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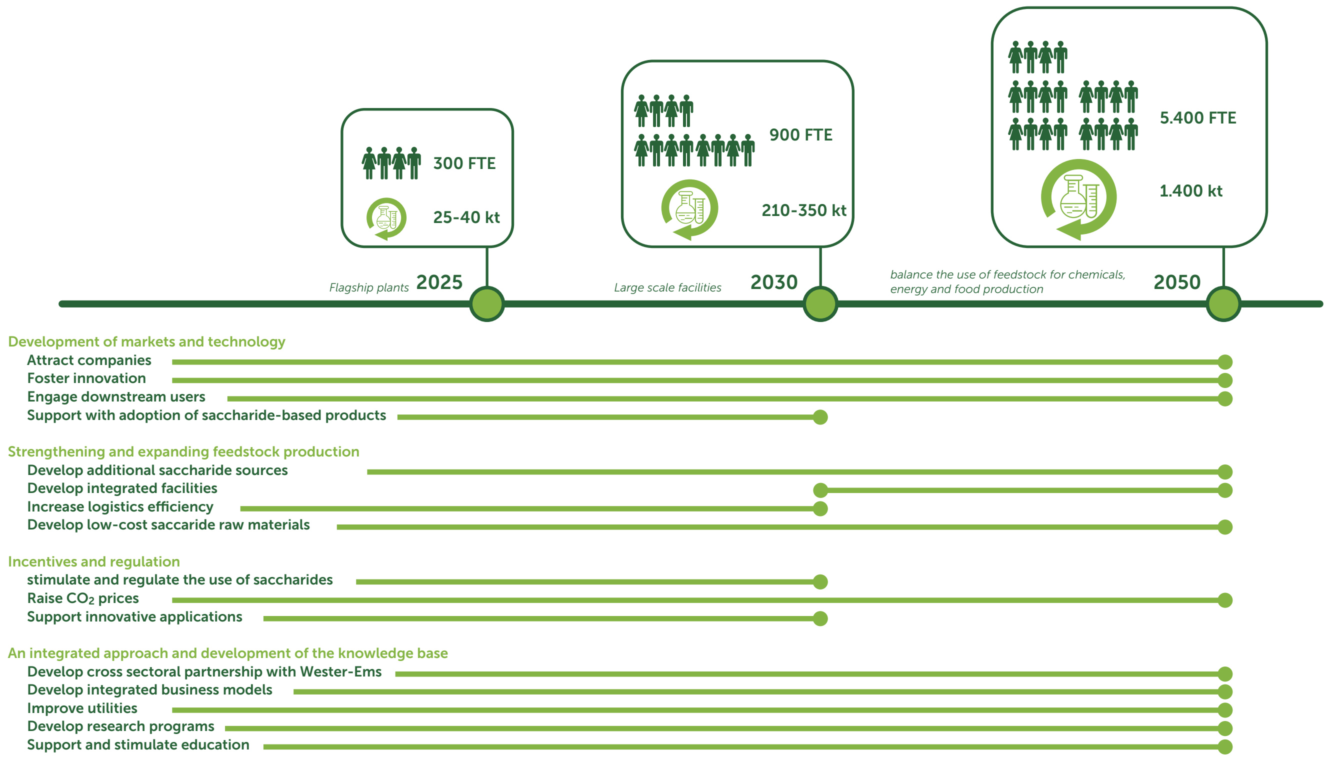
Saccharide Agenda

Summary

In light of our ambitions to drastically reduce carbon emissions, as formulated in the Dutch climate agreement, we must realize a transition from fossil to renewable carbon when producing chemicals and materials. Saccharides are a valuable and readily available source of renewable carbon and therefor a suitable platform for chemicals. Evaluation of typical saccharide-based value-chains by industry experts reveals unique opportunities to produce renewable intermediate chemicals and polymers from regionally available agricultural products and imported feedstock in the period up to 2050. Realization of these opportunities will significantly reduce carbon emissions, give rise to opportunities for existing and future chemical industry in the region and create and preserve jobs in the Chemport region. Changes and improvements in agricultural production and investments in production facilities and infrastructure are necessary. However, industry, government and other stakeholders have to overcome a number of challenges in order to realize a prominent role in a bio-based economy for the region. A saccharide roadmap helps the stakeholders involved to work towards realizing a future of the Chemport region as a major producer of saccharide-based chemicals in the period 2020-2050. Important focus areas of the roadmap are (1) development of technologies and markets, 2) strengthening and expanding feedstock production, 3) development of incentives and regulations and 4) further development of an integrated approach, cooperation and improvement of the knowledge base.



** Impact calculation: FTE: 75 employees per plant, multiplier of 2 for indirect labour; a multiplier of 5 is used to extrapolate the cumulative values from 2030 to 2050*

Kton products which can be produced · *Capacity of plants* · *Required investments* · *Estimated development time* · *Feedstock requirements* · *(In) direct FTE for operating plants*

1. Introduction

The Dutch climate agreement, based on the Paris agreement on global warming and CO_2 reduction, calls for a 49% reduction of greenhouse gas emissions by 2030 and CO_2 neutrality by 2050[1,2]. In the Netherlands the Chemport region (Box 1) is a frontrunner in reducing CO_2 emissions with an active strategy that led to a 44% reduction in 2020[3]. This was achieved mostly by improving efficiency of production processes[3].

