



Sourcing of feedstock for biopolymers

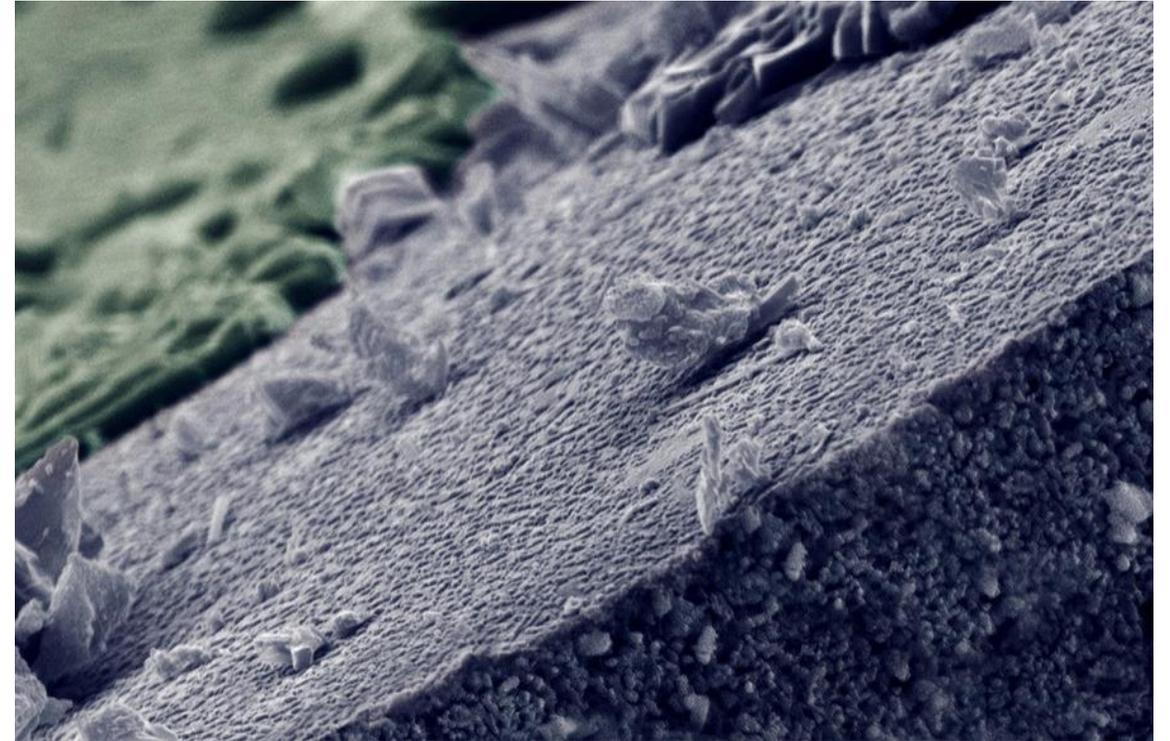
Haldor Topsøe MOSAIK™ Technology
Lars Storm Pedersen

Haldor Topsoe is a **world leader** in catalysis and surface science. We are committed to helping our **customers** achieve **optimal** performance.

We enable our customers to get the **most** out of their processes and products, using the **least** possible energy and resources, in the most **responsible** way.

Catalysis and surface science have a vital role to play

- Chemical processes are used in the production of countless everyday objects, including food, fuel, electronics, and medicine.
- Almost all chemical processes utilize catalysts, and more than 90% of all industrial products are made using catalysis in some way.
- In a catalytic process, catalysts promote the chemical reaction without being consumed by the process themselves.
- When a catalyst catalyzes a chemical process, the chemical reaction happens faster, using much less energy while also avoiding the production of unwanted byproducts.



Catalyst surface magnified to the micrometer scale in one of our electron microscopes.

