



## Press Kit

### About DAWN Technology\*

DAWN Technology is Avantium's **biorefinery** technology. A biorefinery aims to make the most efficient use of **biomass** and eliminating waste streams. All biomass constituents are separated into a range of products and the goal is to get the greatest possible value out of these products. This is called cascading.

**DAWN Technology** is an innovative process that converts non-food plant-based feedstock into high purity industrial sugars and lignin. These sugars, such as **glucose**, are excellent raw materials for chemistry and fermentation processes used to produce a broad range of products. The **lignin** is dense in energy and ideal for energy generation in addition to other higher value applications.

Glucose is a core building block for many industrial products and is increasingly important in the transition towards a **bio-based economy**. All materials made from petroleum today (examples are bottles, t-shirts and carpets) can be replaced with materials made from glucose. This would reduce reliance on petroleum, mitigate carbon dioxide (CO<sub>2</sub>) emissions and help tackle climate change. Today, glucose is predominantly produced from food sources such as corn, wheat, sugar beet and sugar cane. DAWN Technology unlocks the glucose available in non-food agricultural and forestry residues such as wood chips, wheat straw or corn stover.

The DAWN Technology biorefinery produces three main product streams:

1. **Glucose**. DAWN Technology is differentiated from other technologies in its ability to produce high purity glucose. There is no source of high purity glucose from non-food, plant-based feedstock commercially available today.
2. **Mixed sugars**. In addition to glucose, the mixed sugar stream contains a number of other valuable sugars such as xylose, mannose and galactose. Mixed sugars are suitable as feedstock for fermentation processes used to make products such as ethanol, vitamins and acetic acid.
3. **Lignin**. Lignin is the compound that is left once the sugars have been taken out of the original raw material. It is more efficient for energy generation as its energy content is up to 40% higher than the original wood chips used in the process. Energy generation is currently the predominant application for lignin. Additional higher value applications are being developed.

The DAWN technology is an innovative and modern development of an industrial process that has been proven at commercial scale since the 1930s. Avantium has radically improved this process through proprietary inventions. The technology uses **acid** to selectively separate the sugar streams from the feedstock material (i.e. the agricultural or forestry residues). Avantium's proprietary inventions reduce water consumption by 70% with significantly reduced energy consumption. This not only manages the environmental footprint of the process but also improves the cost profile of the resulting products.

\*Terminology in bold is explained in order of appearance in the glossary of terms below



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### Commercial Scale-up

On 10 July 2018, Avantium opened a pilot biorefinery in Delfzijl, the Netherlands, with a maximum capacity of processing 20 tons of dry wood chips per year. The objective of the pilot biorefinery is to scale up the technology, validate the economics, and further optimize the technology and application development.

Avantium is already progressing to industrial scale and has founded a **consortium** of partners committed to developing a commercial biorefinery in Delfzijl that will tap into locally available expertise, utilities and infrastructure. The consortium consists of AkzoNobel, RWE, Staatsbosbeheer and Chemport Europe, each bringing specific expertise and functionality to the biorefinery. This consortium functions as an industrial ecosystem.



Assuming successful results from the pilot biorefinery, Avantium estimates that the design of the commercial scale flagship biorefinery will commence in 2019, and the start-up of the plant in 2022 or 2023. This unique flagship biorefinery is anticipated to have a capacity of 130 kilotons per year of dry matter **wood chips**. This can further be scaled up to 350 kilotons per year.

Avantium aims to license its proprietary DAWN Technology and foresees its global deployment. Potential partners around the world have expressed interest in licensing DAWN Technology for local deployment. These partners aim to add value in the form of industrial sugars to their current available feedstocks. The DAWN Technology is feedstock flexible allowing future biorefineries to use its own locally sourced non-food biomass. The Delfzijl biorefinery will serve as a demonstration facility for these future biorefineries.

