TOP DUTCH

A good place to be great

10 WAYS OF CUTTING CO_2 EMISSIONS

How TopDutch will become fossil free and CO_2 negative by 2050

All industrial countries need to reduce CO_2 emissions. That great ambition calls for a pioneering trendsetter. The TopDutch region - with its chemical cluster Chemport Europe - is taking the lead. Chemport Europe seeks to become the first CO_2 negative chemical cluster in the world. Here, in the TopDutch region, entrepreneurs are already building their sustainable ambitions.

BECOMING THE FIRST CO_2 NEGATIVE CHEMICAL CLUSTER IN THE WORLD

Climate change: a ‘hot’ topic

We’ve been living with an inexorable deadline for a while now: the earth must not warm up by more than two degrees Celsius. International scientists from the Intergovernmental Panel on Climate Change (IPCC) - a United Nations organization - predict doom scenarios if that will happen. In one of these scenarios Greenland's ice cap melts, resulting in millions suffering from water shortages. As well, the world’s food production will decline tremendously. The only way for us to still possibly avoid this disaster, is if we reduce our greenhouse gas emissions.

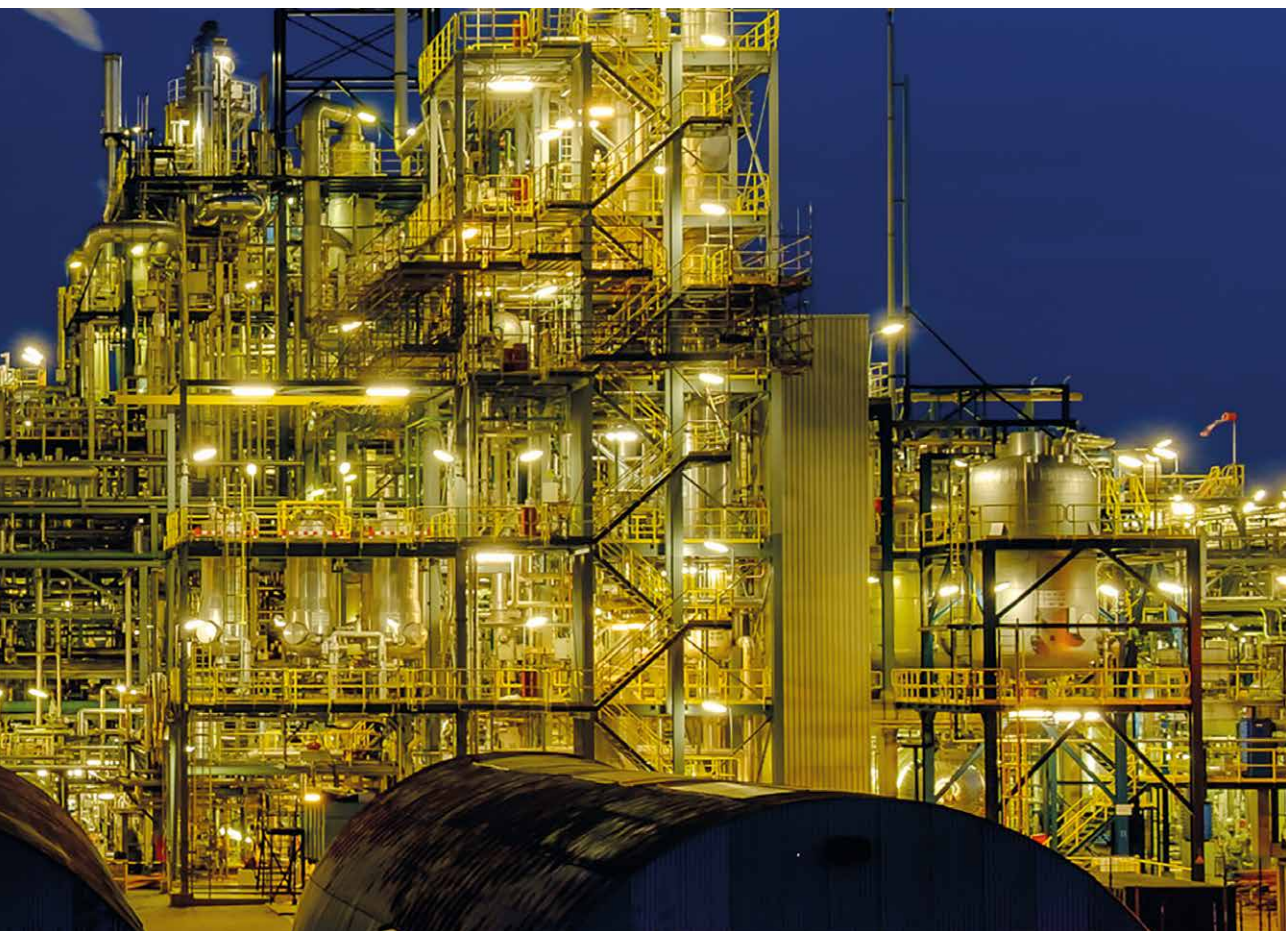
Feeling the urgency

Large quantities of greenhouse gas emissions cause global warming. Since the industrial era, emissions from factories, cars, trucks, and also cattle breeding, have greatly increased. Substances such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2) is the main culprit and