Major political trends

Circular biobased economy



PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11



European Commission - Press release

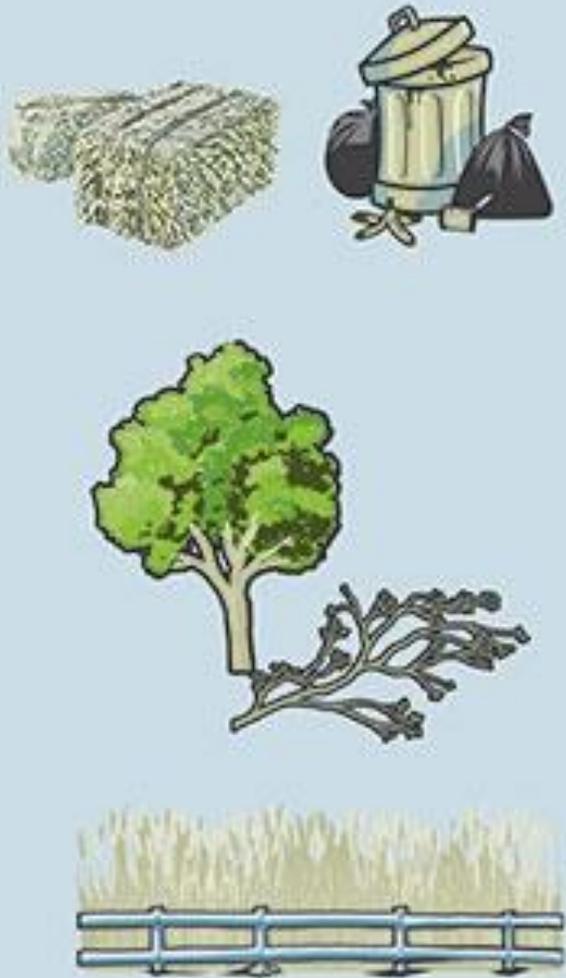
The Future of Food and Farming – for a flexible, fair and sustainable Common Agricultural Policy

Brussels, 29 November 2017

Simpler rules and a more flexible approach will ensure the Common Agricultural Policy (CAP) delivers real results in supporting farmers and leads the sustainable development of EU agriculture.



Biomass and waste



Bio-refinery



Fuel



Chemicals and materials



Feed and food ingredients



Market Pull for Bio-Based Polymers

Coca-Cola Produces World's First PET Bottle Made Entirely From Plants

By: The Coca-Cola Company | Jun 3, 2015

32 personer synes godt om dette. [Opret en profil for at se, hvad dine venner synes.](#) [SHARE:](#) [f](#) [t](#) [in](#) [p](#) [e](#) [t](#) [r](#) [s](#)



Breakthrough Innovation Showcased at World Expo Milan

MILAN, June 3, 2015 – The Coca-Cola Company today unveiled the world's first PET plastic bottle made entirely from plant materials at the World Expo - Milan. PlantBottle™ packaging pushes the boundaries on sustainable innovation by using groundbreaking technology to create a fully recyclable plastic bottle made from renewable plant materials.

RELATED STORIES



Mackenzie Anderson
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Driving Innovation: Coca-Cola and Ford Take PlantBottle Technology Beyond Packaging

NESTE & IKEA take leadership in bio-based home furniture

BY LEPITREB
September 9, 2016

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NESTE and IKEA join forces to industrialize and lead the trend of renewable bio-based materials for home furnishing plastic products.

Il Bioeconomista and other specialized publications relayed that Neste (Finland) and Ikea (Sweden) announced on September 7, 2016 a partnership to deliver renewable, bio-based plastics. The two Scandinavian companies plan to join forces to take leadership in renewable bio-based materials, and invite other companies to jump on the bandwagon of the initiative.

- **Ethylene glycol** is an existing large volume chemical used for **PET bottles** and **fabrics (polyester)**
- New products with new functionalities that are difficult to obtain from fossil sources

pepsi bio bottle [🔍](#)

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Ca. 584.000 resultater (0,49 sekunder)

Billeder af pepsi bio bottle



[→ Flere billeder af pepsi bio bottle](#)

[Rapportér billeder](#)

PepsiCo Develops World's First 100 Percent Plant-Based, Renewably ...

www.pepsico.com/.../PepsiCo-Develops-Worlds-First-100-Percent-... [↕ Oversæt denne side](#)
15. mar. 2011 - PepsiCo's "green" bottle is 100 percent recyclable and far surpasses existing industry technologies. The bottle is made from bio-based raw ...