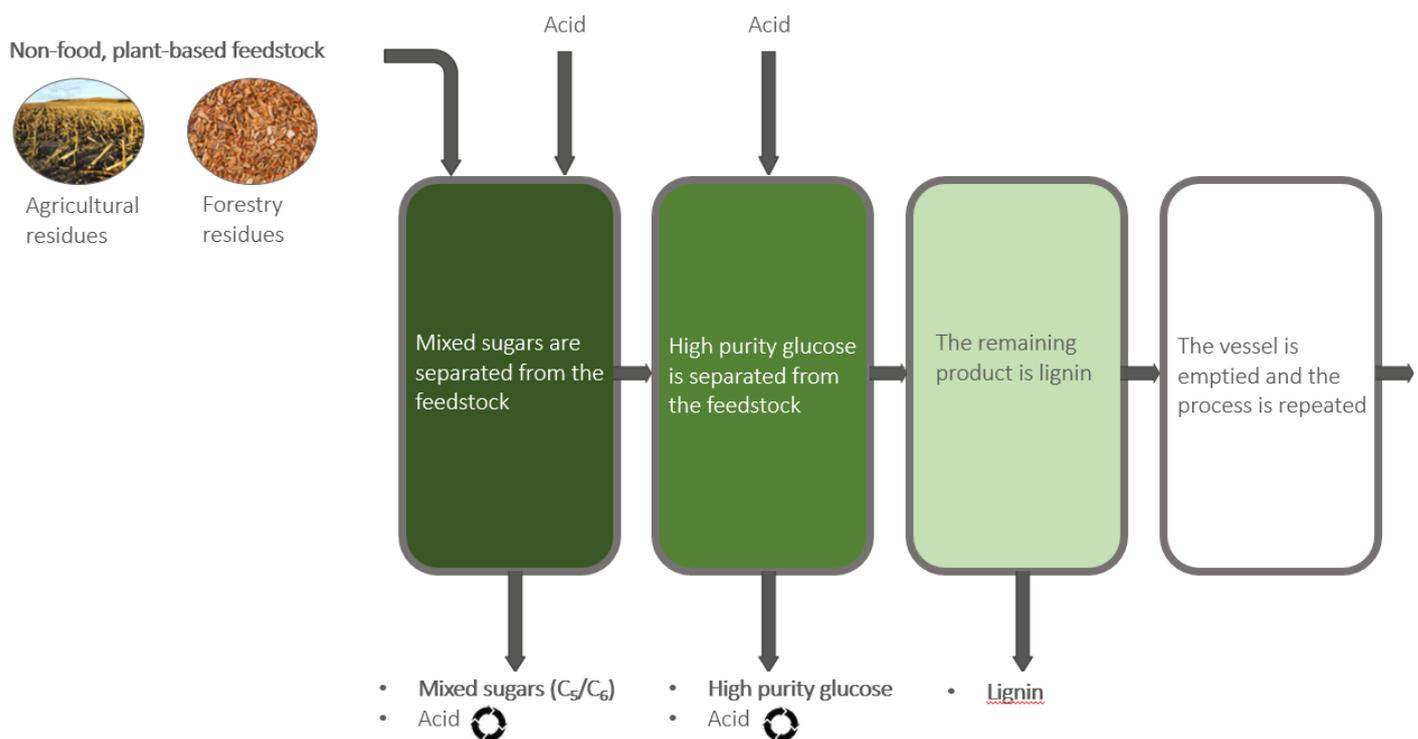


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### The DAWN Technology Process

A simplified schematic overview of the process is depicted below:

- The feedstock is loaded in a cylindrical vessel
- The mixed sugars are separated from the feedstock through the addition of acid (a process called hemicellulose hydrolysis)
- The high purity glucose is separated from the feedstock when acid is added in the second pass (a process called cellulose hydrolysis) in more concentrated form
- Once the sugars are removed, lignin is the remaining product in the vessel
- The vessel is emptied of lignin, fresh feedstock is loaded and the process is repeated
- The acid is recycled to the beginning of the process





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### Glossary of Terms

Our definitions for terminology used in this document (in order of appearance):

#### **Biorefinery/ Biorefining**

A biorefinery is a factory that processes biomass into a range of products and where the goal is to make the most efficient use of the biomass or raw material. Biorefining aims to use every component of the raw material so that nothing goes to waste thereby improving efficiencies and environmental impact.