Box 1: About the Chemport region

"The Chemport region is an ecosystem in the Northern Netherlands where companies that are committed to develop a green chemical sector can flourish. Companies, knowledge institutes and government together create the conditions for transformation and green growth of the chemical industry."

The Chemport region is characterized by two large chemical clusters (Delfzijl and Emmen), large acreage of agricultural land, knowledge institutes that function as talent pools and innovation hubs and excellent rail-, road- and waterway connections. Over 50 globally operating companies in the chemical, energy, food processing, recycling and material processing industries form the heart for the regional economy with direct employment of about 15.000 FTE[16] and considerable impact on indirect employment as well.

The Chemport region covers the North of the Netherlands and is well connected to the German Weser-Ems region. The areas combined cover about 1,5 mln hectares of agricultural land.

Industry in the Chemport region has several options to further reduce CO_2 emissions[2,4], including recycling or circular chemistry[5] and shifting towards bio-based feedstock[6]. By using these concepts, the chemical industry has the potential to decrease greenhouse gas (GHG) emissions in its own processes as well as in its downstream processes, and can act as a catalyzer for other industries[1,7]. In the long term, renewable carbon from biomass is essential to meet the stated goals and realize a carbon neutral economy, while meeting the demand for all kinds of essential products (Box 3)[8]. This agenda specifically addresses the potential of synthesizing (di)alcohols and (di)acids from saccharides as the the two most promising groups of molecules.

Saccharides ("sugars") are versatile platform molecules from a biogenic source like agricultural crops, agricultural residues or wood. After conversion trough fermentation or chemical processes they can be used to produce chemical building blocks. (Box 2)[9]. Currently, most saccharides are used directly in food, but they also appear in other applications including, chemicals and polymers. Potato starch in its polymeric form for example has a long history of non-food usages (adhesive, rheology modifier).

As part of its strategy to develop a sustainable chemical industry in the Northern Netherlands, Chemport Europe aims to accelerate the transition in the Northern Netherlands towards saccharide-based chemicals and align the innovation strategies and investments of key players in the field. This agenda provides a vision and a roadmap that demonstrates how the current set-up of the Chemport ecosystem can be developed into a saccharide-based chemical cluster, with significant impact on sustainable regional employment and economic growth.

2 . Saccharides in the Chemport Region

The Chemport region is well suited to use saccharides to strengthen its economic position, create and preserve jobs in the region and decrease environmental impact. On the demand side, the region can adopt saccharide-based molecules and integrate them in existing value chains of chemicals. On the feedstock side, the region has the potential to use and reinforce the already strong position in agriculture (Box 4) and can also make use of its logistic possibilities.

2.1 Saccharide-based chemicals

The integrated industrial clusters in the Chemport region at Emmen and Delfzijl both produce intermediate chemicals and polymers. Currently, industry develops flagship plants and new production facilities for renewable chemicals based on chemical conversion of biomass. In the future, numerous intermediate chemicals and polymers can be obtained from saccharides after chemical or fermentative conversion (Box 2 and figure 1)[9,10].

Box 2: Fermentation and chemical conversion

Fermentation is a widely used method of converting saccharides into chemicals. In addition to bulk chemicals like acetic acid, higher value fermentation products, such as 1,4 BDO are within reach. Saccharides can also be used in chemically catalyzed processes. By using selective dehydration, oxidation and hydrogeneration saccharides can be converted into products like furandicarboxylic acid, monoethylenegycol or sorbitol.

The oxidation state of saccharides makes them very suitable to synthesize (di)alcohols and (di)acids, because the oxygen atoms required in the products are already present in the starting molecules. In the Chemport region products like mono-ethylene glycol (MEG), propylene glycol, butanediol, phthalic acid, furandicarboxylic acid and succinic acid can be used to produce polymers. Ultimately, these polymers will find their way into valuable and necessary everyday products, like clothing, electronical devices, machinery and cars.

