Brightsite

Transforming industry

A unique 3-generation approach

Advancing towards a circular chemical industry using the latest generation of plasma processes

The aim is that by 2050, a large proportion of the processes and plants on the Chemelot site will be powered by sustainable electricity and that this will make it possible to reduce CO_2 emissions by a substantial margin. Brightsite's program 'Reduction of emissions by electrification' is investigating the possibilities that exist for turning this into reality. Plasma technology is one of the major options currently being examined. We want to develop new generations of plasma processes that are more efficient and an important step towards a circular chemical industry.

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Obtaining climate goals

One of the areas of focus at Brightsite is the development and use of technologies to reduce emissions, by means of electrification. As Arnold Stokking, Managing Director of Brightsite explains: "CO_2 emissions must come down. That is clear, but it isn't easy to achieve. Plasma technology will make it possible to replace the use of natural gas as an energy source for processes and that is why it forms an important avenue to achieve our climate targets. This is what makes plasma activation an important technology for Brightsite, both when it comes to adapting the processes being used in production plants and also for the latest generation of researchers and engineers who are developing this technology and putting it to work. It was with this in mind that prof. dr. Gerard van Rooij was appointed as Professor of Plasma Chemistry in 2020. His appointment is Maastricht University's (UM) first appointment within Brightsite."

A process of the future

During the production of ammonia and artificial fertilizer, hydrogen is extracted from natural gas (the main component of which is methane). As part of that process, CO_2 is generated as a by-product and the majority of that is released into the atmosphere, thereby contributing 35% of the total greenhouse gas emissions on the Chemelot site. Chemelot's ambition is to reduce its emissions of greenhouse gases to zero by 2050. Methane is also used for the heating of crackers. It is released during the cracking process and is then used internally for heating purposes. If, in the future, we are able to heat crackers using electricity, methane could be used for other, worthwhile purposes. By making use of plasma technology, we can utilize methane in the most effective way by converting it into hydrogen and high-quality hydrocarbons, such as acetylene and ethene, which form the basis of plastics, without releasing any CO_2.

"No combustion is involved and no oxygen is used – all of the methane will be used to create carbonaceous products and hydrogen", explains Hans Linden, Program Manager at Brightsite. The high-quality conversion of methane forms one of the cornerstones of plasma technology at Brightsite, as alongside the electrification of the crackers themselves, it enables these to be made greenhouse-gas neutral. Hans Linden continues: "We are convinced that plasma technology offers great potential within the chemical industry. Not only can it be applied to hydrocarbons as a means of generating raw materials that are used in the production of plastics, it can also play a part within the nitrogen chain in the production of ammonia, artificial fertilizer and melamine. From our point of view, plasma technology is THE innovative chemical process technology that is based on green electricity."

What is plasma technology?

Plasma technology has met with widespread interest, as it has the potential to make all kind of processes more sustainable. Plasma is also referred to as the fourth state of aggregation, alongside liquid, solid and gas. Subjecting a gas to an electrical field of sufficient strength creates conditions for gas particles to become ionized. “This ionized gas consists of gas molecules and reactive particles, such as ions, electrons and radicals. That combination of reactive particles then makes (new) chemical reactions possible. Plasma is actually something we’re already familiar with. After all, lightning is nothing other than a discharge of gas that occurs due to a difference in charge between the clouds and the earth”, explains Van Rooij. In the heart of this electrical flame, the heart of the plasma cloud, the temperature is extremely high – 10,000 degrees Celsius, or even higher.

“There are a great many advantages to this. We can use that energy to split and form molecules. The fact that plasma is created by using electrical energy means that this is sustainable, as long as sustainable energy sources are used. What is more, plasma technology is a process in which recovering energy losses can be easier than is the case with its counterpart, electrolysis”, says Van Rooij.

