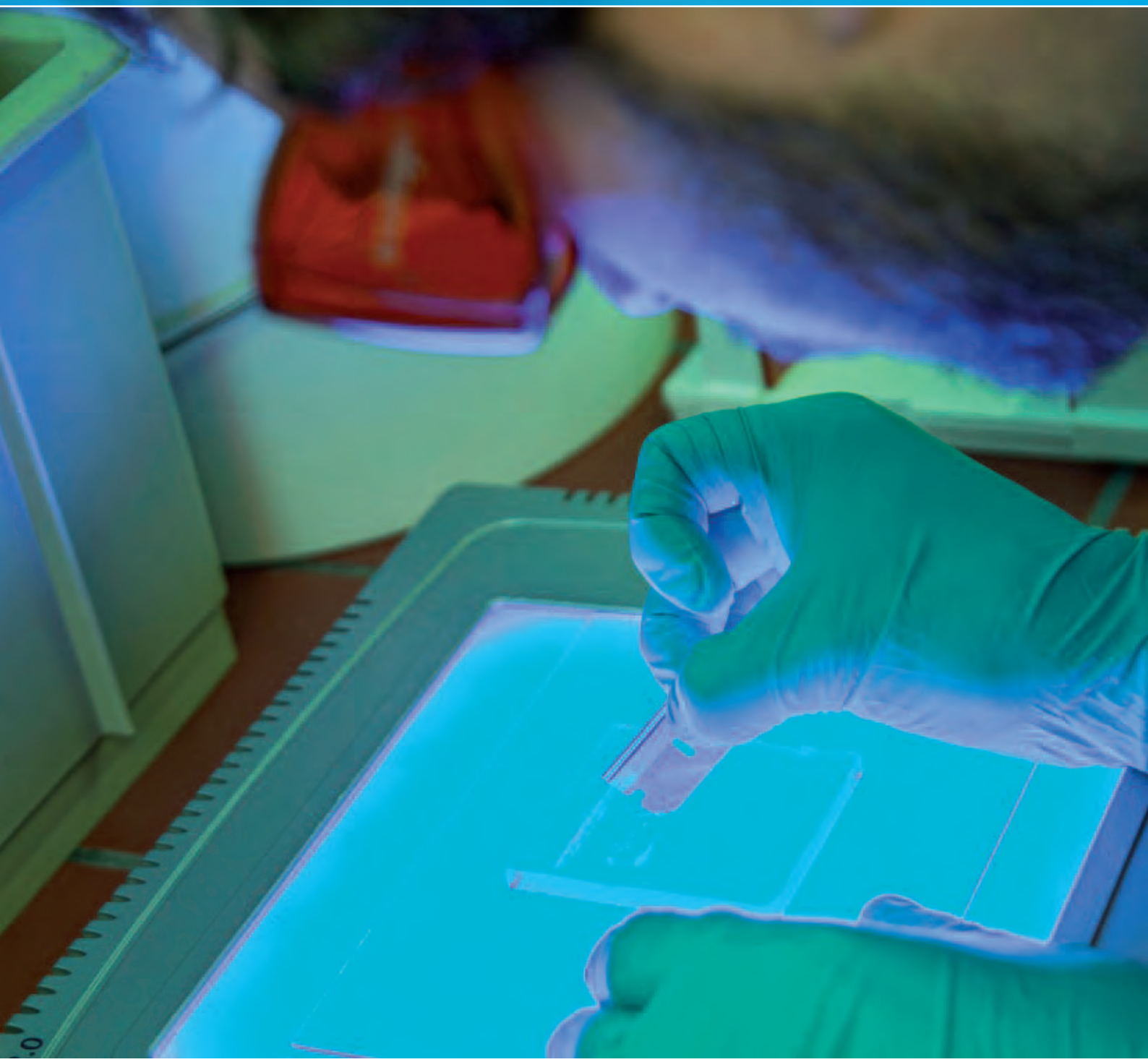
The ultimate aim of the research is to develop a handy division support tool. "The key question is: 'how do you want to use such a tool?'," he says. "Are we going to test pure residues or is the tool only relevant to characterise compost mixes for agricultural use?" In 2014 an experiment will start to measure how residues behave when added to agricultural soil. Termorshuizen had originally hoped to work together on this with a project in Flagship 1 (Carbon based compounds) but it is still too early. "That project has not yet led to an end-product," he says. Only when the end product is defined will they know which residues are left over and which we would be interested in."

Partners

The research project "Towards a quick decision support tool for sustainable use of harvest residues" will run to mid 2017. This project is coordinated by the industrial partner BLGG Research in which the Netherlands Institute of Ecology (NIOO), the Laboratory of Nematology at Wageningen University and the Systems Bioformatics department at the VU University in Amsterdam are cooperating with the industrial partners Bioclear, BioDetection Systems, BLGG Research and ClearDetections.

Synthetic Biology

The Flagship 6 research team is concentrating on modifying cells so they produce more useful compounds and excrete them more efficiently. "The process requires patience," says Ton van Maris of Delft University of Technology. "You have to combine multiple new elements in a cell before it might do what you want it to do. Over the past year we have developed some of these new elements and now is the time to combine them."



*The Flagship **Synthetic Biology** develops tools and techniques for the improvement of micro-organisms. Design and optimisation of novel pathways to desired products is complemented by unique cell membrane engineering aiming for efficient product export and improved robustness of the production organisms.*

'The parts of the puzzle are falling into place'

The first concrete results of Flagship 6 were published in September 2013. The BE-Basic researchers at Delft were able to modify yeast in such a way as to increase the amount of bio-ethanol produced from sugar by 11% (see box). "We have many other projects under way, such as one looking at the production of amino acids," says Van Maris. "We are also able to feed the intermediary results from the fundamental parts of our research through to the other flagships which is a plus. The techniques we are developing to make it easier to modify cells can be applied, for example, by Flagships 1 and 2."

The best combination

Once cells have been made to produce compounds more efficiently, the next stage is to stimulate the cells to excrete them. A team of researchers at Groningen University is focusing on this. "Here too we are trying to combine the best properties of different micro-organisms," says Bert Poolman. "Some organisms have a cell membrane which is very tolerant for alcohols and other (hydrophobic) compounds, but the cell may be less suitable for producing amino acids and alcohol. We are now trying to insert the ether lipids which are good for membrane stability from these organisms into cells which are good producers. Ultimately, we aim to combine all the results to produce more robust cells with more optimal compound production. The different parts of the puzzle are slowly falling into place."

More questions

The researchers are using state of the art techniques in their work and have built their own microscopes for single particle tracking and cell imaging at a very high resolution. "That means we can follow a single molecule on its move through a cell," Poolman says. "This process has delivered fascinating insights, but if I am honest, it has also raised many questions. We have had to alter our way of engineering a cell for amino acid excretion. Sometimes you end up a little further away from the concrete results you are striving for, but in the long-term the science delivers innovations you did not foresee at the start of the programme."