accounts for 85%. Which is why CO_2 emissions are the main focus of attention. The sense of urgency is felt worldwide. In 2015, 195 countries, including the Netherlands, signed the Paris Climate Agreement: CO_2 emissions must be reduced by 49% in 2030, and 80-95% by 2050. China, India, and Western Europe are on track to meet these targets.

Energy-intensive industry

Chemical companies are large energy consumers. The Dutch chemical industry uses over half of the energy needed in all Dutch industry. In particular, heating in chemical processes requires a lot of energy. So, fossil fuels are not only used as raw material for chemical products; they are also used in the process to produce them. Double trouble. However, there are great opportunities for greening the chemical sector. In the TopDutch region, we are leading the way.

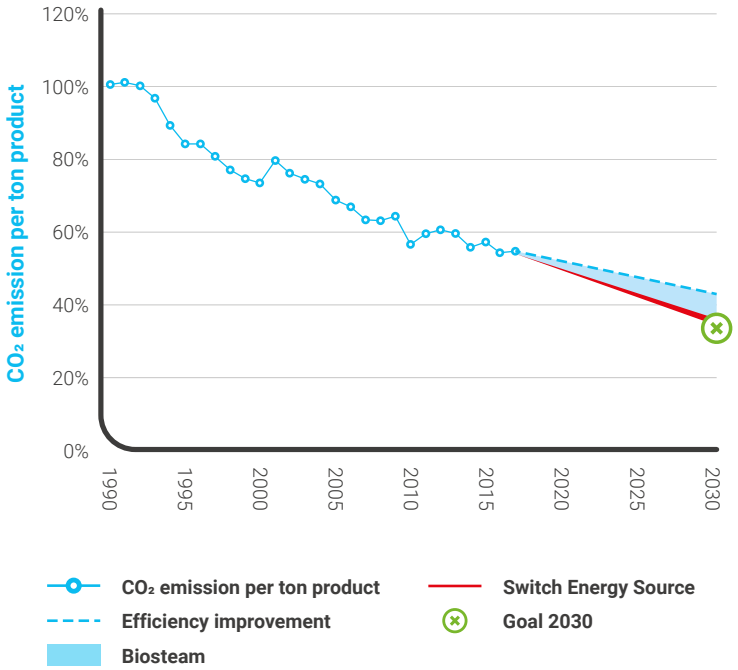


1.

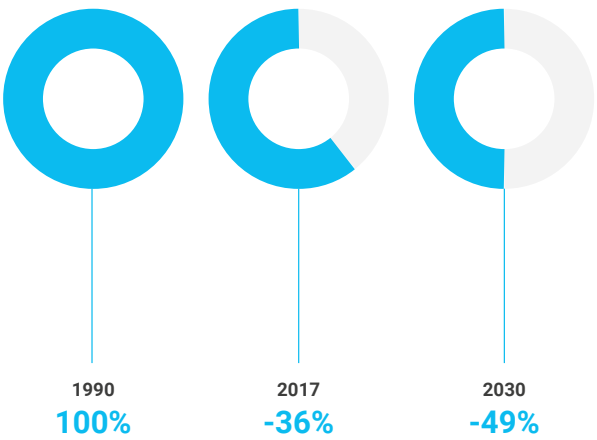
THE TOPDUTCH REGION: A SHOWCASE

The TopDutch region is at the forefront of the sustainability process: a showcase for the Netherlands and the rest of the world. Its chemical cluster, Chemport Europe, has the ambition to become the world's first CO_2 negative chemical cluster. The cluster covers the entire chain: there is a stable supply of biomass - potatoes, corn, sugar beet, and wood residues - a growing supply of wind energy, and a lot of economic activity. In Delfzijl, one of Chemport's two locations, production focuses on energy, plastics, chemistry, metal, and residues. In Emmen, the second location, companies specialize in manufacturing high-quality yarns, fibers, high-tech systems, chemicals, polymers, and biofuels.

