CHEMPORT EUROPE

Changing the nature **of chemistry**

In the Northern Netherlands,
green chemistry and circular projects
actually get off the ground and with
this we are re-shaping the economy.
Cooperation between parties is key.
It works well because we share the
ambition to create sustainable
chemical production chains
and close loops.

www.chemport.eu

CHEMPORT EUROPE

Why the Northern Netherlands?

The aim of Avantium is to develop ground-breaking technologies for sustainable chemistry. We have a great research lab in Amsterdam and in Delfzijl we scale up our technologies in pilot plants and test them for commercial production. Why did we choose the Northern Netherlands? We were looking for a place with the right infrastructure, well-trained people and a local government prepared to invest in new technologies for a green and sustainable future. The Northern Netherlands ticks all the boxes, and has a port which we can use to import biomass.

Our first pilot plant uses the Dawn technology to convert non-food biomass like wood chips or agricultural waste into industrial sugars and lignin. These sugars are turned into chemical feedstocks to make plastics. Currently, we are building a second demonstration plant, which converts sugar into plant-based mono-ethylene glycol (MEG), which is used in the production of chemicals and plastics. A building block for the production of bioplastics in Chemical Cluster Emmen. It can be used to produce 100% bio-PET.

Eventually, we will have to take another step, from pilot plant to commercial production plant. I have visited many places, but the Northern Netherlands is really a wonderful place to work. Coming from Amsterdam, I wondered whether I would fit in – but I have always felt welcome and at home. Cooperation with other companies and the local and regional government is excellent. The Northern provinces want to be at the forefront in green chemistry development and are eager to invest.

Our pilot plants in Delfzijl are important steps, but the ultimate goal is to scale up to industrial plants. We are already discussing options how the Northern Netherlands fits in our commercialization strategy. The level of sophistication is outstanding. It is always a pleasure to take our international relations to the Northern Netherlands.

Tom van Aken,
CEO Avantium

1.

DISCOVER CHEMPORT EUROPE

Chemport Europe is an ecosystem in the Northern Netherlands in which companies committed to the development of a greener chemical sector flourish. These companies, together with knowledge institutions and government are in the process of transforming of the chemical industry. The ambition is green growth. By 2050, only renewable energy and raw materials will be used.

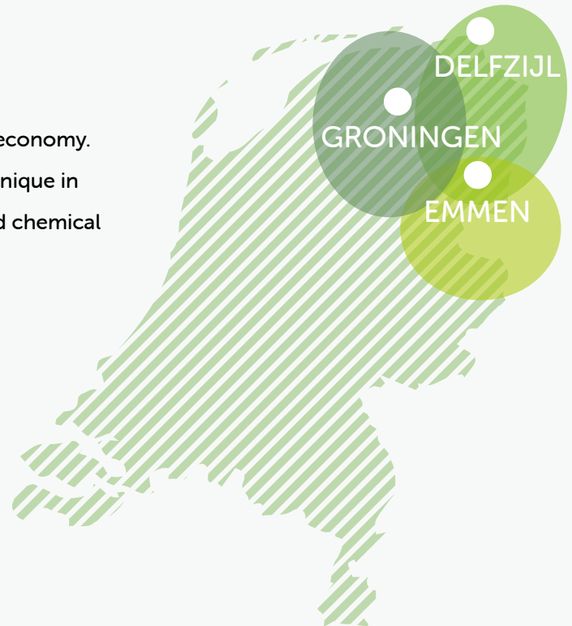
Various routes lead to a greener environment. Feedstock plays an important role in this. The Northern Netherlands has been strong in agriculture for centuries and in chemistry for decades. These two worlds are now becoming more and more intertwined, as crops such as sugar beets, potatoes and also grass and wood are increasingly being used to produce sustainable chemicals. The green growth of companies is central to the ecosystem. Companies can become part of a chain and exchange raw materials with each other.

The region locates two chemical clusters in Delfzijl and in Emmen. The Delfzijl cluster mainly produces intermediate chemicals and building blocks. In. Emmen, the focus is on the production of polymers and fibers. In both clusters an industry was made that gives direction to further innovation and effective cooperation between chain partners for the coming years. With the National Test Center for Circular Plastics in the region, major steps have also been taken in chemical and mechanical recycling of polymers.

green industry of the future

Changing the nature of chemistry

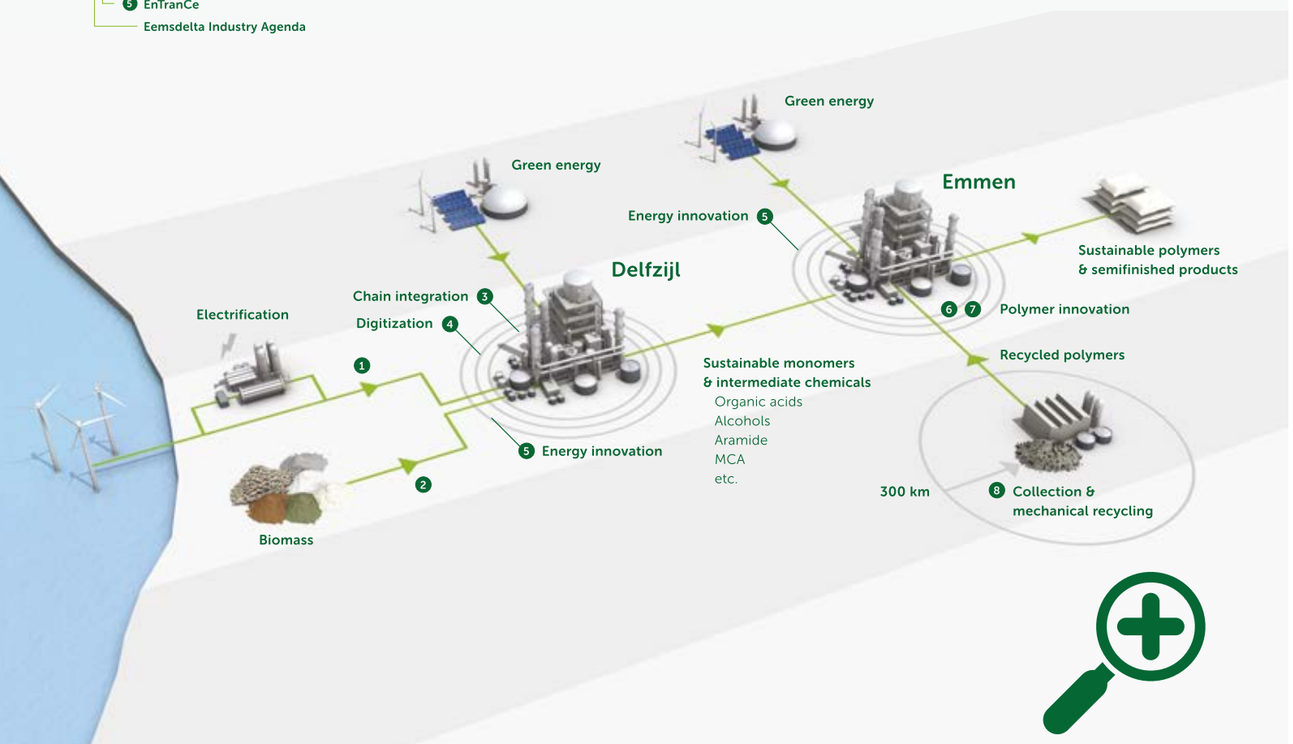
Chemport Europe is moving towards a circular economy. The ecosystem in the Northern Netherlands is unique in the world. There is coherence between R&D and chemical clusters in Delfzijl and Emmen.



Related Research & Development

1. Hydrohub
2. Zernike Advanced Processing (ZAP)
3. Chemport Pilot Centre
4. Smart Industry Hub
5. EnTranCe
6. Sustainable Polymer Innovation Cluster (SPIC)
7. Chemport Industry Campus Emmen (CICE)
8. National Test Centre Circular Polymers (NTCP)

Eemsdelta Industry Agenda



CLOSING THE LOOP

The chemical industry is in need of new green building blocks. These need to be developed in a culture of intensive cooperation between knowledge institutions and industry. There are a number of relevant dedicated institutes and research facilities at Chemport Europe, each with its own strength and focus.

There is more than new building blocks. For new developments and projects, policy is essential. Governments, knowledge institutions and companies work together in a triple helix. The permitting processes for greenfield or brownfield projects operate efficiently and are backed by supporting NGOs. This is a unique form of cooperation that ensures that policies, facilities and financing all focus on successful business operations.

The Northern Netherlands is building an ecosystem that really matters. Not just nationally, but in the European region. Together, all partners are contributing to development circular chains consisting of four components: Feedstock, intermediate chemicals, polymers and materials and recycling. All available in the Northern Netherlands.

That is how Chemport Europe is moving towards a circular economy. The waste streams from one company are the valuable raw materials for another company. Material and energy flows are exchanged where possible.

Together, partners form a coherent production and innovative ecosystem.

"All you need to go green."

2.

CHEMICAL CLUSTER DELFZIJL

Feedstock and Intermediate Chemicals

The chemical cluster Delfzijl mainly produces intermediate chemicals and building blocks. It is at the forefront of the generation of sustainable energy, the useful deployment of industrial waste heat and the application of green raw materials. The chemical cluster of Delfzijl has described concrete steps towards a CO2 neutral cluster.

The agricultural environment, the presence of two ports, the presence of relevant knowledge institutions such as the University of Groningen (RUG), Hanze University of Applied Sciences, NHL Stenden the production and landing of large quantities of (green) electricity and green raw materials, and an integrated chemical cluster provide a favorable starting position.

Companies individually and the cluster as a whole face the task of realizing a transition on 5 fronts: electrification, green raw materials, chain integration, digitization and energy innovation

Related R&D facilities on those several fronts:

Electrification	- 1 mw test center	- TRL 4-7
Biomass	- Zernike advanced processing	- TRL 5-7
Chain integration	- Pilot Center	- TRL 6-8
Digitization	- Smart Industry Hub	- TRL 3-7
Energy innovation	- EnTranCe	- TRL 5-7

Companies on site

- Aldel
- Avantium
- ChemCom Industries
- Contitank Tankstorage
- Delamine
- Delesto (combined heat and power plant (530 MW))
- Dow Benelux
- ESD-SIC
- Evonik
- Gebr. Borg Recycling
- JPB Groep
- Lubrizol Advanced Materials Resin
- NAM
- North Water
- Nouryon
- OCI/Bio MCN
- Photanol
- PPG Industries Chemicals
- SGS
- Siniat
- SkyNRG
- Stork
- Tankcleaning Gebr. Borg
- Teijin Aramid
- Zeolyst

FEEDSTOCK AND INTERMEDIATE CHEMICALS

The chemical industry in the Northern Netherlands runs on salt – a natural resource which is mined and for which there is no truly 'green' alternative. However, in the production train from basic feedstocks to end product, there are many opportunities to turn grey into green.

The production of chlorine from salt is the foundation of many chemical processes. Salt is not a truly green feedstock. Nevertheless, the steam used in the Chemical Cluster Delfzijl chlorine production process is already 70 percent non-fossil, and we are moving towards fully green steam. And you can't have green chemistry without the base chemicals like hydrochloric acid, chlorine and lyme.

It is a three step process towards greener chemistry. First, we need to use green energy for the production of our base chemicals. The second step is to use green hydrogen, both as storage of energy and as a feedstock, for example in production of methanol. The third step is to capture carbon dioxide and use this to make green intermediates.