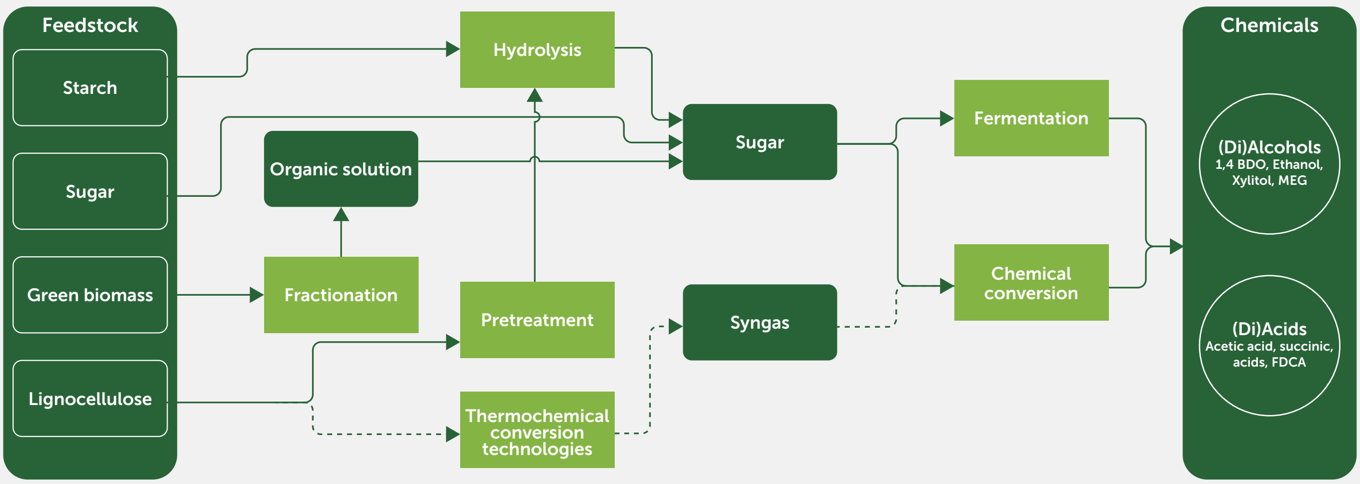


Figure 1: Conversion methods from feedstock through sugar to (di) alcohols and (di) acids

Box 3: CO_2 in a fossil free economy

European industry needs 300 Mton of CO_2 annually to produce materials like polymers, fibers and steel[8]. Due to a lack of market incentives this carbon is mostly fossil based. However, in a fossil free future, bio based sources like saccharides and biogenic waste materials will be the important sources of renewable carbon.

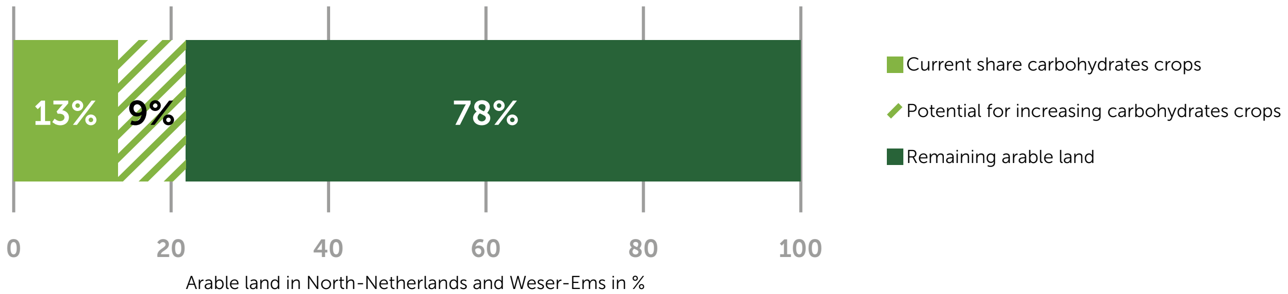
2.2. Feedstock

To meet market demand in the long term, to facilitate specific applications and to be able to respond to fluctuations, different saccharides sources are needed like woody biomass, agricultural crops and agricultural residues (Box 5). Compared to other options, growing crops in the region is an efficient way to produce saccharides. In the Chemport region these 1st generation saccharides are already available in larger volumes (Box 4) and provide a promising starting point for the transition.

In recent years, innovative technology has been developed to produce 2nd and 3rd generation saccharide (Box 5). The Dutch SME Avantium has built a pilot plant at the Chemport Innovation Center (CIC) in Delfzijl to convert woody biomass into pure glucose, mixed saccharides and lignin. This is the first company in the region with a dedicated focus on using saccharide as a platform for chemicals.

Box 4: Saccharides in the Chemport region

In Europe and the Netherlands, saccharides are mainly produced from sugar beet. Other crops are also suitable for the production of saccharides, but the yield from sugar beet is high and has increased significantly compared to potatoes and wheat. The Netherlands has the highest saccharide/ hectare yield (14 ton/hectare in 2016/2017) of the major European saccharide producing countries[11]. Saccharide production in the Netherlands has increased as a result of improved and more resistant sugar beet varieties, more efficient harvesting techniques, the higher average temperatures and more CO_2 which stimulate growth within the Netherland. The Chemport region is an important producer of saccharide from sugar beet and starch from potatoes[8]. The figure below shows the current share of arable land which is used for carbohydrates and the potential for increasing it[4][G].



Box 5: use of 1st, 2nd and 3rd generation saccharides

1st generation saccharides are produced from crops, like sugar beet or -cane corn, wheat and also potatoes. 2nd generation sugar is produced from woody biomass, 3rd generation sugar is derived from residual streams. 1st generation saccharides can be produced efficiently in the region with high yields per hectare and are already available in large volumes. For reasons of sustainability, the use of 1st saccharides produced in the region is preferable above imported feedstock from sugarcane[14]. 2nd and 3rd generation saccharides are less developed but also promising.

3. Opportunities for the Chemport region

For this agenda, a set of typical value chains has been selected to demonstrate the possible economic, environmental and societal impact of the transition towards fossil free saccharide-based chemicals in the region. Reviewing this set of possible value chains allows us to identify challenges related to the region as well as to business and policy.