Pepsi to launch 100% bio-based PET bottle | PlasticsToday

<https://www.plasticstoday.com/.../pepsi...bio...bottle/83680935915...> [↕ Oversæt denne side](#)
16. mar. 2011 - PepsiCo has used bio-based raw materials, including switch grass, pine bark, and corn husks, to create what it's calling the world's first ...

Coke and Pepsi foresee a biobased PET future for bottles ...

<https://www.plasticstoday.com/.../pepsi...biobased...bottles/6814445...> [↕ Oversæt denne side](#)
3. okt. 2011 - Fossil-fuel-based PET's days are numbered in the beverage market if you listen to two of the sector's biggest players, Coca-Cola and PepsiCo, ...

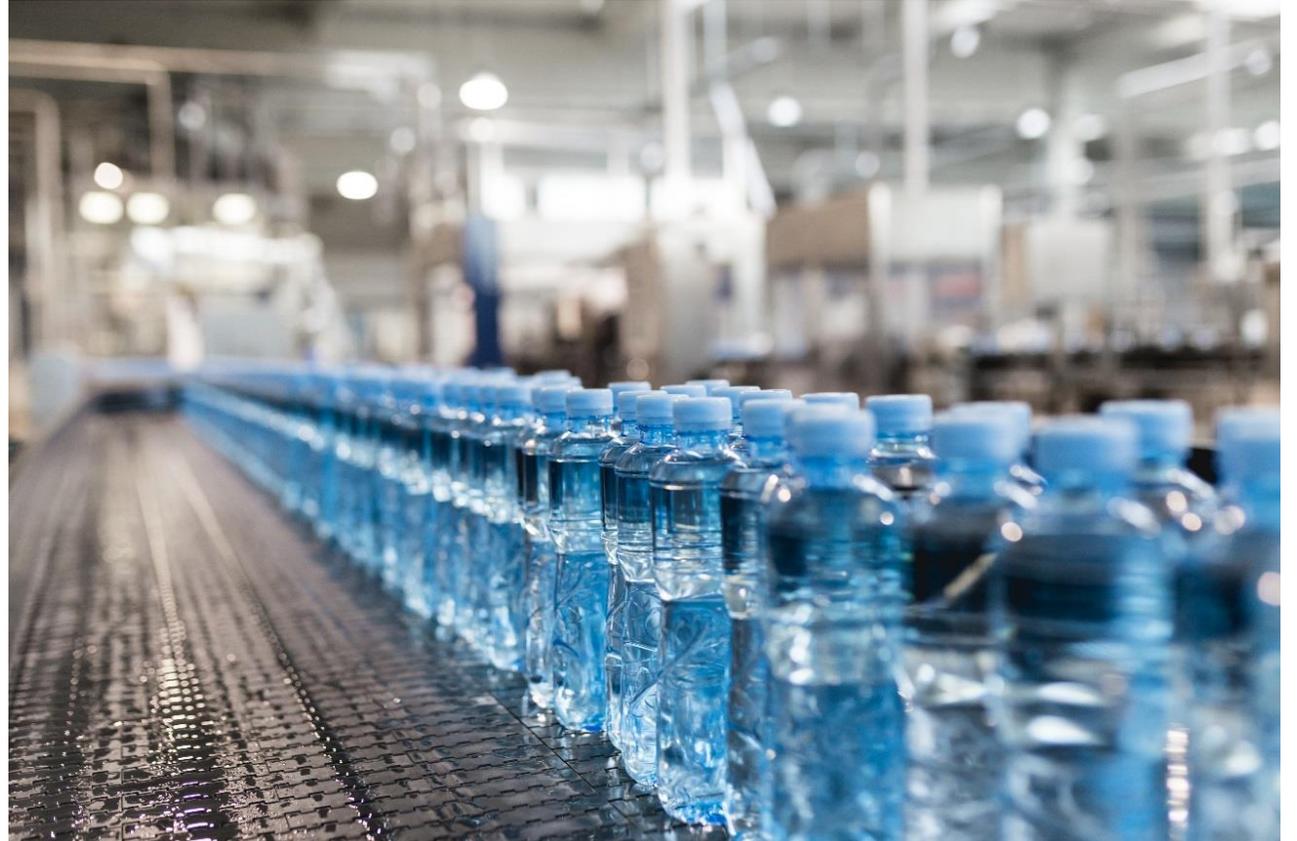
The Race to 100% Bio PET | Plastics Engineering Blog

