SAVONIA
University of Applied Sciences

Bio and Circular Economy

Utilizing Industrial Side Streams for Circular Economy Savonia University of Applied Sciences

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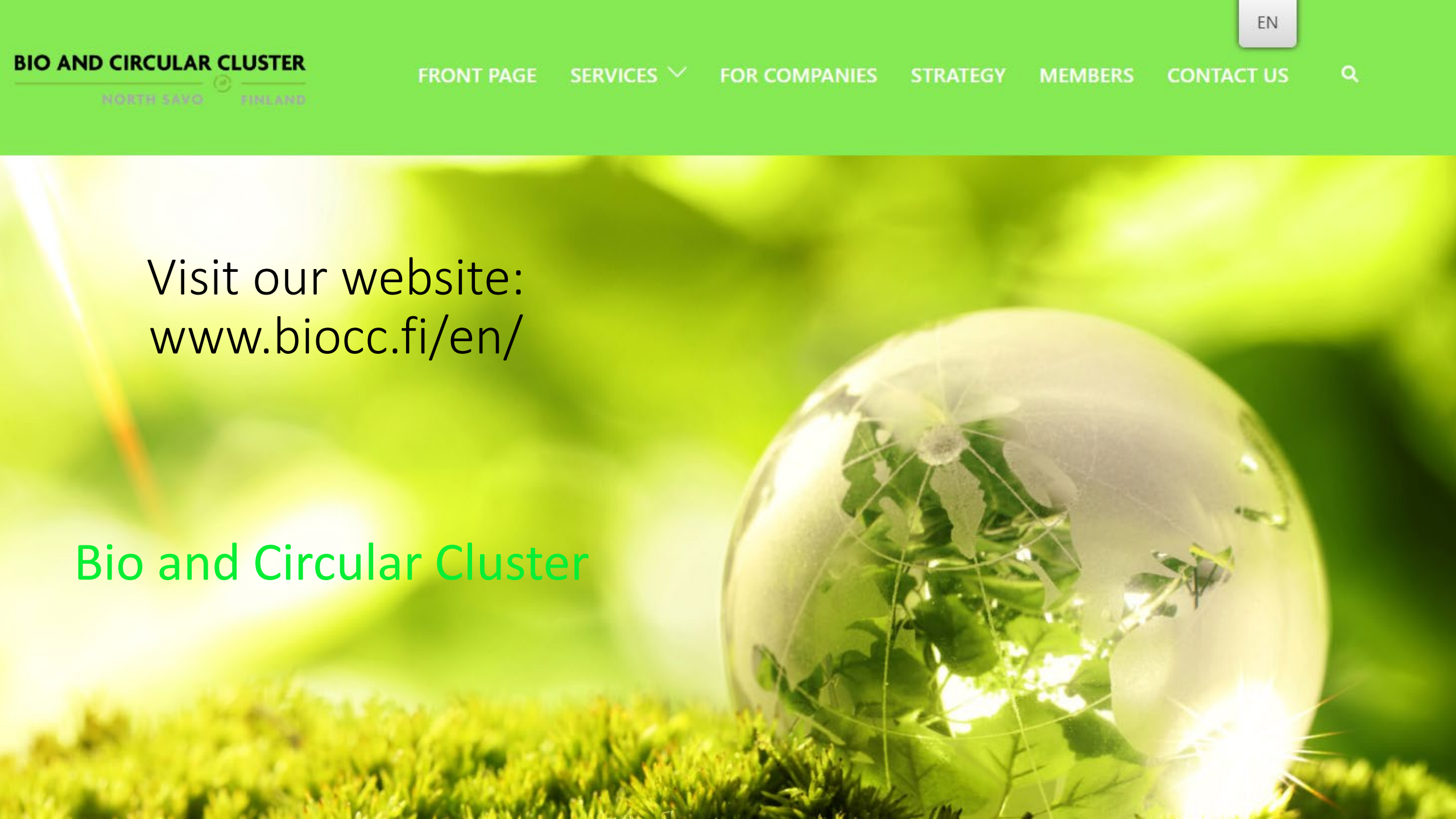
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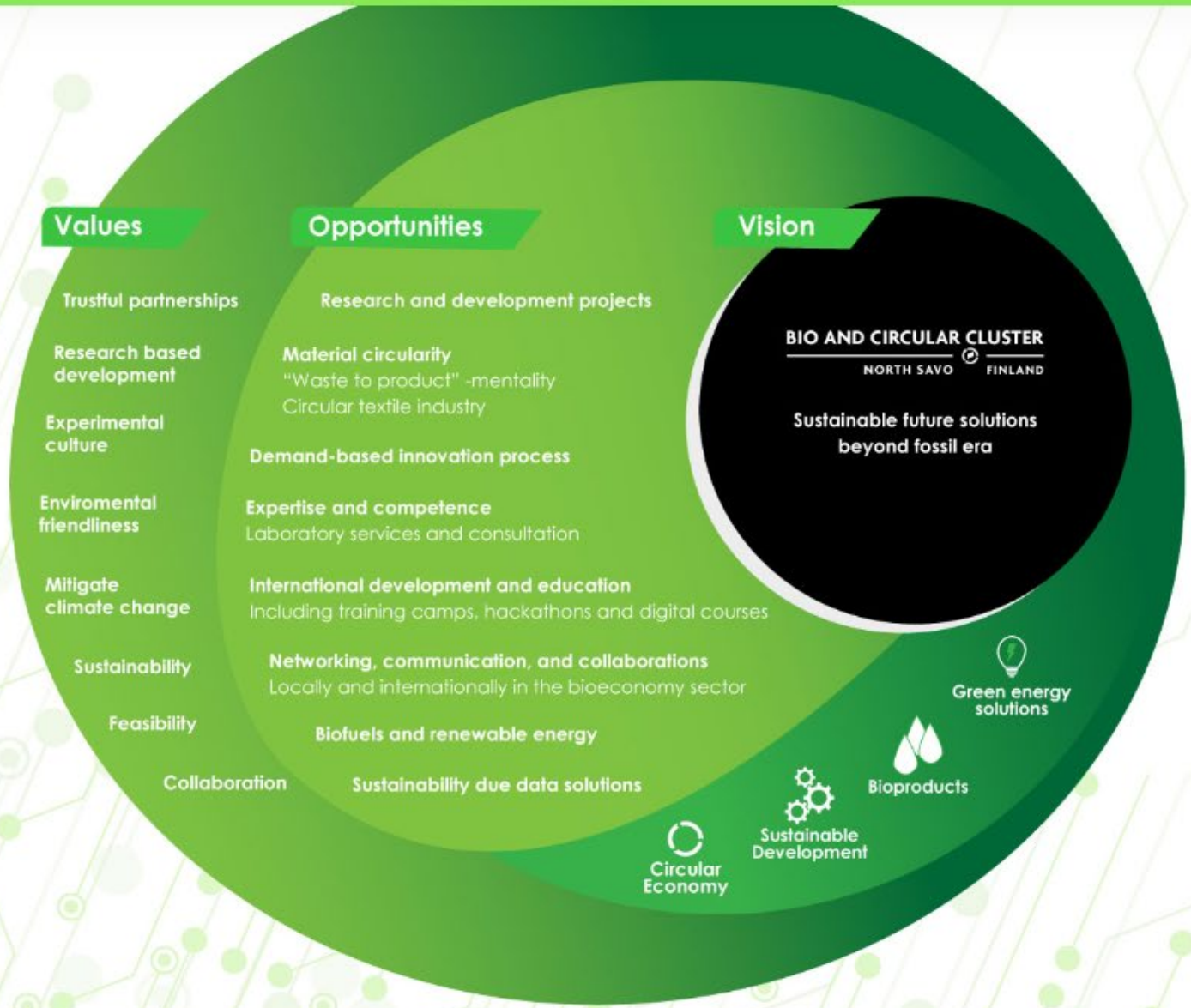
Bio and Circular Cluster