The identified opportunities have been put into a bigger and long-term perspective which covers time horizons from today to 2025, from 2025 to 2030 and from 2030 to 2050. In the following sections, potential value chains (box 6) and their impact are presented for these time horizons. Value chains in the time-scope until 2025 are already developed and on a path to commercial application. For the time scope after 2025, value chains can be considered as likely but also dependent on changing conditions.

Box 6: Typical value chains to identify challenges and opportunities

For this agenda, industry experts have selected typical value chains which, based on their characteristics, could be realized in the Chemport region. These chains are combined into one possible future scenario.

For selection of the value chains, industry experts have considered criteria related to technical, economic and geographical feasibility. For each value chain the fit with the region was estimated based on the potential to connect to existing efforts in the region. Examples of this are the existence of flagship plants and the availability of downstream usage. Economic and technological feasibility have been assessed by looking at the bankability of investments based on CAPEX, current- and expected future technology readiness level (TRL) and market potential. Market potential is assessed by looking at production costs, current demand and expected development of markets.

3.1. Current and near future development (<2025)

The selected initiatives within the time scope until 2025 have a focus on the use of both 1^{st} and 2^{nd} generation saccharides. Pilot plants in the Chemport Industry Campus are already producing glucose and mixed saccharide streams from woodchips and mono ethylene glycol (MEG) from sucrose/starch feedstocks. At the moment plans are being realized to scale-up these facilities to commercial plants. In theory, both 1^{st} and 2^{nd} generation saccharides can be used by facilities that produce butanediol (1,4-BDO) and furandicarboxylic acid (FDCA). These intermediate products are the basis for other intermediates and polymers in the Emmen polymer cluster[A] and ultimately end users around the globe. Some of these products, e.g. 1,4 BDO, already have a competitive cost price compared to their fossil counterparts. Figure 2 shows the requirements and effects for setting these plants.

1,4-BDO is a drop-in chemical used in the production of engineering plastics. A total of 25% EU production is currently located in the Netherlands. Biobased production of BDO has some clear advantages over fossil-based production: the technology is mature, production costs per ton are lower and greenhouse gas emissions are 70% lower. In view of the growing demand for PU, Spandex and PBT, BDO production based on fermentation of sucrose is an interesting opportunity for the region. Currently DSM in Emmen is using 1,4-BDO, which shows the potential synergy in the region.

FDCA is a molecule that isn't currently produced on an industrial scale. It is however an important base for the production of PEF, a technical superior, 100% biobased alternative to PET (plastic bottles / films). In addition, PEF can also be used for the production of fibres, e.g. carpets and textiles. The Chemport region is committed to invest in upscaling production facilities, with land reservations in Delfzijl and financial support from the Province Groningen. Also, synergy with the polymer cluster in Emmen makes an FDCA flagship plant an important near future bio-based opportunity for the Chemport region.

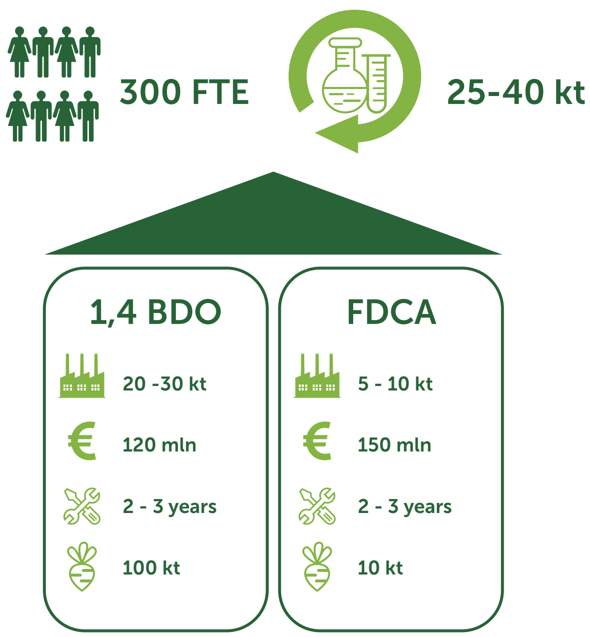


Figure 2: Requirements and impact of 1,4 BDO and FDCA plant

3.2. Vision on midterm development (2025 – 2030)

New opportunities for saccharide-based industry in the Chemport region will evolve, as alternative sources (like S4F)[B] and new technologies for processing saccharides will mature and become available at commercial scale. This will improve the competitiveness of saccharides compared to fossil alternatives and will support the development of markets for bio-based chemicals. In addition to FDCA and 1,4 BDO, the Chemport region can become a producer of chemicals such as mono-ethylene glycol (MEG), polyhydroxyalkanoates (PHA), xylitol and acetic acid. The market volumes of these products are relatively large and total costs and efficiency of conversion are important enablers for the business case. Ongoing innovation in production of feedstock and conversion technology remain important for the industry.

The large industrial facilities for the production of saccharide-based chemicals will have a significant physical and economical footprint that fits well with the industrial ports of Eemshaven and Delfzijl (Box 7). The ports can also offer the required building space for production plants, logistic facilities that guarantee efficient handling of feedstock and products, enough storage capacity for safety stock, central utilities to support production plants and short connections with downstream producers. For example, the industry can make use of the cranes and quays that are currently being used for the import, handling and storage of coal. These facilities could also be used for the handling of dry biomass for production of cellulose and lignin.