Rational engineering

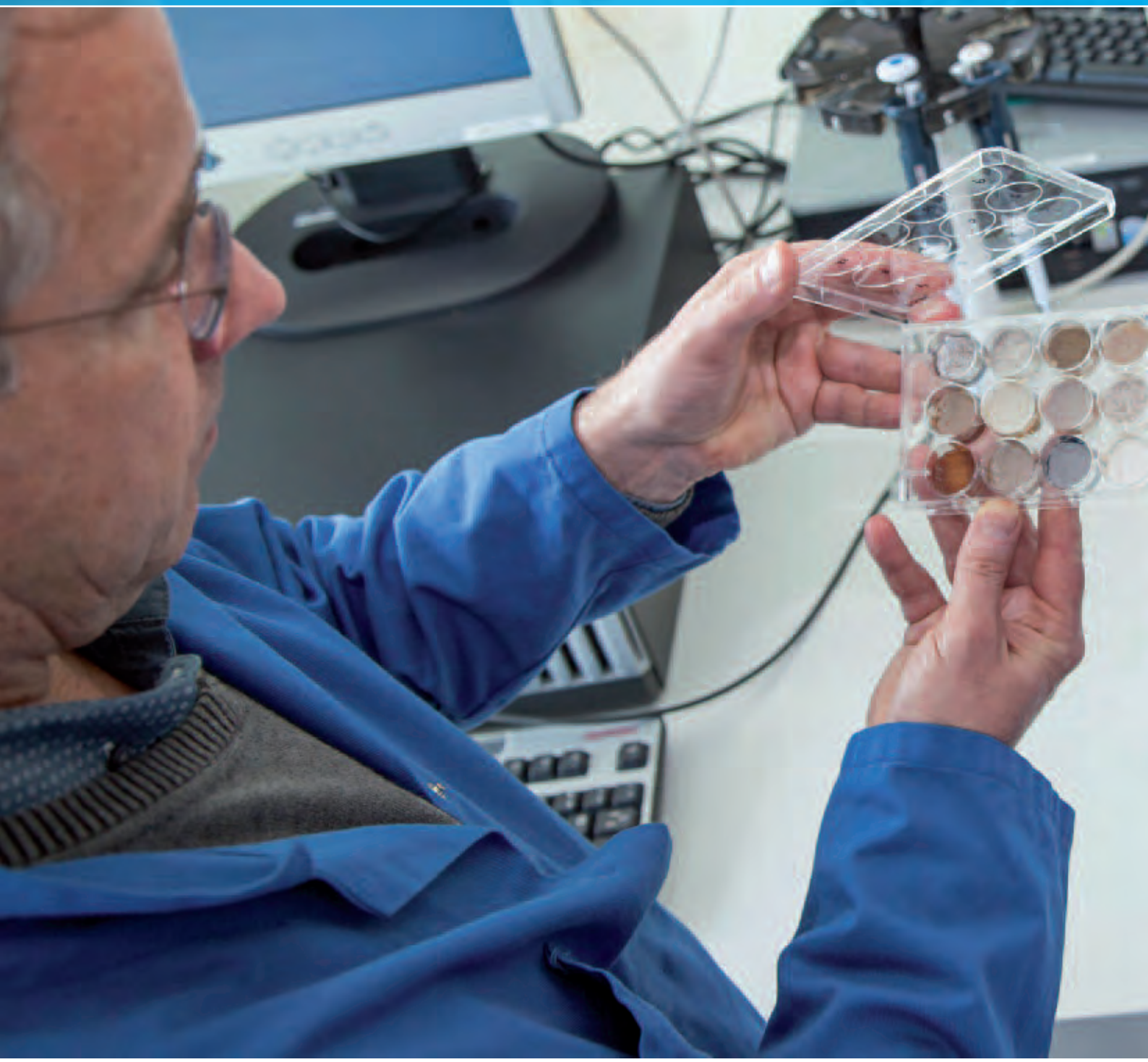
Both Van Maris and Poolman have high hopes for the developments in rational engineering which are taking place in Flagship 6. "We are modifying existing organisms because this approach delivers the fastest applicable results and that is what a biobased economy needs," says Poolman. "But existing organisms are full of surprises because our knowledge of how they function is still limited. It would be fantastic to work with self-built cells, so you would know exactly which parts are present and how they interact and react. So, the ultimate goal is to construct a synthetic cell bottom-up (see illustration). We are far from that point and it goes well beyond the current BE-Basic, but this is our dream and the way forward for the future."

Yeast makes more bio-ethanol

Introducing four genes from bacteria and spinach into yeast enabled Delft researchers to improve the production of bio-ethanol. Yeast (Saccharomyces cerevisiae) turns sugars into alcohol but also makes glycerol as a byproduct. Carbon dioxide, however, reduces the formation of glycerol, leaving more sugars to be converted into bio-ethanol and thereby boosting production. The Delft researchers introduced the Rubisco enzyme from a carbon dioxide-fixating bacterium and a spinach gene into yeast. Together with two other genes from the E.coli bacterium, they were able to ensure the yeast could use carbon dioxide to markedly reduce the formation of glycerol. The researchers believe it will be possible to apply the process on an industrial scale within a few years.

High-throughput experimentation and metagenomic mining

The medical world requires new antibiotics to combat the rise in multi-resistant bacteria and emerging pathogens. Jos Raaijmakers and his team are mining new soil- and plant-associated micro-organisms which could be made suitable for the pharmaceutical industry.



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*The Flagship **High-throughput experimentation and metagenomic mining** develops and applies high-throughput approaches and tools to explore and mine the metagenome, genetic material that comes directly from environmental samples. In addition this flagship aims to engineer and screen enzymes and other products for improved properties.*

'We are already on the trail of one antibiotic'

Almost all known antibiotics originate from soil micro-organisms but only a fraction of the billions of bacteria and fungi which can be found here has been identified. Dutch researchers are looking at how this untapped reservoir of micro-organisms can be made useful to society, such as the production of new enzymes or antibiotics.

Tested on multi-resistant bacteria

Two years after the start of Flagship 7, which is divided into different clusters, Raaijmakers can present the first promising results. "We are already on the trail of one putative new antibiotic and its corresponding biosynthetic machinery," he says. "It has been tested on multi-resistant bacteria found in humans and animals with a positive result in a number of cases." The next stage involves working with the private sector to assess if and how these antimicrobial compounds can actually be made useful for the pharmaceutical industry. The sequencing of genomes of other yet unknown bacterial species selected in 2013 is also on the to-do list for 2014.This genetic code can then be analysed to see if it contains genes to match certain groups of bioactive compounds.

Fungi in agriculture, horticulture and aquaculture

Raaijmakers works for the Netherlands Institute of Ecology (NIOO-KNAW), where he heads the department of Microbial Ecology. "Discovering new microbes, and new antibiotics and volatiles is one of the focus points of our research programme," he says. "We not only focus on resistant bacteria but also on emerging fungal pathogens found in agriculture, horticulture and aquaculture. Discovering new enzymes which can break down substances like plant materials so they can be processed into other useful building blocks is also part of our research area but is still in the early phases."

Useful bycatch

While every project involves results that could be predicted to some extent, the team did make one surprising discovery in 2013. "Some of our research involves identifying new bacteria which can stimulate plant growth and which properties are involved in this," Raaijmakers says. "We've noticed that if you add specific beneficial soil bacteria to plant roots, the plant undergoes substantial chemical changes. For example,the concentration of several plant substances, which can have a positive effect on human health, increased significantly. But we also noticed that bacteria were triggering the biosynthesis of some plant chemical compounds that are still unknown to us. Together with metabolomics groups from Wageningen and Leiden University, we are now going to look at what these compounds actually are, how they work and if they could have specific applications for society." This considerable bycatch has since been upgraded to an important new part of the research programme.