Biorefineries can produce green intermediates as well. Avantium is working on this in Delfzijl, while a company like Photanol uses bacteria to produce useful chemicals. Avantium can provide a second generation sugars for the chemical industry, which don't interfere with food production, for instance.

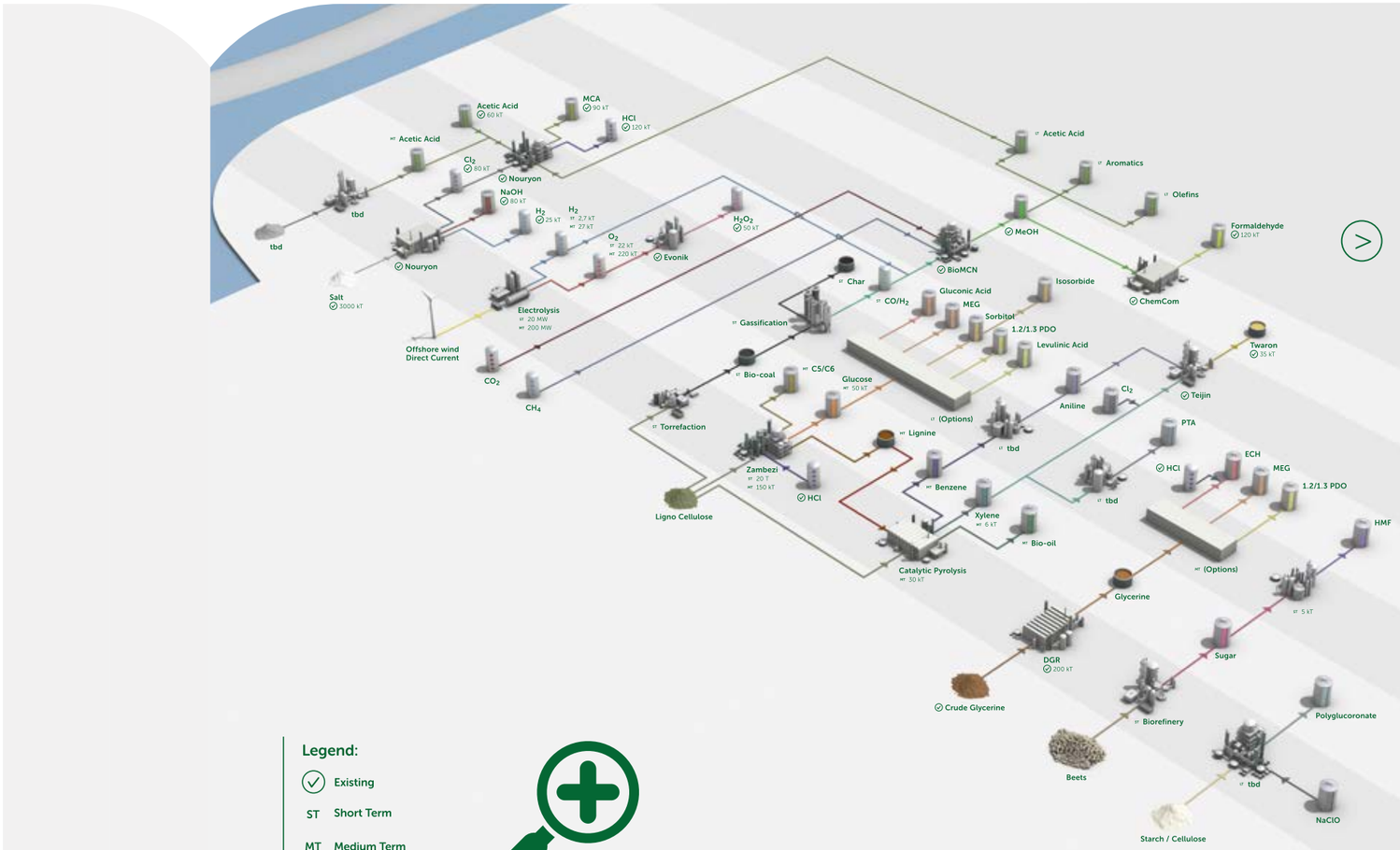
Chemical Cluster Delfzijl

"turning production chains from grey into green"

We are also looking at waste-to-chemicals, turning household waste into useful compounds. Technology is under development and would fit very well in Delfzijl. The challenge is to add as many green alternatives to the production chain.

Chemical compounds with a green alternative

Erik Heeres from the University of Groningen and his brother Andre at the Hanze University of Applied Science have made a list of 28 green chemical products that would fit in Delfzijl. Their list is adopted by all parties in the Chemport Europe ecosystem, and we use it to add ever more green chemicals to our processes.This way, we can plug in ever more green chemicals, turning our production chains from grey into green. >>



Legend:

- ✓ Existing
- ST Short Term
- MT Medium Term
- LT Long Term

New applications for traditional crops

We see new applications for traditional crops, such as sugar beet and potatoes, but also for grass and top timber from the forests. All raw materials for intermediate chemicals. The green transition is a challenge, because without basic chemistry there is no green chemistry. A successful transition to a sustainable chemical sector requires renewable raw materials. Both components are related to the Chemical Cluster of Delfzijl.

Biorefineries can produce green intermediates as well. Photanol uses bacteria to produce useful chemicals, while Avantium is working on this in Delfzijl. They have built a pilot factory to produce so-called second generation sugars for the chemical industry, derived from wood chips and other cuttings form forest management in the Drentse Aa nature reserve. These sugars do not compete with food production. However, for a full scale production facility, additional wood chips and cuttings would have to be imported from nearby regions in a sustainable manner. Plans to realize this are already being developed.

Furthermore, it is possible to convert waste streams, e.g. cellulose from paper or cardboard production, into 'third generation' sugars. This technology is working well in the lab but needs some more research for upscaling to production levels.

Another source for third generation sugars is less obvious: toilet paper, also made of cellulose, could be reclaimed from sewage and converted into sugars that can be used to produce chemicals. Technology to realise this is under development and would fit very well in Delfzijl. The challenge is to keep adding green alternatives to the production chain.

SUGAR BEET	WHEAT	CORN/GREEN FEED	POTATOES	RAPESEED	GRASS
28,000 hectares	117,000 hectares	301,000 hectares	74,000 hectares	14,000 hectares	620,000 hectares

Sources of platform molecules for the chemical industry

sources for the chemical industry

R&D FACILITIES

Feedstock and Intermediate chemicals

In the Northern Netherlands, the necessary ingredients for research and development at the various stages of TRL are all at hand. That is why we are leading in developing green solutions for chemistry.

Biomass

Zernike Advanced Processing Facility (ZAP)

ZAP provides complete facilities for optimizing processes in green chemistry. There is a basic package of equipment and facilities available, but companies are also free to build their own systems inside the Innovation Hall, as BioBTX did. An important benefit is that all permits are arranged. The facility provides companies with around 100m3 of space for pilot-scale testing – scaling up from grams to kilos – of biomass processes that were developed in the lab.

Chain integration

Pilot Plant

To be able to realize innovation and (large-scale) investments in green chemistry, a pilot plant is being set up in the Chemical cluster of Delfzijl. The green chemical processes that will take place there are partly based on biomass. They are circular and provide green building blocks for chemistry and green energy. In this pilot plant, companies can scale up to pre-production scale. The development of knowledge at the Zernike Campus can lead to testing in a test installation. The pilot plant will offer all facilities; cables, pipes for the supply and removal of raw materials and end products. The necessary permits have also been arranged.

Electrification

Hydrohub

The increase in scale in green hydrogen production is of great importance for the the chemical industry. The Hydrohub is an open test center, where partners of the consortium, but also other knowledge institutions and companies, can test innovations from their own lab in electrolysis installations of half a megawatt. When tested on that scale, it becomes clear whether new problems arise and how the technology will behave when scaling up. Once the hydrogen technology in the Hydrohub works properly, it can immediately be converted to an electrolysis plant on an industrial gigawatt scale.

Chemical Cluster Delfzijl

Digitization

Smart Industry Hub

Forces are bundled in the Smart Industry Hub so that the digitization of the economy (Industry 4.0) is accelerated. It is a practical environment in which companies, education and research institutions can experiment with new technologies.

Energy innovation

Entrance

Center of Expertise Energy contributes to the rapid transition to a clean and affordable energy supply. Scientists, students, companies, governments and social institutions share their knowledge in the expertise center. EnTranCe is a public-private partnership that offers room for open knowledge sharing.

BIOMASS
Conversion to pure glucose

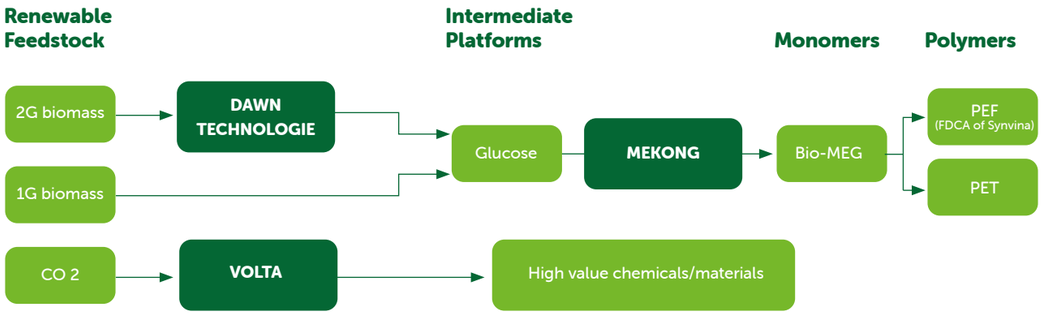
The Dutch company Avantium has a new technology which enables them to convert biomass into pure glucose, and to make ethylene glycol and to produce FCCA – a building block for PEF from fructose. They are also working on the conversion of carbon dioxide into valuable building blocks using electrochemistry.

DAWN Technology
The bio-refinery developed by Avantium is based on technology that is over one hundred years old: the Bergius process to hydrolyze lignocellulose (plant and wood residue) with hydrochloric acid into dissolved carbohydrates. The process was not particularly cost effective however, as it requires large quantities of water to remove the acid – which must then be recovered for re-use.

Avantium developed the so-called DAWN Technology which significantly reduces the water use. Sugars can be separated from the hydrochloric acid without using any water, and lignin is produced using just 20% of the water required in the standard Bergius process. In DAWN Technology, biomass is cascaded into three different streams: mixed sugars from the hemicellulose component in the biomass, glucose from the cellulose component and lignin, which has a very high energy content.

Dawn Technology pilot plant
The new pilot plant in Delfzijl will process 130,000 tons of dry woodchips, and can be expanded to 350,000 tons of dry biomass.

Partners in this plant are chemical company Nouryon, power company RWE and Staatsbosbeheer (the Dutch Forestry Commission)



Mekong
The second new technology is the so-called Mekong process, which produces ethylene glycol. Avantium will build a demonstration plant in Delfzijl for the conversion of glucose into monoethylene glycol (MEG), a building block for polyester production. Conversion of sugar to ethylene glycol now takes four steps, which makes it too costly. The Mekong technology reduces this to one step. The feedstock for Mekong is glucose.

GREEN BUILDING BLOCKS

Developing a biobased version of Twaron®

Twaron aramid fibers® are renowned for their strength, sustainability, safety, heat resistance and low weight and are used in different applications and markets including automotive, ballistic protection, marine, civil engineering, protective clothing, ropes, fiber optic cables and oil & gas.