Bio and Circular Cluster Strategy

Supporting the growth of companies in the industry by bringing together state-of-the-art knowledge in technologies, products and services to develop circular economy



SUSTAINABLE DEVELOPMENT GOALS

Bio and Circular Economy
POHJOIS-SAVO - NORTH SAVO

- We support the utilization and valorization of industrial side streams with various biorefining technologies
- **Bio and Circular Cluster** has been registered at the European Commission's Cluster Platform ECCP, 2022)
- We promote a **sustainable bioeconomy and circular economy**
- Our aim is to support the development of the **waste management globally**
- We support the growth and internationalization of companies in North Savo, Finland.

Current Biowaste Value chain in Kuopio City area

- Separate collection system has been utilized in the city area for households and HoReCA since 1st Jun 2003
- Collection frequency: 1-2 two times per a week, depending on the demand
- Collection rates in 60 000 t/y and capture rate (i.e. what is sorted vs. total biowaste generated: 40 %)
- Biowaste is currently mainly used for biogas and circular fertilizer production.

The HOOP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101000836

Current Wastewater Value chain in Kuopio City are

- About 25 000 m3/day wastewater
- Wastewater sludge 6799 tn/a for digestion
- Wastewater slude is valorized in the biogas and circular fertilizer production

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Fermentors – with wide range of potentials

- Two identical bioprocess equipment (fermenters) with integrated pumps.
- Effective volume 5l.
- Mechanical stirring and gas collection/supply unit.
- Suitability with feeding up to 7 % of dry matter content.
- Temperature controlled from psychrophilic range (under 15 °C) up to thermophilic (50-55 °C).
- On-line measurements of pH, ORP and conductivity (autoclavable sensors).
- Operation in series and parallel.

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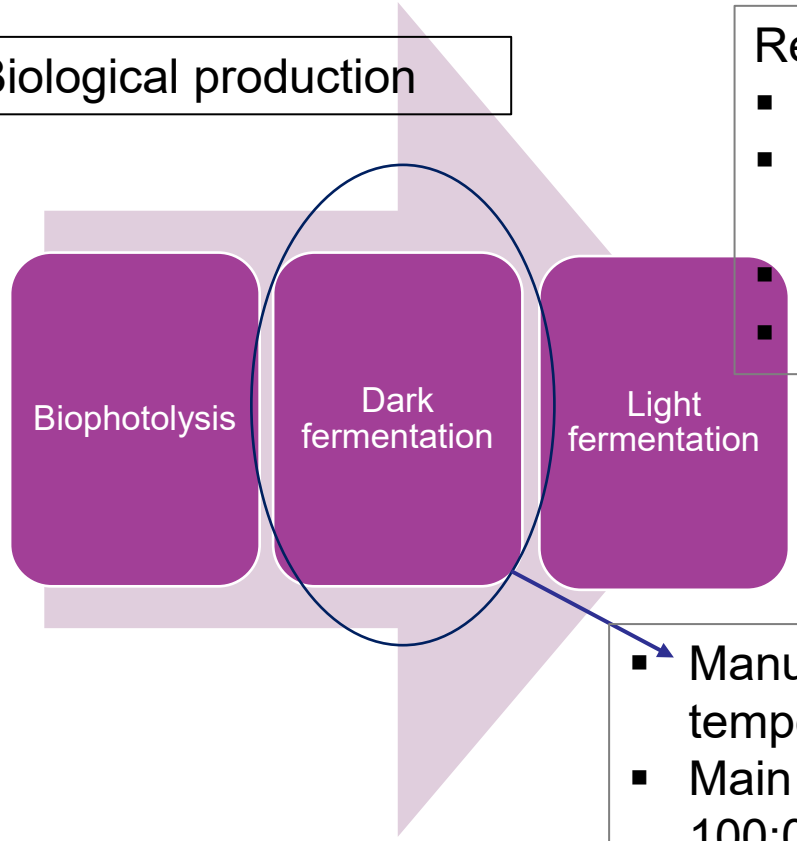
Hydrogen potential

Biological production



References:

- Bio-waste 58 H_2m^3/tVS
- Waste Water Sludge 21 H_2m^3/tVS
- Cabbage 44 H_2m^3/tVS
- Carrot 58 H_2m^3/tVS

- Manure based inoculum with temperature pre-treatment.
- Main nutrient ratio C:N:P 100:0,5:0,1.
- Trace elements: Mg, Na, Zn, Fe, K and Ca

- Mg and Fe co-factors (BOOSTERS) for hydrogen producers → accelerate metabolism.

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Dark fermentation

- Why hydrogen?
  - Renewable energy source.
  - The use of hydrogen in energy production does not cause any greenhouse gas emissions.
  - The use of hydrogen in fuel cells only produces water vapour as emissions.
  - Highest energy content of all chemical fuels per unit mass (hydrogen 120 MJ/kg, methane 50 MJ/kg and petrol 43 MJ/kg).
- Dark fermentation is a favourable technique for the production of renewable bio hydrogen.
  - Bacteria: *Clostridia-*, *Esherichia-, Citrobacter-* and *Bacillus-* genus.
  - Substrates: carbohydrates, proteins, and lipids.
  - End products in the liquid phase: acetate, butyrate, butanol, ethanol, acetone or 2-propanol.
  - The highest yields of hydrogen are obtained when the final products are both acetate and butyrate.
  - Hydrogen production maximization: bacterial metabolism must be directed away from alcohols and other reduced end products and made to produce volatile fatty acids.