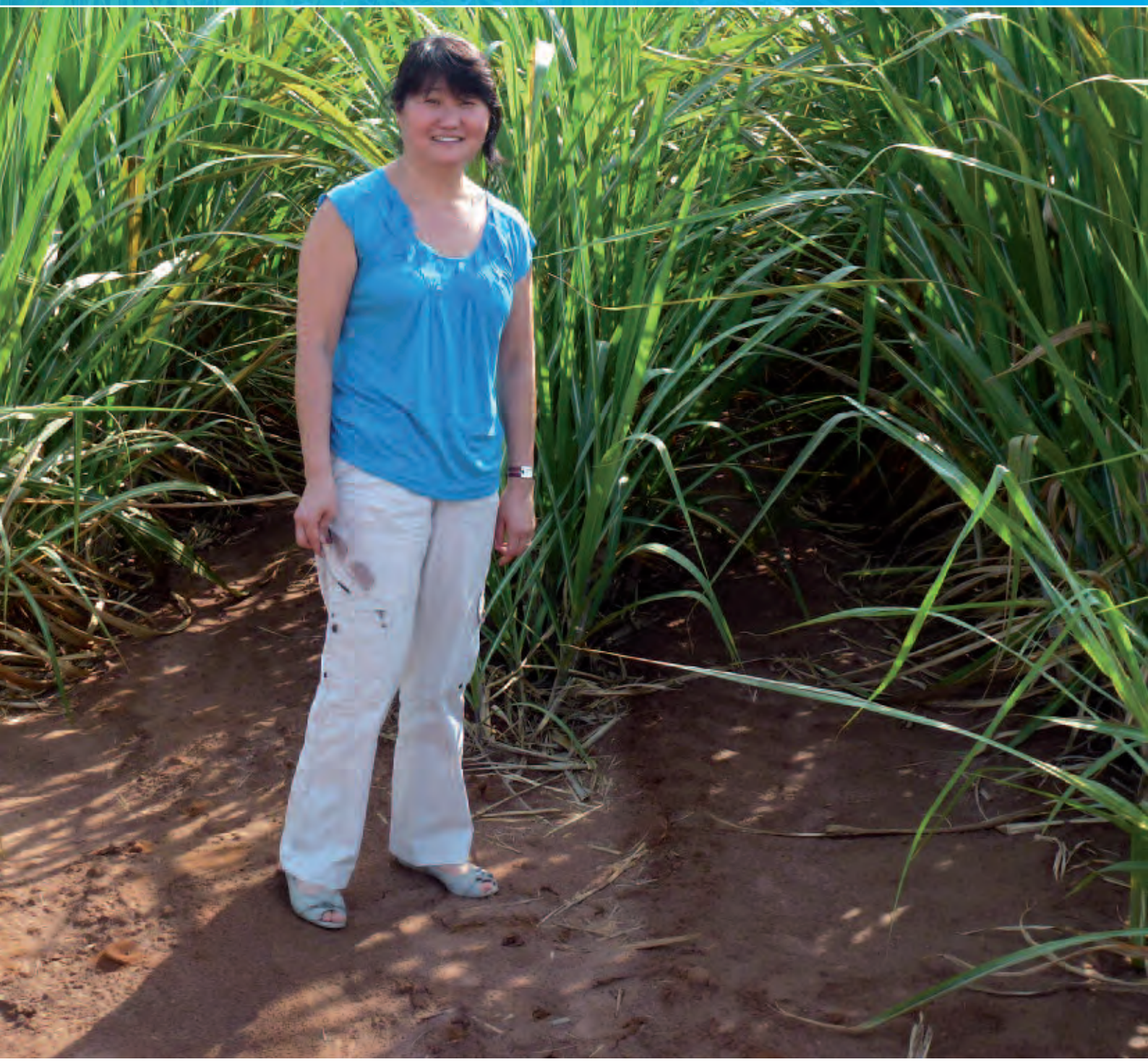
Making clever choices

Research into new micro-organisms is not simple. To identify new antibiotics, micro-organisms need to be able to grow. Some microbial groups cannot be cultured or grow extremely slowly. And if they do grow well, they may not make the desired compounds. "You have to make clever choices to discover something new," says Raaijmakers. "We select natural environments with a high chance of finding new things. For example, we use soils in which certain plant fungi rarely cause problems. In projects like this, such a choice is crucial in determining whether or not you make a new discovery or simply come up with a substance you already know."

The research project 'High-throughput experimentation and metagenomic mining' will run until 2017. The Netherlands Institute of Ecology and Wageningen University are working together on the project with Leiden University, BioDetection Systems BV and MicroLife Solutions.

Environmental impact of chemicals, biobased molecules and processes

The mass production of crops to use as fuel has a major impact on both soil quality and greenhouse gas emissions. In one of several Flagship 8 projects, Eiko Kuramae and her team are developing ways to enable the sustainable production of sugar cane in close cooperation with a group of Brazilian scientists.



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*The Flagship **Environmental impact of chemicals, biobased molecules and processes** develops novel and efficient methods for the evaluation and improvement of chemical safety in the biobased economy. Research is focused on the environmental and human safety issues arising from the transition and implementation of a biobased economy, as compared to existing industrial activities.*

'Ensuring the minimum addition of nutrients while maximising production'

Examining and understanding the way soil functions is crucial in reducing the impact of mass agriculture on the environment. "My project in Flagship 8 is about the role of microbes in soil quality and sustainable soil management when producing crops for industry," says Kuramae. "Mass production and monoculture may negatively affect some soil properties and reduce the microbial diversity which is crucial to make sure soil functions properly. This, in turn, leads to an increase in production of greenhouse gases which have a knock-on effect on global warming." Kuramae, a senior scientist with the Netherlands Institute of Ecology (NIOO/KNAW), is working closely on the project with researchers from three Brazilian institutions: the Agronomic Institute of Campinas (IAC), the University of São Carlos (UFSCar) and University of São Paulo (CENA/USP).

Cooperation with Brazil

Sugar cane is one of the most sustainable crops used in the production of biofuels and Brazil is one of the world's biggest producers. In fact the country is so advanced that most cars in Brazil are equipped to drive on both petrol and biofuel. "We are looking at the impact of these massive fields on the environment and how you can mitigate the bad effects," says Kuramae, who has been working on the project since 2012.

In Brazil, sugar cane fields are usually fed with vinasse, a by-product of ethanol production, which recycles nutrients but may also increase the emission of greenhouse gases, especially if combined with synthetic fertilisers. This has led the scientists to begin developing models to produce sugar cane in a sustainable way. In the Netherlands, the team is looking at what the microbes are doing in the soil itself. This includes examining their role in both the production and absorption of greenhouse gases. "One of our aims is to produce a platform based on microbial genes to monitor both soil quality and nitrous oxide emissions," Kuramae says. "Ultimately, we want to be able to ensure the minimum addition of nutrients while maximising production and reducing the environmental impact."

Multiple uses

In Brazil sharp sugar cane leaves used to be burnt off before the cane was harvested but that process is now being phased out. This means a large amount of straw is left in the fields. This in itself is good for the quality of the soil. But the straw can also be used in the production of ethanol. "So we are trying to find out what is the minimal amount of straw which can be left on the land while ensuring as much straw as possible can be collected to produce alcohol," she says.

Encouraging signs of possible advances

The close ties with Brazil have proved extremely beneficial to the project, says Kuramae, who visited the South American country four times in 2013. "The Dutch and Brazilian teams do have different excellences with complementary expertise, which allows interdisciplinary research," says Kuramae. The team has detected encouraging signs of possible advances in 2013. "We appear to have made a very interesting breakthrough in terms of the behaviour of certain bacterial groups in residues and their role in greenhouse gas emissions," Kuramae says. But she does not want to jump the gun before she is sure. "One of our aims in 2014 is to test this hypothesis."

Societal embedding of a biobased economy

"Our approach is unique because we are working together with industry to establish educational programmes. We are looking at what is needed in practice," says Isabel Arends, who is responsible for the development and implementation of novel education and training modules within the BE-Basic Steering Committee. In 2013, the unit drew up a detailed inventory of the education on offer in the Netherlands and which focuses on the biobased economy.

