BIOCHEMICALS

gaia
Innovative Solutions
for Sustainability

Gaia Biorefiner Results

Screening the Environmental Sustainability of Bio-based Value Chains and Products

Crude Tall Oil to Tall Oil Rosin
Crude Gum to Gum Rosin

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What is Gaia Biorefiner?

Screening the sustainability of bio-based products

Gaia Biorefiner screens the environmental sustainability of bio-based products and value chains. It enables comprehensive sustainability benchmarking of innovations and solutions in areas like biofuels, biochemicals and biomaterials. With Gaia Biorefiner, companies and investors can identify the most resource-efficient and advanced solutions, focus investments and ensure that the benefits of bio-based technologies and products are fully realized.

Why have we developed Gaia Biorefiner?

Bioeconomy is a rapidly evolving field, where novel value chains and concepts are developed and commercialized based on growing demand and global drivers. Sustainability is one of the main drivers of this development, but assessing sustainability is becoming very complex. Many sustainability issues, such as origin of biomass feedstock and related land use issues, are specific for bio-based value chains. Yet companies need practical tools for screening of business ideas and investment opportunities in terms of sustainability.

What does Gaia Biorefiner screen and how?

aGaia Biorefiner highlights the most critical sustainability related issues of emerging value chains. It is an indicator-based tool which includes main aspects of environmental sustainability and builds on globally recognized methodology, classification criteria and data sources. The results are presented in an easy-to-understand and visual way.

What is the benefit of Gaia Biorefiner?

Gaia Biorefiner combines an in-depth understanding of the new value chains and material cycles of bioeconomy with most valid understanding on the sustainability issues. By doing that, it offers a novel opportunity to screen different raw materials, locations, technologies, processes, and product options easily. In addition it enables benchmarking alternative value chains. The results can be used, for example, for selecting the most beneficial options for investments and further RDI as well as planning actions to mitigate highlighted sustainability risks.

How do we understand bioeconomy?

Bioeconomy covers all the products, processes, and technologies that use biomass as their main raw material. As well, services related to these areas are included. Our main focus is on emerging bioeconomy including biofuels, biochemicals, and biomaterials.

Main points of Gaia Biorefiner

- Critical sustainability aspects of bio-based products highlighted and benchmarked to alternatives
- Applicable to biofuels, biochemicals and biomaterials
- Efficient screening of important sustainability aspects with solid methodological basis
- Ability to screen efficiently complex value chains

Four easy steps to screen the sustainability of your value chain

1. Select the product and value chain to be screened
2. Select alternative value chains
3. Locate the value chains geographically
4. Provide value chain specific data if available

Case Description

Case name
Crude Tall Oil (CTO) to Tall Oil Rosin (TOR)

Value chain
Forestry (Finland, Russia, Sweden, Estonia, USA > Kraft Pulping (Finland, Russia, Sweden, Estonia, USA) > CTO > CTO Distillation (Finland)> TOR > End Market (Germany)

Production capacity
31 000 t/year

Energy sources
The distillation plant is in close connection to the neighbouring pulp mill. Excess steam is received from the pulp mill. Electricity and heat is produced in the pulp mill CHP plant (fuel: biomass) and heat is produced at plant (fuel: head and pitch from distillation).

Co-products
TOFA (Tall Oil Fatty Acids) and Fortop600

Reference group
Gaia Biorefiner evaluates the quantitative indicators against a product specific reference group. Of the four product sub-categories (Main bulk chemicals, Intermediate bulk chemicals, Fine Chemicals ans Pharmaceuticals), Intermediate Bulk Chemicals is chosen as the sub-category corresponding to the end product TOR/ Gum Rosin. The reference group for Intermediate Bulk Chemicals is made of 20 common intermediate bulk chemicals (biomass based and petrochemical) and five oleochemicals. If the value calculated for the value chain is among the top 15%, the indicator gives the result competitive advantage. If the value calculated for the value chain is among the middle 70%, the indicator gives the result neutral. If the value calculated for the value chain is among the bottom 15%, the indicator gives the result potential risk. For 4.1 Land use intensity, the corresponding values are 10%/80%/10% and for 7.4 Waste per product ratio, 20%/60%/20%.