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Hydrogen potential – zerofiber (p&p –industry)

- Forest industry/p&p-industry:
  - The forest industry is one of Finland's most significant employers.
  - The basis for production can be found in forests, which are Finland's most important natural resource.
- Zerofiber - non-utilized biomaterial:
  - Producing bio hydrogen from lignocellulose biomass is a viable option, as raw materials made up of lignocellulose do not compete with starchy and food crops made up of different sugars and are also cheaper than these conventional agricultural products.
  - Lignocellulose materials consist mainly of cellulose, pearl cellulose and lignin.
  - Bacteria cannot use cellulose directly as a raw material for hydrogen production. → Cellulose decomposes in the first stage of anaerobic decomposition, i.e. in hydrolysis, into simpler sugars that bacteria can use as a substrate for hydrogen production.
  - Examples of lignocellulose materials include waste and effluents from the pulp and paper industry, including zerofiber.
  - Pulp production consumes water 5-7 m^3/t pulp, waste water is formed 70 kg/t pulp which includes 3-5 kg solid matter/t pulp.
  - Zerofiber is abundantly available in the Finnish industry.

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Hydrogen potential – coffee grounds

- Finns drink the most coffee in the world per capita, raw coffee is drunk more than 12 kg per year, which means roasted coffee 10 kg per year.
- Coffee contains polysaccharides (24 %), minerals (14 %), chlorogenic acids (15 %), proteins (6 %), caffeine (5 %), carboxylic acids (3 %), monosaccharides (1-2 %) and other compounds (30 %).
- Up to 19% of the biowaste generated in Finland is coffee grounds.
- One of the goals of the hydrogen production research is the commercialization of biowaste and especially the production of hydrogen from coffee grounds.

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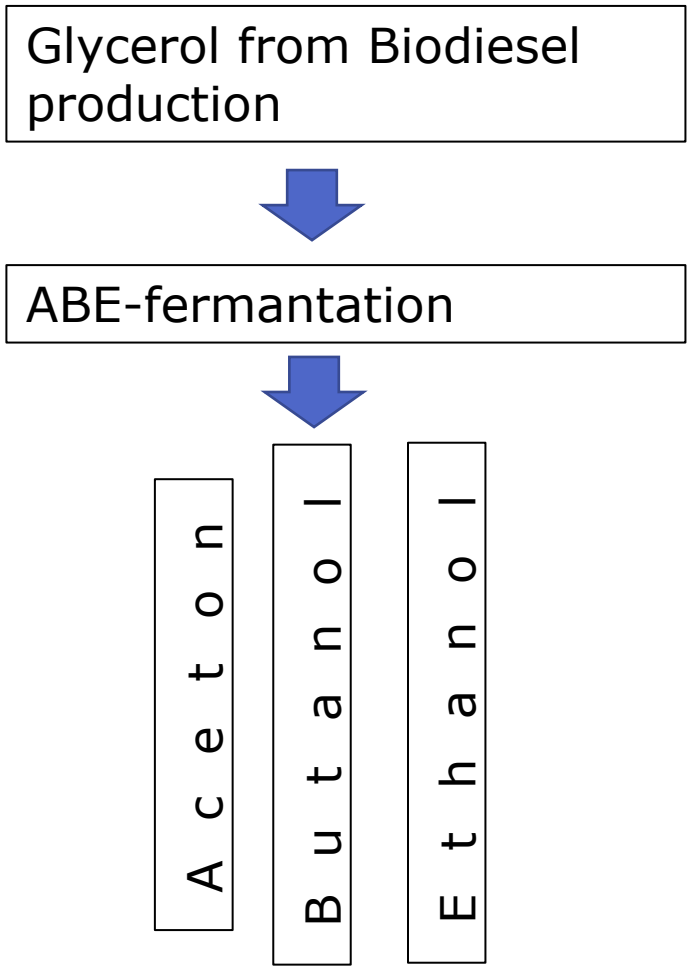
Aceton-butanol-ethanol-fermentation