<https://plasticsengineeringblog.com/2012/.../the-race-to-100-bio-p-...> [↕ Oversæt denne side](#)
13. aug. 2012 - That spurred PepsiCo in Purchase, N.Y. (www.pepsico.com) to counter on March 15, 2011, by announcing the world's first 100% bio PET bottle.

Can biomass replace oil?

In some cases, biomass can not only replace oil – it can be a better option.

- Biomass offers a lot of “chemical functions” that can be reused or slightly altered.
- The global production of bio-based polymers is expected to more than triple from 5.7 million tons in 2014 to approximately 17 million tons in 2020.
- Although the market share for bio-based polymers will remain small (4%) compared to oil-based polymers for years to come, the anticipated growth rates are far higher.



Predicted EU bio-based production and private investment in 2025

Product category	CAGR (%)	Bio-based production in 2025 (kt/a)	Total private investment (EUR million/a)
Platform chemicals	10	353	128
Solvents	1	80	16
Polymers for plastics	4	353	144
Paints, coatings, inks & dyes	2	1,151	437
Surfactants	4	1,974	805
Cosmetics and personal care products	3	687	349
Adhesives	10	462	195
Lubricants	1	254	63
Plasticisers	3	83	52
Man-made fibres	3	738	494
Total	2	6,134	2,683

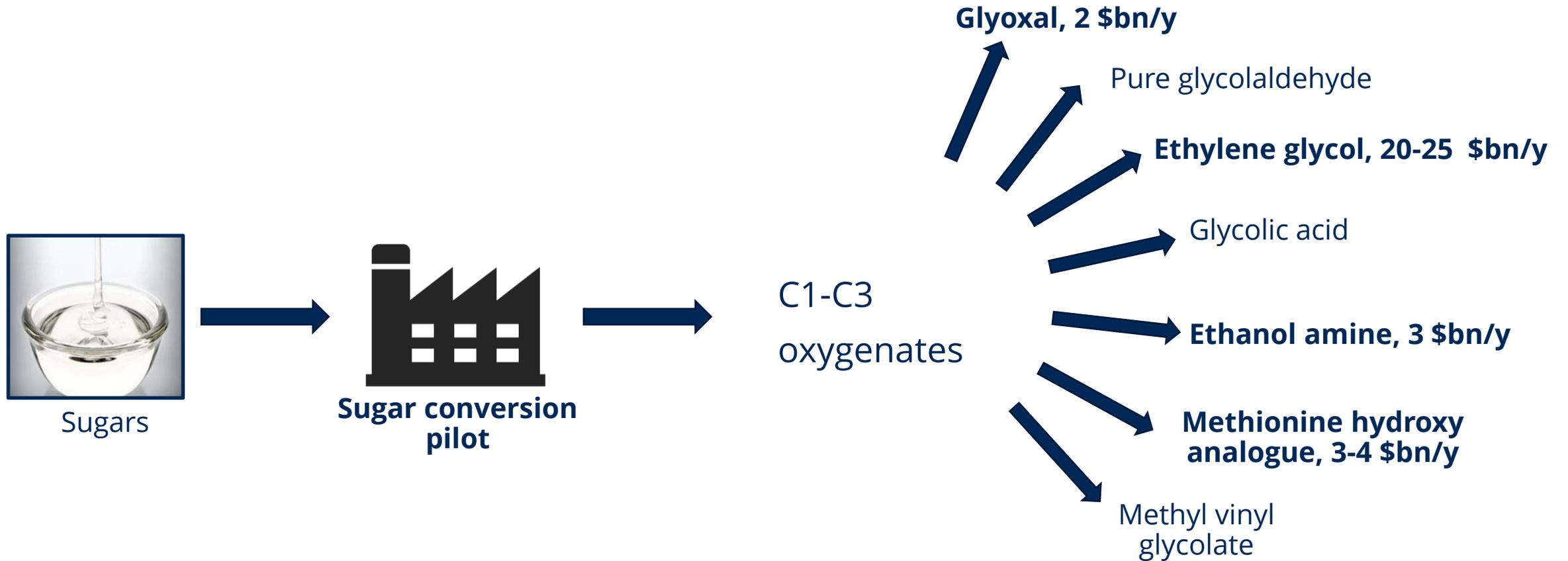
The shift from fossil-based to bio-based chemicals has moved closer

