Brightsite

Transforming industry

Biomass as a substitute for fossil raw materials

Study: how can chemelot use biomass?

Brightsite is committed to creating a sustainable chemical industry. One example of this commitment is using biomass as a building block for chemicals. However, this is still in its infancy and therefore an inventory has been made of the different types of biomass and technologies that could potentially be used. This makes it clear that if we want to use biomass as a raw material, we will need to take a critical look at which technologies are best suited to the processes here at Chemelot.

Chemelot-trainee Esther Montrée has carried out a study into the use of biomass at Chemelot in the future. "In my research, I have listed the challenges, opportunities and possibilities for the use of biomass as a raw material. Where does the greatest potential lie? Since the use of biomass as a raw material is a very complex issue, and much remains to be done before biomass conversion can be achieved on a site like Chemelot, it is important that we take a good look at the various potential pathways," stresses Montrée. Her report, 'The use of biomass at Chemelot', is the first step in this direction.

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Biomass as a sustainable raw material alternative

Achieving the climate targets – a 49% reduction in CO_2 emissions by 2030, a 95% reduction by 2050 compared to 1990 and a fully circular economy by 2050 – is a major challenge. Chemelot endorses the objectives and aims to stop using fossil sources by 2050. This applies to both the generation of energy and to raw materials.

All primary fossil raw materials will eventually have to be replaced by sustainable alternatives. To begin with, we are looking into recycling products, but due to losses arising, other renewable raw materials will be needed to achieve a circular economy; biomass could represent a sustainable alternative of this kind.

Green raw material mist incentive

In the Netherlands, biomass is currently used mainly to generate energy. In these processes, the use of biomass means that the direct emissions from the chimney are 'green'. When biomass is used as a raw material in the chemical industry, only a small proportion is released directly into the atmosphere. The majority of it is built into the products. At present, there is only a political incentive for 'greening' direct emissions, while greening the product building blocks is at least as important from a circularity point of view. Chemelot wants to do its bit here too by replacing fossil raw materials with recycled products or sustainable alternatives," says Carla Koopman, from Maastricht University (Faculty of Science and Engineering, Circular Chemical Engineering).

Need to apply cascading principle

When choosing a type of biomass and technology, biomass cascading – i.e. making the best possible use of biomass – is important. Although it is difficult to determine what is optimal (this strongly depends on the sector, time and transition phase), the value pyramid (see Figure 1) can help.

"It is preferable to use biomass high up in the pyramid (scale 5, 4 or 3); the higher the scale, the purer the biomass should be. Waste from 5 can then be used in step 4, and so on. Because subsidies currently only go to the lower scales (1 and 2: energy and transport), high-grade biomass is used for low-grade products. In the chemical industry, we also have to take into account the cascading principle of using (green) carbon primarily to make products instead of energy applications," Montrée emphasizes.

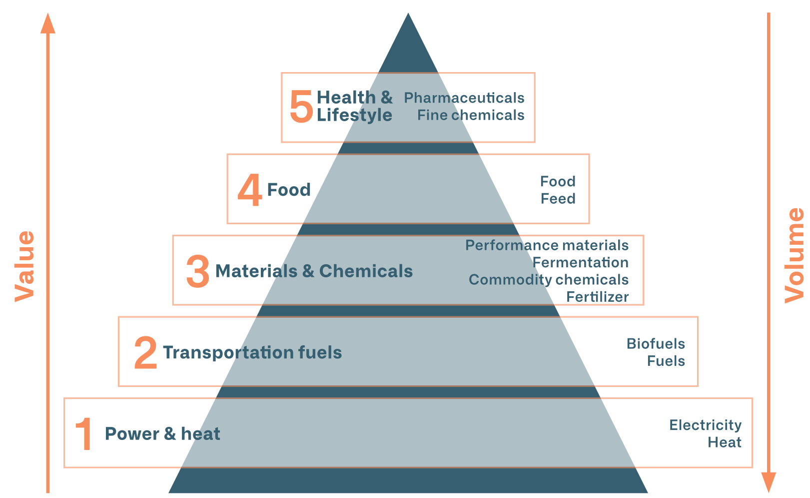

Figure 1: Value pyramid. Based on: J. P. van der Hoek, H. de Fooij and A. Struker, "Wastewater as a resource: Strategies to recover resources from Amsterdam's wastewater," Resources, Conservation and Recycling, 2016.

What type of biomass & technology to choose?

The use of biomass as a raw material in a chemical process involves many considerations, making development and implementation complex. There are various aspects to the complexity, including: certainty about the future availability of and demand for (different categories of) sustainable biomass, technologies to convert biomass into valuable chemicals and materials and its application possibilities (Figure 2).

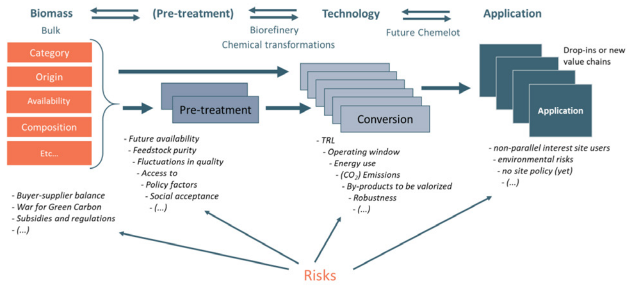

Figure 2: Illustration of the complexity of the integration ofbiomass conversion processes including several risks thatshould be taken into account during a business case and thedecision making.