By 2030, saccharide-based chemicals produced in the Chemport region can replace the production of up to 310 kton of fossil-based chemicals. Total investments in these kinds of facilities are around €500 mln[C] and could result in a combined annual demand for feedstock of over 1,000 kton and a related employment of 600 direct jobs in the region[D], figure 3.

Box 7: Imports and logistics

By 2030, additional saccharide imports from overseas might be needed to fulfill demand. Transport of saccharides overseas is typically done by midsize bulk carriers with a capacity of around 50,000 tons. These vessels require the kind of port infrastructure that is offered by the service providers in the ports of Eemshaven and Delfzijl. These ports are well equipped with basins deep and big enough for Handysize and Supramax carriers. Current storage capacity in the sugar terminal Eemshaven is 100,000 tons. According to the industry experts[8], this is more than sufficient for the required safety stock of industry of approximately 2 weeks.

Selected cases

Four different potential value chains have been identified that could develop between 2025 and 2030: PHA, MEG, Xylitol and Acetic acid. From a technological point of view, other products are also possible. However, these are not yet commerciallly or economically feasible. Ethanol production from saccharide for example is a mature technology, but due to the low market value, production in the Netherlands is not considered competitive with other regions. However, in the future, ethanol production could become viable if large quantities of residual streams from other bio-based processes with impure feedstock become available at competitive prices.

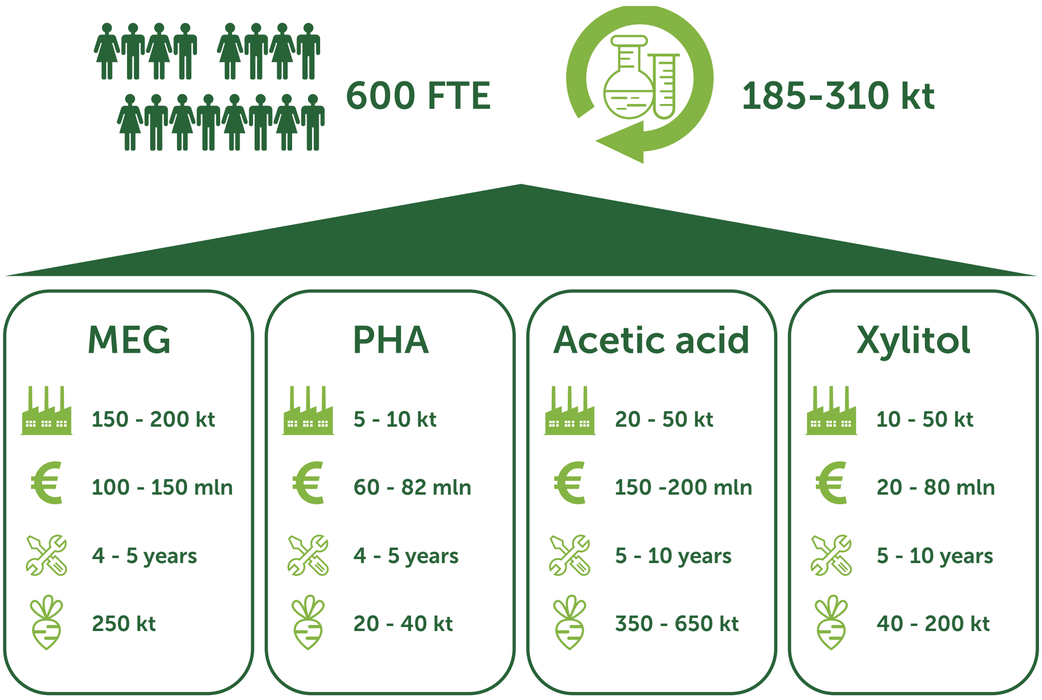


Figure 3

- **MEG** is currently mostly used for the production of PET. The main application of PET is plastic bottles and textile fibers. Bio-MEG can be used to produce 100% Bio-PET. The market for MEG is expected to grow rapidly in the coming years, from 28.000 kton currently to 50.000 kton annually up to 2035[9].

- **PHA** is seen as a promising bio-based polymer because of its biodegradability and some of its other physical properties. PHA is currently being used in niche applications, but cost reduction could lead towards growth in larger markets like packaging or coatings for fertilizers. This will create a potential market in the EU of 10,000 kton per year, compared to current market of 16 kton. Since the European producers currently produce only about two percent of the global market, a European plant could be a profitable investment[17].

- **Acetic acid** is widely used as raw material in the production of industrial chemicals and solvents and in the food, pharmaceutical, textile and cosmetics industry. The global market for Acetic acid is about 14,000 kton of which nearly 10% is being produced within the EU. Although biobased acetic acid is currently up to 30% more expensive than fossil based acetic acid, the large volume market of acetic acid and its wide range of applications make it an interesting product[8].

- **Xylitol** is a naturally occurring sweetener with 40% less calories than sugar. Xylitol can be produced from lignocellulosic biomass which is converted into Xylan and then Xylose. It can also be produced in coproduction with ethanol where it significantly improves the ethanol business case since Xylitol has a much higher market value than ethanol[9]. Currently production of Xylitol is mainly located in China, European production accounts for roughly 25% of the global annual production of 200 kton.