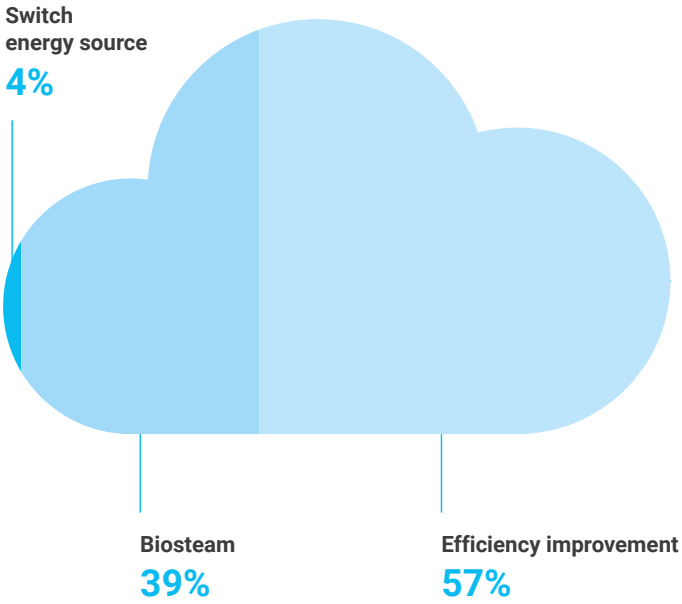
Chemport Europe 2017-2030 Efficient growth with new energy sources



Absolute CO_2-reduction compared to 1990



Contribution to CO_2 saving 2030



Chemport Europe has already been working on reducing greenhouse gas emissions for several years. CO_2 emissions fell from 2.5 Mton to 1.6 Mton between 1990 and 2017. That's 36%. And let's not forget that the production of Chemport's companies increased by more than 17% over the same period. The conclusion: the TopDutch region managed to reduce CO_2 emissions by 45% by growing smartly and efficiently. However, this only concerns the industrial companies. The energy companies are not included.

2.

FROM EMISSION TO A MISSION

Chemport Europe is convinced that the region will succeed in emitting 49 percent less CO_2 in 2030, compared to 1990. The region sets the bar even higher for 2050: the companies in the cluster believe that they can jointly achieve negative CO_2 emissions by then. In 2017, the region presented the Eemsdelta Industry Agenda. It shows the route to a CO_2 negative economy in the North of the Netherlands.

Both individual companies and the cluster as a whole need to achieve a transition on each of the following: energy innovation, electrification, green raw materials, chain integration, and digitization. In order to achieve this, Chemport Europe can also count on the support of renowned knowledge institutions and a helpful government. This has appeared to be a strong pull factor: multinationals and startups that share the ambition to make the chemical industry clean and green establish their businesses in the region due to the strong support system. Chemical, energy, and technology companies have already started to make their operations more sustainable. Here's the ten ways in which Chemport Europe and the TopDutch region will transform even further into a clean, green chemical sector.

1. Optimizing energy efficiency

In recent years, companies at Chemport Europe took a critical look at their energy consumption. The business cluster expects - based in part on studies - that efficiency improvements can lead to a 20% reduction in CO_2 emissions in the coming years. However, the future will call for innovative, costly investments - the relatively simple savings have already been made. Teijin Aramid has ambitious goals. The company, part of the Japanese chemical group Teijin, produces semi-finished products in Delfzijl, which are processed into Twaron (a synthetic fiber) in Emmen. Since 2009, its mission has been to reduce its ecological footprint. “The goal is to achieve an average annual energy saving of 2%,” says Marjan Kamer, Eco-Efficiency Specialist at Teijin Aramid. So far, the company has succeeded. Besides having a strong focus on efficient processes - reuse of heat flows and recycling waste flows - Teijin Aramid invests in innovative installations. “To give an example: recently, a new reactor technology was introduced that ensures more efficient production with less energy.” According to the Eco-Efficiency Specialist, Kamer, Teijin Aramid Delfzijl is well on track to achieving its targets for 2030.

Chemical company Nouryon is also conscious of its use of energy. “That realization has grown, particularly since 2008, due to the high gas price at the time,” says Johan Visser, Site Manager at Nouryon's Chemiepark in Delfzijl.

“Anyone visiting our site is astonished that we don't produce any waste and that they don't see or smell any polluting smoke. We have already been able to significantly reduce our CO_2 emissions. Partly through investments in clean technologies, we’ve reduced energy consumption by more than 40% per ton of product since 1990.”