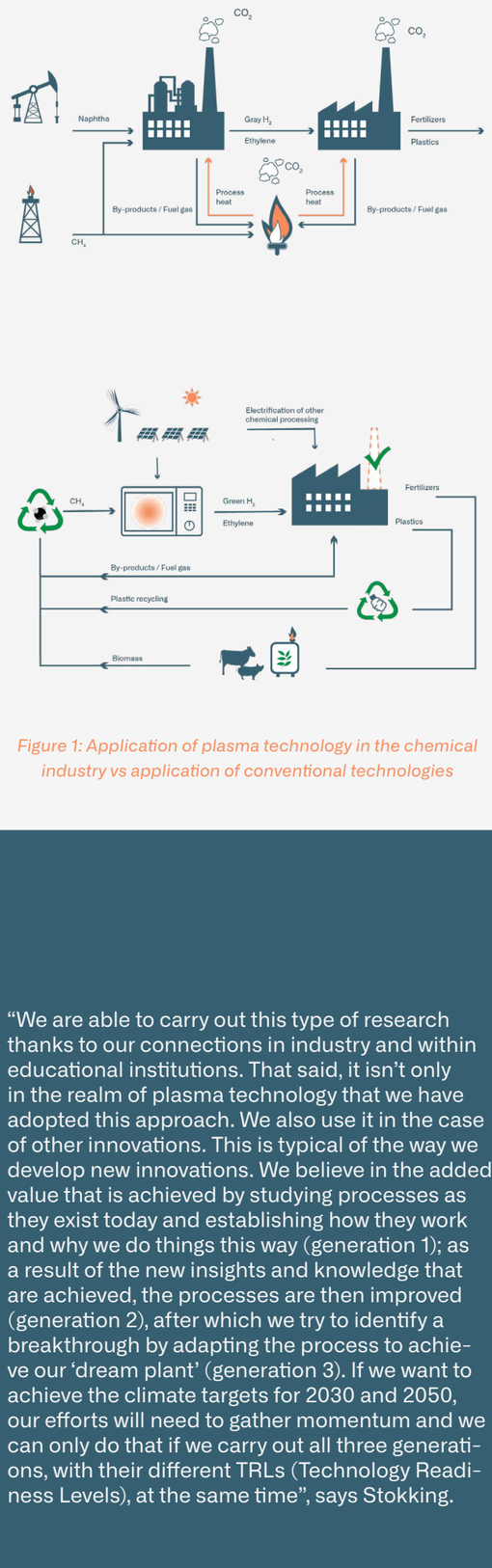


Figure 1: Application of plasma technology in the chemical industry vs application of conventional technologies

A unique approach

Although research into plasma technology is also under way elsewhere, Brightsite’s 3-generation approach, which combines structured fundamental research and applied industrial research, is unique.

Hans Linden, *Program Manager Brightsite:*

“We want to develop new plasma processes that are more efficient and will help us move forward towards a circular chemical industry.”

“We are able to carry out this type of research thanks to our connections in industry and within educational institutions. That said, it isn’t only in the realm of plasma technology that we have adopted this approach. We also use it in the case of other innovations. This is typical of the way we develop new innovations. We believe in the added value that is achieved by studying processes as they exist today and establishing how they work and why we do things this way (generation 1); as a result of the new insights and knowledge that are achieved, the processes are then improved (generation 2), after which we try to identify a breakthrough by adapting the process to achieve our ‘dream plant’ (generation 3). If we want to achieve the climate targets for 2030 and 2050, our efforts will need to gather momentum and we can only do that if we carry out all three generations, with their different TRLs (Technology Readiness Levels), at the same time”, says Stokking.

3-generations in parallel

“What is important is that we make careful use of green electricity, which is why we focus on an efficient process such as plasma technology. The basics of the process were developed in Germany in the last century – namely the Hüls process, in which methane is converted into hydrogen and acetylene. We want to develop new plasma processes that are more efficient and will help us move forward towards a circular chemical industry”, says Hans Linden.

Arnold Stokking, *Managing Director Brightsite:*

“Plasma technology is an important avenue to achieve our climate targets.”

This can be achieved by working on three generations of technology in parallel (Figure 2). The first generation is based on the existing technology. A feasibility study is being carried out, which should lead to an initial design on the scale of a pilot project. The second generation is all about optimizing the process on a demonstration scale. The third generation is more fundamental, in that its focus lies on the process that needs to be developed from scratch and can be used to produce ethene directly. Ultimately, it would be possible for this to be scaled up to plant level. In order to achieve that, Brightsite is collaborating with Maastricht University, DIFFER and various companies, located on the Chemelot site or elsewhere, in improving the process. These projects are also supported by site-users SABIC and OCI Nitrogen.