GS

*The Flagship **Societal Embedding of a Biobased Economy** optimises the societal embedding of the products and processes developed by BE-Basic. The flagship focuses on the identification of socio-economic aspects and sustainability issues and the development of adequate systems to monitor and model these. They develop effective and efficient education, communication and societal valorisation programmes.*

'Preparing our future workforce for jobs in the biobased industry'

The central focus of Flagship 9 is making sure biobased products and processes developed by BE-Basic find optimal acceptance in society. This involves identifying socio-economic aspects and sustainability issues, developing models for monitoring, improving the relationship with stakeholders and developing effective education. "The inventory we drew up in 2013 makes clear what is available in terms of education relevant to the biobased economy and where we can play a role," says Arends. This inventory served as the basis for the new BE-Basic educational programme that will start in 2014.

A role for secondary schools, vocational training and hbo colleges

Education plays a major role in ensuring society is aware of what the biobased economy entails and is ready to work within it. "For secondary education we see a role for BE-Basic in supporting dedicated activities that have already proven successful, like the DNA-labs on the Road (see box) project, the RUG Discovery Truck and the schools' competition 'Imagine'," she says. "We've also found out that vocational schools (mbo) and hbo colleges already pay considerable attention to the biobased economy. We are looking at how we can encourage links between them and the Bioprocess Pilot Facility and at developing educational modules for this."

Master's degree course in Brazil

The inventory also showed Dutch university students are well served, particularly in Delft, Wageningen and Groningen. "A highlight for us in 2013 was the Master's degree course 'Biobased economy beyond bio-ethanol' which we developed and taught, together with our alliance partner in Brazil," says Arends. "This course ran for three months and was taught by Brazilian and Dutch staff plus a number of industrial experts from Brazil and BE-Basic. The course was open to employees in the private sector and post-graduates."

Distance learning and online tools

The Master's course was a pilot project and the experience will be incorporated into the educational plan BE-Basic is now working on. "We experimented with off-site lectures and online tools," Arends says. "One of the lessons we learned is that we need a platform to facilitate the exchange of teaching materials. We have been granted € 3 million in total to lead an educational programme that runs from secondary schools to post-graduate level. This new programme includes 13 courses for post-graduates aimed at international collaboration. Online education is now a key issue for Delft University of Technology. Our plan also involves developing a MOOC (Massive Open Online Course) focusing on the biobased economy, so we can reach an international audience and stimulate them to do a Master's degree in a BBE subject."

The inventory also brought insights into the actual status of Dutch biobased education. "Our most important task is to create highly skilled professionals who can seize the initiative and develop processes and products based on bio-renewables," Arends states. "But it is equally important they have expertise in the social and legal aspects and the context, such as the acceptance levels in society. The programme is internationally orientated to deliver this knowledge and skills at a global level." It also focuses attention on life-long learning and SMEs. In addition, BioBrug in Groningen will start a programme to facilitate the industrial needs on the national level.

Racing on toilet paper

The DNA-lab on the Road 'Racing on toilet paper' visits high school students across the country. The youngsters, aged 15-18, carry out experiments and make bio-ethanol using yeast and toilet paper. The travelling laboratory was developed by the Kluyver Centre and is manned by Delft University of Technology, now on behalf of BE-Basic. At the Science Centre Delft, children aged 8-12 can participate in a shorter version of this project.

Genomics for industrial fermentation

Flagship 10 was launched at the end of 2013. The Flagship is continuing interesting and new leads in the research previously undertaken by the Kluyver Centre which has stopped operating after 10 years. "We are researching filamentous fungi (such as Aspergillus niger), yeasts and lactic acid bacteria," says flagship manager Martin Wijsman who is Innovation Manager at dairy company FrieslandCampina. "All these micro-organisms can be used to produce ingredients and additives for the food industry as well as biofuels and bioactive compounds."

*The Flagship **Genomics for industrial fermentation** focuses on improvement of the conversion capacities of microorganisms, by e.g., non-GMO methods, for industrial scale fermentation.*

'The power of this research derives from 'going back to nature'

The Flagship has two portfolios, both of which have received government subsidies under the TKI-BBE scheme: AMBIC and ISIM. Flagship manager Martin Wijsman works closely with deputy manager Han Wösten, who is affiliated to Utrecht University and who led the Kluyver Centre's filamentous fungi programme. "BE-Basic's power lies in the partnership between universities, scientific institutes and private companies. That is why we, as an industrial partner, want to continue and extend this research within BE-Basic," says Wijsman. Wösten continues:
"We are looking at how to make products the best way possible by using micro-organisms and how we can optimise the role of these products and compounds in food. This is what genomics is about: which genes are active and when, and how can we use them to optimise the way the organism works."

Project AMBIC: enzymes for industry
Yeast and filamentous fungi are central to the AMBIC project. "In the main, we are looking at how we can optimise the formation of products," says Wösten, "One aspect of this involves the development of biofuels which are made by yeasts. Yeasts can produce bio-ethanol, n-butanol and isobutanol. One problem with increased production is that the biofuel is toxic for yeast. So we are looking at how we can make bakers yeast more tolerant to isobutanol." Another project looks at 'zero growth'. Many industrial processes make use of microbial fermentation. "It would be best if energy is not invested in microbial growth but rather in product formation," says Wösten. Wijsman adds: "There are two factors that determine the success of biofuels. The first is the sensitivity of yeast towards the product they are producing. The second is the high cost of enzymes. If the microbes don't waste energy on growth, they produce more efficiently, thus reducing the costs. We need to make progress in both these fields to make biofuels affordable."

Project ISIM: optimising lactic acid for industry
The other main area of subsidised research, ISIM, concentrates on optimisation of lactic acid bacteria used by the food industry in the production of sausage, salami, cheese and yoghurt, among other foodstuffs. Groningen and Wageningen universities are both involved in this project. "The power of this research is that you are going back to nature," says Wijsman. "Researchers will look for new lactic acid bacteria and examine how they exchange genetic information in nature. Eventually this will allow processes to be adapted and optimised." Wijsman expects any future inventions could have a role within his company. "We could, for example, develop a new taste of cheese or type of yoghurt. Lactic acid bacteria break down proteins in milk in different ways and the resulting breakdown products determine taste. If we can make use of these we could create products with different tastes. If we achieve that, we will stand out from our competitors in the market."

EBD Programme: Economy, Policy and Sustainability

"Developing policy and ensuring the support of stakeholders and the public are preconditions to take sustainable biobased products in the market," says Patricia Osseweijer, chairman of the Steering Group Economy, Policy and Sustainability (EBD). "What makes this programme unique is that companies, NGOs and knowledge institutes are working together to identify hurdles and come up with solutions and to define a common standpoint to communicate with the wider public." In 2013, this entailed launching an Innovation & Societal Roadmap and a Macro-economic Study.

'We need effective policies to implement sustainable bioproducts'

The EBD programme is supported by the government-backed TKI-BBE, (Top Consortium for Knowledge and Innovation, Biobased Economy). As an integral part of this, in 2013 the team started developing an Innovation & Societal Roadmap and a Macro-economic Study focusing on sustainability and bio-renewable innovations. "The overall objective of the roadmap is to provide insight into the societal preconditions for the economic and sustainable introduction of bio-renewable chemical and energy production," Osseweijer explains. "The project is aimed at describing and prioritising the actions which will be needed and should deliver its results in 12 months. It will also interact with the Macro-economic Study. That study (called MEV II) provides insights into the likely macro-economic impact of the large-scale use of biomass in the Netherlands (including its imports) and aspects of its sustainability."