Categories and biomass availability
There are many different types of biomass (see Figure 3). At present, first generation biomass, such as agricultural and forestry crops, and its residues, are mainly used for a variety of purposes (food and feed, energy, transport fuels).

There is limited availability of these forms and society is critical of the use of these crops. It is therefore important to also consider other biomass categories (second and third generation) as a possible source of raw materials for the chemicals industry. It is also questionable whether enough biomass will be available to meet future demand if the chemical industry switches entirely from fossil raw materials to biomass. By way of illustration, assuming a recycling loss of 50%, for Chemelot this would mean that approximately 2 Mt of carbon from sustainable sources would be needed annually to absorb these losses. It is therefore likely that we will need to import biomass.

Conversion technologies
In the report, Montrée looks at various technologies, including anaerobic digestion, fermentation in combination with catalytic dehydration, pyrolysis, gasification, torrefaction, hydrothermal liquefaction, transesterification and hydroprocessing. Although many of these technologies have not yet been proven (on an industrial scale), the development of biomass conversion technologies has accelerated rapidly.

“It’s best to choose a type of biomass that is consistently available throughout the year and can be processed using robust technology.”

“It is difficult at first glance to establish which technology and which biomass are the most attractive. There are many aspects in play here. It’s best to choose a type of biomass that is consistently available throughout the year and can be processed using robust technology. We should be performing a life cycle analysis (LCA) for each biomass. Should you opt for a pre-processing operation for the energy, for example, or choose a technology that doesn’t require such a step? How circular and sustainable is the entire chain from raw material to product? It is a complex question and we need to take various aspects into account. Brightsite is the party that can help Chemelot to solve this puzzle,” says Koopman.

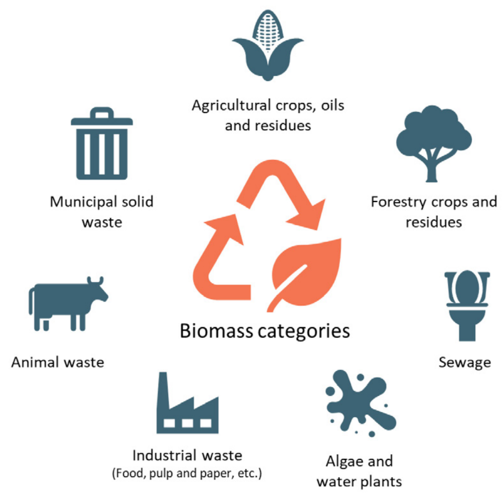

Figure 3: Different types of biomass.

Promising biomass & technologies

Pyrolysis
Pyrolysis is a technology to thermally convert (dry/dried) biomass into bio-oil, biochar and/or gases such as methane, H2 and CO. During the pyrolysis process, the biomass raw material undergoes various reactions, including depolymerization, dehydration, decarboxylation, esterification and the breaking of C-C bonds. To make the pyrolysis process more attractive from a financial perspective, heat exchangers can be integrated into the process to recover energy from the gaseous product. The recovered energy could be used to dry wet biomass or to heat the pyrolysis chamber. This technology would connect well with the naphtha-based value chain – together with methane, the most important value chains at Chemelot – for the production of bio-based drop-in chemicals.

High-pressure fermentation
This is a relatively new concept for the biochemical conversion of biomass. During high-pressure fermentation, biogas with a methane content of up to 90-95% can be produced (green gas). The remaining 5-10% consists of CO2.

The green gas could be used directly in the natural gas grid without further upgrading or purification. Due to the applied high pressure (10-50 bar), methane and CO2 can be separated directly, since at these pressures CO2 is in the liquid phase and methane in the gas phase. However, the process is not yet advanced enough to be used on an industrial scale.

Conclusion: biomass as a real, green alternative

Since 100% circularity through recycling is not achievable, investments will have to be made in other routes in order to achieve the climate targets that have been set. Biomass is a good alternative – as far as we're concerned the real green alternative at the moment – to supplement carbon losses in the chemicals industry. However, this issue is complex and calls for choices to be made. The next step is to draw up a targeted plan for the use of biomass at Chemelot and to make a choice of biomass and technologies.

Now is the time to take action, otherwise we'll miss the boat. It is wise to use a two-stage rocket: in the short term, we need to use technologies that convert first-generation biomass, and then in the long term focus on the conversion of second and third-generation biomass feedstocks. You need to avoid developing applications that are ultimately not socially accepted.

What is needed for successful implementation of biomass conversion?

- Continue to look broadly at the range of technologies on offer. Take a critical look at which technology is best suited to the site-user and to Chemelot;
- Focus on technologies that can use multiple types of biomass as raw material;
- Choose a technology mainly based on the characteristics and robustness of the technology and the final products; don't necessarily opt for a particular biomass bulk feedstock that may not be available in bulk in the future.

The current study looked, in particular, at drop-in possibilities at Chemelot. Looking into the possibilities of new value chains that embed green carbon in new products can also offer opportunities and is worth considering.

Does your company identify with Brightsite's working methods?

Would you like to know more about the possibilities of biomass or do you want to collaborate on this theme? Then please do get in touch with us.

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