Brightsite

Transforming industry

Clean Hydrogen production crucial for transition to circular chemistry

Brightsite is driving the development of commercial applications for the innovative technologies needed to achieve the climate targets. The sustainable production of hydrogen is one of the cornerstones of the transition to circular chemistry. Chemelot is now home to various initiatives dealing with clean hydrogen production. Brightsite is playing its part by developing next-generation plasma technologies and a method for comparing the variable costs of various hydrogen production technologies.

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Demand for hydrogen set to rise

Chemelot is a major producer of hydrogen (200 kilotonnes per year). Hydrogen is an important feedstock in the production of ammonia, which in turn is converted into substances such as fertilizers, melamine, acrylonitrile and caprolactam. The current processes for producing hydrogen use natural gas (1 billion cubic meters) and emit CO_2 (1.8 megatonnes). Brightsite's program line 1 – 'Reducing emissions through electrification' – looks at how to produce hydrogen sustainably, without emitting CO_2. Plasma technology is one of the main options currently being examined. Electrolysis is an excellent way of capturing a potential oversupply of green electricity and solving problems in transporting this power, but the variable production, transport and storage of hydrogen pose challenges for the chemical industry. However, not all problems can be solved with one technology, and a chemical site also offers unique possibilities. Therefore, alternatives must also be developed. Another interesting technology for hydrogen production is gasification.

"We are looking for the best way to produce hydrogen without emitting CO_2. We certainly need hydrogen to make Chemelot more sustainable and thus achieve the ambition of reducing greenhouse gas emissions to zero by 2050. In the future, we will need it not just for the CO_2-free production of ammonia, but also for the pretreatment of pyrolysis oil, derived from plastics, to eventually replace naphtha. We will continue to produce some of the hydrogen we need on site, and we also expect to purchase some clean hydrogen," explains René Slaghek, Program Manager of program line 5 'Transition scenarios and system integration'.

René Slaghek, *Program Manager Brightsite:*

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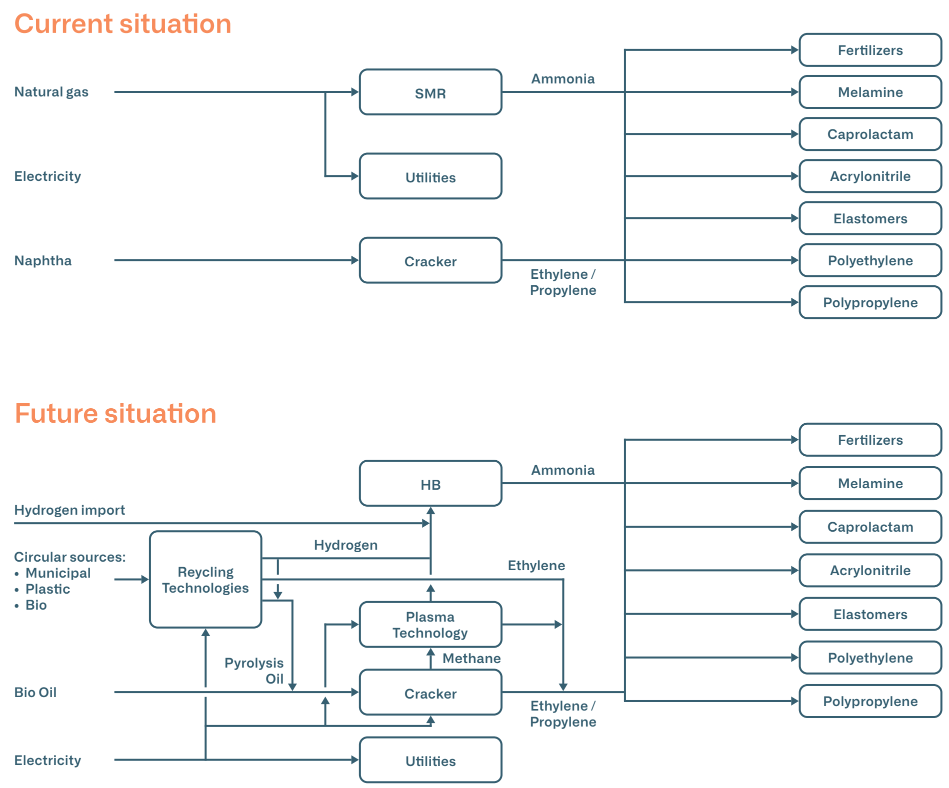

Figure 1: Integrated Chemical Site Like Chemelot

Synergy & system integration

Although Chemelot is currently an integrated site based on naphtha and natural gas (especially methane), the future is all about electrification and the greening of raw materials. “To successfully make the transition to a climate neutral Chemelot by 2050, we are setting out all of the opportunities for factories to go green. In program line 5, Brightsite is looking at how the different processes can be tied together. It’s one thing developing the right technologies to achieve the transition to a green Chemelot, but the technologies also need to be optimally integrated into the Chemelot system. The key is to choose the most cost-effective solution for Chemelot as a whole. We look at the dilemmas, obstacles and risks but also at the social synergies and new opportunities across the site and beyond. This applies just as much to other issues and processes as it does to hydrogen, and we need to look at all of these together. Thanks to the variety of processes at Chemelot, there are a lot of synergies to be achieved and many opportunities to process future residual products,” emphasizes Slaghek.