Sustainable wood use, public knowledge and perceptions

"One example of the policy recommendations we are developing for biobased products are the guidelines for sustainability in wood energy supply chains," says Osseweijer. "We rounded that project off in 2013 by delivering three case studies for biomass supply chains, together with the methodology and results. Now, for example, there are draft guidelines which wood pellets have to meet to ensure they are produced in a sustainable way." Another project successfully completed in 2013 is the public qualitative research project 'Microsociety 2030', based on a representative focus group. Such research is necessary to get insight into how to win public acceptance for the biobased economy so it can become embedded in society. "The research focused on how people look at developments in the biobased economy," Osseweijer says. "What stands out is how unaware people generally are of what is meant by the biobased economy. In addition, people often say they will only start adopting more sustainable patterns of behaviour if their neighbours do as well." Nevertheless, a follow up quantitative study to this research project showed that 75% of people do support sustainable development principles.

Internationalisation

The biobased economy does not stop at national borders, so international alliances and the sharing of knowledge are an important focus point of the programme. "We, for example, take part in the International Energy Agency," Osseweijer points out. "Dutch knowledge institutions are active in different taskforces and this means important research results connected to the biobased economy become available to Dutch organisations. We can also explain the Dutch perspective. In addition we will be active in international programmes run by BE-Basic; the European Commission and the Biobased Industry Consortium. This will be based on knowledge and expertise built up through the Centre for Life Sciences and Society. We have received €100,000 from the NWO to anchor this expertise in BE-Basic." Over the next year, Osseweijer expects the interaction with other flagships will increase. "And we will reach the stage in which we focus more on disseminating our results into policy recommendations, and via education and communication with the public at large," she says.

Identifying change agents

How do you motivate the public at large to take an active step towards a biobased economy? Following on from the study 'Microsociety 2030' a project has now been started to identify neighbourhood change agents who will be offered concrete help in establishing local projects with biobased solutions. This is happening through a project group involving Delft University of Technology, the VU University, Natuur en Milieu and Tertium.

The report 'My 2030s – Citizens in a Biobased Economy' can be found at www.tertium.nl/my2030s.

International Activities

BE-Basic's strong international focus is reflected in the membership of the consortium, which includes leading EU institutions like Imperial College from the UK. Moreover, BE-Basic puts its international focus into practice through strategic partnerships in a selected number of countries: Brazil, Germany, Malaysia, the United States and Vietnam.

United States

We have expanded our activities with our American partner Amyris. Amyris is applying an industrial synthetic biology platform to provide high-performing alternatives to petroleum-sourced fuels and chemicals.

In addition to the alliance with Amyris, BE-Basic has selected the Energy Biosciences Institute (EBI) at Berkeley and the Oak Ridge National Laboratory (ORNL) as partners, due to their excellence in research and the opportunities for BE-Basic partners. EBI and ORNL are leading in investments in research programmes for bioenergy and biorenewables.

An article on our activities in Brazil can be found on page 28 and 29.

Germany

Germany's cluster for industrial biotechnology (CLIB2021) and BE-Basic have signed a memorandum of understanding to cooperate in developing the bioeconomy.

The alliance will focus on the bilateral exchange of educational programmes, the alignment of societal programmes around feedstock sustainability, a joint approach to third-party international partners and facilitating joint technology development through the organisation of targeted joint workshops.

Other fruitful German research agreements with Karlsruhe Institute of Technology and Technische Universität Dortmund illustrate our joint strengths within several BE-Basic projects.

Malaysia
The Oil Palm Biomass Center (OPBC) is a Malaysian public-private partnership in which BE-Basic and several of its partners participate. BE-Basic has explored various initiatives with the OPBC through a memorandum of understanding.

BE-Basic was very involved in Malaysia's National Biomass Strategy and the Macro-economic Impact Study, both of which were executed under the supervision of AIM (Agencia Inovasi Malaysia). Both studies underlined the clear opportunities presented by a higher added-value (chemicals, advanced bio(jet)fuels) industry on the basis of sustainable biomass, rather than focused use for power production.

A detailed study on the integrated conversion of palm biomass to commodity intermediates was executed as a model for large scale tropical crop residues by TU Delft and Universiti Teknologi Malaysia (UTM). This was done in close collaboration with various small and large palm players and the chemical industry.

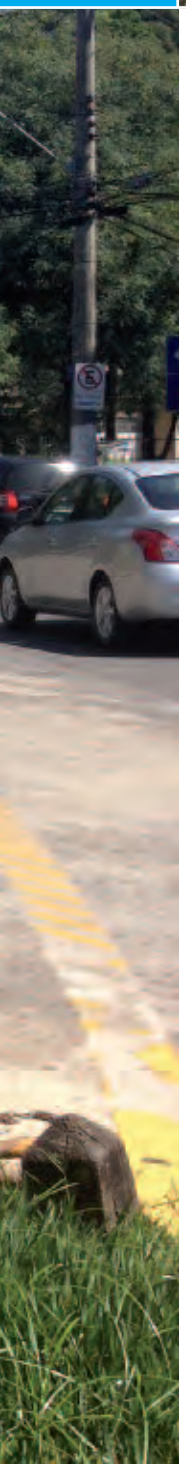
The underlying horizontal programme Sustainable Biobased Products in ASEAN for BE-Basic builds on earlier work and regional industry-academic-government networks, developing a focused programme on two product groups of higher added value: bioplastics and advanced biojet fuels. These cases are concrete and connect regional needs to global markets and trends. Secondly, the underlying programme aims to simultaneously improve common ASEAN food and feed production, especially in sectors of significant local (rice, sugar) and global (palm oil, rubber, tea and coffee) impact. The benefits will be both regional - boosting the economy, biodiversity and jobs - and global, in terms of sustainability and security of supply.

Vietnam
The signing of a letter of intent between the Vietnam Academy of Science & Technology (VAST) and BE-Basic resulted in a delegation from VAST and the Ministry of Science & Technology visiting BE-Basic and its partners in September 2012.

A joint research and innovation programme (VN-BASIC 2013-2017) has since been established focusing on three main themes:
1) bioremediation, soil quality and safety monitoring in Vietnam;
2) mining Vietnamese microorganisms for novel antibiotics and enzymes;
3) microbial enhanced pre-treatment and conversion of rice straw into chemical building blocks and biofuels. The total volume of joint R&D activities is around € 4 million, funded by both the Dutch and the Vietnamese sides.
For more on the Vietnamese activities, see page 30 to 31.

International alliances: Brazil

The biobased economy is a global economy and BE-Basic's alliances with Brazil, one of the world leaders in the development and application of biofuels and biochemicals, have intensified significantly in recent years. Major steps have been taken since the opening of the BE-Basic & TU Delft Brazil office in 2012, in terms of both joint research & development and the education of our future work force.



Successful R&D and education partnership with Brazil

2013 was a very successful year for BE-Basic Brazil. To mention a few highlights: BE-Basic and São Paulo Research Foundation (FAPESP) approved two new collaborative R&D projects, bringing the total to six and with a total volume of about $7million. BE-Basic Brazil also presented its international activities to Lilianne Ploumen, Dutch Minister for Foreign Trade and Development Cooperation, during the recent Dutch government economic mission to Brazil. The Agronomic Institute of Campinas hosted the fifth BE-Basic & FAPESP workshop, bringing together 52 participants to discuss potential new projects. Furthermore, the University of Campinas and the BE-Basic Brazil office worked together towards the development of dual degree PhDs and by organising the first joint advanced course on entrepreneurship for a biobased economy. These educational activities form an increasing part of BE-Basic Brazil's activities.