#### **Biomass**

Biomass is organic matter especially of plant origin. These materials are renewable and originally found in nature in the form of agricultural and forestry products like wood, woody plants, corn, sugar beet and rapeseed. The residues of these products also contain starch, carbohydrates, fats and proteins.

#### **DAWN Technology**

DAWN Technology is the brand name of Avantium's biorefinery technology developed under the project name Zambezi. Internally, Avantium uses river names for its projects and upon commercialization, the company adopts a brand name.

#### **Glucose**

Glucose is a sugar consisting of six carbon atoms (C6). It is a core building block for the transition to a bio-based economy and is growing in demand across many industries. Glucose serves as a feedstock for the production of a broad range of chemicals and materials produced via chemistry or fermentation processes. The resulting products can be existing and new bio-based chemicals such as FDCA (furandicarboxylic acid, a sugar based chemical compound), bio-MEG (monoethylene glycol), propanediol, succinic acid, vitamins, enzymes, PLA (polylactic acid, a biodegradable thermoplastic polyester) and PEF (polyethylene-furanoate, a 100% biobased, 100% recyclable polymer).

#### **Lignin**

Lignin is the mass that remains after the sugars have been removed from the initial raw material. It is more efficient for energy generation as its energy content is up to 40% higher than the original wood chips used in the process. Energy generation is currently the predominant application for lignin. Additional higher value applications are being developed. Interestingly, the lignin looks a lot like the briquettes we use when we grill outside but now not coal-based.

#### **Bio-based Economy**

A bio-based economy exists when predominantly plant-based materials, i.e. biomass rather than fossil-based raw materials (petroleum) are used as feedstock for making the chemicals, materials and products we consume. The main applications include plastics, fibers, chemicals, transport fuels, electricity and heat.



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### **Mixed Sugars**

Mixed sugars refer to a stream of sugar molecules called C5 and C6 sugars. The C refers to the number of carbon atoms contained in that specific sugar molecule. Examples of sugars are xylose, mannose and galactose. Mixed sugars are not further separated in our process due to factors like the cost of separation, availability of the particular sugar in the mixed sugar stream and the market price of the sugar compound. Several fermentation processes such as the production of ethanol, vitamins and acetic acid do not require further separation of the sugars for the process to be efficient.

### **Acid (hydrochloric)**

Hydrochloric acid is a chlorine-based acid used in the DAWN Technology process acting both as a solvent and a catalyst. One of the breakthroughs is that the hydrochloric acid is recycled in an energy efficient way.

### **Consortium**

Avantium founded a consortium of partners committed to developing a commercial biorefinery in Delfzijl, the Netherlands. Besides Avantium, the consortium consists of AkzoNobel, RWE, Staatsbosbeheer and Chemport Europe, each bringing specific expertise to the biorefinery. Avantium is the inventor, developer and owner of the DAWN Technology. Avantium invested in and built the pilot plant in Delfzijl and is also the future licensor of the technology. For the specific flagship commercial scale plant, Staatsbosbeheer will coordinate the supply of residual wood from the Netherlands and northwestern Germany in the form of wood chips. The biorefinery will leverage the synergy that exists in infrastructure, utilities and expertise at the AkzoNobel production site in Delfzijl and they may also consider the glucose from the plant as a feedstock in their production process. RWE will use the lignin from the flagship plant to generate renewable energy. Chemport Europe provides expertise, network and financial support from the northern provinces of the Netherlands.

### **Wood chips**

Wood chips are the form in which Staatsbosbeheer supplies the forestry residue from three sources:

1. Forestry residues from the unusable part of the tree such as the tops, branches, bark and parts of trees unsuitable for the wood processing industry due to conditions such as poor growth, damage or disease
2. Residues from nature and landscape management
3. Residues from saw mills like sawdust.

Avantium aims to use only certified (FSC, BetterBiomass, PEFC and/or ISCC) wood chips in its production process.

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