2. ABE-fermentation

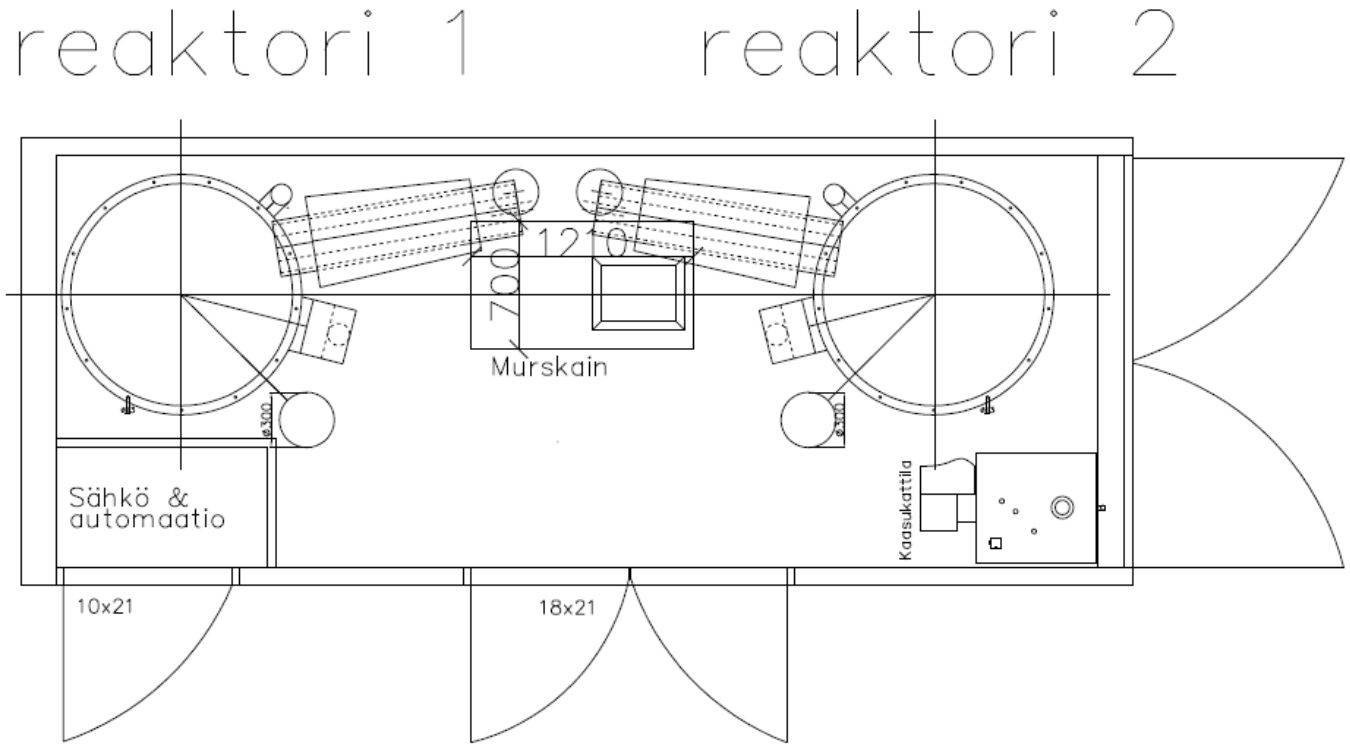


Carbohydrate-based waste streams are used as raw material, from which three main products are produced through the fermentation reaction:

- Acetone
- Butanol
- Ethanol

ABE fermentation produces fatty acids as intermediates and by-products, which are usually sought to be removed, as they affect the purity of the final products and inhibit the production of ABE products.

Pilot-scale fermentation equipment



Pilot 1: Utilization of waste and side streams of construction and mining industry and implementation of the circular economy

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Companies that are involved with the pilot:

- Niiralan kulma Ltd, Kuopion opiskelija-asunnot Ltd, Jätekukko Ltd ja Mestar Kuopio Ltd:
  - The aim is to promote the recycling of crushed concrete, brick and asphalt and also utilization of ash.
    - For example directly in the construction plot, civil engineering or in transport infrastructure construction.
- Fatec Ltd:
  - The goal is to promote the utilization of side streams during the project.
    - For example utilising mineral side streams in manufacturing of for example concrete and cementitious adhesives.
- Yara Suomi Ltd:
  - The interest is the utilization of waste and side streams, mainly waste rock, as well as researching the beneficial use of tailings and developing cost-effective logistic operations.