- Haldor Topsoe's MOSAIK™ technology produces chemicals from biomass at a cost that competes with that of traditional oil-based chemicals.
- Cost often put an end to the desire of lawmakers, industry, and consumers to replace oil with sustainable raw materials, such as biomass. However, new technology can change that.
- Haldor Topsoe researchers have devised a novel process that produces several chemicals from biomass – at an attractive cost that can compete directly with similar oil-based chemicals.



MOSAIK™ is a New Platform for Oxygenated Chemicals from Biomass

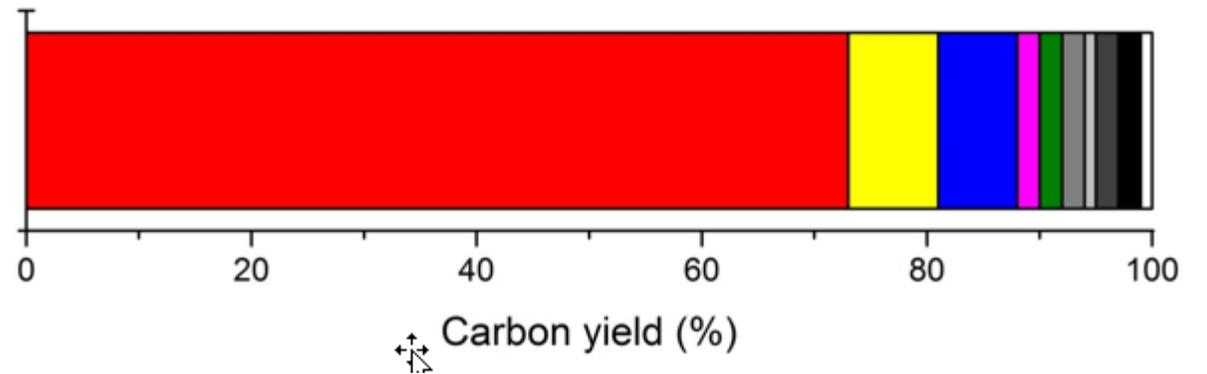
Oxygen retained in the C1-C3 is a competitive advantage compared to e.g. gasification



Product composition

C1-C3 oxygenate products

- Process is highly selective towards C1-C3 with 85% of carbon in useful compounds

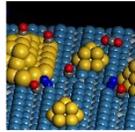


Overview of competing technologies for producing bio chemicals compared to MOSAIK™



Fermentation

- Suited for small scale chemicals production (acids) and large scale for simple alcohols.
- High TRL.
- Many different products accessible.
- Often expensive product purification, leading to high production costs.
- Important chemicals: ethanol, butanol, isobutanol, lactic acid, succinic acid, itaconic acid.



Catalysis

- Potentially suitable for large-scale chemicals production.
- Only few useful products directly accessible.
- Low TRL
- May lead to more intensive processing than fermentation, thereby lowering production costs.
- Important chemicals: sorbitol, gluconic acid, furfural, mixed glycols, (furan dicarboxylic acid, ethylene glycol, lactic acid)



Gasification

- Suited for large scale chemicals production.
- Existing chemical infrastructure can be used.
- High TRL.
- Not cost competitive with conventional routes.
- Important chemicals: methanol, methane, hydrogen, ammonia, formaldehyde.



Pyrolysis

- Enable direct conversion of raw biomass to a liquid product.
- Low-Medium TRL.
- Low cost method of processing the biomass.
- Very complex product spectrum in the bio-oil makes it unsuitable as a chemicals feedstock.