2. Exchanging residual heat

Chemical processes require a lot of heat, which traditionally comes from natural gas. For a long time, chemical companies discharged their residual heat into the air, or into surface water. In recent years, there has been a growing understanding that exchanging residual heat results in savings. In the TopDutch region, saving energy does not stop at the gates of individual companies. At the two Chemport locations, many pipelines were laid that supply heat to 'neighbors'. Take the Nouryon Chemical Group. Annually, the company produces around 2.7 million metric tons of salt in Delfzijl. Mainly for chlorine production, which also takes place in Delfzijl. Both activities require a lot of electricity and heat. The chemical company produced most of it with its own, smaller, gas-fired power stations.

But the company found alternative sources of heat in the form of its neighbors. Nouryon has been drawing steam from waste processor EEW since 2013. Since 2017, Nouryon has also been using steam released at the biomass plant at the Eneco energy company. A 2.7 km long pipeline was laid for this purpose. In Delfzijl, Nouryon turned 10% of its energy consumption green with the new steam supply - saving more than 100,000 metric tons of CO_2 from being emitted each year. This corresponds to the CO_2 emissions of 12,500 households. The pipeline is the start of a local steam network, to which more companies will connect. According to the Director of the Nouryon plant, 70% of the steam is no longer produced by fossil fuels, thanks to the use of residual heat from surrounding companies. "We still have one gas-fired steam installation that supplies heat. This modern and relatively clean gas-fired power station will continue to operate until 2030. But ultimately, we want to move away from fossil fuels. This is also what the government wants us to do," says Visser.

A common practice at Chemport Europe: exchanging residual heat among neighboring companies via biosteam pipelines (photo: Nouryon Chemical Group, Delfzijl)

3. Switching from coal to biomass

With a CO_2 emission of 8 Mton, RWE's coal-fired power station is the biggest polluter in the Netherlands. But that's set to change. In the coming years, the energy company will gradually transform the polluting coal-fired power station into a biomass power station. By mid-2019, 15% of the energy supply will come from wood residues from the Baltic States. According to Marinus Tabak, Plant Manager at the RWE plant in Delfzijl, this in itself represents a CO_2 reduction of 1.3 Mton. "In 2021, 30% of the power station's output will be biomass. In 2025, we'll be running entirely on biomass," says Tabak. RWE invested tens of millions of euros into the modern multi-fuel power station for biomass co-firing.

"There was no need for a new installation, but it did require adjustments," says Plant Manager Tabak. "Burning biomass is technically quite complex. However, we already gained a lot of knowledge thanks to our Amer power station in the center of the Netherlands that runs on 80% biomass." Investments were made primarily in logistics. "Coal can be placed in the field and can get wet. Biomass must be stored in a dry place. Therefore, silos have been built. Biomass is also a much more critical material - it burns differently, grinds differently, and other substances are released when burned."

The government has agreed to subsidize biomass for the next eight years. “We will use that time to make the process cheaper, because energy from biomass is still expensive. We're therefore looking for partners who are also interested in wood waste as a raw material. 800,000 metric tons of residual wood will be coming this way each year.” RWE already found a partner in Avantium, which uses biorefinery to extract valuable substances from the wood before it is burned. The burning of biomass is sometimes criticized as being at the expense of forestry. “But it is certified waste wood, or waste,” refutes Plant Manager Tabak. “Also, a low CO_2 society is only possible by using various routes, i.e. wind and solar energy, as well as biomass.”

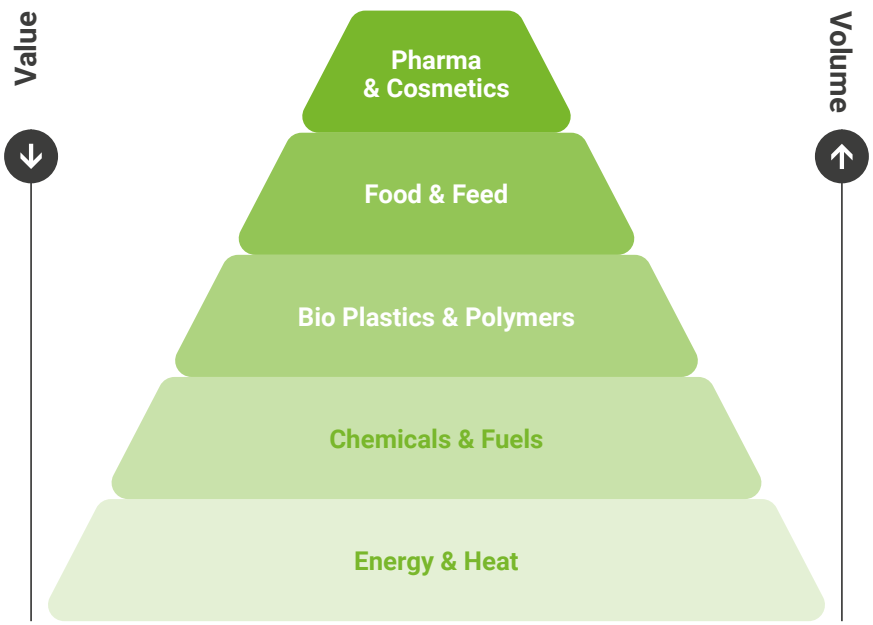
4. Biorefining green raw materials from biomass

Burning biomass may produce green energy, but further from that, it has relatively little added value. It is, therefore, not seen as the highest achievable goal. An important link is the integration of biorefinery processes between the biomass power and the power plants, where preliminary sorting takes place.