- Municipal cooperation is perceived as important, because thus side streams could be used more effectively, e.g. in municipal road projects.

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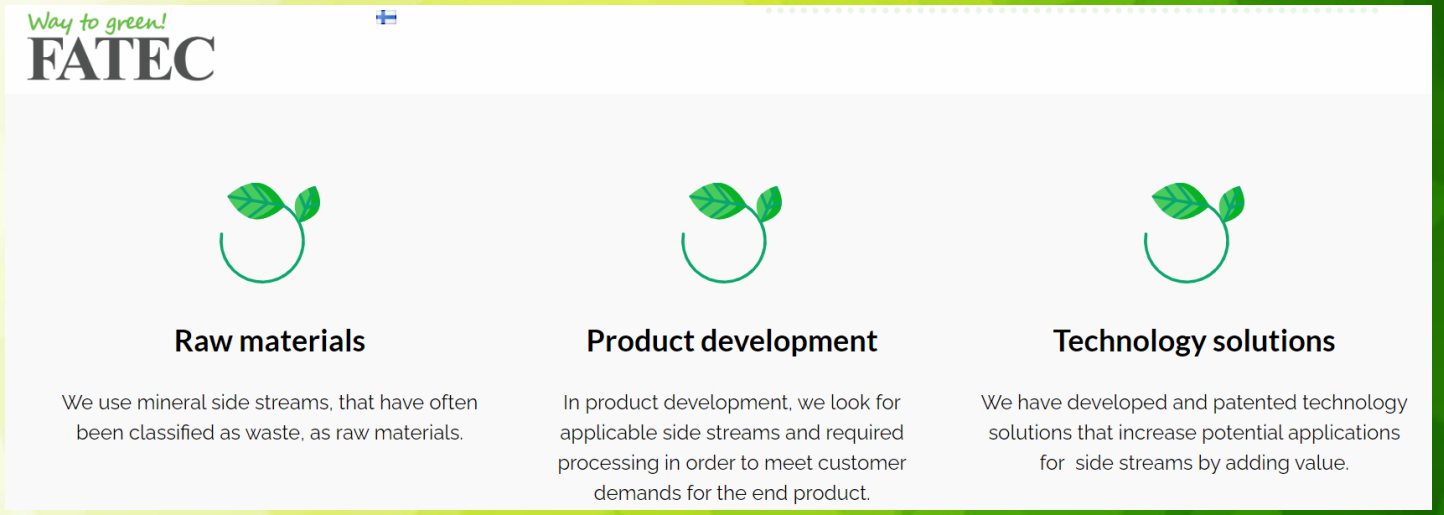
Fatec Ltd

- Located in Siilinjärvi.
- Solutions provider in circular economy.
- Objective is to provide solutions that enable productization of mineral side streams in a cost- and energy-efficient way.
  - This reduces the amount of waste, the use of natural resources, and emissions especially when replacing cement.
- The ability to combine side stream processing technology in production scale and our decades long experience in concrete, mortar and cementitious adhesive industry are our main strengths.



See more: https://fatec.fi/en/etusivu-english/

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Pilot

- In the pilot, an operational model is being built for the utilization of waste, demolition and side streams, tailings and ash, for example in infrastructure construction.
- As well as the aim of the pilot is to improve predictability of urban planning.
  - Urban planning enables the utilization of these side streams.

- Increasing open communication and cooperation between operators is important.
- Building an operational model is long-term and it takes time.
- The implementation of the operational model continues after the project.

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Operational model

- The project brings together producers and users of recycled materials and also infrastructure designers.
- The goal is to reduce the costs of demolition of buildings by developing the predictability of material flows and to draw up preliminary agreements between recycled materials producers/suppliers and users.
- As a result of the project, the supply and the demand of recycled materials will meet more efficiently than at the moment.

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The aim

- One of the goals of the operational model is to reduce the use of nonrenewable material.
- Also one aim is to investigate how the logistics of the materials can be developed.
- Can the material be temporarily stored and piled up so that it is always available.
- At the same time, the environmental permit required for logistics and piling up of the material is under investigation.
- End of Waste Regulations - allows waste materials turned into products.

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To be considered

- Kuopion Vesi Ltd has announced that it does not accept the use of waste material near water pipelines.
  - In connection to this, the risk factors possibly caused by the waste material are also investigated.

Thank you!

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