Teijin Aramid, part of the Japanese Teijin Group and the Dutch BioBTX are working on super-strong synthetic fiber made entirely of sustainable materials.

Teijin Aramid produces super-strong fibers in the Northern Netherlands under the brand name Twaron®. The company manages a production chain in this region. Emmen is home to the world's largest aramid factory. They have three factories in Emmen. A spinning plant, conversion and after-treatment facilities, and an Endumax® plant.

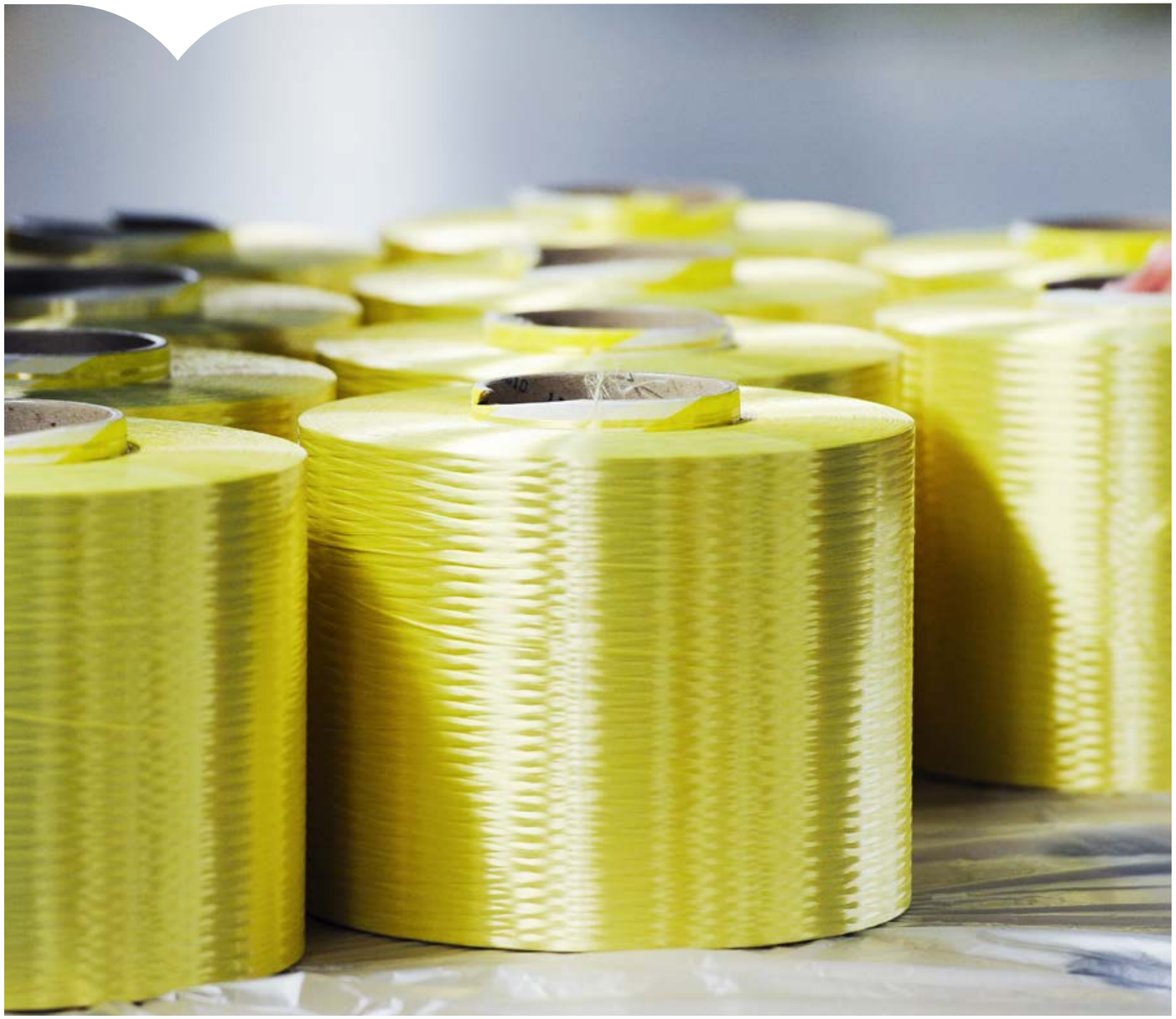
At the spinning plant, they apply an advanced process to create Twaron® yarn. The polymer they make in the factory in Delfzijl is dissolved and spun into Twaron® yarn. Part of the production yield goes to their conversion and after-treatment facilities, where they process it in accordance with the customers' wishes.

Their fibers are used worldwide in products that need to be made stronger, lighter and more durable. For example, in car tires, light freight containers and protective clothing. To produce Twaron®, fossil resources are used for which Teijin Aramid is looking at alternatives. The company wants to examine the possibility of producing a so-called bio-based version of their Twaron®fiber.

BioBTX

To develop a green feedstock, Teijin Aramid works together with the BioBTX company. This company developed a sustainable technology that can transform renewable resources, such as biomass and residual products, into chemical resources, mainly benzene, toluene and xylene (BTX). Using the BioBTX technology, it is possible to produce these so-called aromats in a sustainable manner and, thus, largely reduce CO2 emissions. BioBTX recently opened a pilot plant to produce aromats at the Zernike Campus in Groningen. Based on these aromats, the Syncom chemical company will produce specific building blocks.

It is technically feasible to make bio-based BTX and polyester. Via this path, they are demonstrating that it can also be used as a raw material for high-quality applications that have very strict quality requirements.



GREEN BUILDING BLOCKS

Making biofuel from CO^2

Nowadays, there are even more innovative technologies to extract chemical raw materials from CO^2.

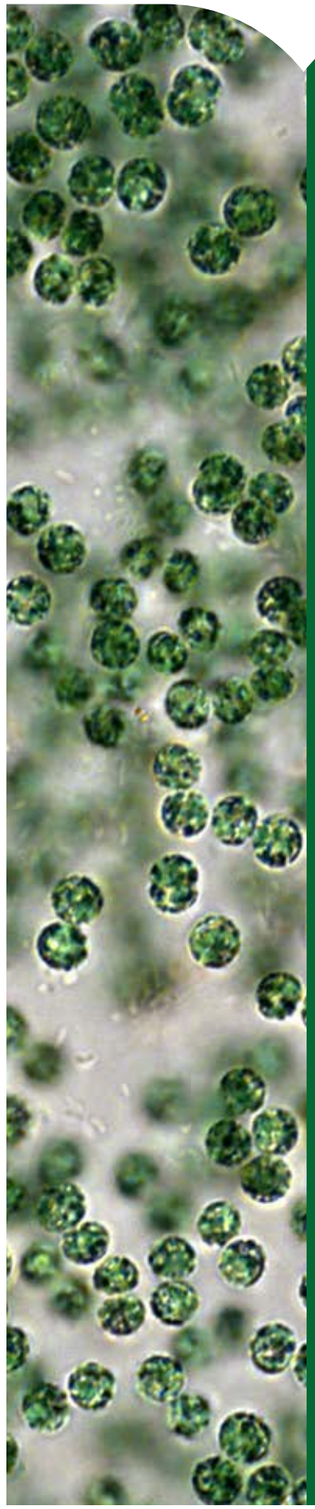
With so-called cyanobacteria, CO2, water and sunlight, Photanol can in principle make all organic building blocks that already exist in nature. Their core business is adding value to CO^2.

It's all about cyanobacteria. These blue algae are photosynthetic, just like plants: they convert CO2 into sugars by using sunlight. Photanol developed a technology that modifies the blue algae so it produces other chemically usable products, such as organic acids: a raw material for bio-plastic and cosmetic. The bacteria can also be used to produce bio-ethanol, an alternative to kerosene.

Photanol is testing the process on a large scale at a pilot plant at Nouryon chemical group's site in Delfzijl. Already, seventeen products can be produced in the lab. Three of them will be tested in the pilot plant. Those products will include organic acids for the production of polymers, for example.

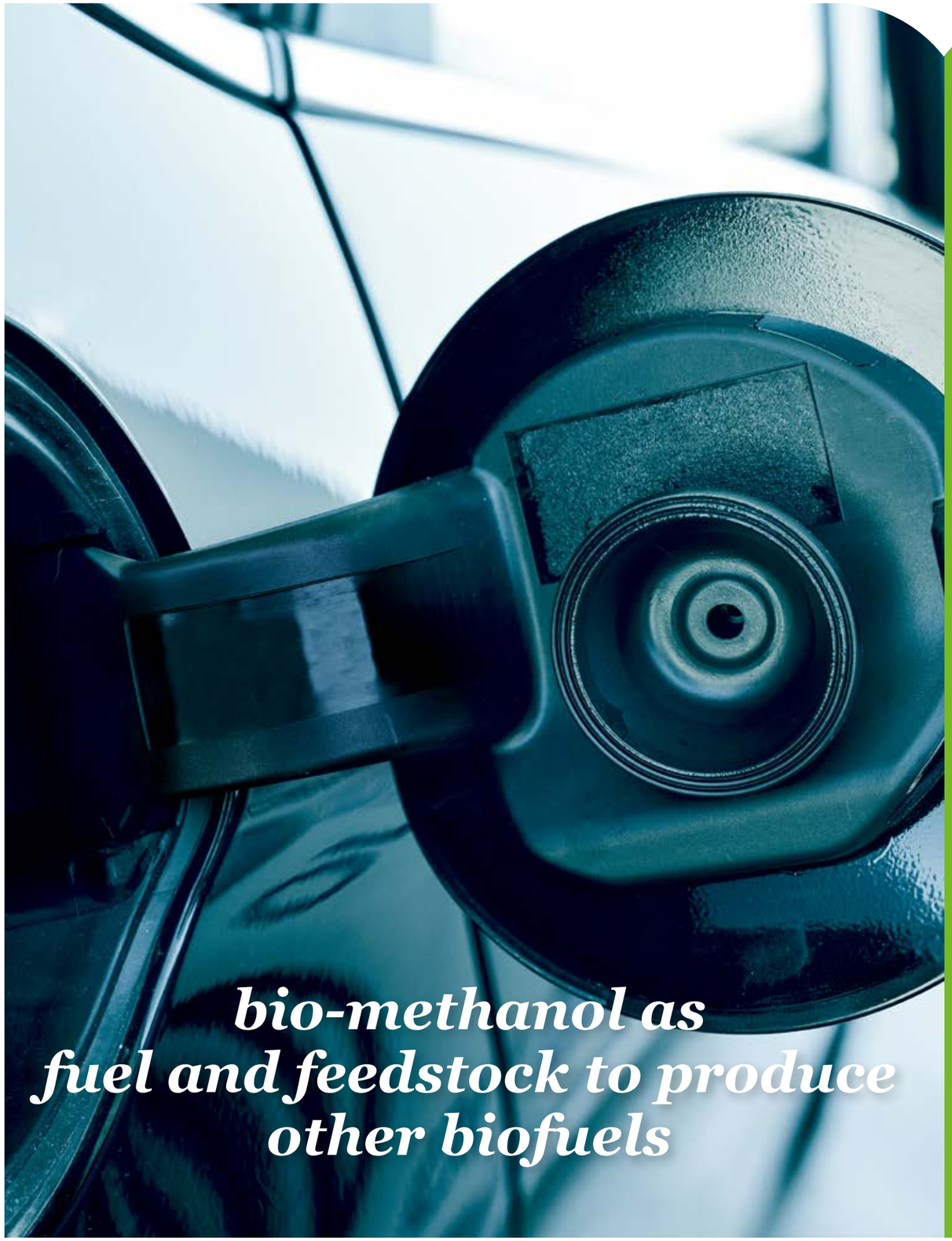
For Nouryon, the technology of both Photanol and Avantium represents an important step in the greening of raw materials. In the future, both partners will produce the same raw materials from renewable sources. That will enable them to turn the production of monochloroacetic acid more green.