And that is exactly what technology company Avantium has been proving in their pilot plant for the past year. Wood residues from nearby Dutch and German forests are separated into three streams for high-grade applications. One third of this biorefinery process' outcome consists of pure glucose, which can serve as a raw material for chemical, pharmaceutical, and food industries. Another third of the yield consists of sugars with various applications, including organic acids and ethanol. The last part is lignin, which is considered an efficient fuel and a good alternative to coal in bio-energy plants.

"The biorefinery process is carried out by hydrolysis, which distinguishes it from existing technologies" says Ronnie Pals, Avantium's Pilot Plant Manager. 'Energy consumption is low: the process runs at room temperature and therefore calls for relatively little heat. The wood residues are dissolved in hydrochloric acid, of which we recycle 99 percent.' The Plant Manager says he regularly receives foreign companies interested in the technology to valorize their own residual flows. The next step is the construction of a commercial plant for large-scale production of industrial sugars from wood residues. Construction is expected to start in 2022 or 2023, and the expected production capacity is 135,000 metric tons of biomass a year.

Value chain biomass



'The arrival of the biorefinery is a tremendous breakthrough for the chemical cluster, because it brings a large stream of green chemical raw materials onto the market.'

Johan Visser, site manager Nouryon Delfzijl

"The arrival of the biorefinery is a tremendous breakthrough for the chemical cluster, because it brings a large stream of green chemical raw materials onto the market," says Nouryon Director Visser. "It's fantastic: after our steam supply, our raw materials are now also slowly becoming green."

5. Using bacteria to make green raw materials from CO_2

Nowadays, there are even more innovative technologies to extract chemical raw materials from CO_2. Chemport Europe based scale-up Photanol is able to create an alternative for raw materials solely with bacteria, solar energy, and CO_2. "It's all about cyanobacteria," says Director Véronique de Bruijn. These blue algae are photosynthetic, just like plants: they convert CO_2 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 products." The bacteria can also be used to produce bio-ethanol, an alternative to kerosene. According to De Bruijn, planes should be able to fly on it in the future.

This technology kills two birds with one stone: not only do these chemical building blocks require no fossil resources to be produced, the bacteria also love polluted CO_2. “We've already tested this at steel manufacturer Tata Steel in IJmuiden,” says De Bruijn. Microbiologists from the University of Amsterdam developed artificial photosynthesis in 2008. This year, Photanol will test the process on a large scale at a pilot plant at Nouryon chemical group’s site in Delfzijl.

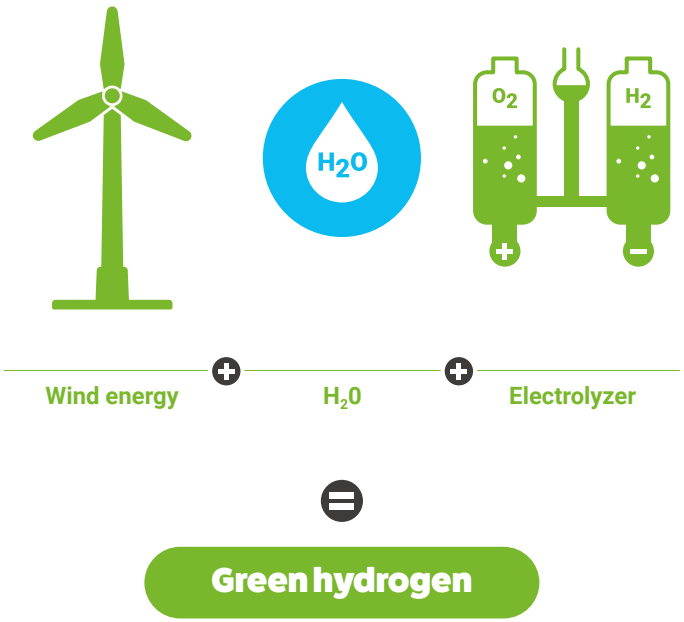
The two parties have concluded a joint venture for this purpose. According to Photanol's CEO, the aim is to open a commercial plant in 2022, which will produce between 20 and 30 metric kilotons of acetic acid a year.
For Nouryon, the technology of both Photanol and Avantium represents an important step in the greening of raw materials. “In the future, both partners will produce the same raw materials from renewable sources. That will enable us to turn the production of monochloroacetic acid more green,” says Nouryon Director Visser.