From waste to raw material

There are solutions available for producing clean hydrogen. “We have to make the right choices to suit the plants that need hydrogen for their processes – like SABIC (for processing pyrolysis oil) and OCI Nitrogen (for ammonia production) – and to maintain the balance on the site as a whole. Our existing plants are probably not going to make all the clean hydrogen they need themselves. Other investors and new plants will be needed for this. A number of initiatives are already under way at Chemelot. One of these is the RWE project FUREC (Fuse Reuse Recycle), which creates hydrogen from waste streams. The goal is to design an installation that uses gasification to process household waste into raw material pellets, which on the Chemelot site are converted into clean hydrogen via gasification. Plastic Energy focuses on converting plastic waste to pyrolysis oil, to be used as a renewable feedstock for new plastics.

These are two examples that convert waste streams into raw materials and work in synergy with each other. For example, the plastic that Plastic Energy cannot process can be converted by FUREC,” says Slaghek.

Unique technology comparison

In order to make sound judgments about the best technology for hydrogen production in the long term, it is helpful to have a way of comparing technologies in terms of cost price. Although there are already methods for comparing the cost of technologies, the disadvantage is that these are closely linked to market conditions. “Brightsite has developed a new and accurate method in which market conditions have no longer effect on the determination or correction of the cost price,” says Joris van Willigenburg (Senior Chemical Engineer/Technology and Sustainability Consultant). “Multi-product processes, such as many of the new hydrogen production processes, involve various by-products. The method commonly used to calculate the cost price of the desired product is to subtract all of the by-products from the raw material cost at their market price. And market conditions can play a major role in determining the cost price of products for these processes. In other words, technologies involving by-products are complex and sensitive to the values of those by-products and the values that influence them, such as the price of oil. Variable costs, such as the costs of raw materials and energy, are difficult to determine. We have now developed, and validated, a method for ensuring that the variable production costs of processes involving (many) by-products can be compared fairly. Among other things, this gives us meaningful insights into the sensitivity to CO_2 pricing and decoupling of oil and gas prices.”

Figure 2: Working method and applied methodology

Calculate impact & give advice

This method has been applied to 11 hydrogen production technologies, not all of which are multi-product. “I presented our findings at the Clean Hydrogen Conference on May 18, 2021 (see box ‘Clean Hydrogen Conference’) and a scientific publication will follow soon. The method can be used widely and adds value to all kinds of multi-product processes, for example improving life-cycle assessment and CO_2 footprinting,” says van Willigenburg. “Here at Brightsite, we aim to make evaluations and give advice based on facts and data. We calculate what impact choices will have, and this study is a great example. We discuss these results with the plants, but the decisions are ultimately up to them. We only say whether something is advisable based on the facts,” adds Slaghek.

Raw material		**Huls H2**	**Converted**
Propane	t	3.1	3.1
Natural gas	GJ_{LHV}	295	338
Electricity	MWh_e	58	57.5
Naphtha	t	0	-7.80
CO_2-emission rights	t		-4.42
Products			
Hydrogen	t	1.00	1.00
Ethylene	t	4.80	0
Benzene	t	0.40	0
Carbon	t	0.55	0.55

1 Conversion of ethylene and benzene to naphtha, natural gas, electricity and emission rights

2 Calculate cost savings

Figure 3: Pilot evaluation of hydrogen by means of Hüls process

Plasma technology

Plasma technology makes it possible for electrification to replace the use of natural gas as an energy source for processes and that is the reason why it forms a very important avenue that will enable us to achieve our climate targets. Using plasma technology, for example, we can utilize the methane released during the cracking process in the most effective way possible by converting it into hydrogen and high-quality hydrocarbons, such as acetylene and ethylene, 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. 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. In the heart of this electrical flame, the heart of the plasma cloud, the temperature is extremely high. Under these conditions, molecules can be split and formed very quickly. Due to the fact that a plasma flame is generated using electrical energy, the process is very sustainable when green electricity is used. Want to learn more about plasma technology? Click here.

Clean Hydrogen Conference

The online Clean Hydrogen Conference took place on the afternoon of Tuesday, May 18. During this conference, which is part of the Brightlands Chemistry of the Future series, national and international speakers shared their views and experiences of alternatives to electrolysis for producing clean hydrogen. Three alternatives for producing clean hydrogen were discussed during the conference program: 1) the gasification of biomass to produce hydrogen and green CO_2; 2) formation of acetylene/ ethylene and hydrogen from natural gas with plasma technology, and 3) the splitting of natural gas to form pure carbon and hydrogen. Brightsite contributed with talks given by Managing Director Arnold Stokking ('Brightsite's approach to the raw material transition'), Joris van Willigenburg ('Hydrogen variable cost analysis for multi-product processes'), René Slaghek ('Role of clean hydrogen in a sustainable circular chemical site) and a joint presentation by Prof. Gerard van Rooij (Professor of Plasma Chemistry, Maastricht University (UM)) and Hans Linden (Manager of Brightsite's program line 1) on 'Hydrogen, electrification and circularity – a plasma chemistry perspective'.

Joris van Willigenburg, *Technology and sustainability consultant:*

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

The future outlook is that Chemelot has met the national goals for greenhouse gas reduction by implementing the most cost-effective measures while ensuring production. In 2050 Chemelot is entirely carbon-neutral, based on an optimal transition pathway. Do you want to contribute to this program, or do you want to make use of our services?

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