Advanced courses

The educational activities are part of Flagship 9's large-scale programme focusing on embedding the concept of a biobased economy firmly in society, and on stimulating education. This programme aims to stimulate and prepare our future international workforce for jobs in the biobased economy. It develops and provides education for broad international usage (with an initial focus on Brazil). Where possible BE-Basic members collaborate with colleagues from its international partners. "The focus in Brazil is on advanced courses (graduate and post-graduate level) for academic and industrial participants," says Ernst-Jan Bakker, director of the TU Delft Brazil & BE-Basic Brazil office in Campinas. "An educational programme has been developed based on an inventory of present advanced courses, interest and future workforce demands, and covers topics such as multicomponent mass transfer and thermodynamics in biochemical engineering."

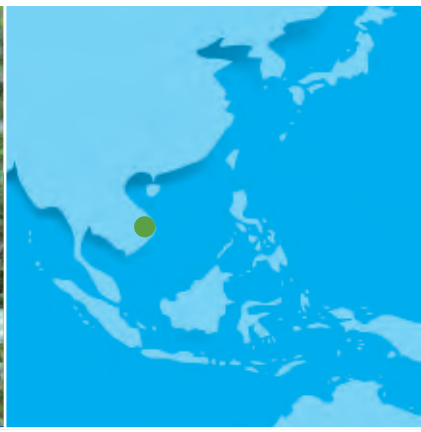
The programme kicked off in 2013 with a joint course - Biobased Economy Beyond Bioethanol – which looked at business development and entrepreneurship. Professor Gustavo Paim Valença of the UNICAMP School of Chemical Engineering is (together with Professor Luuk van der Wielen) responsible for this course. "Joint education leads to closer collaboration and new ideas, while supporting both UNICAMP and BE-Basic's ambitions to further internationalise their activities," he says. "The students benefit from accessing new, complementary topics, presented by international academic and industrial experts in a global context. These are topics which are very relevant to the current and future biobased economy workforce. "

Dual degree

Another topic of interest is the Brazilian doctorate programme BIOENERGY, an initiative of the universities UNICAMP, USP and UNESP. BE-Basic provides fellowships for approved joint PhD projects with joint supervision, leading to dual degrees upon successful completion. Professor Andreas Gombert, UNICAMP coordinator of the initiative, says the dual PhDs will help to strengthen and stimulate new collaboration. "This programme will create stronger and new alliances between UNICAMP and BE-Basic researchers, as well as the Brazilian and Dutch research communities, by educating highly skilled people in the strategic area of bioenergy," he says. The first dual degree project was defined in 2013 and is expected to start in early 2014. Delft University's Rector Magnificus Karel Luyben, visiting UNICAMP in 2013, highlighted the fact that the need for education is growing exponentially. He and UNICAMP Vice-Rector Alvaro Crósta issued a statement during the visit setting a target of 25 dual degree PhD students by 2020.

International alliances: Vietnam

The wide availability of biomass, the good infrastructure, rich biodiversity and the environmental and agricultural challenges make Vietnam an interesting partner for BE-Basic. From Vietnam's perspective, the alliance is essential to speed up research and biotechnological development. "Vietnam has a rich biodiversity and is a paradise for renewable nature mining," says professor Dang Thi Cam Ha.



'Vietnam is a paradise for renewable nature mining'

The alliance between BE-Basic and the Vietnam Academy of Science and Technology (VAST) was officially launched in November 2013. Both sides are very happy with the relationship so far. "Earlier projects with the Dutch were very successful and show scientific collaboration with the Dutch works," says Dang Thi Cam Ha. The research programme is made up of three parts. The first involves monitoring and bioremediation of Vietnamese soils, crops and biomass. "The second focuses on the search for new probiotics, genes and bioactive compounds found in Vietnam's natural resources, and the third on exploiting raw materials for the production of chemical building blocks."

Spontaneous growth on polluted ground

The process of restoring the damage caused by Agent Orange – a defoliant sprayed over large parts of the country during the Vietnam War - has been ongoing for years. "For years nothing would grow in some places," says Professor Bram Brouwer, executive director of the BE-Basic Foundation and initiator of the Vietnam alliance. "But in some places, there has been spontaneous growth. Underground fungi and bacteria are breaking down the dioxins. That is unique." Dang Thi Cam Ha adds: "We have seen that there are many active groups of micro-organisms which interact in certain ways. We have also found other compounds that have an impact. This technology could, therefore, be used in other contaminated areas and thus could become an export product."

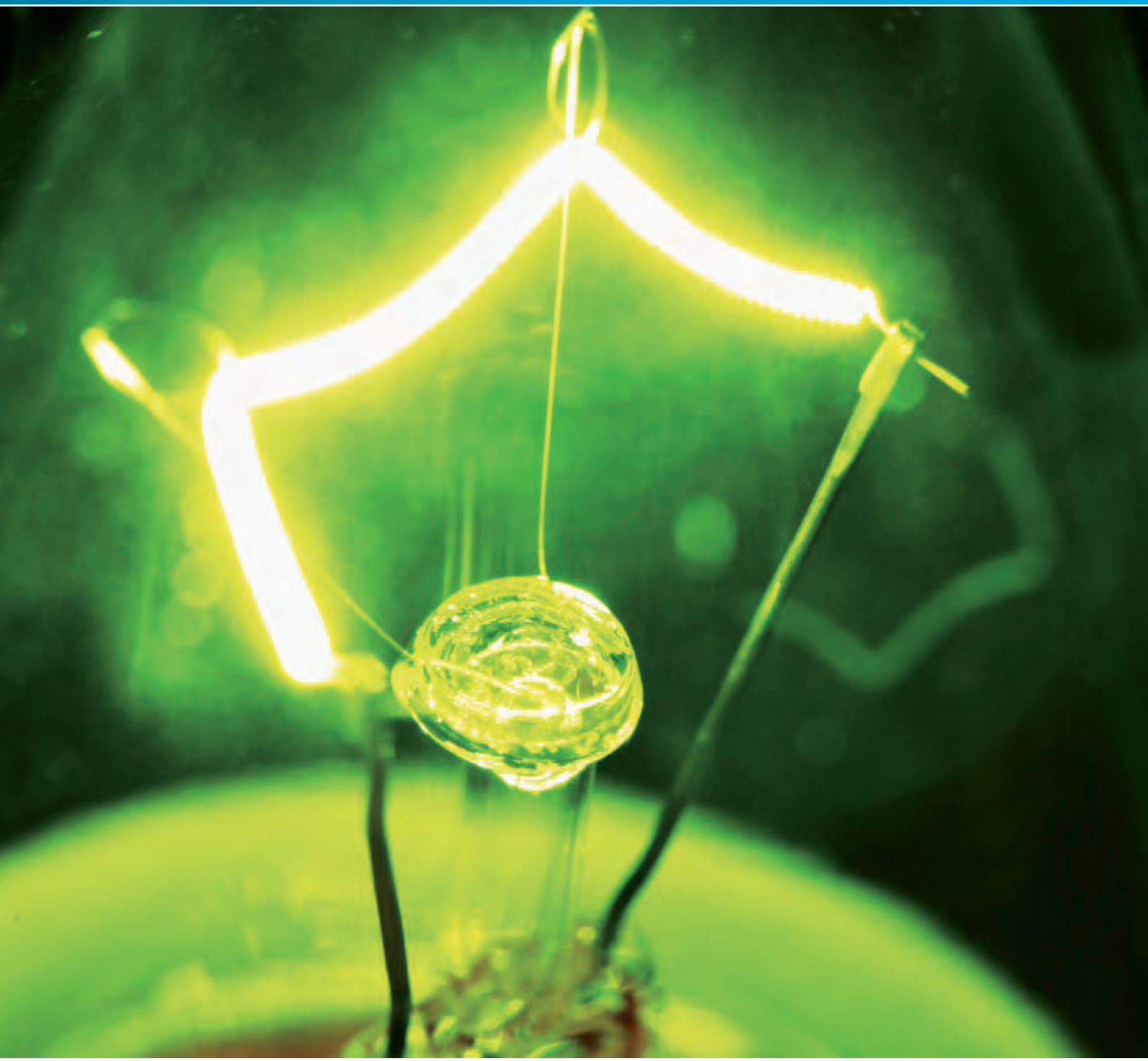
It would be remarkable indeed if the scientists are able to turn this environmental disaster around and use it to take a positive step towards the development of a biobased economy. "It has been suggested that the enzymes we are finding may contribute to the faster and more efficient breakdown of lignin as well, and so result in a better lignocellulosic conversion into sugars," says Dang Thi Cam Ha. This could be an important step in processing the large amounts of biomass needed for the biobased economy. At the moment, breaking down lignin – found in the cell walls of plants and some algae – is a major bottleneck. The process is expensive and polluting. "We want to find a biological method to simplify this first step in processing biomass," says Brouwer. "The Vietnamese research is in the explorative phase. Research is needed to establish if this enzyme can make a contribution."