Each year, Nouryon produces 87 metric kilotons of monochloroacetic acid in Delfzijl, emitting 1,000 metric tons of CO_2 a year. “That's not a lot. But if we consider the entire chain, we have to add 320 metric kilotons of CO_2 emissions. We use methanol for the production of monochloroacetic acid, which is produced elsewhere from natural gas. We may not be responsible for this fossil resource, but we do feel it that way,” says Visser.

6. Switching to green hydrogen

To make the chemical industry completely independent of fossil energy, Chemport Europe is also strongly committed to the use and production of green hydrogen. The sector needs this raw material in production processes with very high temperatures. Reaching those temperatures is not possible with electricity. Chemical companies are already producing hydrogen. But this comes from natural gas; in the future, hydrogen must be obtained from renewable energy.

Green hydrogen production



Green hydrogen is produced by electrolysis, a process that uses sustainably generated electricity to split water into hydrogen and oxygen. The technology has been around for some time, but still needs to be taken into production on a large scale. Nowhere in the world has this been achieved, but various parties in the TopDutch region have plans for hydrogen production. The most energy-efficient technology is being sought in a 1 Megawatt (MW) test center. A consortium of companies, including Nouryon and Gasunie, has announced the construction of a hydrogen plant with a capacity of 20 MW. Visser states: “for the time being, this scale fits in well with our needs. The plant will mainly produce hydrogen as a raw material for chemical processes on its own site.”

'The TopDutch region is the ideal location for a hydrogen plant, since in the near future, large quantities of wind energy will be coming ashore here.'

Harry Talen, plant manager Engie

Hydrogen is also primarily a solution for the storage of sustainable energy. If large surpluses of wind and solar energy from the wind farms come ashore, they can easily be converted into hydrogen here. That, in turn, can easily be converted into green electricity at a later stage or another location. That means it's not surprising that energy companies are making considerable efforts to use hydrogen as well. The Swedish NUON/ Vattenfall is looking into how it can run one of the units of the Magnum power plant in the North of the Netherlands on hydrogen. This power station is intended to become a super battery of renewable energy. The French energy company Engie has great ambitions, too. Together with Gasunie, the company plans to build a 100 MW hydrogen plant in the Eemsdelta. So far, it will be the largest in Europe; only Germany has a 20 MW hydrogen plant. "Engie chose the Netherlands because of the favorable price development of offshore wind energy," says Harry Talen, Plant Manager at Engie. "The Northern Netherlands in particular is regarded as an ideal location, because large amounts of wind energy will come ashore in the near future."

”Furthermore, the ability to use the existing gas infrastructure to transport hydrogen is advantageous. The Netherlands is to stop gas production by 2030.” According to Talen, the fact that Chemport Europe will become a large hydrogen consumer also played a role in choosing the TopDutch region for the settlement of the plant. “The same goes for politicians that are making big efforts to stimulate the hydrogen economy in the region.” According to Talen, fifty Engie employees are working fulltime on plans for future hydrogen production. Engie expects the amount of renewable energy to rise sharply in the coming years, to a capacity between 2 to 10 Gigawatts (GW). In this scenario, the energy company expects the 100 MW hydrogen plant to be operational by 2022. In the period from 2025 to 2030, Engie hopes to upscale the plant to 1 GW. Talen tells us: “the gas infrastructure will be used to supply the chemical industry with hydrogen. Gasunie will convert this into a suitable hydrogen network.” Engie also plans to store hydrogen using salt caverns in the North of the Netherlands that are currently being used for gas storage. “This is a cheaper solution than storing renewable electricity in batteries.” The Engie/Gasunie consortium also plans to supply hydrogen to the mobility sector in the future. “Hydrogen is certainly suitable as a fuel for transport over longer distances and heavier transport, such as buses and semis,” says Talen.