3.3. Long-term development (2030- 2050)

Driven by the need and ambition of the industry to be CO_2 neutral in 2050, more fossil feedstock for the industry must be replaced by renewable alternatives in order to reach the goals of the Paris Agreement. Next to recycling and circular chemicals, bio-based feedstock like saccharides are an essential part of this transition. Therefore, the demand for saccharide is expected to increase significantly which means that innovations are required. Low-energy conversion technology and the increased use of feedstock like saccharides will allow the industry to balance the use of feedstock for chemicals, energy and food production. This kind of innovation could lead to the development of additional value chains and facilities for the processing of saccharides. Figure 4 shows the quantified effects that these plants might bring to the region[E].

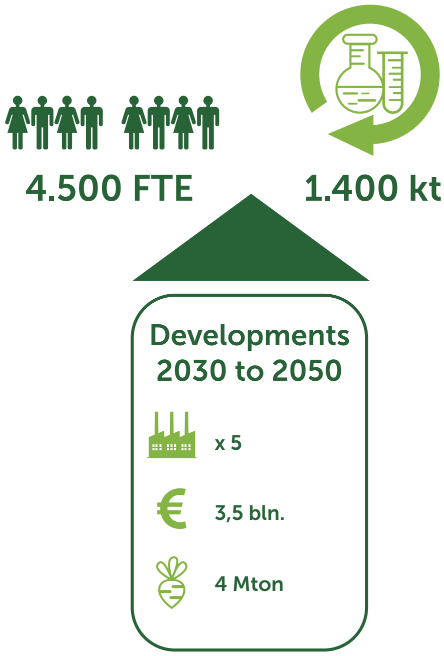


Figure 4: Estimated effects from 2030 to 2050

Succinic acid

A typical example of an innovative solution is a process in which locally available residual wood is being fermented into succinic acid (figure 5)[12]. The idea to produce succinic acid from biomass is not new, but technological advances are needed to develop successful business cases.

Succinic acid can be used for the production of polymers or resins. When technology reaches maturity, succinic acid can be produced through fermentation of residual materials with locally available residual heat as an energy source. This gives a small environmental footprint that can become even smaller when process residues are used to improve soil. These small scale and circular processes hold the promise to optimize the use of feedstock for all applications and keep capital costs relatively low.

Next to succinic acid, technology can enable the production of numerous other intermediate chemicals. An example is the conversion of beet residues and potato pulp into organic acids. By adding these type of business cases to the mix, saccharide-based building blocks will become more important in the chemical sector between 2030 and 2050.

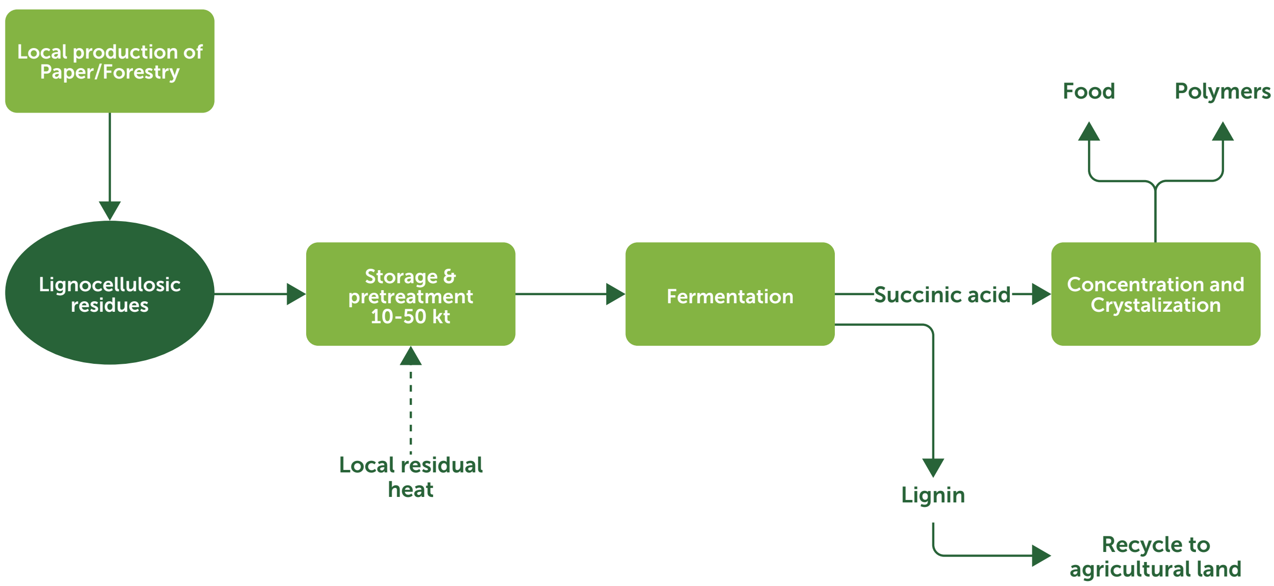


Figure 5: Innovative process for the production of succinic acid

4. Impact & challenges

4.1 Impact

Over time the impact of saccharide-based industry on the region can be substantial, and it can play an important role in a new economic perspective of the Chemport region. Saccharide-based industry reduces carbon emissions throughout value chains and offers new opportunities for research and jobs in a region that is currently marked as highly dependent on fossil resources[13]. The value chains and the future perspectives indicate that by 2050 1,75 Mton of chemicals can be produced from saccharides. This equals about one fourth of the total amount of chemicals currently produced in the Chemport region[3]. If the facilities in this agenda are realized they will account for 5.400 jobs in industry and logistics. The transition of resources for industry might also affect the agricultural sector, as it offers a new economic perspective for farmers as producers of feedstock for both food and materials.