Generation 1 – charting the feasibility
The Generation 1 study started in February 2021 with a nine-month feasibility study. This will examine not only the technology, but other aspects as well. “Our intention is to chart the business case and to do that, we are collaborating with OCI Nitrogen and SABIC. What are the possibilities and what technology will be needed? We will also be looking at a variety of feedstocks and end-products, as well as establishing the safety and public acceptance of these developments. We are expecting to have the results by the end of this year,” says Linden.

Generation 2 – optimizing the process
Generation 2 will be all about optimizing the Hüls process. Thanks to the very latest insights, we expect to be able to make the process more efficient, achieve greater selectivity, while consuming less energy. At the moment, we are awaiting the outcomes of funding applications that will enable us to install a test facility in the new plasma lab on the Chemelot site.

Generation 3 – designing a new process
This research will take place on a more fundamental level and will mainly be carried out by Maastricht University. The project will examine possible methods for enabling ethene to be produced directly, which would allow considerable boosts to efficiency. If this is successful, we will have something very valuable on our hands, say Linden and Van Rooij.

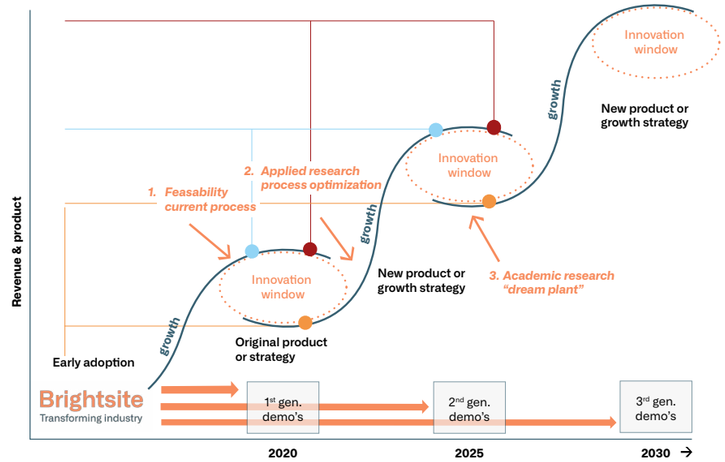


Figure 2: The Brightsite Innovation Approach
TLR 9 > 1 now, tomorrow and the future