New bioactive ingredients from woods and the sea

Another project focuses on finding new bioactive ingredients. "We've collected lots of samples from nature and have identified new genes using metagenomic research," says Dang Thi Cam Ha. "In the short term, we plan to identify these new compounds, publish our findings and file for patents. Professor Le Mai Huong, who is also part of the team, points to the additional knowledge they are gathering from the sea. "Vietnam is rich in sea-based micro-organisms. We have more than 2,000 km of shoreline and several hot springs. These contain many active compounds which could be used in food and pharmaceuticals." This research is particularly interesting for BE-Basic because it could lead to the discovery of new antibiotics. Bram Brouwer is also interested in the potential of hot spring bacteria. "They may contain enzymes which could play a role in breaking down lignin. If they can function in these warm, acid environments, they may also be able to remain active in a reactor. All in all, there are many reason to continue full steam ahead with our alliance with VAST."

BE-BIC: BE-Basic's Business and Innovation Centre

BE-BIC stimulates and supports all the innovation activities taking place within the BE-Basic research programme. "This makes it important to identify potential new entrepreneurs at an early stage," says Bram Brouwer, director of BE-Basic and responsible for the BE-BIC operation. To facilitate this, in 2013, 50 scientists went on an awareness training course led by business coaches Hans Le Fever and Math Kohnen from eNovITe. "For scientists sharing knowledge with society should be a greater good," Le Fever says.



'Sharing knowledge with society is a greater good'

In 2013, all postdocs and PhD candidates working on research projects within BE-Basic followed a course to raise awareness on how their technological know-how can be turned into business. "Many of them are focused on their research which is their strength," says Le Fever. "But they are less concerned with how they can exploit their inventions. BE-Basic is a public private partnership, so the ultimate aim is to develop commercial products." During the training programme, it became clear some participants already had ideas for starting a company based on their technological inventions. And some 40% of them want to take part in a follow-up workshop in June 2014.

The follow-up programme is the Action Lab, in which the scientist and a team take a business-like approach to their own research. The focus is on drawing up an investor-ready plan. "It is important to rigorously challenge everything – from the legal aspects to the finances – before you can bring a product successfully to the market," says Le Fever. "We support scientists in the thinking process to enable a brilliant technological invention to come to fruition. They have to think about the interests their research can serve." The ultimate aim is to attract funding for launching a company or to find a development partner.

More start-ups than expected

"Entrepreneurship is an important part of the innovation centre, which begins in the early stage with raising awareness among scientists," says Bram Brouwer. "Now the complete programme is up and running, there has been a drive towards innovation in some areas. Within the Flagships themselves, an increasing number of inventions are leading to patent filings. Different scientists are commercialising their inventions via start-ups funded by BE-Basic subsidies. We had hoped to start five new companies. We've already reached that, so the total project will well exceed the key performance indicator for start-ups."

Discoveries rolled out by industry

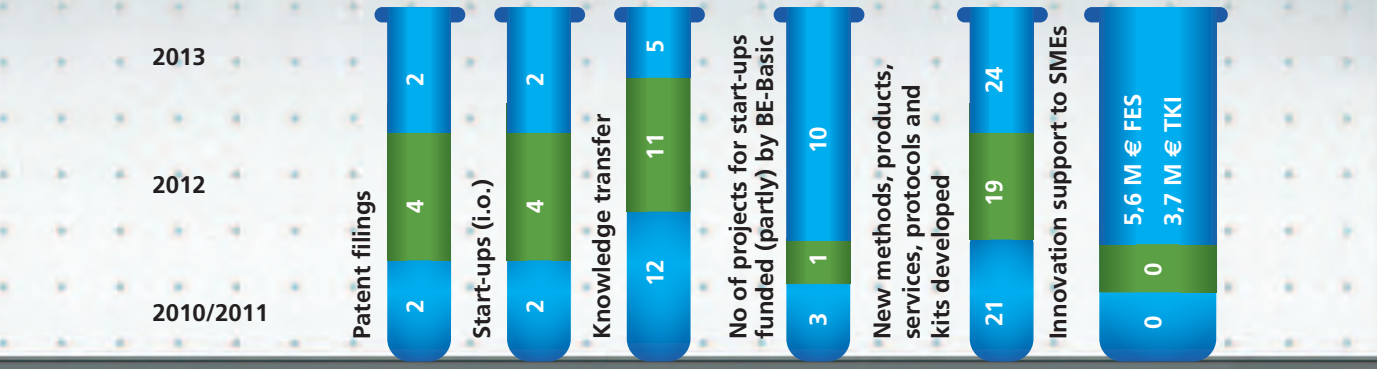
A close relationship with industry is crucial to the BE-Basic Programme. "We are not only looking at our own inventions," says Brouwer. "We also look at demand from society at large and from industry and what solutions are needed. The development of sustainable biobased products depends largely on developing an entire value chain. Turning biomass into a concrete product involves different companies and organisations and that means you become part of an interdependent value chain. You could see us as a broker: we are creating a network of different players and so are facilitating the development of a biobased economy." The ultimate aim is to ensure industry takes BE-Basic's discoveries to the market. "The only way to grow the biobased economy is to let big industry roll it out," says Brouwer.