Alternative value chain
Crude Gum to Gum Rosin: Pine forests (China) > Pine tapping (China) > Crude Gum > Crude Gum cleaning and distillation (China) > Gum Rosin > End Market (Germany)

Why this value chain is chosen as an alternative
Gum Rosin can be used for similar purposes as Tall Oil Rosins (TOR). Gum Rosin is an established product and can, similar to TOR, be used for paper size and adhesives production. Current world production is 0.8 million tonnes.

Production capacity
400 000 t/year

Energy sources
Fuel for heating is assumed to be subbituminous coal. Chinese grid average fuel mix is used as fuel mix for electricity production. No heat recovery or area surplus is assumed.

Data sources for value chain data

TOR
Ecoinvent database (see attachment for details), Forchem

Gaia Dataset for Location Specific Data: Finland, USA, Sweden, Russia, Estonia

Gum Rosin
Sust Forest web page and the reports: “Gum naval stores turpentine and gum rosin from pine resin” by FAO, “Greenhouse gas and energy life cycle assessment of pine chemicals derived from crude tall oil and its substitutes” by Franklin Associates

Gaia Dataset for Location Specific Data: China, Germany

Crude Tall Oil (CTO) to Tall Oil Rosin (TOR)

Potential competitive advantage

The value chain has several potential competitive advantages from an environmental sustainability viewpoint. Competitive advantages rise in all climate change indicators: GHG emissions from transport and GHG emissions from production and Carbon sequestration. The water scarcity in the region of production is low, and the share of renewable energy sources is high. The raw material production site provides ecosystem services, and there is no threat to food production, nor risks through indirect land use change. No threat to nutrients balance is raised by the production. Chemicals used in the production process provide no environmental hazard. Fossil intensity is low and material efficency is high.
The product has a competitive in biodegradability.

Potential risks

Potential risks are raised by solid waste and waste gas treatment requirements. The potential risks for the product are disadvantages in storage properties and product functionality.

Crude Gum to Gum Rosin

Potential competitive advantage

The value chain has several competitive advatages from an environmental sustainability viewpoint. Although GHG emissions are moderate, carbon sequestration occurs in the forests. The water scarcity in the region of production is low, and no desalination is required. The share of renewable energy sources is high. The raw material production site provides ecosystem services, and there is no threat to food production, nor risks through indirect land use change. No threat to nutrients balance is raised by the production. Chemicals used in the production have no safety hazards. Mineral intensity is low and material efficency is high. Land use efficiency is better than the comparative chains, but still moderate compared to all crops. No threat to nutrients balance is raised by the production. The end product is biodegradable.

Potential risks

Potential risks are found from GHG emissions from transport, due to long distances and GHG emissions from production indicators, due to high fossil share of energy sources and high energy intensity. Health hazard of production chemicals. There are risks related to use and disposal of the end product.