7. Producing bio-methanol from CO_2 and green hydrogen

The underground storage of CO_2 is often raised as a last resort to achieve the Paris targets on time. However, the TopDutch region has an alternative to this Carbon Capture and Storage (CCS), which the region regards as a sham solution. “The argument is that with CO_2 storage, the problem is passed on to future generations, while there are plenty of useful applications for CO_2.” Besides Photanol, mentioned earlier, bio-methanol producer BioMCN plays an important role in this. The company produces 900,000 metric tons of methanol a year, of which 60,000 metric tons is bio-methanol. Although this quantity makes BioMCN the world's biggest producer of bio-methanol, the total production of bio-methanol is just a fraction of the total amount of methanol produced worldwide each year: 70 million metric tons. Paul Compagne, COO at BioMCN, explains: “bio-methanol is used as biofuel and ends up in the gas tank. It’s blended in gas, which is an EU requirement. Regular methanol is used as a raw material in the chemical industry, but also in the cosmetics and paint industry. Because of the higher price of the green variant, it is not yet an attractive option for regular industry.”

The Groningen-based company produces methanol from natural gas, and bio-methanol from green gas obtained from biomass fermentation plants. BioMCN sees great opportunities for further greening. One way is to convert captured green CO_2 from a fermenter containing green hydrogen into bio-methanol. “From 2020 onwards, 15,000 metric tons of extra bio-methanol will be produced thanks to this process,” says Compagne. Key to scaling up bio-methanol production for BioMCN is the large-scale production of hydrogen nearby. ”To fully turn our current production green, no less than 1.4 GW electrolysis capacity is needed to produce this hydrogen,” Compagne claims. “So that will take a while. But this green building block presents a fantastic green future. The possibility of turning hydrogen and captured CO_2 into bio-methanol means that we actively reduce the CO_2 emissions of ourselves and our fellow companies.”

Paul Compagne,
COO BioMCN

8. Electrifying processes

The chemical industry can save substantially on fossil energy by beginning to electrify. Chemical companies now mainly use natural gas for their heat supply. But due to the falling prices of sustainable wind energy, electricity supplies are becoming increasingly profitable. According to the 2018 Eemsdelta Industry Agenda, it is expected that the use of sustainably generated electricity will soon save 10% of natural gas for the entire site. At Nouryon, the production process is already very energy efficient and the steam supply is largely green. But according to Visser, there are still big steps to be taken in energy consumption. “It takes a lot of energy to make salt chlorine. Our electricity consumption for chlorine production is about 60 megawatts. Half of that we make ourselves, the other half we buy.”

According to Visser, electrifying salt plants at the beginning of the production chain is a vital step. “The first electrified salt plant is already in place; it was built in 2007 in response to increasing gas prices. Plans for the development and construction of a second electrified salt plant are ready. It should be operational by 2021. The production capacity of the first plant is 350 metric kilotons; the second will be 800 metric kilotons. In total, the four current salt plants account for 2.7 million metric tons of production a year.” The final two will also be phased in or replaced by 2050. The investments are substantial, partly because it's a completely different technology. “It's also subject to the condition that sufficient green electrical energy is generated by that time,” emphasizes Visser.

Powerhouse North Sea

The North Sea is set to grow into a sustainable powerhouse in the years to come. In the northern part, off the coast of Groningen, Gemini Wind Farm provides 600 MW of offshore wind. A tender has been put out to extend the park with facilities to generate another 700 MW. The TopDutch region has the ambition to realize even more offshore wind farms in the future. The TopDutch region also receives 700 MW of sustainably generated energy via the 580 km long NorNed undersea cable between Norway and

Largest windpark in Europe

Gemini Windpark

the Netherlands. This year, another 700 MW will follow via the COBRA cable, an underground connection that feeds wind energy from Denmark. On land, in Eemshaven, 275 MW of onshore wind energy is available.

According to Plant Manager Talen, there are great opportunities to scale up the production of electrolyzers. “These are currently made manually by companies such as Siemens and ThyssenKrupp. If demand increases, the price will fall due to serial production. It remains to be seen how we'll deal with the unprofitable top in the early stages. Substantial costs will also be incurred in the development phase.” Despite these challenges, Engie’s Plant Manager believes green hydrogen production will have a big impact on CO_2 reduction. “The industry is currently still making hydrogen from natural gas. The production of one kilo of hydrogen releases 10 kilos of CO_2.”

9. Optimizing processes through digitization

To make processes even more efficient, the use of IT and big data is seen as an important solution. Everything revolves around in-depth data analytics: patterns are discovered from big data and can be used to make predictions. The technology is so advanced that it can calculate under which circumstances a process takes place most energy efficiently. AkzoNobel, for example, already uses sensors in its chlorine production in Rotterdam and Delfzijl that collect data and can thus optimize processes.