Sugar cracking

- Developed infrastructure for feedstock.
- High yields C1-C3 with few by-products.
- Enables economically feasible production of existing chemicals with large markets and production of new chemicals with promising applications.
- Product stable and thus easy to store and transport
- Need to increase TRL

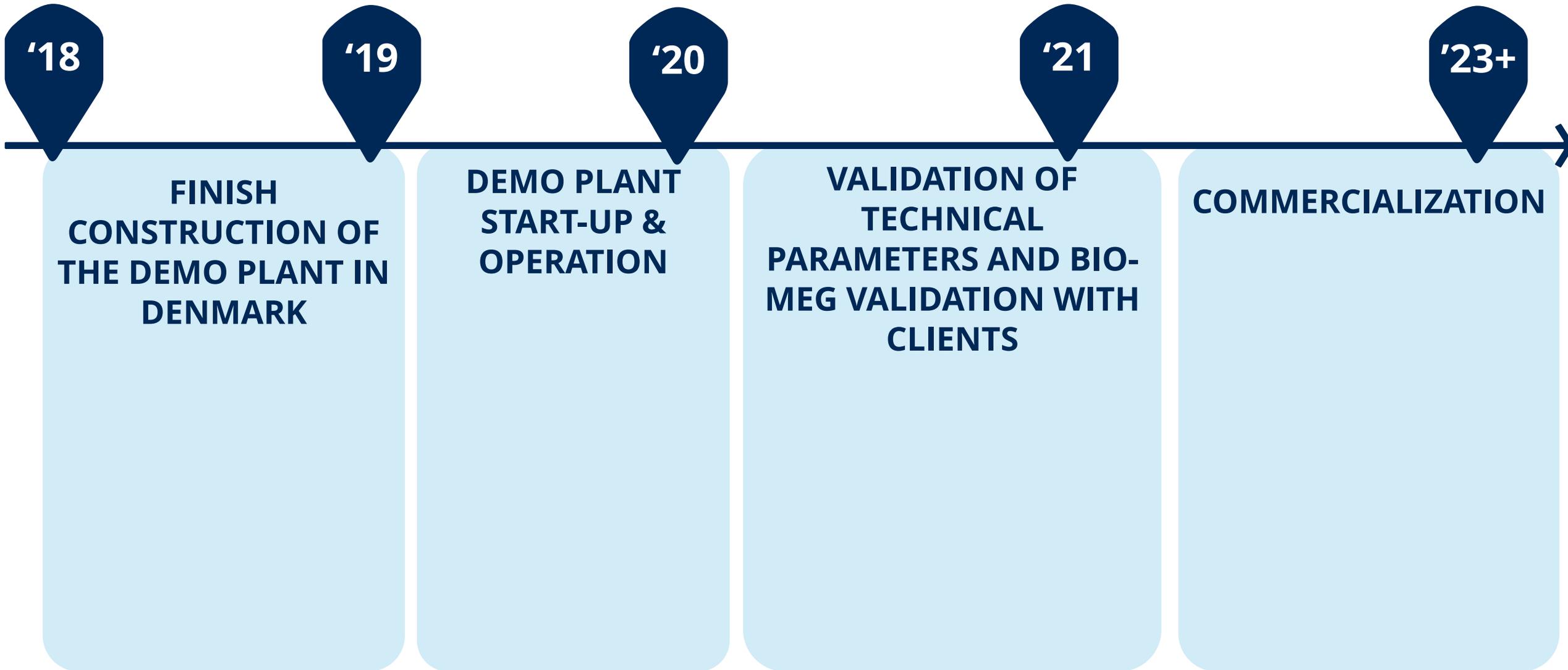
MOSAIK™

Partnerships

- In 2017 Topsøe and Braskem made a partnership to commercialize ethylene glycol production from Topsøe MOSAIK™ technology, based on sugar as bio feedstock
- Ethylene glycol is a platform chemical for PET plastics
- Innovation Fund Denmark also invested in the development of the MOSAIK™ technology platform in 2017