The aim is to open a commercial plant in 2022, which will produce between 20 and 30 metric kilotons of acetic acid annually. Products obtained from the pilot plant have been tested by market parties. Possible applications in the field of food, feed, cosmetics, detergents, coatings, oil and gas production, composites and polymers were examined.



"converting carbon dioxide into sugar"

Bio-based chemicals such as cyanobacteria have the potential to emerge as the sustainable production platform for next-generation clean chemicals. They are competitive where feedstock costs are a significant part of the production cost, drastically reducing the need for land and water, and increasing the CO2 capture capacity. Moreover, they do not produce large amounts of waste, and they prevent conversion losses of sugar.



bio-methanol as fuel and feedstock to produce other biofuels

BIO-METHANOL

Industrial quantities with high quality

Methanol can be used in many chemical processes, and is also added to petrol. Methanol is mostly produced from natural gas, but it can also be synthesized from carbon dioxide and hydrogen, for example in power-to-gas systems that convert excess green energy from wind or solar sources. Methanol is used by the chemical industry to produce formaldehyde, dimethylether and even ethylene.

BioMCN in Delfzijl is Europe's largest producer of bio-methanol. This is a second-generation biofuel that is chemically identical to methanol, but is produced using biogas. It is a highly versatile product that can be used both as a fuel and as a feedstock to produce other biofuels.

Bio-methanol can also be used as a chemical building block for a range of future-oriented products, including bio-MTBE, bio-DME, bio-hydrogen and synthetic biofuels (synthetic hydrocarbons). BioMCN uses bio-gas from biomass fermentation for the production of methanol. BioMCN is the first company in the world to produce and sell industrial quantities of high quality bio-methanol.

Green hydrogen plays a significant role in renewable methanol. The Gasuniue New Energy company and Nouryon specialty chemicals are considering building a 20 megawatt plant in Delfzijl to produce hydrogen. If the plan goes ahead, the main customer for this hydrogen will be BioMCN. The plans are part of a much larger package to stimulate the hydrogen industry in the Northern Netherlands.

In order to produce renewable methanol, BioMCN will combine the hydrogen with carbon dioxide produced as a by-product in biogas plants, to produce green methanol.

SYNGAS
Converting low-grade biomass

Syngas (a mixture of carbon monoxide and hydrogen) can be produced from biomass. However, most processes require high quality biomass that could also serve other purposes. Torrgas developed a process to turn organic waste into high quality syngas.

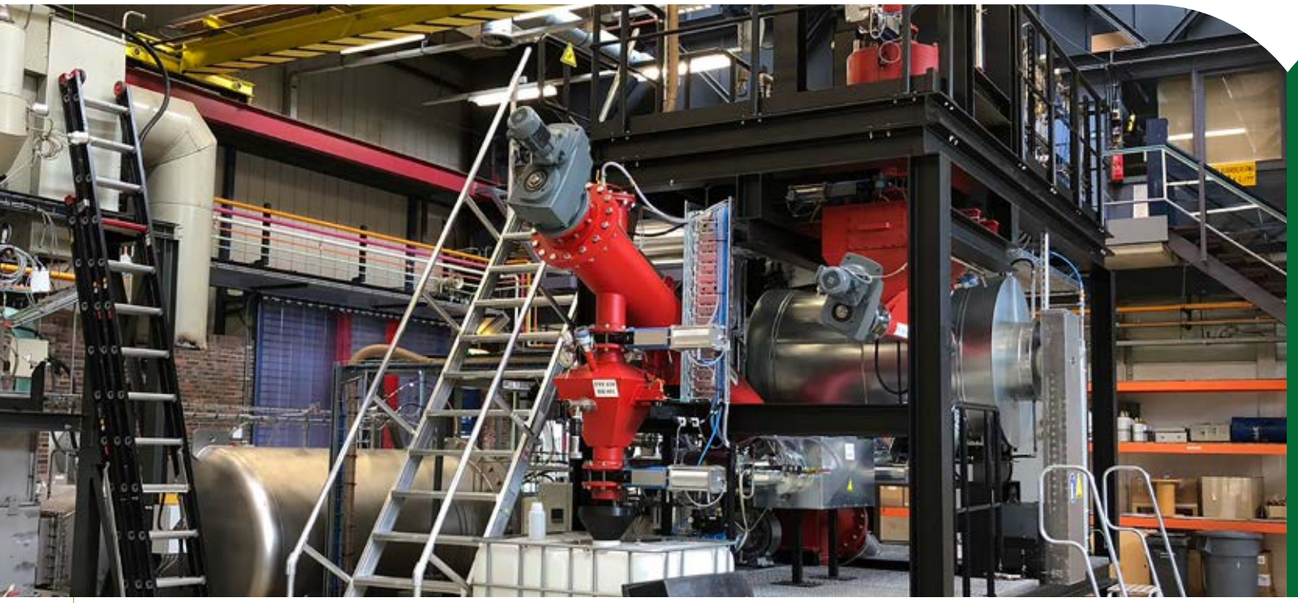
Working on biomass for over 15 years produced a valuable lesson: biomass is far too variable in quality to be used as feedstock in an industrial process. It can be too wet, too dry or too fibrous and can block the equipment. Torrgas learned these lessons the hard way, but also found a solution.

That's why Torrgas developed a pre-treatment called torrefaction. This mild version of pyrolysis removes all moisture from the biomass and then partially cracks the hydrocarbons, removing the low-energy hemicellulose fraction and leaving behind the cellulose and lignin.
This so-called torrefied biomass is then turned into syngas, using a patented two-step process in which the char is removed. Char is a problem in the production of syngas, as it causes sintering inside the plant. By removing it, Torrgas can also sell this engineered carbon in a wide variety of high-end applications, for example for usage in the purification of water or flue gas.

The syngas can be used in different ways: as a feedstock for the chemical industry, e.g. in the synthesis of bio-methanol or acetic acid, as a source of green hydrogen, or the carbon and hydrogen can be recombined into methane. All three solutions could be useful in Delfzijl.
Torrgas is currently running a demonstration plant at DNV-GL in Groningen, which has an input capacity of 1 Megawatt hour. In the near future, this plant will be moved to Delfzijl, to be tested in a production setting which includes users of their end products. In due time, a 25 Megawatt hour facility will be built, producing synthetic natural gas (methane).

It is the conviction of Torrgas that high-quality biomass should not be used to produce syngas. With the application of torrefaction, they can produce a stable and high quality feedstock for the gasification process from low-quality materials like twigs and leaves. A process capable of processing grass or straw is booking progress.

Torrefaction could be done locally, even at the induvidual farm level. The light and energy-dense 'coals' which are produced can then be transported to a central gasification plant. Even rice stalks, which are often burned in the field, could be utilized this way. Calculations show that nature captures enough carbon and hydrogen to substitute substantial quantities of fossil fuels, without competing with food production or endangering nature conservation.



Countless possibilities

- Substitute for Natural Gas
- Bio-based Chemicals
- Hydroformulations
- Biochemical Synthesis
- Activated Carbon Feedstock
- Sulfur free Petcoke
- Metallurgical Coke

3.

CHEMICAL CLUSTER EMMEN

Polymers, materials and recycling

Chemical Cluster Emmen has been working on the high-tech development and production of synthetic materials for many years. Intermediate products, plastics and ingredients are produced on an industrial scale for further processing in the Netherlands and abroad. Companies in the process industry hold a strong international competitive position.

The focus in Emmen is on polymers and fibers, chemicals, recycling & upcycling. This strong focus inspires the entrepreneurs, knowledge institutes and the government in this cluster to excel in green materials, with an emphasis on polymers, fibers and composites for manufacturing, construction and infrastructure.

Emmen is home to an artificial fiber cluster and the largest total processing capacity for recycled polyester in Europe. The largest production facility for super-strong high-tech aramid fibers can also be found in the region. It is the largest chemical park with environment classification 6 (emmtec Industry & Businesspark) in Northern Europe. Companies individually and the cluster as a whole face the task of realizing a transition on several fronts: polymer innovation, energy innovation and recycling.

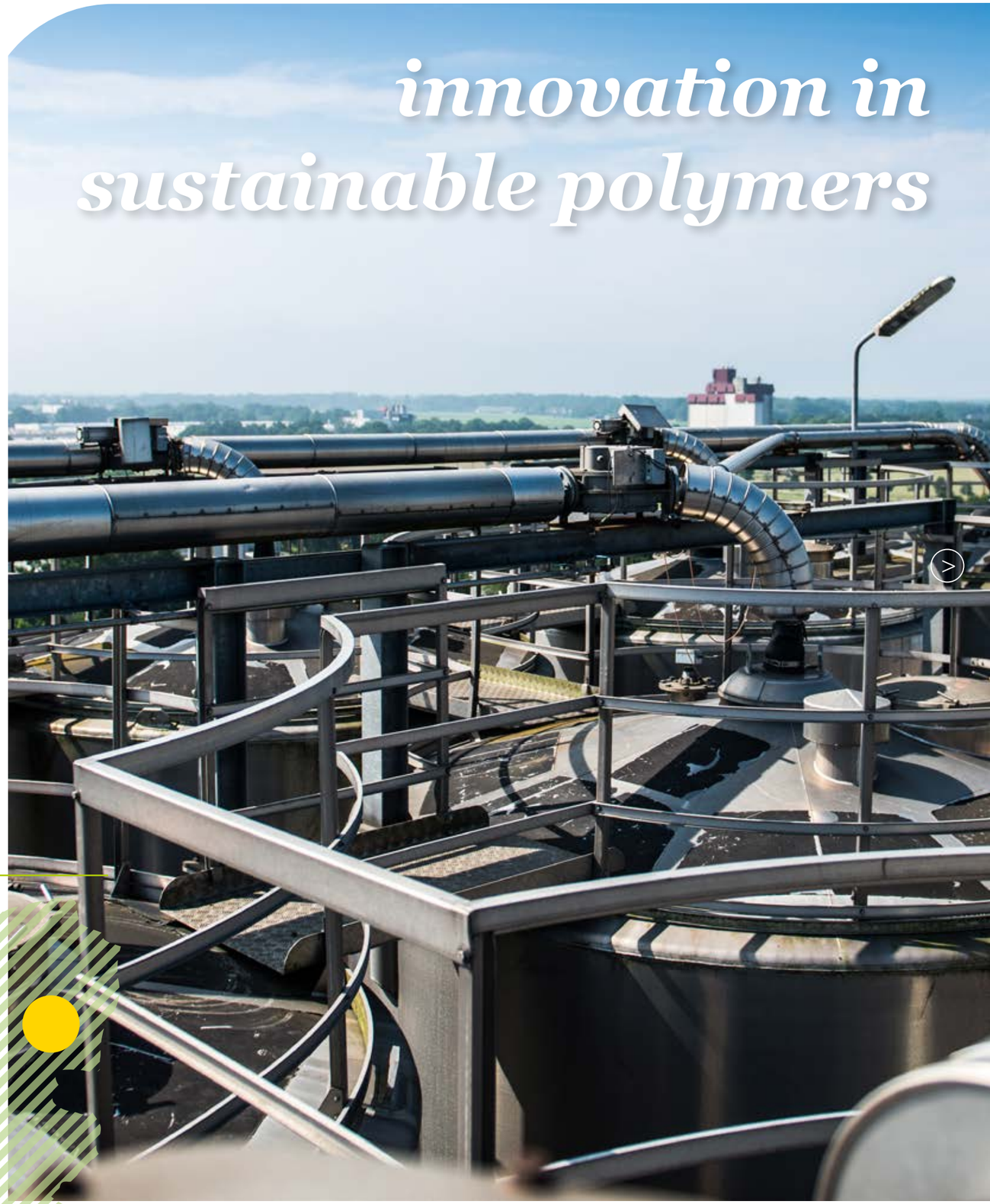
Related R&D facilities on those fronts:

Polymer innovation	- SPIC*	- TRL 5-7
	- Chemport Industry Campus Emmen (CICE)	- TRL -
Recycling	- National Test Centre Circular Plastics	- TRL 6-9

* Sustainable Polymer Innovation Cluster

Companies on / nearby site

- BG&M bouw
- DSM
- Coolrec
- Cumapol Emmen
- DPH (Dutch Polymer Handling)
- Drentea / VDB groep
- Eekels
- EMMTEC services
- Engie
- Fiby (composites)
- H&P Moulding
- Innofil3D (BASF)
- Jellice
- JPB
- Low&Bonar
- Machinefabriek Emmen
- Morssinkhof Plastics
- Morssinkhof Sustainable Products
- N-xt Fertilizers
- Senbis Polymer Innovations
- Stork
- Sunoil
- Teijin Aramid
- Verwater



BIOPOLYMERS

Polymers, materials and recycling

In order to make our plastics truly green, biopolymers are needed. Some, like polylactic acid (PLA) are already on the market, others are still under development. Especially in Emmen, biopolymers are rapidly moving to the market.

The future for sustainable plastics is in bio-based polymers. But the present is in recycling. Recycling will have the biggest impact in the near future. The technology for converting old plastics into new products via mechanical recycling is already well developed, while chemical recycling is developing fast. The next step is to add bio-based components to this process.

Ultimately, plastics should be either fully bio-based or circular. PLA-based plastics are already on the market and the production volume is increasing. These plastics are biodegradable, but only under industrial conditions. Companies like Senbis use PLA in twine, while Innofil3D makes PLA based filaments for 3D printers.

PHA (polyhydroxyalkanoate) is used to make plastics that are fully biodegradable, even in a garden compost heap. However, the development of these plastics lags some fifteen years behind those made of PLA. Overall, it will take some time to develop a larger spectrum of biodegradable polymers. 'The use of these polymers has to grow, and this growth should pick up speed.

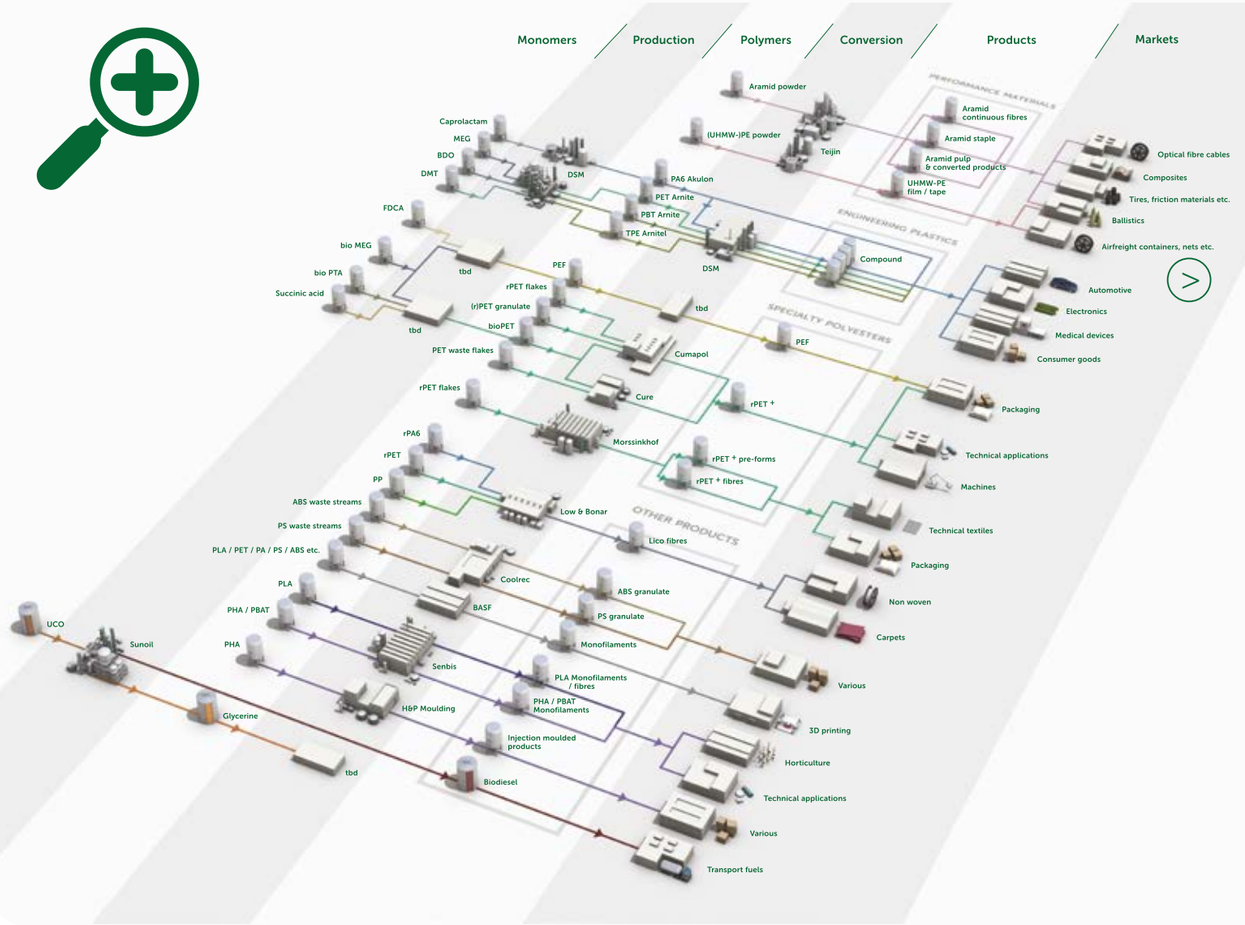
Chemical Cluster Emmen

"in biopolymers, Emmen is a real major league player"

In Chemical Cluster Emmen, quite a bit of research is done on PHA and other biopolymers. What makes Emmen unique is that several companies have found niche markets for which they developed products. Currently, new PHA applications are developed together with the Fraunhofer Institute in Potsdam. A development on the horizon is the development of bio-composites, bioplastics reinforced with e.g. hemp fibres and bio-based resins. In biopolymers, Emmen is a real major league player.

Chain of production in Chemical Cluster Emmen

Monomers, polymers and markets



R&D FACILITIES

Polymers and recycling

Polymer innovation

Sustainable Polymer Innovation Cluster

SPIC-Emmen is an innovation cluster in the Northern Netherlands that offers equipment, facilities and services to the plastic industry. Within the cluster, many key technologies surrounding polymer development and production are available.

Polymer innovation

Green Pac Polymer Application Centre

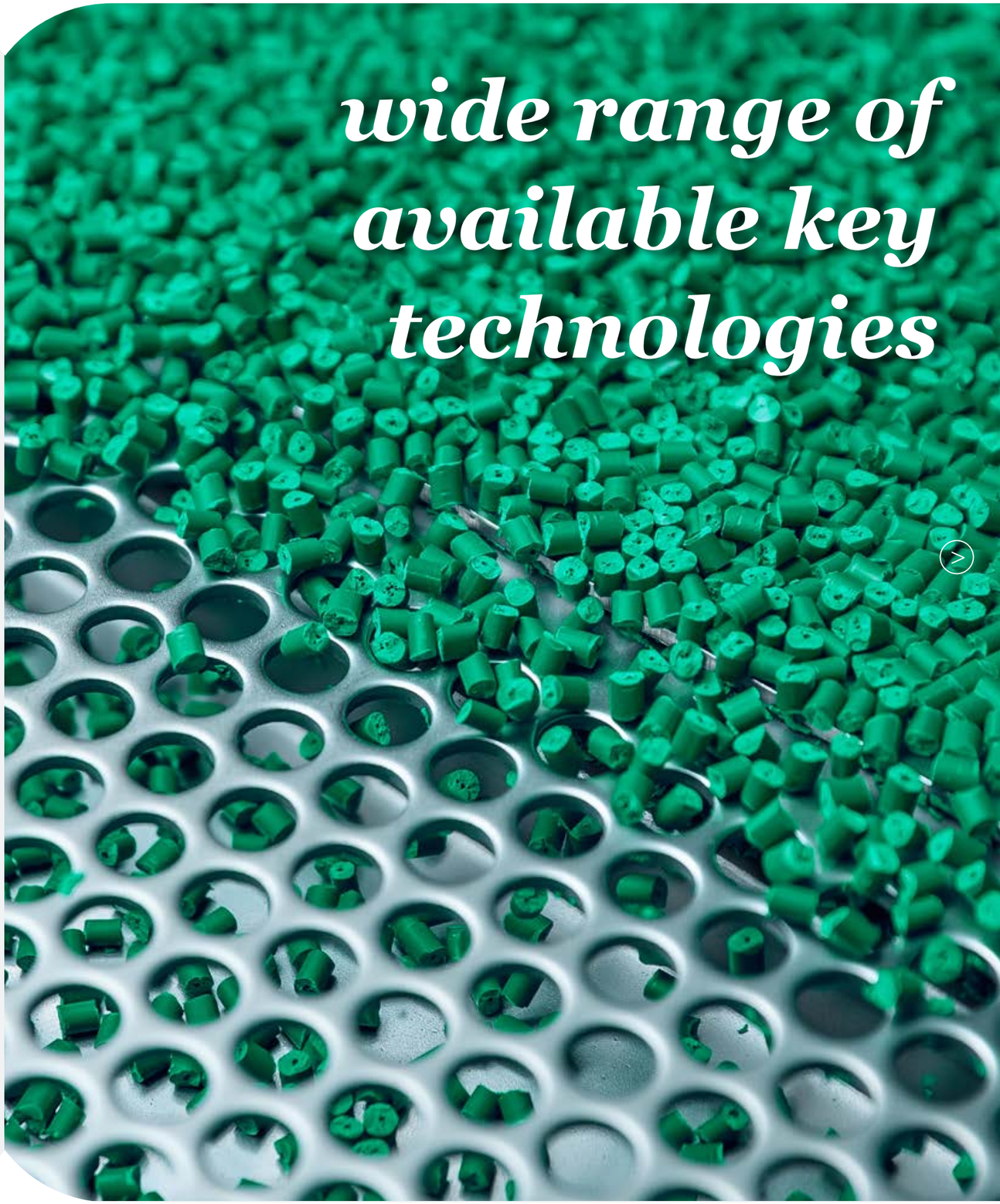
Under the GreenPAC banner, the knowledge institutes NHL Stenden and Windesheim jointly work on (green) plastic-, fiber- and composite applications. Focus is on knowledge development and education. GreenPAC clearly strengthens the innovative power surrounding the polymer industry.