10. Using and producing sustainable products

Lastly, at Chemport Europe products are made that are sustainable in use. Besides saving CO_2 by choosing green building blocks and optimizing production processes, the CO_2footprint of the end-product also needs to be reduced. This is illustrated by the Twaron synthetic fiber of manufacturer Teijin Aramid. “The yarn is five times as strong as steel, but much lighter. Products that incorporate Twaron are therefore more energy efficient,” says Marjan Kamer, Eco-Efficiency Specialist at Teijin Aramid. “Thanks to Twaron, the weight of long conveyor belts is sometimes as much as 40% lower, which results in a 15% reduction in energy consumption. Containers for air freight now also contain Twaron, which means that less kerosene is used for air transport.” There is a high demand for yarn, so Teijin Aramid will be expanding its production capacity in the years to come, most likely in both Emmen and Delfzijl. This expansion is beneficial for the company's sustainability ambitions and therefore for the desired energy innovation within Chemport Europe (discussed in point 1). Thanks to the expansion, the company is now able to introduce energy efficient technologies that otherwise would not be profitable.

“Our motto is: reduce pain, increase gain, align chain. This is how we are setting out to make our own production process greener, while at the same time supplying our customers with a product that is as sustainable as possible,” says Kamer. Teijin Aramid compares the life cycle analysis (LCA) with the costs, known as life cycle costing (LCC). This makes it clear how much CO_2 is saved throughout the entire chain and what financial benefits this will bring. According to Kamer, this provides surprising insights. “Although Twaron is still made from fossil fuels, CO_2 savings form the biggest gain in the entire chain. To give an example: with car tires, only 10% of the CO_2 impact comes from the use of fossil resources and production, while 90% of the CO_2 emissions are produced when driving.” Meanwhile, Teijin Aramid is also working on greening their raw material consumption. The company found a partner in the Groningen startup BioBTX, a chemical technology company that converts renewable raw materials, such as biomass and residual products, into chemical raw materials, in particular benzene, toluene and xylene (BTX). “The technology of BioBTX makes it possible to make sustainable use of the raw materials Teijin uses for the production of Twaron. In the future, greening could achieve a significant reduction in CO_2 emissions.”

3.

THE STRENGTH OF THE TOPDUTCH REGION

The TopDutch region is bursting with green initiatives. Involved entrepreneurs and companies made it very clear how constructive their mutual cooperation is. “Companies think very much in terms of solutions,” feels Ronny Pals, Plant Manager at newcomer Avantium. “The ambition is not just about words, but how they are translated into action. This is perhaps where the greatest strength lies.” Although Chemport Europe may not be Europe’s largest chemical cluster, the entire chain is represented here. “That means that we can play the game of becoming CO_2 negative on a relatively small scale and win the game first as a cluster together,” says Nouryon Director Johan Visser. “It's a superb process. You literally see the chemical clusters turning green, right in front of you.”

’Companies think very much in terms of solutions. The ambition is not just about words, but how they are translated into action.’

Ronnie Pals, pilot plant manager Avantium

4.

SUSTAINABLE DEVELOPMENT GOALS

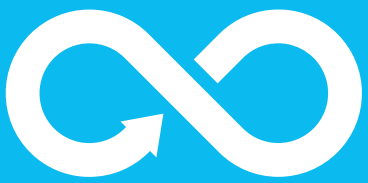
In 2015, the United Nations adopted a new global agenda, which sets seventeen goals to end poverty, inequality, and climate change. These 17 Sustainable Development Goals aim to turn the world into a better place by 2030. In goal 12, the UN points out that, in view of the growing world population, the production of goods must be made much more efficient: 'producing more with less'. Polluting energy sources must be reduced. Despite technological progress, it is estimated that countries will be consuming 35% more energy by 2020. For the Netherlands, the Sustainable Development Goals form a future agenda for sustainable development in the period between 2015 and 2030, which is to be translated into national policy. The progress of the Netherlands toward the 17 targets has been measured since 2016. Last year, the Netherlands recorded an improvement on most of its targets, including those on sustainable consumption and production.

Ten TopDutch ways to reduce CO_2 emissions

1. Optimizing energy efficiency
2. Exchanging residual heat to save energy
3. Switching from coal to biomass
4. Biorefining green raw materials from biomass
5. Using bacteria to make green raw materials from CO_2
6. Switching to green hydrogen
7. Producing bio-methanol from CO_2 and green hydrogen
8. Electrifying processes
9. Optimizing processes through digitization
10. Using and producing sustainable products

CO_2 reduction for UN Sustainable Development Goals

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



Ensure sustainable consumption and production patterns

13 CLIMATE ACTION

Take urgent action to combat climate change and its impacts

JOIN TOPDUTCH

Want to find out more about what makes the TopDutch region a good place to be great, or view the digital edition? Head over to our website www.topdutch.com

Are you interested in exploring what your business possibilities could be? Connect with Errit Bekkering, our Green Chemistry expert.

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