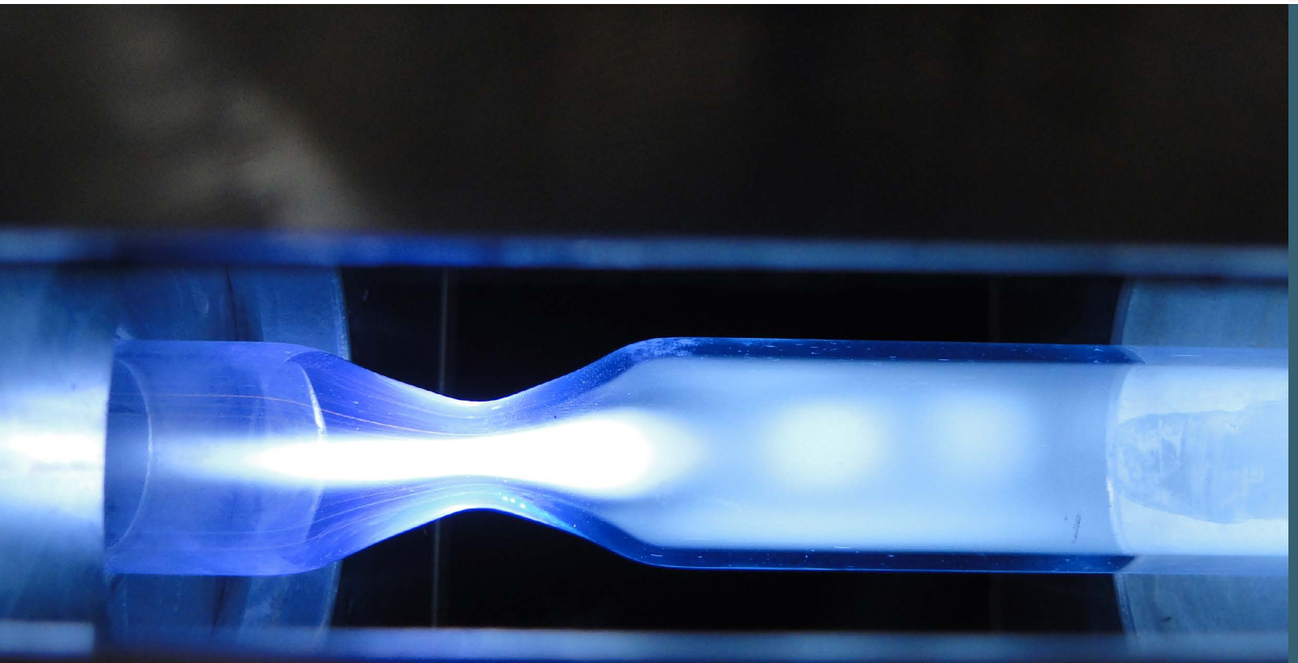
Plasma lab

In order to facilitate research into the 2nd and 3rd generation of plasma technologies, a plasma lab is being developed on the Brightlands Chemelot Campus, which is expected to be open this summer (2021). “In this lab, we will specialize in advanced ways of looking at, and into, plasma. By using innovative techniques, we will be able to re-examine this relatively old process in a much more detailed way, such as by measuring what temperatures occur where and what reactions actually take place. That will be step 1. After that, we will be able to take those insights and use them to optimize and adapt the process. By combining state-of-the-art plasma technology (fundamental insights) with the very latest technical facilities to measure inside the plasma (in 3D), we expect to learn a lot and increase the selectivity of processes”, says Van Rooij.

Within this Brightsite lab UM, TNO and Sitech will be working together and Van Rooij will work with a team with a strong chemical basis, but also a physical and modeling component. “Not only are we building bridges to local industry, but also to other academic spheres as well. The great thing is that in parallel to this, we will begin teaching the bachelor’s program in Circular Engineering in the forthcoming academic year (2021-2022), which aims to train the engineers of the future. Students will certainly want to have a look behind the scenes at the plasma lab,” predicts Van Rooij.

Prof. dr. Gerard van Rooij, *UM professor of Plasma Chemistry:*

“In order to facilitate research into the 2nd and 3rd generation of plasma technologies, a plasma lab is being developed on the Brightlands Chemelot Campus.”



Plasma technology performed in the DIFFER lab in Eindhoven.

Widely deployable

The plasma program is intended to lead to a considerable step forwards in the direction of circular chemical processes. “Methane will be our first area of focus, but the possibilities are endless. For example, they also include reactions with nitrogen and other hydrocarbons and artificial fertilizer, or the environmentally friendly production of green fiber plastics. A more detailed analysis of nitrogen fixation (the Birkeland-Eyde process) and the optimization of that process will be the next step”, says Van Rooij. The focus currently lies on Chemelot; however, Linden and Van Rooij both believe that many different parties are interested in the components that Brightsite is bringing to the table. “The technology itself is generic and can be used anywhere. In fact, it can be used at any facility where plastic is produced and/or where there a need for hydrogen. It is clear that naphtha crackers at other locations will also stand to benefit from the technology we are developing and in time the same will apply to other chains. We believe that with this 3-generation approach, the Netherlands is embarking upon a new and significant area of research into the use of electricity in a variety of chemical processes”, concludes Van Rooij.

Hans Linden, *Program Manager Brightsite:*

“The focus currently lies on Chemelot; however, many different parties are interested in the components that Brightsite is bringing to the table.”

Does your company recognize itself in the working method of Brightsite?

The future outlook is that in 2050 the majority of all processes and installations in the chemical industry are powered by renewable electricity. Brightsite stands for the development and upscaling of these technologies and the conversion of expertise into a revenue model. Do you want to contribute to this program, or do you want to make use of our services?

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