Recycling

National Test Center for Circular Plastics

The NTCP is an independent testing center and is actively working on improving the techniques for sorting and recycling plastic packaging. The focus is mainly on the possibilities for reusing plastics from waste. In this way, the raw materials for plastics remain in circulation. The test center is open to the entire market as an accessible facility, and acts as a catalyst and driver in this.

Chemical Cluster Emmen



GRANULATE FROM PET

Bottles from 100 percent rPET

Morssinkhof turns some 1.5 billion PET bottles per year into new granulate which is mainly used to make new bottles. The recycling company expects to increase their product range made from rPET.

Morssinkhof buys the plastic bottles from all over (Northern) Europe. The bottles are shredded and the PET is regranulated in their factory in Zeewolde. This granulate is then not yet suitable for use in food packaging (like new bottles). That is why the granulate is transported to their plant in Emmen, where the granulate is heated again, in deep vacuum.

After this treatment, the granulate is foodgrade and has the right viscosity for the production of rPET bottles. Brand owners purchase the rPET and use it to make new bottles. Coca Cola company adds rPET to its regular production, Bar le Duc produces bottles which are made from 100 percent rPET from Morssinkhof. In this process, bottles should be clean, preferably collected through the deposit system. They should also be well sorted, as only clear or light blue bottles yield a granulate that can be used for all new clear bottles. Coloured bottles can only be used to make coloured granulates.

However, Morssinkhof strives to create more added value at their plant in Emmen. As the granulate is already warm after treatment, it makes sense to use it to produce preforms, the intermediate product that is later blown into a full-size PET bottle. The Emmen site has injection-moulding machines with a capacity of 6,000 tons per year. Plans are to eventually produce up to 330 million preforms per year. This will make them the first independent preformproducer in the Netherlands. Not all rPET is suitable for food packaging. Therefore, Morssinkhof aims to use the available spinning machines to make rPET yarn. The company is currently working on realizing this. In Europe, some 4 million ton of PET bottles are used, half of which will be recycled. Depending on the quality, these could be used to produce fibers, sheet plastics or bottles. Morssinkhof is ready to increase their use of rPET, and is therefore building silo storage capacity for 5,000 tons of granulate at their location in Emmen.

Bar-le-Duc, bottler of water products, sells its products in bottles that consist of 100% recycled polyethylene terephthalate (r-PET). The bottles are produced with recycled PET granules (MOPET-A) from Morssinkhof-Rymoplast. By applying MOPET-A there is a reduction of 4.3 kg CO2 emissions per kilogram compared to applying 1 kg virgin fossil-based PET.

BIODEGRADABLE PLASTICS

Innovative solutions for various applications

For certain applications, the solution to plastic waste is the use of biodegradable plastics. These plastics should break down in nature. However, polymers tend to respond differently to different natural environments. Even compostable products may break down well on controlled industrial composters, but not on your garden compost heap.

Senbis has recently launched a compostable wine for horticultural use. Senbis Polymer Innovations is specialized in creating innovative solutions with polymers that will break down under various, specific conditions. Using commercially available biopolymers (based on polylactic acid) and their specialized knowledge, they came up with a formula that produced twine which degrades in industrial composters. This is a desirable trait for horticulturalists. It means that at the end of the growing season, their organic waste with the twines used to bind the plants is still industrially compostable organic waste, which costs less to dispose of than non-organic waste.

Another product that is ready for the market is dolly ropes for the fishing industry. Dolly ropes protect nets that are dragged over the seafloor from abrasion and are usually made from polyethylene. These ropes abrade during use, and can come off entirely. This releases large amounts of plastic in the ocean.

Senbis worked out how to make tough ropes from bioplastics that are degradable in a marine environment. They have successfully done some small-scale tests. However, the degradable dolly ropes are more expensive than the standard ropes. And even though the price is a small fraction of the total fishing costs, skippers are reluctant to adopt these more environmentally-friendly dolly ropes. New fishing regulations could make a difference here.

Finally, Senbis is working on a trimmer line used for grass cutting. These plastic lines abrade during use, shedding small flakes. The team managed to create a polymer mixture that is tough enough for use but will degrade in ordinary soil. Turning these polymers into a firm line is a challenge, but they are almost there.

Senbis combines knowledge of (bio)polymers with extensive experience in making plastic fibers. The biopolymers are sourced from the market and are converted in Emmen into the various fiber- and monofilament products. Senbis has pilot facilities for specialty productions but also cooperates with partners like Morssinkhof Plastics to produce large quantities of yarns on their spinning machines. In addition, Senbis is planning new investments in production machinery for polymer compounding and monofilament production, with which it wants to produce more sustainable products.

"the solution for plastic waste"

MONOFLAMENT

Research in 3D printing filaments

Innofil3D, based on the Emmtec Industry & Business park in Emmen, became part of BASF 3D Printing Solutions in 2017. The company is now part of a large family, and that changed the dynamics of our company.

Innofil3D produces filaments for 3D printing, based on a wide range of polymers. As 3D printing is a relatively young technology, printing materials are constantly being improved. For example, there is a lot of research performed on reducing anisotropy in the strength of printed parts. Furthermore, every application has its own demands on the printing material. For a large part, their research and development is application driven.

After the takeover by BASF, the Emmen-based company became part of a global network and gained access to a lot of knowledge and facilities. For example, it can now use BASF's simulation software to predict properties like mechanical strength of a part before printing. All this helps Innofil3D to grow faster. The company is constantly working on extending our portfolio with new materials. And the production is increasing as well. Over the last two years, Innofil3D grew from around 30 to some 40 employees in Emmen.

The regional network is just as important. The company use all the facilities present at Emmtec, like the labs. But they also have students and employees who are trained in the region. For their recycled PET filaments, Morssinkhof in Emmen is the supplier of raw materials.

"leading 3D filament manufacturers in Europe"

RECYCLING ALL KINDS OF PLASTIC

The Northern Netherlands is a hotbed for innovative plastic recycling. There is a great deal of knowledge of and experience with the recycling of plastics, from depolymerisation to design to logistics and handling. We have everything in place to recycle all possible kinds of plastics. This can be done through mechanical, chemical or thermo-chemical recycling.

Mechanical recycling

Mechanical recycling (shredding PET bottles and turning the flakes into granulate) is the easiest way to re-use plastics. But the end product cannot be used in food packaging, unless – as is the case with PET bottles – there is a fully closed system without any contamination. Also, coloured plastics are a problem in mechanical recycling. The pigments stay in the granulate which makes it difficult to use in specific applications.

Chemical recycling

Chemical recycling, breaking polymers into monomers, is a solution to both problems. In Emmen, the companies Cumapol and Morssinkhof developed the CuRe technology a method of chemical recycling which turns coloured polyester into new polymers. Contaminations and unwanted pigments can be separated from the depolymerized plastics, creating virgin building blocks. This way, polyester carpets can yield new polyester fibres. This type of rPET yarn is now being produced in Emmen by polyester company Cumapol together with recycling company Morssinkhof. They can already produce different types of yarn for different products, from carpet fibres to ropes or ratchet straps. Other companies, most of them located in Delfzijl, convert polymers into even more basic building blocks.

Thermo-chemical recycling

Both technologies require a relatively clean stream of used plastics. Mixed plastics are usually burned as waste, generating some electricity. But there is also the option of thermo-chemical recycling. In this process, mixed plastics are heated in the presence of a catalyst, which breaks the polymers down to their basic aromatic building blocks of benzene, toluene and xylene (BTX). BioBTX in Groningen has just opened a pilot plant, creating these aromatics from glycerine. The next step is to use solid plastic waste as feedstock in their process, and turn this into BTX. Like Cumapol, they have developed the conversion process themselves. >>

Other companies, most of them located in Delfzijl, convert polymers into even more basic building blocks. EnerPY produces oil, gas and carbon from organics and plastics, using a microwave-based type of pyrolysis. Torrgas turns materials into syngas (a mixture of hydrogen, carbon monoxide and carbon dioxide). An advantage of these methods is that they can recycle laminated products with plastic foils and paper.

Household waste

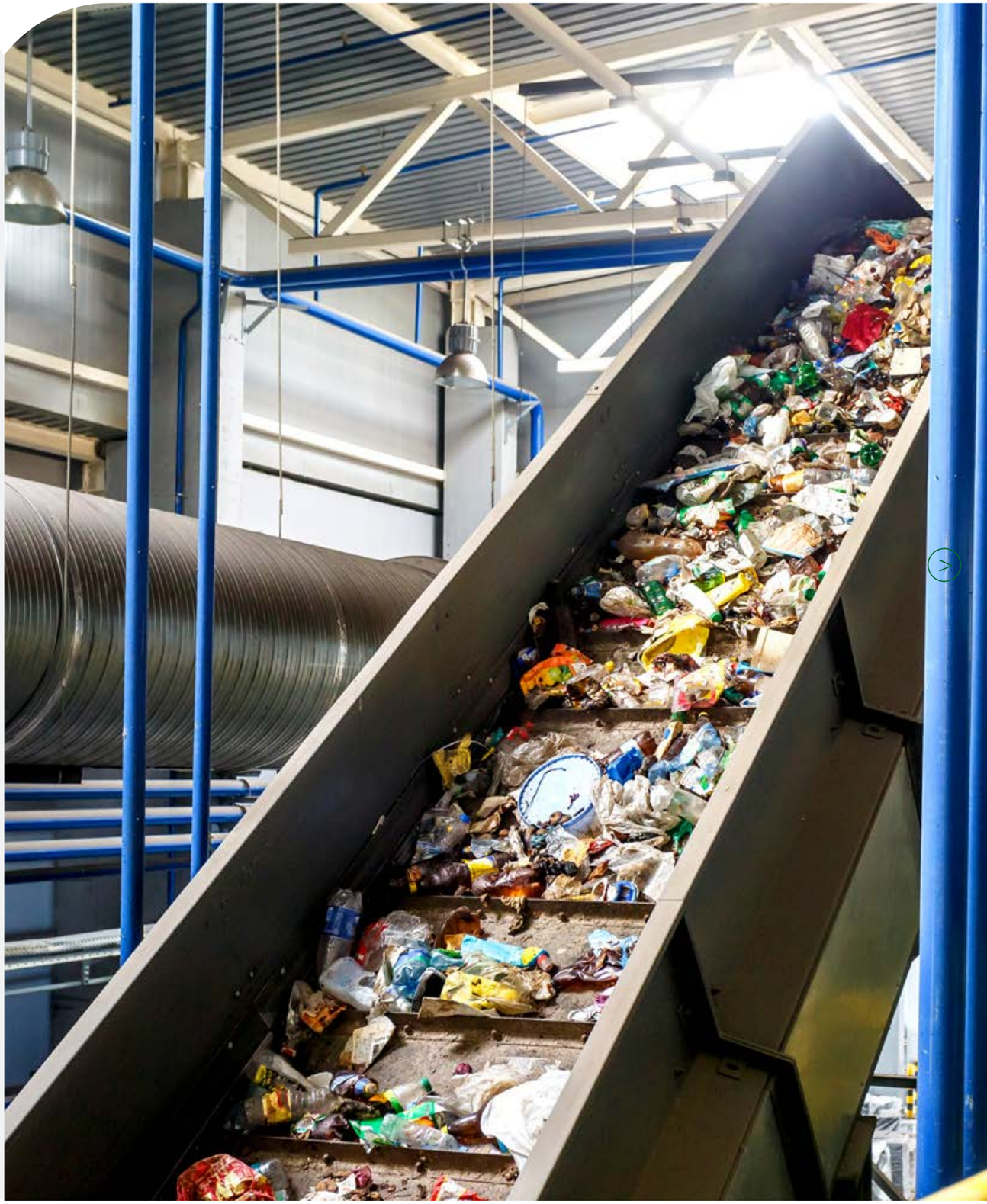
A largely untapped resource is textile. Companies producing sports shirts are interested in recycling. It is possible to convert old polyester shirts into new ones. Getting plastic from household waste is more complicated. The Frysian waste collector Omrin has built a plastic sorting line together with HVC and Midwaste in Heerenveen, where they can separate different types of plastics from household waste. Morssinkhof is adding another recycling line to specifically recycle high-density polyethylene (HDPE) and polypropylene (PP). In Wijster, Drenthe, Attero is also sorting and recycling various plastics form consumer waste.