4.2 Challenges

Despite the opportunities it presents, the transition to a saccharide-based industry in the Chemport region won't come easy. In addition to the required transition of the regional ecosystem, various technological, regulatory and economical challenges that need to be overcome.

Regional challenges

- Landuse: there is no level playing field vis-a-vis production of corn for biogas (200.000 ha in the Weser-Ems region)[4].
- The exemplified development of industry will require skilled workers. Current labor markets for these professionals are tight, not only in the Chemport region, but also in the wider region.

Business challenges

- Conversion costs of saccharides into bulk chemicals are relatively high compared to the value of these chemicals.
- Global markets for biobased chemicals are underdeveloped
- The costs of bio-based products remain relatively high compared to fossil in most cases.
- Investors are hesitant to invest in capital intensive facilities.

Technological challenges

- Downstream processing of saccharide-based intermediates can be costly.
- Concentration of saccharides from crops requires a substantial amounts of energy.
- Saccharide syntheses produces unwanted by-products.
- Fermentation processes can be costly.
- Production of modifying enzymes that are needed for fermentation is expensive.

Policy challenges

- Creating a biobased industry is underexposed in government policy on all levels. Currently the focus in policy is on the circular economy, and carbon-free energy sources and on circularity in order to decrease CO_2 emissions.
- Incentives for the compensation of the higher cost of biobased products compared to fossil alternatives are not provided by current national and European policies (unlike for energy).
- Keeping industrial facilities in the region is not part of national or European policy (although it is essential for the ecosystem and much easier than developing or attracting new industries).

5. Saccharide Roadmap

In the long term, biobased resources will be used for materials, food and (to a limited extent) for energy. The challenges that arise from this combination of applications requires an integral approach that aligns goals and activities of the agricultural sector, industry, policy makers and others.
A saccharide roadmap can help the stakeholders involved to work together on the future of the region as a major producer of saccharide-based chemicals in 2050. Until 2025, the focus of the roadmap is on preparation for upscaling and strengthening the existing base of the region. Towards 2030, the focus shifts to scaling up production and efficient handling of resources. The long-term scope until 2050 covers development and implementation of new technologies that can be used to develop new materials and minimize the impact of the production of saccharide-based chemicals.

5.1 Development of markets and technology

The industry focusses primarily on lowering the cost and improving quality of selected products by developing pilots and technologies at company owned facilities. This is supported in the Chemport region by lab and pilot facilities in Emmen, Delfzijl and at Campus Groningen. When companies are successful in developing competitive products, they may want to get involved in for large scale development in the industrial clusters. Business cases for these companies can be accelerated by developing downstream processing for different intermediate products and by using the infrastructure for transport and handling that is already in place. New industry can also make use of nearby downstream users of their products and the presence of a substantial chemical sector in the region.
A crucial element for all business cases is that they support production of saccharides in an ecologically and economically sustainable way.

Strategic actions

1. Attract companies with biobased ambitions and business cases that support sustainable production through the value chain
2. Foster innovation by industry to develop reliable and competitive processes
3. Engage downstream users for different (intermediate) products (i.e. DSM)
4. Support existing clusters to adopt of saccharide-based products

5.2 Strengthening and expanding feedstock production

Towards 2025 a potential increase of beet sugar production of 15% in the region[F] an increase in the use of woody biomass are sufficient to cope with the increasing demand for saccharide-based chemicals. However, based on the perspectives in this agenda, demand for raw feedstock for chemicals and materials could multiply up to 30-40 times by 2050. For the required additional saccharides the nearby Weser – Ems region could be a viable option, complemented by imports through the ports of Eemshaven and Delfzijl. The industrial ports are also ideal sites for the processing of saccharides into chemicals and the integration and alignment of these facilities with the facilities already in place for downstream processing, logistics or energy production. In the long term the shifting balance towards the production of molecules from biomass could provide an alternative business case for the infrastructure in the ports and on industrial sites.

Strategic actions:

1. Develop additional saccharide sources in the region (through regional development and/or import)
2. Develop co-siting and integrated (logistic) facilities for saccharides in the ports
3. Develop efficient logistics towards ports and downstream processors of saccharides and intermediate products
4. Develop low cost saccharide raw materials

5.3 Incentives and regulations

To support a competitive, sustainable and independent European industry, governmental organizations have a role in supporting innovation and in stimulating and regulating the use of saccharides and other renewables for chemical applications. Initiatives in general look for governmental support to mitigate risk on their endeavors or remove roadblocks. Guaranteed offtake for instance is an effective way to reduce risk for new business cases. A necessary condition for bio-based chemicals markets to develop is a level playing field with energy applications of biomass and circular resources.