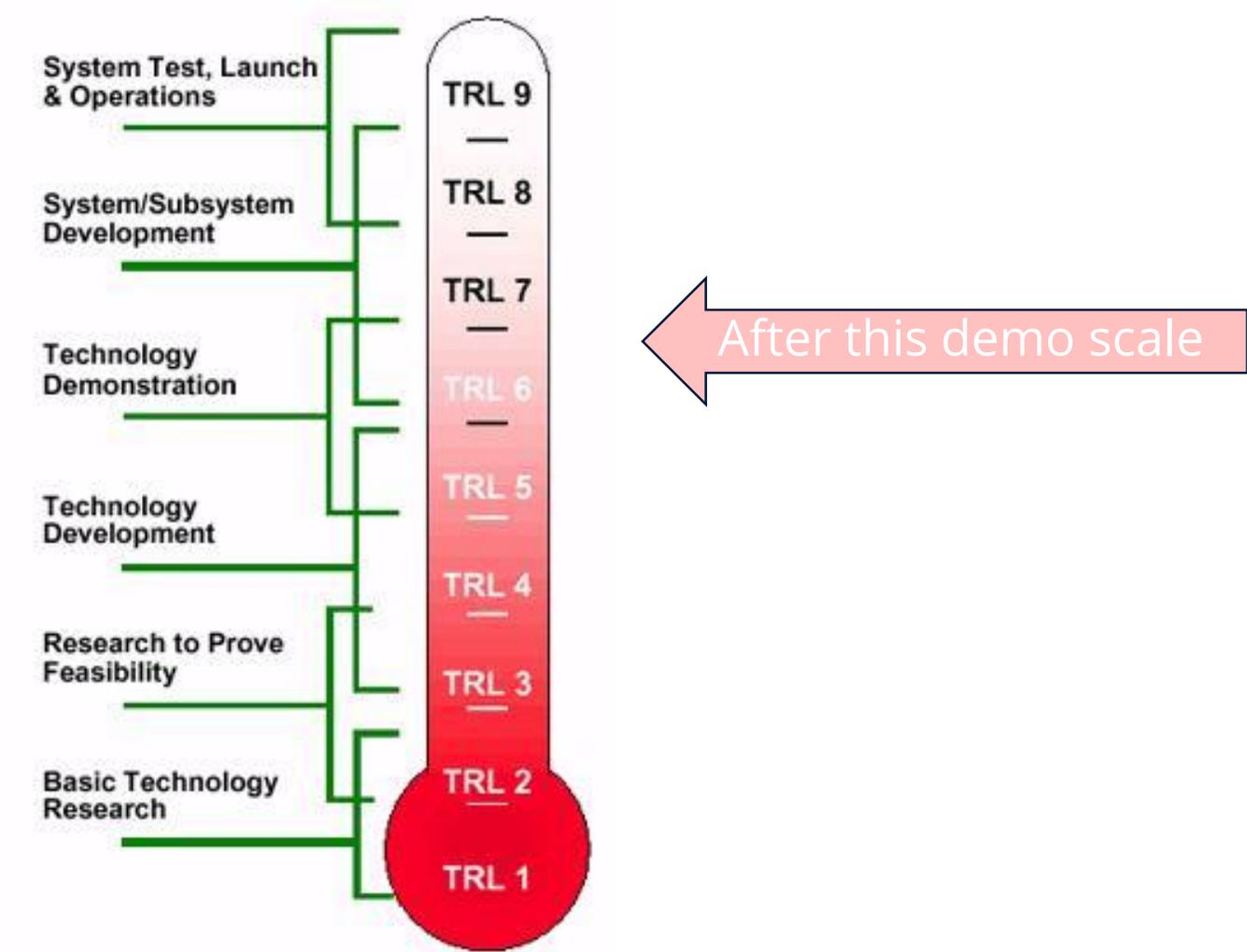


Timeline for demonstration & commercialization of Bioglycols with Braskem





MOSAIK™ Technology Readiness Level (TRL)



Conclusions

- The market for biobased platform chemicals is expected to grow in the next 5 years
- Our objective is to commercialize the MOSAIK™ technology which is a platform for a number of chemicals
- A full scale plant can be up running +2023 for producing a platform chemical for PET plastic