Start-ups founded by BE-Basic Foundation:
Waste2Chemical (W2C) B.V. (2010)
Clear Detections B.V. (2011)
MicroLife Solutions (MLS) B.V. (2011)
BDS Chili B.V. (2011)
Blgg Research B.V. (2012)
Delft Advanced Biorenewables (DAB) B.V. (2012)

Facts and Figures

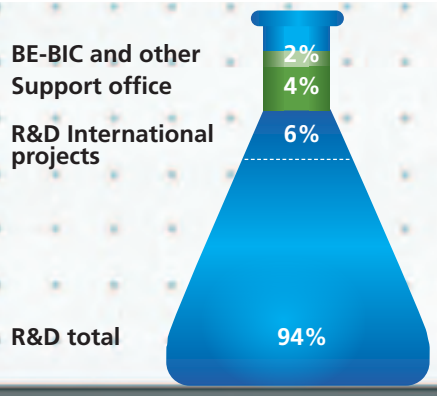
2013

Cumulative scientific output

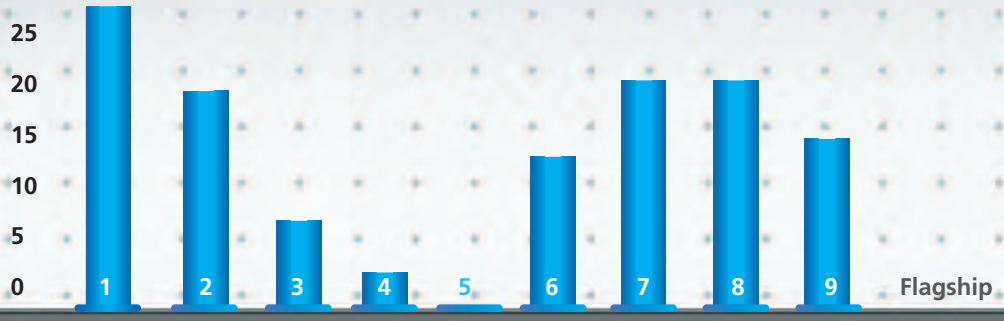


Valorisation output 2013

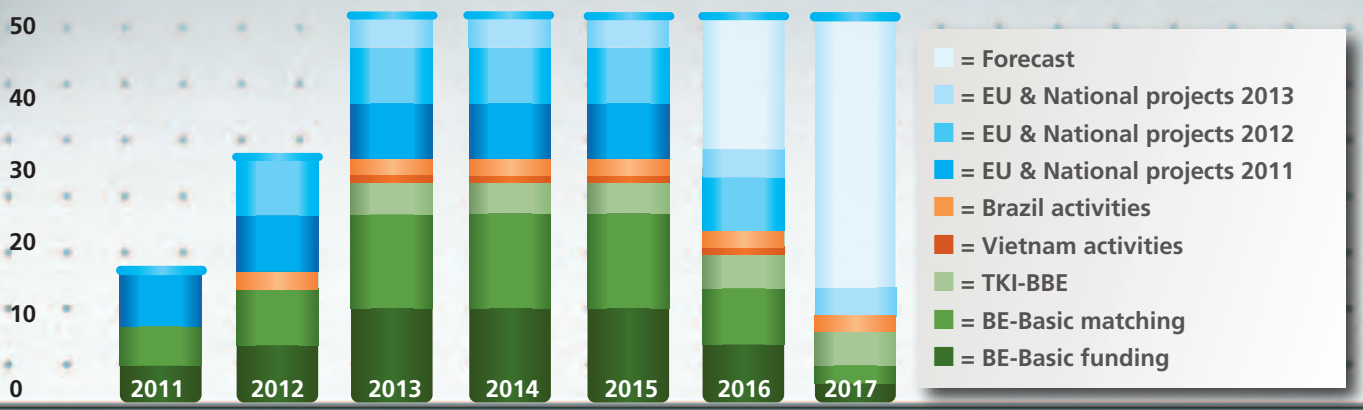
International workshops



Distribution of BE-Basic funds (Total budget 120 M €)



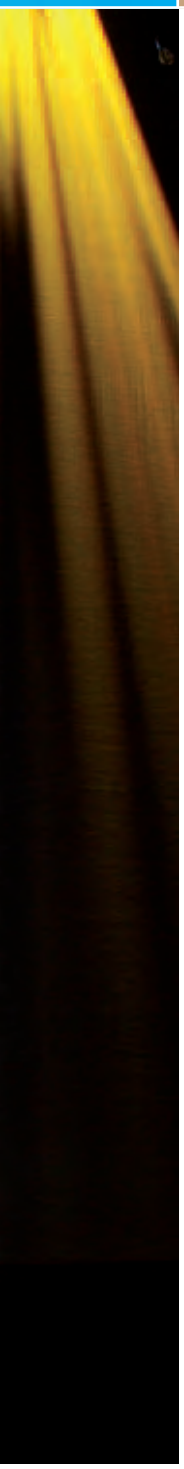
Total approved budget per Flagship per end 2013



Size of different funds acquired in addition to BE-Basic (M € per year)

Roel Bol, the government's Special Envoy Green Growth, speaks about the biobased future

"The shift towards a biobased economy is gathering pace. More companies in both the Netherlands and internationally are focusing on this field. The time is ripe to introduce products and processes to the market," says Roel Bol, the Dutch government's Special Envoy for Green Growth. Bol has been in the position since the end of 2013 and sees boosting sustainability as a key issue.



'Seize the opportunities now and take products to market'

The biobased economy has become an important item on the agenda in the space of just 10 years. "You see that in the dedication of the people who work at BE-Basic and in the substantial financial commitment behind them," says Bol. "BE-Basic has stimulated significant movement and has some great research projects. It is important to pluck the fruits of those labours and seize the opportunities to launch these products and processes on the market. That begins with communication: be proud of what you have done. I think researchers should not be afraid to blow their own trumpet about the results and perspectives they have achieved."

Industrial partners

Bol believes the strength of biobased developments lies in the consortium-based structure. "It is the combination of government, industry and civic organisations which drives recognition of the biobased economy programme and BE-Basic has had a role in that," he says. "It is important that everyone is aware of the importance of biobased developments, because in the end, it will be up to consumers. The consumer chooses what he or she buys on the basis of quality, price and then sustainability. So you have to make it clear that today's developments are useful to industry and will enable companies to better serve their clients. Industry is increasingly aware of the benefits. The market for bioplastics, for example, has doubled in a couple of years. And BE-Basic also offers opportunities to start-ups."

International growth

Interest in biobased developments is mounting abroad as well. "Northern Europe is ahead of the rest but there is an increase in interest from countries like Italy and Spain," says Bol. "In mid 2013, the European Commission launched its own Joint Technology Initiative for biobased industries. The budget is a pretty substantial € 3.8 billion, of which € 2.8 billion has come from industry. There is also considerable activity outside Europe – in China for example. This also presents an international opportunity for the open Dutch economy. Working with other countries where there are interesting scientific challenges or which could be significant suppliers is crucial. Take Brazil, for example, with its strong agricultural traditions and large chemical industry and which BE-Basic already works with."

Focus

"The world is a big place so it makes good business sense to focus," Bol says. "Which countries are important to work with? What structural activities can you take part in? This is a choice made by the consortium as a whole, including the industrial partners. Funding is finite, international alliances require constant work. Choose an alliance which allows you to incorporate continuity. Generations to come are going to need these biobased developments. I expect a further acceleration of developments over the next couple of years, partly due to these international links. It would be prudent to be ready for them."

Who is who

Bram Brouwer
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Yvette van Scheppingen
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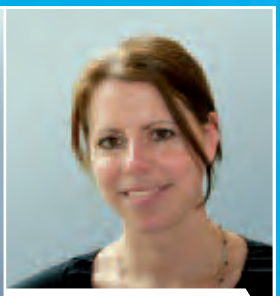

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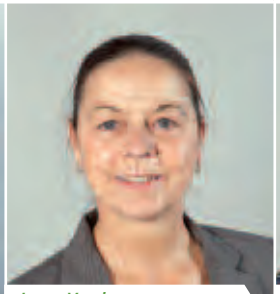

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Han Wösten
Vice Flagship Manager FS10

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IPRC panel composition

The IPRC members involved in the evaluation process of the BE-Basic programme are:

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- *Prof. dr. Matthias H.C. Reuss, University of Stuttgart, Germany*
- *Prof. dr. Sven Panke, Department of Biosystems Science and Engineering, ETH Zurich, Switzerland*
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