National Test Center for Circular Plastics

However, much of this recycled plastic is not suited for high-end applications. This is one reason why the packaging industry, the Ministry of Infrastructure and Water Management and other partners have invested in a national test center for circular plastics in Heerenveen. Design of products is very important for consumer products. This will allow producers to test whether their plastic packaging or products can be recycled, in batches up to 100 kilograms.

Within the ecosystem, it is possible to recycle tens of kilotons of plastic per year. The Northern provinces annually produce some 90 kilotons of plastic waste.

Recycled plastics from Heerenveen and Emmen find their way directly to producers like Philips Drachten, but more often to chemical recycling in Delfzijl for basic building blocks or Emmen where monomers are produced. These materials are then used in regular polymer production. Chemport Europe ecosystem has all that, concentrated in a just a few square kilometres at a limited number of locations.



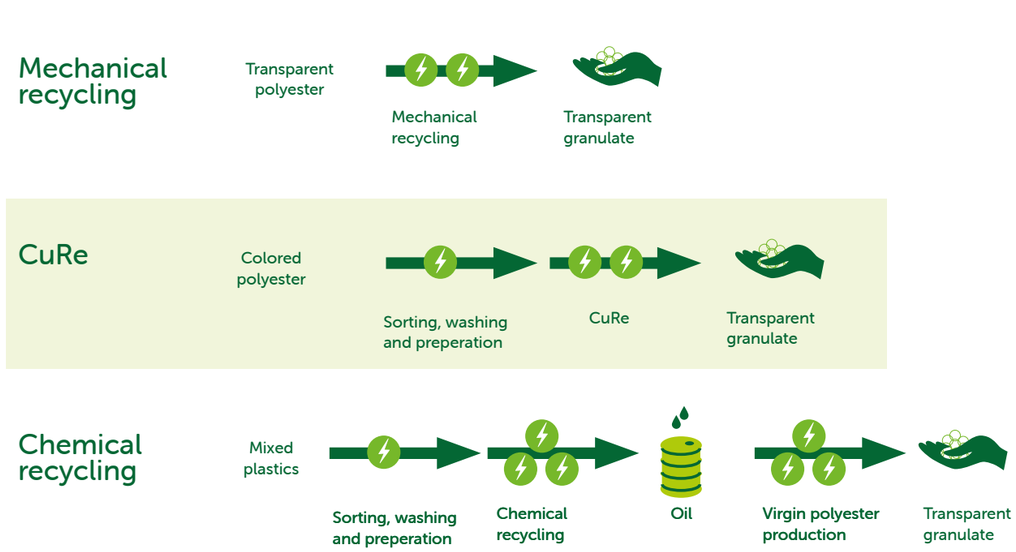
CHEMICAL RECYCLING

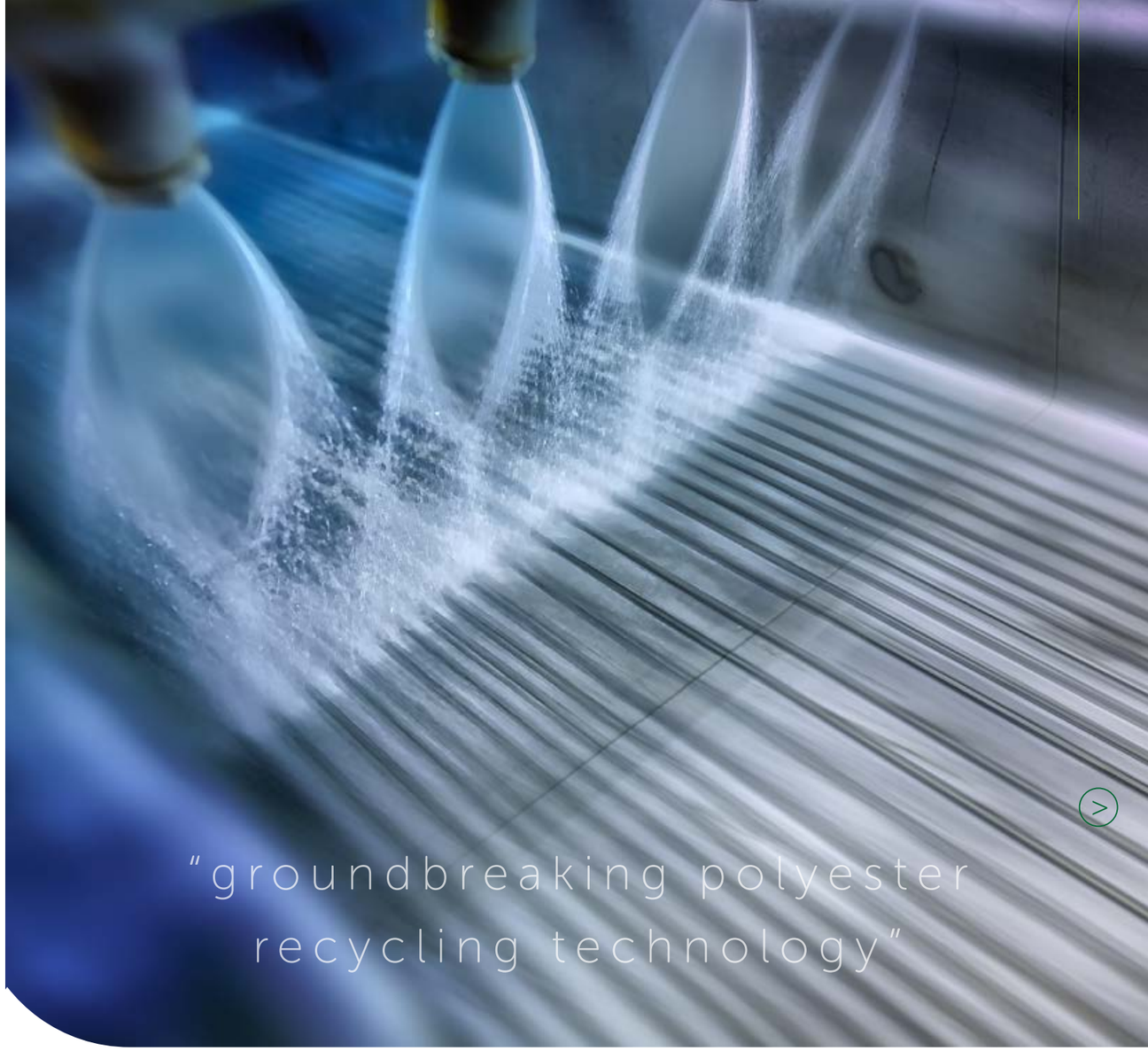
CuRe technology

A promising innovation is chemical recycling of polyester (PET), called CuRe Technology. The goal is to recycle used polyester waste streams in polyester suitable for very demanding applications such as carpets, textiles and food packaging materials.

This technology has been launched by the Cumapol, DSM-Niaga and Morssinkhof companies. This partnership has been kicked off with a pilot plant, to prove the technical and financial sustainability of a new technology for polyester recycling.

Existing polyester recycling techniques require a relatively clean waste stream of clear or light blue polyester bottles. For that reason, colored polyesters or mixed polyesters often lack the economic feasibility for recycling, and therefore end up in incineration. The pilot plant enables a continuous polyester recycling process for post-consumer and post-industry polyester waste streams – including packaging materials and textile products – and removes contaminants and colorings from the original plastic materials.





So far, food packaging recycling has been done mechanically. CuRe Polyester Recycling Technology allows the treatment of any type of used polyester, removing the color and turning it back into clear pellets with the same properties as virgin grade polyester. It is our ambition to purify the polyester waste so that it can be used in any new polyester application, including for food contact.

Realizing low energy recycling of various polyester product waste streams offers great advantages; a large stream of polluted plastics can be kept in the cycle thanks to chemical recycling.

R&D

The chemical recycling of PET plastics was a research project in which the Emmen-based Cumapol company collaborated with three knowledge institutions. These were NHL Stenden University of Applied Sciences and Windesheim University of Applied Sciences, united in Green PAC, and the University of Groningen.

4.

CAMPUS GRONINGEN

Healthy Ageing, Sustainable Society, Energy

The place to be for innovation, research and entrepreneurship. It is the fastest growing Campus in the Netherlands, housing 200 companies, 3 knowledge institutes (University of Groningen, University Medical Center Groningen, Hanze University of Applied Sciences), over 45,000 students and providing more than 20,000 jobs. In addition to the knowledge institutes, the Municipality of Groningen, the WEST Business Association and the Provincial authorities of Groningen are also contributing to Campus Groningen, as a driver of innovation.

At Campus Groningen, they work towards the society of the future by focusing on the societal impact fields of Sustainable Society, Healthy Ageing and Energy (transition). From their broad knowledge base and entrepreneurial attitude, they actively contribute to the needs of society. Giving space to this broad knowledge means that they can make the smart start in Groningen.

Open innovation

The Campus offers a wide range of open innovation (starter and R&D) facilities for various themes to facilitate the network. For example facilities in Energy, Chemistry, Agrifood, Biobased Materials, Pharma and Data. These testing grounds can be used by companies and knowledge institutions alike. Thanks to connections both within and outside the region, new innovations - which originate on Campus Groningen - quickly find their way to the market to create impact from Campus Groningen for the region.

Related R&D Facilities

Energy innovation - EnTranCe	- TRL 5-7
Chemistry Innovation - Innolab Chemistry	- TRL 2/3 – 6
Biomass - Zernike Advanced Processing	- TRL 5-7
Nanotechnological innovation - NanoLab	- TRL 2 – 4
Hydrogen Innovation - Hydrohub	- TRL 3 – 6

Companies on site

- Avebe
- Axon Medchem
- Bebr
- BioBTX
- CLiQ SwissTech
- Charles River
- EV Biotech
- Innocore Pharmaceuticals
- IMEnz Bionengineering
- Mercachem-Syncom
- Ofichem
- PolyVation
- Polyganics
- Photanol
- SG Papertronics
- TBCertain

INNOVATION ON EACH LEVEL

The transition to sustainable green chemistry requires a culture of intensive cooperation between knowledge institutions and industry. There are a number of relevant dedicated institutes and research facilities in the Northern Netherlands, each with its own strength and focus. The key lies in two secrets: open innovation and collaboration. There is a vibrant breeding ground for innovations and high-tech solutions like the start of Innolab formula. This lab was initiated by Nobel laureate Prof. Dr. Ben Feringa.