Strategic actions:

1. Stimulate and regulate the use of saccharides for chemicals
2. Raise CO_2 prices to create a level playing field for biobased chemicals, energy and circular chemistry
3. Support innovative applications of saccharide-based products through a guaranteed offtake

5.4 An integrated approach and development of the knowledge base

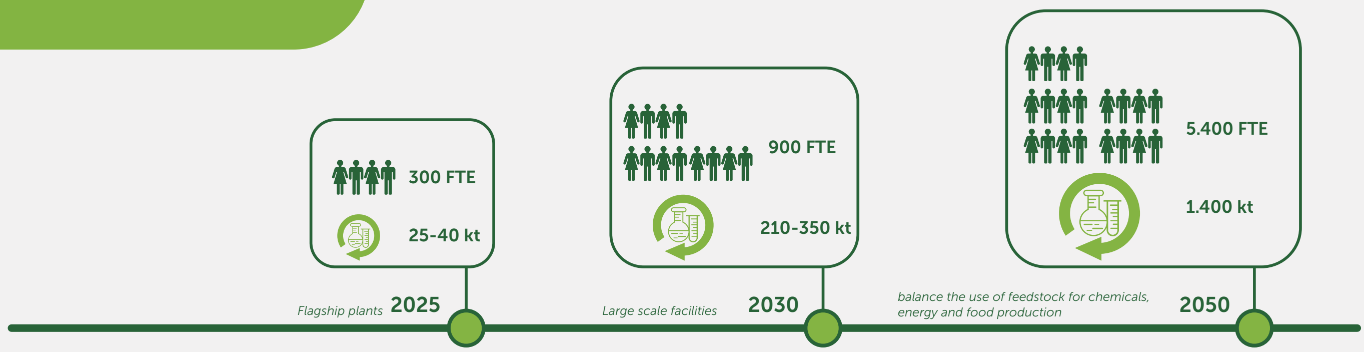
In a future chemical industry, renewable carbon from saccharides needs to be applied in combination with residual products, renewable hydrogen, CO_2 and other circular chemicals. Low-energy conversion technology and the use of residual heat from powerplants, chemical plants or datacenters could also be important elements in a future ecosystem. Public and private infrastructure and utilities are important to connect supply and demand in an efficient way.

R&D departments of the industry, universities, competence centers and governmental organizations have to make sure that innovation capacity in the Chemport region is being utilized to develop the technology that is needed to integrate sustainable options in the clusters. Also, schools for vocational education on all levels are needed to support the development and assure the availability of blue- and white-collar workers for the industry.

Strategic actions

1. Develop cross-sectoral partnerships in the Chemport region and Weser-Ems region between the agricultural-, food-, feed-, chemical- energy- and waste industries to create synergies and circular use of molecules.
2. Develop integrated business models with maximum valorization of (intermediate) products within the ecosystem
3. Develop utilities to connect and energize facilities in an efficient way (heat, water for industrial use and other)
4. Develop a national and European research program with a focus on the circular use of saccharides-based chemicals and the use of residual products and residual heat
5. Support and stimulate biotechnology and technology oriented educational programs on all levels

Roadmap



Development of markets and technology
- Attract companies
- Foster innovation
- Engage downstream users
- Support with adoption of saccharide-based products

Strengthening and expanding feedstock production
- Develop additional saccharide sources
- Develop integrated facilities
- Increase logistics efficiency
- Develop low-cost saccaride raw materials

Incentives and regulation
- stimulate and regulate the use of saccharides
- Raise CO_2 prices
- Support innovative applications

An integrated approach and development of the knowledge base
- Develop cross sectoral partnership with Wester-Ems
- Develop integrated business models
- Improve utilities
- Develop research programs
- Support and stimulate education

** Impact calculation: FTE: 75 employees per plant, multiplier of 2 for indirect labour; a multiplier of 5 is used to extrapolate the cumulative values from 2030 to 2050*

Kton products which can be produced | Capacity of plants | Required investments | Estimated development time | Feedstock requirements | (In) direct FTE for operating plants

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(A) Once produced these products can be used by different industries around the globe to produce polymers and plastics. BDO can be used in the Emmen chemical cluster by DSM.
(B) S4F is the abbreviation of Sugar for Fermentation, defined as sugars suitable for fermentation but cheaper than crystal sugar and nod competing with crystal sugar (Sanders, J, 2020)
(C) Estimation based on capacity of facilities and price level May 2020
(D) Estimation based on 75 employees per plant and a multiplier of 2 for indirect labor
(E) In order to quantify the possible effects in the time horizon of 2030 to 2050 a multiplier of five is used on the cumulative effects of time horizons up to 2025 and 2025-2030.
(F) Suiker Unie estimated an increased yield of sugar / ha from 14 ton in 2020 to 16,2 to in 2025.
(G) An rough estimate of the of current and potential arable land for the use of carbohydrates has been made based on previous research (4) and insights of the Project Team.

COLOFON

Saccharide agenda Northern Netherlands

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Johan Sanders - Sanovations
Olaf van Baal - Cosun Beet Company
Zea Strassberger - Nouryon