Results

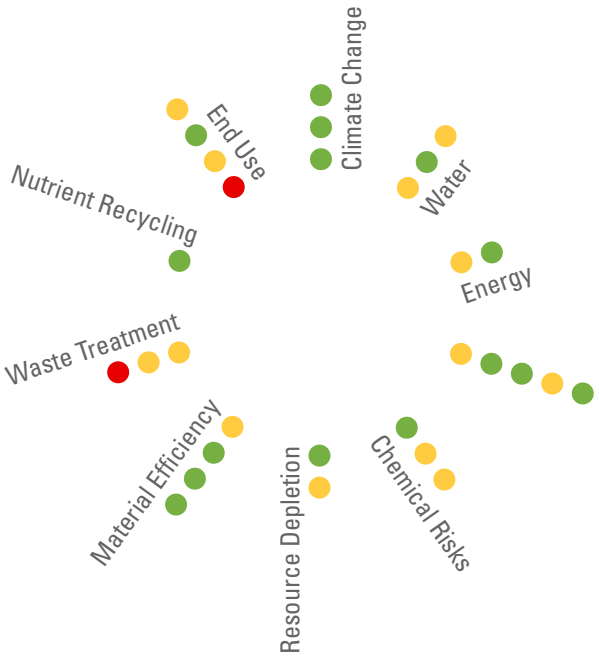
	FORCHEM CRUDE TALL OIL TO TALL OIL ROSIN	CRUDE GUM TO GUM ROSIN
1. CLIMATE CHANGE		
1.1 GHG emissions from production	● Small. The fuel used is mainly biomass.	● Remarkable. The fuel used is coal
1.2 GHG emissions from transport	● Small	● Remarkable. Long distance transport
1.3 Carbon sequestration in raw material production	● Significant positive impacts likely	● Significant positive impacts likely
2. WATER		
2.1 Water intensity	● Moderate. Mainly from raw material production: Kraft pulping	● Small
2.2 Water scarcity where produced	● No water scarcity	● Minor over consumption of water resources
2.3 Desalination before production	● Desalination of other than ocean water. 44% of total water used in boiler in distillation step is desalinated	● No desalination
3. ENERGY		
3.1 Energy intensity of production	● Moderate. 44% of energy intensity results from raw material production	● Remarkable
3.2 Share of renewables in production energy	● Remarkable (over 50 %). Energy requirements are covered by pulp mill, which uses biomass as fuel	● Moderate (10 to 50 %)
4. LAND USE		
4.1 Land use efficiency of raw material production	● Moderate land area needed	● Moderate land area needed
4.2 Land use synergies through ecosystem services	● Remarkable synergies. Forests provide significant ecosystem services while biomass is produced.	● Remarkable synergies
4.3 Threat to food production from raw material production	● No threat	● No threat
4.4 Threat to biological diversity from raw material production	● No significant impacts	● No significant impacts
4.5 Risks through indirect land use change	● No or minor risks. Global primary raw material (pine forests) production is not growing and not competing with food production	● No or minor risks. Global primary raw material (pine forests) production is not growing and not competing with food production
5. CHEMICAL RISKS		
5.1 Environmental hazard of production chemicals	● Small	● Small
5.2 Health hazard of production chemicals	● Moderate	● Highly hazardous to human health. Oxalic acidc causes serious eye damage
5.3 Safety hazard of production chemicals	● Moderate	● Small