Chemport Industry Campus Emmen

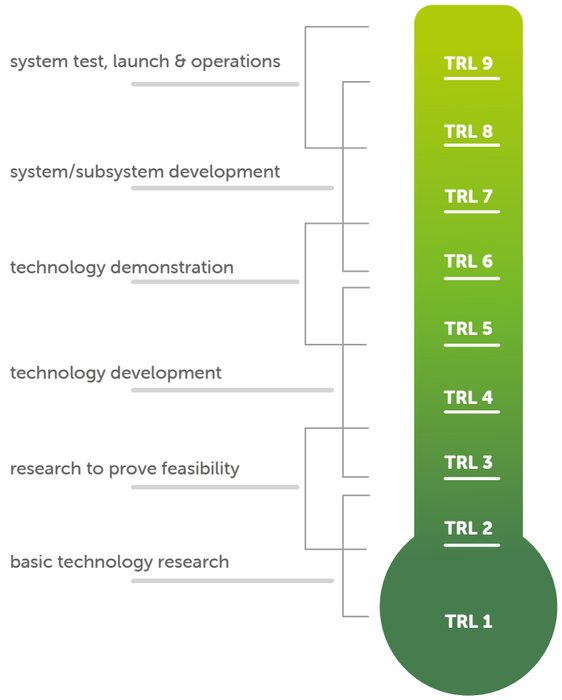
In our region concrete steps are currently being taken to arrive at a visible and inviting open innovation in the field of green plastics. This location, named Chemport Industry Campus Emmen, will allow the business community and jobs in the green chemistry sector of the cluster to continue to grow and flourish. It will do so making use of the current ecosystem and expertise of companies established at or nearby the Emmtec Industry & Business Park. The campus will be oriented towards further knowledge development of polymers, the effective growth of a number of related companies, attraction of talent and personnel, future-proofing of the current complement of personnel and a joint positioning and branding in order to further develop Chemical Cluster Emmen into a European player in the field of green plastics.

"We have the facilities, from idea to product"

FROM LAB TO INDUSTRY

The Northern Netherlands has quickly become an exceptional ecosystem for fast-growing start-ups and innovations. For a few years now, Groningen has been ranked second as the fastest growing, successful start-up city in the Netherlands in the Deloitte 50 ranking.

Many technologies for extracting raw materials have already been tried and tested. But the biggest challenge is to scale up the technology. A desirable chemical reaction in a test tube is not easy to reproduce on an industrial scale in new technology. Students from the Hanze and the University of Groningen are also working on research upscaling processes there. Fundamental research is mainly carried out at the University of Groningen (TRL 1 and 2). This concerns experiments on a very small scale, working with milligrams. The Hanze University works at TRL 3 and 4, which is more applied research. In order to also serve the higher levels, the Zernike Advanced Processing facility (ZAP) has been established in Groningen. Real kilograms can be produced there, i.e. TRL 4 and 5. The next step will be the pilot center in Chemical Cluster Delfzijl, designed to provide a bridge via TRL 6, 7 and 8. Once that has been achieved, we will have a train in the Northern Netherlands, from the lab to industry.



Our business contacts help the ecosystem with the process of greening and they facilitate companies that want to scale up or establish themselves here.

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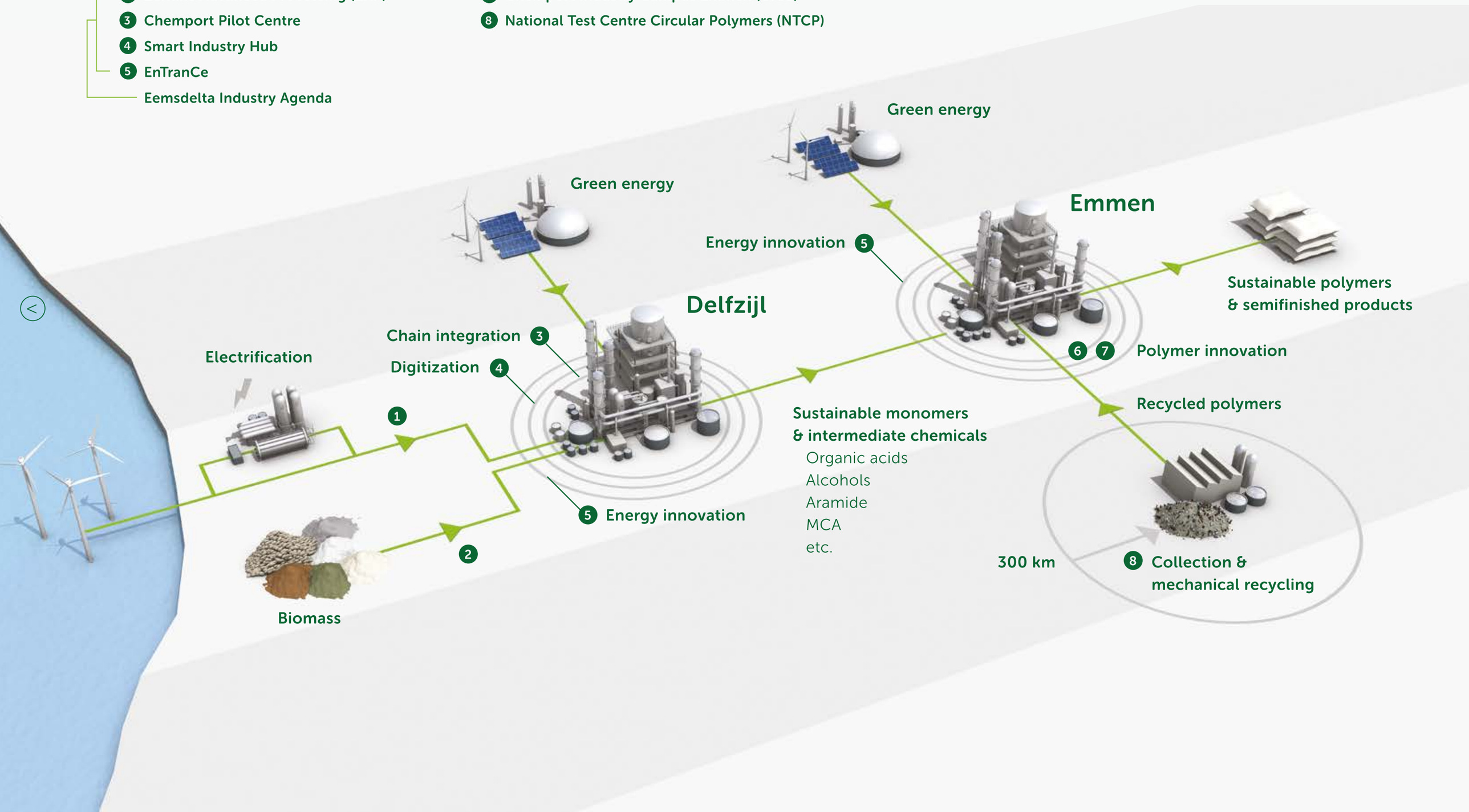
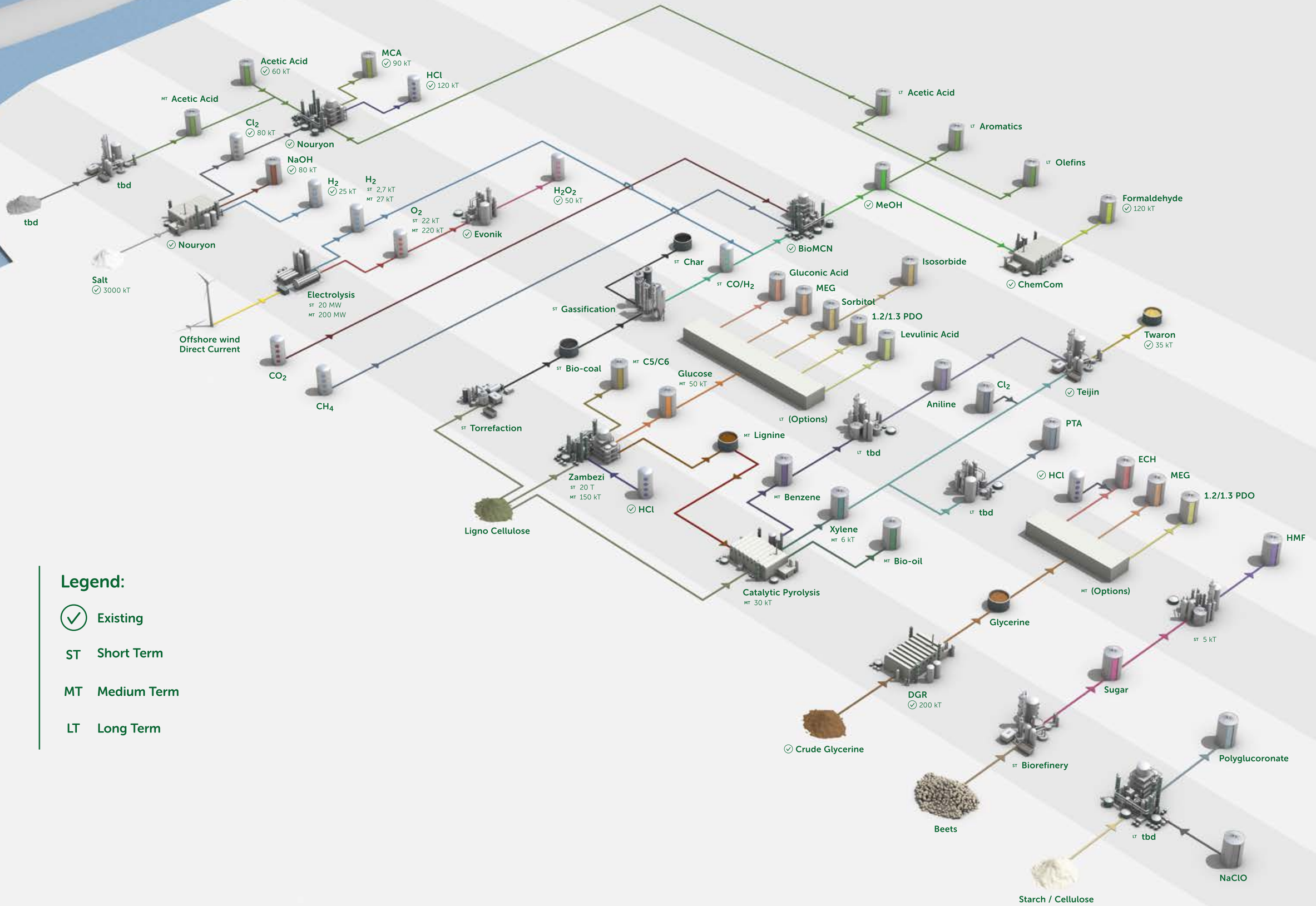
Related Research & Development

1. Hydrohub
2. Zernike Advanced Processing (ZAP)
3. Chemport Pilot Centre
4. Smart Industry Hub
5. EnTranCe

Eemsdelta Industry Agenda

6. Sustainable Polymer Innovation Cluster (SPIC)
7. Chemport Industry Campus Emmen (CICE)
8. National Test Centre Circular Polymers (NTCP)





Legend:

- ✓ Existing
- ST Short Term
- MT Medium Term
- LT Long Term

Chain of production in Chemical Cluster Emmen

Monomers, polymers and markets