Results

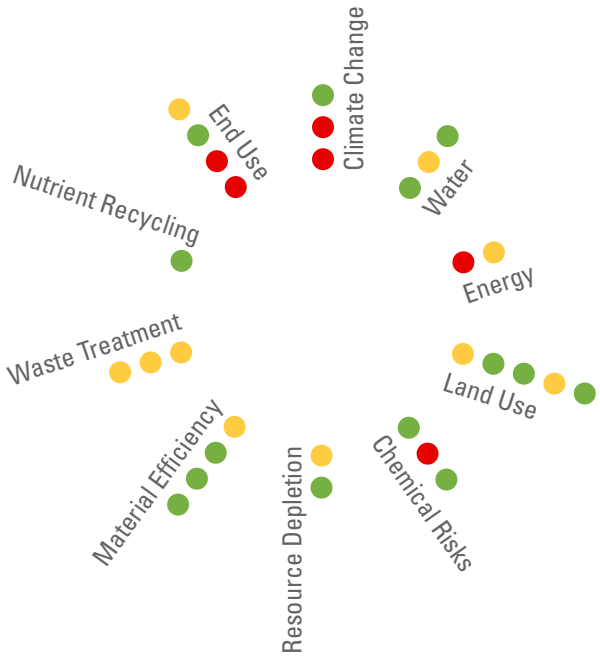
	FORCHEM CRUDE TALL OIL TO TALL OIL ROSIN	CRUDE GUM TO GUM ROSIN
6. RESOURCE DEPLETION		
6.1 Fossil intensity	● Small. Raw material is biomass and energy requirements are covered by pulp mill, which uses biomass as fuel.	● Moderate
6.2 Mineral intensity	● Using minerals	● Small
7. MATERIAL EFFICIENCY		
7.1 Alternative uses of raw material	● Raw material could be used for other solutions	● Raw material could be used for other solutions
7.2 Main raw material utilization rate to products	● Over 80 %	● Over 80 %
7.3 Product type ratio	● Over 50 %	● Over 50 %
7.4 Waste per product ratio	● Less than 20 %	● Less than 20 %
8. WASTE TREATMENT		
8.1 Wastewater treatment	● Some treatment needed	● Some treatment needed. Wastewater contains organic acids
8.2 Waste gas treatment	● Some treatment needed. Waste gas contains sulfurous compounds	● Some treatment needed. Volatile organic compounds are formed
8.3 Solid waste treatment	● Remarkable treatment needed	● Some treatment needed. Assumed that solid waste suitable for normal waste treatment is formed
9. NUTRIENT RECYCLING		
9.1 Threat to nutrient balance from raw material production	● No threat. The nutrient balance in Finland is at EU average. This indicates that there is a risk for overnutrification. The raw material production process does not include fertilization, agriculture or livestock production and therefore this is irrelevant.	● No threat. Not relevant for forests
10. END USE		
10.1 Storage properties	● Very sensitive to surroundings. Thermal insulation needed	● Very sensitive to surroundings
10.2 Risks related to use and disposal	● The product is hazardous to environment, human health, or safety. The product may cause an allergic skin reaction	● The product is highly hazardous to environment, human health, or safety
10.3 Biodegradability	● Biodegradable. The product is readily biodegradable	● Biodegradable
10.4 Product functionality	● For rubber production and use in paper sizing, the functionality of the comparative end products is the same.	● Gum Rosin is slightly better than the comparative product TOR in adhesives as the softening point is lower and the color is more clear.

Environmental sustainability of value chain of TOR compared to value chain of Gum Rosin

Crude Tall Oil (CTO) to Tall Oil Rosin (TOR)



Crude Gum to Gum Rosin



Potential competitive advantage Neutral Potential risk

Tall Oil Rosins (TOR) can replace the use of Gum Rosin in adhesives, rubber and paper sizing production. The indicator based sustainability analysis shows that both value chains have several competitive advantages. The two potential sustainability risks found for TOR in the analysis are related to solid waste treatment from the raw material production step, sulphate pulping and the storage and handling properties of the end product. The production of Gum Rosin includes more potential risks, related to energy requirements, fossil use in transport and GHG emissions resulting from this and hazardous properties of process chemicals. The screening results from the Climate Change indicators indicate that the value chain for TOR production has competitive advantage over the value chain for Gum Rosin production, which shows alerts for GHG emissions from processing and long distance transport. TOR production is more resource intensive, with respect to water intensity, but on the other hand less with respect to energy intensity. The value chain for TOR production has no chemical hazard alerts, while the value chain for Gum Rosin production has one health risk alert. TOR production uses minimum amount of fossil fuels and as a consequence has a competitive advantage compared to Gum Rosin production. Gum Rosin is produced without minerals and therefore has a competitive advantage over TOR production in mineral intensity.

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Gaia Consulting Ltd

Gaia Biorefiner is created and provided by Gaia Consulting. We are a leading sustainability consultancy. In addition to bioeconomy, our areas of expertise include sustainability, energy, climate change and environment, as well as risk management and innovation. We provide our clients with profound and multi-disciplinary know-how, and a cross-disciplinary approach to meet challenges with uncompromised high quality and reliability.

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